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Changes in demography along a thermal gradient in the intertidal crab Petrolisthes cinctipes
Different demographic groups within a population (i.e., males/females, small/large individuals) are often distributed differently along environmental gradients, suggesting different ecological or physiological needs. The intertidal zone porcelain crab Petrolisthes cinctipes is distributed along a vertical thermal gradient within the intertidal, though it is currently unknown how individuals are distributed along this gradient. We monitored under-rock temperature and crab demographics (size, sex) over summer and autumn months in fixed transects along the species' vertical distribution boundaries. In the upper intertidal, under-rock temperatures were strongly size dependent, with smaller rocks reaching temperatures up to 37°C but larger rocks never exceeding 20°C. Lower in the intertidal, rock size was less important and no rocks exceeded 17°C. Results show mean crab density much lower in the warm high intertidal (83 crabs/m2) compared to the cooler low intertidal (171 crabs/m2). In addition, we found male-skewed sex ratios in the upper and lower intertidal zones where male crabs were 25% and 21% more abundant than female crabs respectively. From these data we can conclude that under-rock temperatures influence demographic parameters of P. cinctipes within the intertidal.

P3.192 ACKERLY, KL*; CHAPMAN, LJ; KRAHE, R; McGill University; *kerri.ackerly@mail.mcgill.ca*
The relationship between fast-start performance and electric signaling under high and low oxygen in the African mormyrid, Gnathonemus victoriae
Many fishes perform quick and sudden swimming maneuvers known as fast-starts in an attempt to escape when threatened. In pulse-type weakly electric fishes, including African mormyrids, these responses are accompanied by transient increases in electrical signal production known as novelty responses. While these novelty responses may heighten an individual's perception of their surroundings, they are aerobically powered and may come at a high energetic cost when compared to fast-start performance, which relies primarily on anaerobic muscle. The juxtaposition between the two key aspects of fast-starts in these fishes, the aerobic novelty response and the anaerobic swimming performance, makes them an interesting model for studying effects of hypoxia on performance and sensory information acquisition. In this study, the mormyrid fish *Gnathonemus victoriae* was acclimated to either high- or low-dissolved oxygen (DO) levels for eight weeks, after which fast-starts and concurrent novelty responses were quantified under both high and low DO test conditions. Our results indicate no effect of hypoxia on fast-start performance regardless of acclimation or test condition. Novelty responses were given upon each startle, whether or not the fish also performed a fast-start, although they were significantly stronger when accompanied by a fast-start. Novelty responses were also reduced in normoxia-acclimated individuals when tested under hypoxic conditions. Overall, our results indicate an effect of hypoxia on sensing but not fast-start performance.

P3.102 ACKERT, K*; MARTINO, B; SORKIN, R; BYRNES, G; Siena College; *gbyrnes@siena.edu*
Understanding the mechanical tradeoffs for arboreal locomotion in squirrels
Animals must regularly negotiate complex 3D terrain in trees. They are able to accommodate large changes in substrate compliance, height, and gap distance without falling to the ground, which would result in exposing them to potential predators. The discontinuous arrangement of substrates in arboreal habitats continuously challenges animals to make choices about which substrates to move over and which to avoid. However, by avoiding some subset of the available substrates, due to branch diameter, compliance, or other properties, animals must make longer paths through the trees or to the ground, which will incur an additional locomotor cost. Therefore the goals of this study are to determine substrate use and path lengths of squirrels (*Sciurus carolinenesis*) in the field to examine if trade-offs occur between safety and economy. On average, paths were approximately sixty percent longer than the shortest, straight-line path between starting and ending points. Further, because squirrels spent much time on the ground, and climbed to and from the ground on large stiff branches, both the diameter and stiffness of branches was higher than estimates of average branch properties from transects through the study area. Our data suggest that there is a trade-off between branch selectivity and locomotor cost and that squirrels in our study prioritized safety over economy.

P2.184 ADAMS, D.S.*; LEWIS, G.; FISH, F.E.; West Chester University; *da762671@wcupa.edu*
Assessment of swimming records for thunniform propulsors
Many marine vertebrates need to swim at high speeds to migrate, capture food, and escape predation. The thunniform mode is associated with high-speed swimming. Pelagic marine predators (e.g., tuna, swordfish, dolphins) swim in the thunniform mode, possessing a stiff fusiform body, narrow caudal peduncle, and sickle-shaped caudal propulsor. The literature is replete with records of maximal speeds for thunniform swimmers, but no comprehensive review has been undertaken to assess the validity of the claims. Differences in data collection (e.g., high-speed video, satellite transmitters, unreeling fishing line, boat observations) and subjective descriptions of swimming effort (e.g., burst, maximal, peak, cruise, steady, sustained, routine) have cast doubt on record values of performance. Data on swimming speeds of specialized perciform fishes (Scombridae, Istiophoridae, Xiphiidae) and cetaceans (Odontoceti, Mysticeti) were compiled from the primary literature dating from 1923 to 2015. Swimming speeds were categorized as either burst or sustained for each group. The distribution of speeds indicated that the highest performance (36.1 m/s) was displayed by swordfish (*Xiphias gladius*) and marlin (*Makaira* sp.), although the sources were questionable fishing reports. Similarly, the highest speeds (>15.0 m/s) for cetaceans were for a killer whale (*Orcinus orca*) and bottlenose dolphin (*Tursiops truncatus*) based on uncertain observations. There is wide variation of the distribution of swimming speeds reported for thunniform swimmers that is dependent on species, methodology, classification of performance, and motivation of the swimmer. Accurate information of speed capabilities for thunniform swimmers is necessary for application toward engineering biomimetic autonomous underwater vehicles with enhanced speed and efficiency.

P1.141 ADEMI, B.*; D'ALMEIDA, A.; RAND, M.S.; Carleton College; *mrand@carleton.edu*

-Adrenergic Stimulation, cAMP, and Edema Cause Dorsal Crest Erections in Anole Lizards

Male *Anolis sagrei* erect a vertical ridge of tissue along their neck and spine during escalated aggressive encounters with other males. The function of the crest erection is thought to modify the lateral profile of a fighting male, suggesting an important behavioral cue. However, very little is known regarding the physiological and cellular regulation of crest development. Previous work in our lab has shown that the -adrenergic receptor (BAR) agonist isoproterenol produces crest erections and the BAR antagonist propranolol inhibits crest formation. We found that pharmaceuticals developed for specific mammalian - and -receptors had varying efficacies on the *Anolis* receptors. For example, salbutamol, a -2 agonist, induced crest formation, but terbutaline failed. The -1 agonist methoxamine inhibited -stimulated crest formation, while phenylephrine occasionally induced a crest. To understand the intracellular mechanisms involved in crest formation, we used the forskolin analog NKH-477 to increase intracellular cAMP. Systemic injections of NKH-477 induced full crest formation, while small volume injections directly into the crest produced a localized, partial crest at the injection site. Based on these results in combination with our histological examinations, we hypothesize that BAR stimulation of vascular smooth muscle increases intracellular cAMP, which causes vasodilation of vessels within the crest organ. Further, we hypothesize that leaky capillaries within the crest allow fluid to leave the blood vessels and this increases the extracellular fluid volume that causes dorsal crest erection.

P1.39 AJA, A*; SALLAN, L; HSIEH, T; DODSON, P; Univ. of Pennsylvania, Temple University, Univ. Pennsylvania; *caja@sas.upenn.edu*

Just how different? Quantifying Vertebral Diversity in Primitive Tetrapods

The size and shape of vertebrae within the axial vertebral column are influenced by ecology and phylogeny, in addition to body size. Parameters such as total vertebral number, and dimensions and angles of vertebral processes have been correlated with locomotor type, performance, and axial mobility. Despite studies across a wide range of extant taxa including fish to primates, these data have not been expanded towards understanding Paleozoic tetrapod biomechanics. Yet, this ancestral assemblage underwent major biomechanical innovations which enabled the evolutionary water-land transition, critical to the explosive diversification of land vertebrates. Temnospondyls were a diverse set of stem-amphibians that arose in the mid-Mississippian (346MYA) and went extinct in the Early Cretaceous (120MYA. Early works on temnospondyls described and categorized their diversity of ecologies, habitats, and gross morphologies, including complex vertebral morphologies. However, no study has quantified temnospondyl vertebral diversity in, or addressed their effects on, biomechanical metrics such as stiffness of the spine, or lever arms of epaxial musculature. We undertook a 2D geometric morphometric study of the shape differences and investigated the biomechanical consequences of pre-sacral vertebral morphology in the temnospondyls by calculating, plotting, and analyzing principal components to determine disparity patterns. We document the diversity of all aspects of centra, neural spine, and transverse process shape. Principal components separate the temnospondyls into clusters consistent with their phylogeny, body size, geological age, and, most biomechanically relevant, habitat. This project lays the groundwork for a series of quantitative studies to understand differences within this diverse group and to better understand key innovations in the axial column for terrestrial locomotion.

P1.192 AKCAY, C; VERNASCO, B.J.; STANBACK, M.T.; MOORE, I.T.*; BONIER, F; Virginia Tech, Davidson College, Queen's University, Ontario; *caglar@vt.edu*

Do close neighbors increase aggressive interactions and CORT levels in female tree swallows?

Animals compete for resources that are required for breeding and self-maintenance such as nesting sites, mates, and food. High levels of competition can be a source of stress for individuals, as suggested by a many studies showing increased stress hormones (glucocorticoid levels) when densities are high. For example, in tree swallows, *Tachycineta bicolor*, females can compete vigorously for nest boxes and there is evidence that in dense populations, females exhibit increased levels of glucocorticoids (CORT). Previous studies however did not distinguish between the effect of population density, settlement patterns, and the frequency of aggressive encounters. Here we present an experiment where we manipulated the distances between nest-boxes after settlement to manipulate the frequency of aggressive interactions between females while keeping the population density constant. Specifically after settlement, we moved a randomly selected group of boxes closer together and another group farther apart. We carried out behavioral observations to estimate the frequency of aggressive interactions and obtained blood samples from females both before and after the manipulation to look at changes in CORT. Most aggressive interactions were observed at the settlement period, before the manipulation. We found no effect of the nest-box distance manipulation on female CORT levels or the frequency of aggressive interactions. We discuss these results in the context of how population density may affect stress hormones in natural populations.

P3.67 ALCANTARA, R.S*; WALL-SCHEFFLER, C.M; Seattle Pacific University; *alcantarar@spu.edu*

Push it, Push it Real Good: The Energetic Cost of Stroller Running

Humans living in societies with stroller use often engage in stroller running following the transition to parenthood. The addition of a stroller into the running experience has the potential to be disruptive of gait and put a premium on stamina. This study investigates some of changes of embarking on stroller running, including potential changes in metabolic cost, speed and stride length. While stroller running is a uniquely human endeavor, doing something with upper extremities whilst locomoting, is something in which other bipeds could potentially engage. Additionally, people have potential options in how they push a stroller, and we investigated each of our variables at different stroller pushing styles. People with limited stroller experience prior to our study (N=16, 10 men and 6 women) pushed a stroller loaded with 16kg while running around a track for 800m at each of four conditions, performed in a randomized order. Each runner was instructed to "maintain a consistent pace" within and across their conditions. The conditions consisted of three stroller-pushing conditions, in addition to the non-stroller control: (1) Pushing with both hands, (2) Pushing with one hand, (3) Pushing and Chasing. There were not significant differences in speed, stride length, or cost between the three stroller conditions and speed, though pushing with one hand did show a different slope in a model predicting cost from mass and speed. There was a significant decrease in stride length ($p<0.001$) and in speed ($p<0.01$) between non-stroller running and all three stroller conditions. There was not however a significant change in metabolic cost, suggesting that for a given speed, the metabolic cost of running with a stroller is higher than without, and that humans adapt to stroller running by slowing their pace in proportion to the additional effort. Additionally, men and women showed slightly different patterns of cost and speed changes, potentially due to the fact that in this sample, men ran significantly faster than women ($p<0.05$).

P3.132 ALICEA-SERRANO, AM*; JAIN, D; DHINOJWALA, A; BLACKLEDGE, TA; Department of Biology, Univ. of Akron, Ohio, Department of Polymer Science, Univ. of Akron, Ohio; *ama251@zips.uakron.edu*

Do biomaterials co-evolve with behaviors? Evolution of spider silk properties of orb webs in Hawaiian Tetragnatha

Web architecture evolved rapidly during adaptive radiation of Hawaiian *Tetragnatha*, with similar web architectures evolving repeatedly on different islands. But, whether silk bio-materials can co-evolve with such rapid changes in web architecture remains a mystery. In this study we tested for diversification in silk properties. We predict a relationship between silk properties and the performance of webs. Since Hawaiian *Tetragnatha* typically inhabit tropical montane forests -where high humidity predominates- we also predict that adhesive forces of capture silk will be greatest at higher humidity - in contrast to typical synthetic adhesives. To characterize bio-material properties of Hawaiian *Tetragnatha*, Major Ampullate (MA) and capture spiral silk, orb webs where collected at two sites in Hawai'i - Upper Waiakea Forest Reserve, Hawai'i and Waikamoi Nature Conservancy Preserve, Maui. Four species of orb weaver *Tetragnatha* where target in this study, *T.hawaiensis* present in Hawai'i and *T.stelarobusta*, *T.trituberculata*, *T.hawaiensis* and *T.acuta* present in Maui. To determine material properties for two key functions of orb webs, and their chemical bases, we performed tensile and adhesion tests using a Nano Bionix test system. Solution State NMR was also used to assess salt composition of glues. Results of this study will help us see if spider silk material properties are adjusted to its architectures which is important to comprehend spider diversification, and in to gain further knowledge that will help in the development of new bio-materials.

P1.66 ALLEN, J.J.*; CHENEY, J.A.; SWARTZ, S.M.; Brown University; *Justine_Allen@brown.edu*

Wing muscle insertion in two phyllostomid bats

Bats are the only mammals capable of powered flight. Aerial locomotion is achieved with wings composed of bilayered skin. Among other elements, the skin contains muscles and organized bundles of elastin fibrils. One set of muscles, the plagiopatagiales proprii (mpp), are variable in form but present in all bats studied so far; the mpp may control camber of the wing during downstroke. The mpp are unusual in that they do not have skeletal attachments. We investigated the caudal and rostral insertion points of the mpp in two species of phyllostomid bats, *Carollia perspicillata* and *Artibeus lituratus*. Wing tissue was fixed and processed for histology. The caudal insertion was similar in both species: each mpp attached via collagen to a spanwise elastin fiber near the trailing edge of the wing. The rostral end revealed differences between species. In *C. perspicillata*, most muscle cells in an mpp bundle terminated on a spanwise elastin fiber. A few muscle cells extended rostrally and their collagen wrapping (endomysium) appeared continuous with the surrounding collagenous matrix. In *A. lituratus*, each mpp terminated in a tendon continuous with collagen that organizes the muscle bundle (endomysium and epimysium). This tendon is uniquely embedded with numerous elastin fibrils. Rostrally, the elastin-collagen tendon intersected spanwise elastin fibers in the armwing. In both species, the attachments might allow the mpp to distribute contractile force across the wing via the mesh-like elastin network. Bat wings are thin, resilient, flexible and aeromechanically complex. Understanding the microstructure, arrangement, and interactions among the wing elements will improve our understanding of bat flight and might inspire the design of lightweight, compliant, and active materials that can withstand aerodynamic loads.

P1.127 ALLEN, E A*; GEORGE, S A; College of William and Mary, Williamsburg, VA, Georgia Southern University, Statesboro, GA; *georges@georgiasouthern.edu*

Differences in protein expression among P. ochraceus larvae in fluctuating versus constant low salinity environments

Global temperatures have been steadily increasing annually, causing increases in artic ice melting. The resulting freshwater from this artic ice retreat enters local river systems, which flow down to the Pacific Northwest and add freshwater to the Salish Sea. With significant melting occurring in the summer months from May to June, the Salish Sea receives multiple influxes of low-salinity water every summer that can persist for a couple of days. These freshwater events can lower surface water salinity from normal 31ppt to as low as 21ppt. Understanding the impact of these low-salinity events is particularly important for the larvae of seastar *Pisaster ochraceus*, which are limited in their ability to swim out of low-salinity surface waters. Since *P. ochraceus* can take over 200 days to develop and metamorphose, larvae are bound to experience at least one low-salinity event during their development. This study looked at the effect of a constant low-salinity environment versus a fluctuating salinity environment on *P. ochraceus* survival, morphology, development, and protein expression. No significant differences in larval survival and body size were found between treatments. However, low-salinity reared larvae had significantly shorter posterolateral arms, which has implications for feeding and swimming behaviors. Osmoregulatory and mechanosensory protein expression was upregulated in fluctuating salinity treated larvae, while low-salinity reared larvae were not significantly different from the controls. This upregulation indicates that *P. ochraceus* larvae are changing their protein expression in response to the lower salinity environment.

P1.1 ALLEN, LC*; HRISTOV, NI; MERSON, M; Winston-Salem State Univ., Winston-Salem State Univ., Center for Design Innovation, TERC; *allenl@wssu.edu*

Creating iSWOOP Moments: Using Technology and Visual Storytelling to Increase Science Learning Opportunities at Carlsbad Caverns National Park

iPads and other technologies are not a panacea for deficiencies in science learning, but they can open doors and expand minds especially in informal settings. Roving with iPads was an unanticipated innovation of the iSWOOP project, a pilot funded by the National Science Foundation at Carlsbad Caverns National Park with the intent of making park-based science a visible, interactive part of interpretive programs for visitors. Now wildlife biologists are using this technology, loaded with high-impact visuals, to help park rangers facilitate conversations about park-based science. We examine how roving with an iPad-based visual library, provided by on-site scientists, became part of interpretive practice, specifically how it: revealed the use of national park lands for basic science research, fit interpretive goals for fostering connections; led to new tactics for initiating interaction; and added value for visitors. We also describe challenges and trade-offs that prevented adoption among some interpreters. Based on data from observations, interpreters' reports, and rove statistics, roving with iPads shifted where and how interpreters approached visitors; appeared to increase the number of contacts; added value to visitors' experience; and increased opportunities to talk about scientific research. We will expand the use of iPads to five additional parks, during the next phase of the project. This will allow us to further test the use and effectiveness of iPad-based visuals to help facilitate ranger-led conversations about park-based science in the National Park System.

P3.142 ALTAF, AW*; SNYDER, NM; REED, WL; North Dakota State University; *nicole.snyder@ndsu.edu*

Yolk melatonin alters heart rates and developmental rates in early chicken embryos

Maternal investments in eggs affect offspring growth and development, but the mechanisms of these effects are not always clear. Melatonin is a hormone with wide ranging effects on phenotypes, and is found in egg yolks. We evaluated the influence of yolk-derived melatonin in early chicken (*Gallus gallus*) embryos. We assigned forty eggs to one of four treatment groups (melatonin, Luzindole (a melatonin antagonist), saline vehicle, or a melatonin and Luzindole mix), and injected eggs with 100 ul of their respective treatment before incubation. After approximately two days of incubation we opened eggs, staged embryos using Hamilton-Hamburg stages, and measured embryonic heart rate. Embryos from eggs treated with melatonin had significantly lower heart rates and faster developmental rates than embryos from vehicle control eggs. Likewise, Luzindole-treated eggs produced embryos with significantly lower heart rates and faster developmental rates than embryos from vehicle control eggs. Embryos from a mix of melatonin and Luzindole had heart rates and developmental rates that were similar to the embryos from the vehicle controls. We hypothesize that embryos with higher maternal melatonin in their eggs may grow faster and more efficiently than embryos in eggs with lower melatonin levels. These results suggest that maternal melatonin may influence embryonic developmental trajectories, and could ultimately affect offspring survival and fitness, which should be further evaluated.

P1.205 AMATO, CM*; MCCOY, KA; East Carolina University; *amatoc13@students.ecu.edu*

Dose and temporal analysis of vinclozolin-induced penile abnormalities

Hypospadias has increased 200% in the past 40 years, making it the second most common birth defect in the United States. Normal penile development is driven by androgen signaling from the testis, which masculinizes the genitalia through downstream developmental signals. Penis development is tightly controlled by endogenous androgens derived by the testes beginning at embryonic day 13.5. Disruption of androgen dependent signaling during this masculinization window alters penile development and results in mis-localization of the urethra ventrally along the shaft of the penis. Both humans and rodents exhibit a continuous proximal-to-distal range of urethral mis-localization, but the mechanisms that drive this variation are not well known. To begin to understand the drivers of hypospadias severity, we must understand the developmental timeline for initiation of genital masculinization. To determine how dose and timing of androgen signaling antagonism affected hypospadias severity CD1 mice (n=3) were gavaged with a corn oil control, 75, 100, 125 or 150 mg/kg of vinclozolin during two overlapping developmental windows (E 13.5-16.5 and E 14.5-16.5). On E18.5 pups were sacrificed and urethral length was evaluated histologically. We find that E 13.5 is an important day for genital masculinization, and that exposing individuals to vinclozolin during this embryonic time point leads to a shorter urethral length and alters genital masculinization across the dose response. We identify a dose and time window that future studies analyzing developmental and molecular mechanisms driving hypospadias can use to induce consistent variation in hypospadias severity.

P1.120 ANDERSON, A.L.*; GIFFORD, M.E.; University of Central Arkansas; *aanderson21@cub.uca.edu*

Determinants of dispersal patterns in the stream salamander, Desmognathus brimleyorum

Dispersal is a fundamental ecological and evolutionary process. Understanding the mechanisms that influence dispersal is especially important in the context of landscape fragmentation and global climate change. Long distance dispersal has been shown to contribute disproportionately to species persistence in fragmented landscapes and range shifts related to climate change. An individual's propensity to disperse is dependent on a variety of both extrinsic and intrinsic factors. A spatially explicit mark recapture study is being conducted to better understand the multiple factors (stream heterogeneity, body size and condition, behavior, and resource limitations) influencing dispersal and population dynamics in the stream salamander, *Desmognathus brimleyorum*. The aim of this study is to effectively make population level inferences about factors influencing dispersal and how it contributes to population dynamics of *D. brimleyorum* within a stream corridor. It is predicted that there will be an association between survival rates and habitat variation along the stream corridor and that the traits of individuals will correlate with dispersal phenotypes.

P3.190 ANDERSON, R. A.*; MCCADAM, B. E.; SIMPSON, D. T. ; Western Washington University; *Roger.Anderson@wwu.edu*

Patterns of home range and habitat use by an ectothermic desert myrmecophile

Integrative theory of animal movement comprises analyses of a complex of constraints and opportunities integrated by the animal that cause the spatiotemporal patterns of the animal across mesohabitat and microhabitat scales. For a desert lizard, the dynamics of its home range use are presumed to depend on interactions of 1) extrinsic factors such as habitat structure, thermal variation, and distribution of prey, predators and potential mates interacting with 2) intrinsic impetuses such as physical discomfort, hunger, fear, and procreation, and 3) intrinsic biomechanical and cognitive constraints. We used radio-tracking and powder-tracking to discern the movements within and among daily activity periods in adults of the Desert Horned Lizard, *Phrynosoma platyrhinos* over several years in early summers in the Alvord Basin, at the northern extreme of the Great Basin desert scrub. We examined the adult lizards' use patterns of its home range, mesohabitats and microhabitats with respect to various correlates such as thermal environment, plant cover, visual field, ant colonies, and microhabitat use by predators, and distribution of conspecifics. Confidently interpreting the primary causes of home range and habitat use by an ectothermic terrestrial vertebrate even in the simplicity of desert scrub is a formidable challenge.

P2.29 ANDREW, J. A.*; GARLAND, T. JR.; CHAPPELL, M. A.; SALTZMAN, W.; University of California, Riverside; *jandr010@ucr.edu*

Effects of housing temperature on energetics and performance in California mice (Peromyscus californicus)

Acclimatory responses to low temperatures have been characterized in many small mammal species. For example, when housed at temperatures of 5-10°C for several weeks, small rodents typically show increases in both basal and maximal aerobic metabolic rates, as well as associated morphological changes (e.g., increases in the mass and activity of brown adipose tissue). However, relatively few studies have examined whether cold acclimation alters locomotor performance or behavior that involves exercise abilities. As part of research on the energetic and immune consequences of fatherhood, we are interested in these possibilities in male California mice. Here, we tested the hypothesis that cold acclimation would alter morphological, physiological, metabolic, performance, and behavioral traits (e.g., body mass, total fat, muscle mass, hematocrit, grip strength, resting metabolic rate, maximum oxygen consumption (VO2max) during forced exercise, maximum sprinting speed, and predatory aggression). Adult male California mice were weighed daily and housed in groups of 3-4 at room temperature (23°C, n=65), 10°C (n=48) or 5°C (n=25) for 2-4 weeks, then underwent a 7-day testing regimen. Neither body mass nor sprint speed differed statistically among housing conditions. However, mice housed at 5°C had higher mass-adjusted VO2max than those housed at room temperature ($p<0.05$), confirming results for other species of Peromyscus. This work was supported by NSF IOS-1256572 and NIH HD075021.

P2.68 ANNEAR, CK; Radford University; *cannear24@gmail.com*

Vigilance behavior in green and red macaws (Ara chloropterus) in response to anthropomorphically generated sounds on the Las Piedras River in the Madre de Dios region of Peru

Green and red macaws (Ara chloropterus) frequently visit colpas on the banks of rivers in the Amazon rainforest, presumably for the beneficial dietary function of the salts accessible there. However, their bright feathers stand out against the brown clay of the colpa making them more visible to potential predators. In order to compensate for their increased vulnerability macaws at colpas display a number of vigilance-related behaviors such as frequent head turns, look outs, and flash behavior that may aid them in avoiding predators. As humans encroach on their habitat, there are increasing reasons for macaws to view human made sounds as a predictive of danger, due to a substantial history of hunting and poaching. The current experiment explored how macaws at colpas behave towards human made sounds and whether their responses suggest that they view humans as predators. Over the course of a month during the non-breeding season at the Las Piedras Biodiversity station in the Madre de Dios region of Peru we played multiple audio stimuli to the macaws coming daily to a colpa located on the banks of the remote Las Piedras River. These playbacks included harpy eagle calls, screaming piha calls, boat engine noises, chainsaw noises, human voices, and synthesized digital audio. Our results strongly suggest that birds respond differentially to these calls. We found that the birds responded heavily to the boat engine playback and the chainsaw playback with many fly-aways and head-turns but this was different than their behavior towards the Harpy Eagle playback. The Harpy eagle playback had multiple head-turns but no fly-aways and we observed that the birds would freeze and not communicate when it was played. In future studies it would be interesting to look at the movement of the birds and flight patterns to the different playbacks.

P2.10 ARCHIE, J.; California State Univ., Long Beach; *james.archie@csulb.edu*

Demographic Collapse and Recovery of Sky-island Populations of Sceloporus occidentalis in the Mojave Desert Due to Drought and Monsoonal Rains

Climatic fluctuations in the Mojave Desert of California include extended drought periods that have resulted in the demographic collapse of populations of the western fence lizard (*Sceloporus occidentalis*) found on desert sky-islands. Over a 6 year period (2010-2015), which coincided with a severe 3-year drought, we carried out a mark-recapture study of two lizard populations (1450m and 1850m). The high elevation population was up to four times more dense than the low elevation population, which is at the lower elevation limit of the species in the Mojave Desert. Both populations experienced demographic collapse during the 2012 and 2013 seasons due to the lack of juvenile recruitment. The frequency of first-year lizards dropped from highs of 55-83% of all lizards captured per hectare during the 2011-2012 sampling periods down to 0% in 2013 as no (i.e., zero) first-year lizards were found either on the sampling grids or anywhere on the mountain (10 sampling days and 225 person-hours of searching). Population densities declined by 50% (1850m) and 30% (1450m) over this period. In both localities, inter-annual adult recapture frequency (survivorship) increased following the severest drought year (2012-2013). Although the drought in southern California has continued through 2014 and 2015, sporadic summer monsoonal rains in 2013 and 2014 resulted in successful juvenile recruitment to both populations due to increases in insect activity following late summer and fall blooms of both annual and perennial plants. The low elevation population was rescued from likely extinction by these monsoonal rain events which are uncorrelated with winter rainfall drought conditions.

P1.157 ARUL NAMBI RAJAN, A*; HABERKERN, N; WEATHERHOLT, A; CHUNG, A; RIVERA, A; University of the Pacific; *a_arulnambirajan@u.pacific.edu*

Neural Determinants of Behavior in an Organism without a Nervous System

Pax6 has proven to be a crucial regulatory element in development of structures ranging from eyes to kidneys, and plays a particularly interesting role in neuronal systems. Furthermore it has been shown to be a master regulator protein of a highly evolutionarily conserved network of genes. The fact that orthologs of this crucial protein are present in an organism that lacks all organized tissue, like the sea sponge, offers us insight into how intricate pathways may have originated and how they have been conserved and exapted for novel functions in animals with more complex body plans. Previous studies have revealed that the sponge model, *Ephydatia muelleri*, has the ability to induce behavioral "sneezing" responses in which the sponge inflates and contracts its osculum and ostia in quick succession following an external stimulus. In order for such a response to occur, it has been hypothesized that *Ephydatia* must possess some rudimentary sensory system to signal these actions. Furthermore the *Ephydatia* genome has been shown to carry a number of known pro neuronal and synaptic genes. Showing that these genes are regulated by the Pax6 transcription factor and assessing their role in the sponges basic behavior will help us better understand the fundamental origins of nervous systems as a whole.

P1.51 ARYAFAR, H; CARRILLO, A; BERQUIST, R; FRANK, L; VELASCO, B; FORSGREN, K; DICKSON, K*; California State University, Fullerton, University of California, San Diego, University of California, San Diego; *kdickson@fullerton.edu*

Description of the male genital papilla in the California grunion, a silverside fish that spawns on sandy beaches

The California grunion, *Leuresthes tenuis*, exhibits unusual reproductive behavior in which adults spawn on sandy shores and the externally fertilized eggs develop within the sand. Spawning occurs at night during spring high tides in March-August. Females deposit eggs ~8-10 cm deep within the sand while males release sperm as they surround females at the sand surface. Fertilized eggs incubate in the sand until a subsequent spring high tide washes them out and triggers hatching. While extracting gametes for other experiments, we noticed a small structure protruding from the genital pore of male, but not female, grunion. A subsequent investigation using magnetic resonance imaging, dissections, and histology allowed us to morphologically characterize this muscular genital papilla. The structure could not be found in female grunion, using the same imaging and histological techniques. Therefore, we hypothesize that the structure represents a sexually dimorphic trait in *L. tenuis*, which may be used to identify males noninvasively even after individual fish have released their gametes. We also hypothesize that the genital papilla represents a specialized structure that evolved in male grunion to eject sperm under pressure so that they can fertilize eggs that the females have deposited within the sand, unlike in other fishes in which such structures are used for internal fertilization.

P3.156 ATWOOD, A.C.*; DAVIS, J.E.; Radford University; *aatwood4@radford.edu*

The Effects of Royalactin on the Growth Rate, Mortality Rate, and Lifespan of Aedes aegypti

Royal jelly is a secretion that is produced by worker bees, and fed to the queen bee. It consists of several proteins, which are essential to the growth and reproductive success of the queen bee. Within royal jelly, the glycoprotein royalactin is thought to be of particular importance in epigenetic modulation that leads to the increased growth, lifespan, and fecundity of queen bees. The protein functions, in part, by upregulating epidermal growth factor via signal transduction, which in turn leads to both epigenetic and phenotypic changes. Although the effects of royal jelly on bees is widely known, there has not been much research to investigate the effects of royal jelly on other arthropods. We set out to determine the effects of royal jelly on *Aedes aegypti*, with a focus on their growth rate, mortality, and lifespan. Mosquitos were given one of several treatments including royal jelly, heat-denatured royal jelly, royalactin plasmid+ *E. coli*, and lab strain *E. coli*, as well as methoprene (a juvenile hormone agonist) in concert with royal jelly. All groups were compared against an untreated control. In this poster presentation, we will discuss the differences in growth, mortality, and lifespan between the test groups, and their implications in relation to the function of royalactin in a non-hymenopteran model organism. We will also explore various potential experiments that relate to our findings.

P3.112 AUGENSTEIN, I.I.; GHOSSEIN, N.I.*; SCHWARTZ, N.L.; GARLAND, T.; HORNER, A.M.; Cal State University, San Bernardino, Univ. of California, Riverside; *ahorner@csusb.edu*

The Influence of Activity and Age on Endurance in Mice Selected for High Voluntary Wheel Running

Voluntary locomotor activity may be affected by a variety of intrinsic factors (e.g., physiology) and environmental factors (e.g., substrate). Voluntary activity is known to decline with age in mammals due to decreases in neurological motivation and musculoskeletal vitality. Because disuse and aging exhibit similar pathologies and performance deficits, isolating the influences or effects of a single factor is difficult. In this study we used house mice that have been selectively bred for voluntary wheel running over 70 generations in order to determine the effects of varying activity level and age on endurance. A total of 32 mice from four control (C) and four high wheel running (HWR) lines were housed either in cages with monitored wheels (active treatment: AT) or in cages with no wheels (inactive treatment: IT). Endurance was measured as time to exhaustion during an incremental speed test on a treadmill elevated to nearly 30°, and was tested for each mouse at two early stage aging time points (14 and 16 months). For mice with wheel access (N=16 AT), daily wheel revolutions were recorded at 0.25-0.5 Hz for the month prior to endurance testing. Additionally, the duration and number of pauses during each mouse's two hour peak activity was recorded to quantify the intermittency of an individual's wheel activity. HWR lines demonstrated significantly greater endurance times, regardless of treatment or age. However, endurance performance decreased significantly with age in all line x treatment combinations except for the HWR-AT group, which maintained nearly the same mean performance times. Our results suggest that activity level and motivation are both important contributions to age-related decline in locomotor performance.

P3.7 AYERS, KD*; GUMM, JM; Stephen F. Austin State University; *krisdayers@hotmail.com*

Hybridization between the invasive Cyprinodon variegatus and endemic C. rubrofluviatilis

Invasive species threaten biodiversity and native species through hybridization. This is the case with pupfish species throughout Texas and the Southwest. We are investigating the extent of hybridization and genetic introgression between the invasive sheepshead minnow (*Cyprinodon variegatus*) and the Red River Pupfish (*Cyprinodon rubrofluviatilis*). Morphological characters have documented the presence of *C. variegatus* in the Brazos River and to identify possible hybrids. Based on patterns of morphological data collected between 2006 and 2012. the invasion of Sheepshead Minnow is advancing upstream at a rapid rate. This presents a serious threat to the remaining populations of *C. rubrofluviatilis*. We are using genetic analysis of microsatellites to confirm the presence of Sheepshead Minnow in the Brazos and Red Rivers. Preliminary genetic evidence suggests hybridization has occurred between these species. Analysis of samples collected from several locations between 2010 and 2015 allow us to track the progression of *C. variegatus* upstream and to determine the leading edge of the invasion. Resampling of specific locations also allows us to monitor the rate of introgression over the last five years. Understanding the extent to which hybridization and genetic introgression has occurred will help determine if conservation efforts are needed for *C. rubrofluviatilis* . Furthermore, genetic analysis will facilitate prompt conservation measures protecting *C. rubrofluviatilis*.

P2.35 BACHMAN, G ; Univ. of Nebraska, Lincoln; *gbachman@unl.edu*

Ecological significance of locomotory heat generation in ornate box turtles.

Although increases in body temperature resulting from muscle contraction are known to promote limited endothermy in some large reptiles, it is possible that the modest increases in body temperature (Tb) observed during exercise in smaller reptiles may nevertheless be ecologically relevant. We examined the potential impact of heat generated by movement in ornate box turtles while running outdoors in sun and shade, indoors on cold sand, and while digging through cold sand. Body temperature was measured with implanted temperature transponders. In the running trials, the Tb of individuals running quickly after prey or for cover were compared to temperatures of stationary individuals under the same thermal conditions. Running significantly increased Tb over resting. Digging in cold sand simulated emergence from hibernation. This also produced an increase in Tb. In another study, we measured the rate of heating and cooling and found that Tb increases faster than it decreases, thus heat dissipation is relatively slow. Our findings suggest that heat generated during activity could both limit above ground activity in warm conditions and promote digging during entry into and emergence from hibernation.

P1.121 BAILEY, S.D.*; NOVARRO, A.J.; University of Virginia, University of Maryland; *sdb3xf@virginia.edu*

Retreat from the heat: Are burrowing traits in red-backed salamanders correlated with climate?

Many animals are able to live in a wide range of environmental conditions. For example, widespread species tolerate a broad range of temperature and moisture conditions. Such species must possess traits and strategies that allow them to cope with the physiological consequences of climatic variation. One mechanism by which animals persist in variable climates is the evolution of morphological variation. Morphology affects all aspects of the organism, especially individual fitness. Specifically, morphology may alter performance, which in turn affects overall fitness. The red-backed salamander (*Plethodon cinereus*) is a lungless woodland salamander that relies on its environment for gas exchange. Thus, it requires a cool and moist microhabitat at all times. Yet, it occurs along an extreme climate gradient, from North Carolina, US to Quebec, CAN. The major behavioral strategy that *P. cinereus* uses to evade unfavorable climates is burrowing in underground retreats. We were interested in whether individuals from warmer and drier sites have developed morphological traits that promote burrowing behavior. We predicted that individuals from warmer and drier sites would have wider heads and longer toes. We based our prediction on the observation that mole salamanders (*Ambystoma* species) have large heads and long toes for burrowing the majority of the year. We measured morphological traits of salamanders collected from ten transects along an elevation gradient on Salt Pond Mountain, VA. Our results will shed light on the capacity for morphological variation in salamanders to promote resilience to climate warming.

P2.182 BALISI, M.B.*; CHANG, J.; University of California, Los Angeles; *mairin@ucla.edu*

Hypercarnivory and extinction risk in North American fossil dogs

Hypercarnivory and bone-crushing are metabolically costly specializations, and their appearance in a lineage is invariably irreversible: an example of an evolutionary "ratchet". While modern ecosystems are relatively depauperate of hypercarnivores and bone-crushers, these specializations have repeatedly arisen in the fossil record, permitting exploration of a) how hypercarnivory may affect extinction rate and b) how quickly an empty hypercarnivore niche is filled. North American fossil dogs (Mammalia: Carnivora: Canidae) comprise over 100 species spanning a wide range of ecomorphologies, including iterative occurrences of hypercarnivory. Here, we reconstruct the initial rise of hypercarnivory in canids, examining a morphospace of 10 ecomorphological indices over nine time slices from the origin of Canidae (40 million years ago) to the height of canid species richness (25 species at its peak; 15 million years ago). Hotspots of elevated extinction rate correspond to areas of the canid morphospace occupied by large - but not small - hypercarnivores, matching the prediction of hypercarnivory representing an evolutionary "dead end". However, hypercarnivory is slow to arise in canids. With non-canid carnivorans occupying the carnivore and large-hypercarnivore space, canids first saturate the omnivore and small-carnivore space. Even as large hypercarnivorous non-canids become extinct, canids remain in the omnivore and small-hypercarnivore space, becoming large hypercarnivores only after several million years. This significant lag in the movement of canids into the large-hypercarnivore space suggests that the turnover resulted from passive replacement and ecological release rather than active displacement. Strikingly, little ecomorphological overlap occurs among canids and non-canids, confounding hypotheses that canids declined taxonomically from competition with other carnivoran clades.

P3.151 BARREIRA, S*; MCSTAY, B; SEOIGHE, C; BAXEVANIS, A.D.; National Human Genome Research Institute, National Institutes of Health, Centre for Chromosome Biology, National Univ. of Ireland Galway, School of Mathematics, National Univ. of Ireland Galway; *sofianbarreira@gmail.com*

Genomics of Hydractinia: Characterizing and Determining the Biological Relevance of Highly Repetitive Regions

Repetitive elements comprise around two-thirds of the human genome. Large tandem repeats such as ribosomal genes (44kb), segmental duplications (<130 kb), and telomeric repeats comprise the short arms of acrocentric chromosomes. Importantly, these sequences are missing from the human reference genome. Establishing their organization and distribution is crucial to fully understand cellular function. To extend these regions, careful approaches are necessary to ensure accurateness of sequence information, orientation, and placement. Using these kinds of approaches, we have successfully extended the sequence content after the last human ribosomal gene (rDNA) repeat on the telomere side by 550 kb. Currently, our group is sequencing two *Hydractinia* species, organisms that have already shown great promise for the study of regeneration, early developmental processes, and bioluminescence. Since the overall repeat and AT-content of *Hydractinia* is quite high (47% and 65%, respectively), we intend to apply similar strategies as those used with the human genome sequence to identify important repetitive regions such as centromeres, telomeres, and rDNA in these *de novo* assemblies. This will not only enable us to offer a more complete assembly than those of any other available model organism but also provide a foundation for better understanding their origin and biological relevance.

P2.120 BARRETT, B.M.*; NEUBERT, P.L.; FALATKO, D.; OTA, A.; EcoAnalysts, Inc., Stantec, Eastern Research Group, Inc., U.S. Environmental Protection Agency Region 9, Water Division; *cbarrett@ecoanalysts.com*

A new genus and species of Eulepethidae Chamberlin, 1919 (Annelida: Polychaeta) from deep water sites off South Oahu and Hilo, Hawaii.

The U.S. Environmental Protection Agency Region 9 (EPA) is responsible for the management of five Ocean Dredged Material Disposal Sites located off the south coast of O'ahu and off Hilo, Hawai'i. The biological characterization of the sites in 2013 included benthic infaunal analyses of macroinvertebrate organisms, which recorded the first occurrence of the Family Eulepethidae (Polychaeta) from Hawaiian waters. This family of scale worms currently has 26 recognized taxa in six genera distributed throughout tropical waters worldwide with the majority of taxa described from the western Atlantic and Gulf of Mexico. A description of the new species is presented in addition to a generic review of elytral morphology that supports the erection of a new eulepethid genus.

P1.166 BASHAM, J*; DAVIS, J/E; CAUGHRON, J; Radford University; *bashamjc@gmail.com*

The effects of obstacle geometry and magnetic fields on the streaming motion of neotropical ant species

Streaming locomotion is a behavior pattern common in superorganismic colony species. While movement-based decision making in such species has been the subject of several recent studies it is still poorly understood. In particular, it is unclear how the moving individuals recognize and respond to varying features of objects they may encounter along their path. In the current study we set out to investigate how various species of neotropical ants alter motion patterns in relation to various geometric three-dimensional printed shapes, both with and without the presence of a magnetic field. Research was conducted in May-June 2015 in the Las Piedras watershed of the Madre de Dios region of Peru. A variety of three-dimensional geometric models, both with and without neodymium magnets, were placed into active ant trails from seven different species of ants. Interrupted steam patterns were recorded and assayed, and ant samples were collected for later identification. Results suggest pointed species related variations in motion patterns and magnetic sensitivity. We discuss the implications of these findings for future studies and their relation to movement patterns and sensory capacities in social insects.

P3.154 BASTIN, BR*; SCHNEIDER, SQ; Iowa State University; *brbastin@iastate.edu*

A Nodal signaling cassette in Platynereis dumerilii: conservation and gene duplications shed light on left-right patterning evolution

The Nodal signaling pathway has long been known to pattern left-right asymmetry in deuterostomes. Its absence in ecdysozoans suggested initially that Nodal signaling was a deuterostome innovation. More recently Nodal and its downstream effector Pitx were shown to be conserved in lophotrochozoans, and involved in left-right patterning in mollusk embryos. However, other components of this pathway have so far received little attention, including potential Nodal receptors Alk4 and Alk7, Nodal's co-ligand Cripto, and components upstream of Pitx. To better understand the evolution of this major pathway in Lophotrochozoa, we examined its role in early embryos of the marine annelid *Platynereis dumerilii*. We discovered a remarkably well-conserved Nodal signaling cassette. *Platynereis* embryos exhibit early asymmetric *nodal* expression followed shortly by *pitx*. *nodal* expression is preceded by maternal *alk4* and *alk7* and zygotic anterior expression of *cripto*. In addition, we discovered recent gene duplications of *cripto*, *pitx* and the Nodal modulator *foxh*, suggesting greater plasticity of the Nodal signaling casette in Platynereis than in other lophotrochozoans. Together the conservation of Nodal signaling components and recent duplications of core components in Platynereis provides new insights into the evolution of Nodal mediated left-right patterning outside of the deuterostomes.

P1.101 BATTLES, A.C.*; KOLBE, J.J.; University of Rhode Island; *andrewcbattles@gmail.com*

Can lizards take the heat? Cities alter the thermal ecology of Anolis lizards

One of the many changes to local environments produced by urban development is an increase in ambient temperature. This urban heat island effect is due to the replacement of vegetation with heat absorbing surfaces, such as buildings and roads, resulting in a spatially and temporally variable thermal mosaic in urban areas compared to the relatively cooler and homogeneous thermal environments of adjacent natural areas. Ectotherms, such as reptiles, are especially sensitive to the thermal environment, with body temperatures either conforming to ambient conditions, or actively regulated to achieve a preferred temperature. We studied the thermal biology of *Anolis crisatellus* and *Anolis sagrei*, two trunk-ground anoles found in the Miami metropolitan area in both natural forest fragments and highly developed urban areas. We predicted that urban areas would be warmer than natural areas, and that lizards in urban areas would have higher average body temperatures. In the field, we randomly distributed copper model lizards to measure operative temperatures, the body temperature of a non-thermoregulating lizard, and compared these to lizard body temperatures measured throughout the day. We found that urban areas have higher average temperature than natural areas, and that lizards have higher body temperatures in urban sites; in both natural and urban sites, lizards maintained higher body temperatures than operative temperatures. Because of the importance of temperature in physiological and chemical processes, as well as potential altered costs of behavioral thermoregulation, warmer urban areas have the potential to affect lizard fitness and, ultimately, natural selection.

P3.79 BAUER, C.M.*; HEIDINGER, B.J.; NEEDHAM, K.B.; GRAHAM, J.L.; KETTERSON, E.D.; GREIVES, T.J.; North Dakota State University, Indiana University; *carolyn.marie.bauer@gmail.com*

Does a migratory lifestyle accelerate telomere loss in Junco hyemalis?

By migrating, birds may increase their reproductive success via exploitation of seasonally abundant food resources while increasing annual survival by avoiding resource-poor habitats during winter. Long-distance migration comes at an energetic cost, however, and may elevate oxidative stress. Telomeres, repetitive DNA regions that protect chromosomes from degradation, shorten during exposure to oxidative stress. We therefore hypothesized that a long-term cost of a migratory life history strategy may be greater telomere attrition. We predicted that within a population and among individuals of the same age, migrants would have shorter telomeres as compared to residents. We compared first-year individuals in an overwintering population of Dark-eyed Juncos (*Junco hyemalis*) that included both a migratory (*J.h. hyemalis*) and a resident (*J.h. carolinensis*) subspecies in western Virginia. As predicted, first-year migrants had shorter telomeres than first-year residents. These results suggest that accelerated telomere shortening may be one potential consequence of a migratory life history strategy.

P3.116 BAUMGARDNER, G.A.*; YEATON, I.J.; SOCHA, J.J.; Virginia Tech; *gab24@vt.edu*

Flying snake landing: How limbless gliders dissipate energy on impact

Nearly all gliders use limbs when landing, which lessens the impulse on the body and prevents injury. However, gliding snakes (genus: *Chrysopelea*) land by impacting with their bodies, which must absorb localized forces and dissipate the body's kinetic energy. Snakes have been anecdotally observed to land on many complex substrates, including the ground, tree branches, tree trunks, and leafy vegetation, but the physics of impact have not been studied. Here we ask, what strategies do snakes use to the dissipate the energy of impact to land safely on branches and leaves? To investigate this question, we recorded and analyzed high-speed video (500 and 2000 fps, Photron APX-RS) of *C. paradisi* landing after short trajectories (0.5 to 0.8 m horizontally and 0.8 m vertically) onto a horizontal pole as well as into an artificial tree. For snakes landing orthogonally on a bar, the dorsal surface was tracked throughout the landing event and the curvature of the body calculated. At impact, curvature changed near the contact location and propagated anteriorly and posteriorly from the impact site. Curvatures posterior to impact were greater as the body swung below the bar. When landing on a leafy tree, the snakes sometimes used the neck region to hook onto branches and leaf stems, with the neck bending up to 180 degrees laterally. This analysis shows that snakes can successfully land on complex substrates using passive and active changes to local body curvature. Supported by NSF 1351322.

P3.59 BAUTISTA, T.R.*; DOWNS, C.J.; BALL, R.; DOCHTERMANN, N.A.; MURPHY, S.; MARTIN, L.B.; University of Michigan, Hamilton College, Lowry Park Zoo, North Dakota State University, University of South Florida; *tbautist@umich.edu*

Immunity scales with body mass among terrestrial mammals

Body mass influences various morphological, behavioral and physiological traits, but effects on immune systems have been little studied. By contrast, life-history characteristics of species and individuals has been found to influence various aspects of immunity, but many of these effects may manifest because effects of body mass on life history traits themselves. To discern the forces that shape immunity among species and hence understand broadly what factors mediate variation in immune systems, we examined how leukocyte counts relate to body mass and various life-history traits in 400 species of mammals spanning 5 orders of magnitude in mass. Total white blood cell (WBC), neutrophil and lymphocyte counts were compiled from the International Species Information System (ISIS), and life-history traits and body mass were extracted from Pantheria. We first determined whether body mass or various life-history traits (e.g. longevity, reproductive pace-of-life) better predicted immune system composition; a second model was then generated to reveal how different leukocyte types scaled with body mass. We found that total WBCs scaled positively to body mass across species and this effect was strongly driven by neutrophils. Lymphocytes however scaled negatively to body mass among species. These relationships indicate that the size of hosts alone influences how species cope with infections, which could partly explain why some host species pose greater risk than others to community-level disease dynamics.

P2.17 BEAR MAGALLANES, SE*; PADILLA, DK; California State University Monterey Bay, Stony Brook University; *sbearmagallanes@csumb.edu*

Vulnerability of two species of snails to predators in eelgrass and macroalgal communities

This study focused on predator prey interactions of the crab *Pugettia gracilis* and sea stars of the genus *Leptasterias* and two herbivorous snails, *Lacuna vincta* and *L. variegata* that graze on macroalgae and microalgae that foul eelgrass. Habitat differences can change foraging behavior of predators and either aid or hinder efficiency of predation. We examined the vulnerability of *Lacuna* in eelgrass and macroalgal habitats to predation by the crab and sea star. We determined the maximum feeding rate of each predator on each species of snail, and tested whether there was size specific predation or if predators had a preference or potential for greater impact on each species of prey. Finally, we tested whether feeding efficiency differed in the two habitat types. In no choice laboratory experiments the crab ate significantly more *L. variegata* (1.4/hr) than the sea star (0.7/hr) and both predators had the same feeding rate on *L. vincta* (crab - 0.9/hr, star 0.6/hr). When given a choice, the crab preferred *L. variegata* and the sea star showed no preference. Neither predator was size selective and the size of the predator did not impact feeding rate. The vulnerability of snails in the two habitats was tested with mesocosm experiments. Because of low recovery of snails in controls, we were unable to detect significant differences between the predators in the two habitats. Results suggest feeding rates for the sea star were half those in laboratory. The crab seemed to prefer *L. variegata*. Mesocosm design must be refined to facilitate recovery of snails and more replicates are needed to determine if there are significant differences in predation in the two habitats.

P2.59 BEECHLER, BR*; SPAAN, R; STEINAUER, M; VAN DAM, GJ; EZENWA, VO; JOLLES, AE; Oregon State University, Western University of Health Sciences, LUMC, Leiden, University of Georgia; *breebeechler@gmail.com*

Longitudinal variation in Schistosome burden in African Buffalo is mediated by immunity, nutrition and exposure

Schistosomiasis is parasitic disease that remains a problem in many tropical and subtropical regions throughout the world, especially in developing countries, with different species of parasites infecting a wide spectrum of mammalian hosts. We used a longitudinal study design to investigate the patterns of Schistosoma spp. infection in a wildlife host species, African Buffalo in Kruger National Park South Africa. We used a serum ELISA to an antigen produced by female worms which quantitatively represents active adult worm burden to determine that there was significant longitudinal variation in worm burden within individuals. Animals had an increase in burden over the capture period, with increases in each dry season and decreases in the following wet season. Whether an animal demonstrated a loss or gain in burden between capture session correlated with the likelihood of exposure (season), as well as the degree of susceptibility (changes in immunity).

P3.53 BEECHLER, BR*; BOERSMA, KS; EZENWA , VO; GORSICH, EE; HENRICHS, BS; SIEPIELSKI, AM; JOLLES, AE; Oregon State University, University of San Diego, University of Georgia; *breebeechler@gmail.com*

Bovine Tuberculosis alters pathogen community structure in African Buffalo

Global changes have resulted in drastic increases in the emergence of infectious diseases worldwide. The consequences of these emerging events impact conservation efforts and human health, yet most research into the impacts of an emerging disease are limited to the disease in question. These diseases emerge into hosts that are concurrently infected with numerous pathogens, as is the norm in free-ranging animals, but our understanding of the response of the disease community as a whole to an emerging disease is limited. A framework developed to understand the effects of disturbances on functional trait diversity in multispecies communities (Boersma et al 2014) may offer a new approach. We investigated how an invading disease (Bovine Tuberculosis) affects the functional and taxonomic diversity of a community of pathogens in African Buffalo (Syncerus caffer), using data from a longitudinal study where animals were captured twice a year from 2008-2012. We first asked how taxonomic diversity of pathogens changed in 47 buffalo that acquired BTB during the course of the study. We than asked if these changes were different than the changes in 47 uninfected buffalo randomly selected from the population. We then used a trait-based approach to ask whether the community of pathogens changed in functional ways after BTB infection using both the 47 buffalo which acquired BTB and 47 uninfected buffalo. Lastly we evaluated whether host traits (age, condition, immunity) correlated to the degree to which the buffalo disease and trait community changed after infection with BTB and compared it to the control hosts (uninfected with BTB).

P3.179 BENNICE, CO*; HANLON, RT; BROOKS, WR; Florida Atlantic University, Marine Biological Laboratory, Florida Atlantic University ; *cbennice@fau.edu*

Niche partitioning by the common octopus and mimic octopus in a tropical sandy habitat in Florida

Sympatric species have evolved ecological, morphological, and behavioral specializations in combination with spatial and temporal distribution patterns to allow for coexistence. To explain species coexistence, how each species exploits its niche and any biotic interactions must be determined. Two species of octopus (*Octopus vulgaris* and *Macrotritopus defilippi*) with similar resource requirements overlap in an intracoastal habitat in southeastern Florida. The following aspects are examined for both species: (1) spatial distribution of octopus dens, (2) microhabitat heterogeneity, (3) foraging behaviors and (4) foraging times. Octopus den locations are marked by GPS to quantify spatial patterns within and between species. The importance of habitat heterogeneity is determined by quantifying substrate composition of the microhabitat (1.00 m^2 around den) and immediate habitat (0.13 m^2 directly over den). Video is used to score foraging behaviors and 24h video determines octopus activity time. Results have identified significant spatial clustering for *O. vulgaris*. Spatial patterns have not yet been determined for *M. defilippi*, but a non-random dispersal pattern is anticipated. Micro- and immediate habitat heterogeneity are important for both octopus species. Preliminary results indicate both species use similar foraging behaviors, but vary in their activity times; *O. vulgaris* forages primarily nocturnally while *M. defilippi* forages primarily diurnally. This study will identify ecological and behavioral components that facilitate coexistence of these sympatric species, provide insight into cephalopod ecology, and provide baseline conservation requirements for unique sand-dwelling organisms, which potentially use this habitat for mating and a nursery.

P2.137 BENSON, K.; GESLEWITZ, W.; ROMANO, L.*; Denison University; *romanol@denison.edu*

Characterization of snail expression in the primitive pencil urchin, Eucidaris tribuloides

We are utilizing the sea urchin as a model system to explore the functional consequence of changes in genes and their cis-regulatory elements during embryonic development. In particular, we are examining genes that are required for development of the larval skeleton. Skeletogenic cells ingress into the blastocoel and form two ventrolateral clusters in response to cues from the overlying ectoderm. These cells then secrete a variety of proteins, which leads to the formation of a pair of triradiate spicules on either side of the archenteron. We are currently focused on the molecular basis of differences in skeletogenesis between derived species and the "primitive" pencil urchin, *Eucidaris tribuloides*. In derived species, there are two ingression events: the skeletogenic mesenchyme ingresses from the vegetal plate in the early gastrula while the non-skeletogenic mesenchyme ingresses from the tip of the archenteron in the late gastrula. In the pencil urchin, there is just one ingression event with both skeletogenic and non-skeletogenic mesenchyme migrating away from the archenteron during late gastrulation. The *snail* gene encodes a transcription factor that is required for epithelial-mesenchymal transitions (EMTs) and is known to be upregulated upon ingression in derived species. This gene is also associated with metastasis in humans. Former students isolated this gene from the pencil urchin; we have now performed whole mount in situ hybridization to characterize its expression during embryonic development. In the future, we will study its transcriptional regulation so that we might gain more insight into the initiation of EMT as well as the heterochronic shift in the ingression of the skeletogenic mesenchyme that has occurred during echinoid evolution.

P2.108 BERGAMINI, RR*; PROPPER, CR; Northern Arizona University; *Rex.Bergamini@nau.edu*

Local-scale micropollutant effects on an aquatic vertebrate population

Chronic exposure to xenoestrogens can result in endocrine disruption concomitant with reproductive impairment in aquatic organisms. Combined field and laboratory studies are necessary to understand the complex interactions between environmental variables and functional endocrine outcomes. Using western mosquitofish (*Gambusia affinis*), we assessed morphological and molecular effects of low level exposure to endocrine disrupting chemicals (EDCs) in natural- and laboratory-exposure settings. We collected male and female *G. affinis* (N = 20) from five Verde River watershed sites in central Arizona differing in point and nonpoint pollution sources including wastewater treatment plant effluent, mining leachate and agricultural discharges. We assessed morphological, gonopodial and vitellogenin (Vtg) concentration differences among the populations. We then exposed male and female *G. affinis* (N =20-24) collected from a reference site to a 30-day water exposure from Verde River sites previously identified as containing EDCs, and assessed gonopodial and Vtg differences among groups. Last, we exposed a reference and a Verde River population of male *G. affinis* (N = 10-12) to 0 or 1 nM ethinyl estradiol (EE2) for seven days. The first study found significant differences in female fecundity and male incidence of detectable Vtg among Verde River sites; treatment of adults with water from sites inducing a Vtg response in males did not induce shifts in gonopodial morphology. Finally, EE2 treatment did not affect any measures between EE2 treatments, but site-related differences in gonadosomatic index ($P < 0.0071$) and gonopodial R4:R6 ratio ($P < 0.0001$) were significant. Our results suggest that understanding existing population differences when testing wild species is critical in assessing the consequences of exposure to EDCs.

P3.146 BIDDLE, J.F.*; SEAVER, E.C.; Univ. of Florida, Whitney Laboratory for Marine Bioscience; *joseph.biddle@daemen.edu*

Role of MAPK signaling during early development of the marine annelid Chaetopterus sp.

Cell signaling is a critical process in animal development. Functional studies of cell signaling can shed light on the varied developmental patterns across the animal kingdom. Additionally, by comparing how these functions differ between organisms one can glean insight into the evolution of animal diversity. In this study, a MAPK inhibitor (U0126) was used to block the MAPK signaling cascade for 2-3 hours during early development of the annelid *Chaetopterus* sp. Immunohistochemical and morphological analyses reveal that after drug exposure, an abnormal mesoderm and endoderm phenotype was observed in three day old larvae (L3). The phenotypic responses observed in this study were graded and varied directly with the concentration of the MAPK inhibitor. We hypothesize that the MAPK cascade may be activated during gastrulation, evidenced by the presence of an abnormal phenotype when embryos were exposed during gastrulation. The phenotype observed in Chaetopterus shows similarities to that observed in two other annelid species: *Platynereis dumerilii* and *Capitella teleta* suggesting that there may be a conserved role for MAPK signaling during morphogenesis of mesoderm in annelids.

P2.147 BLACKMAN, AR*; NOVARRO, AJ; Oberlin College, OH, University of Maryland, College Park; *ablackma@oberlin.edu*

Do salamanders respond morphologically to introduced species?

Character displacement, or the evolution of differences that reduce competition, provides one mechanism through which closely related species can coexist. The introduction of nonnative species provides a valuable system for studying character displacement, as novel interactions between native and nonnative species may alter the evolutionary trajectory of the native species. Gray-cheeked salamanders (*Plethodon montanus*) were introduced to Mountain Lake Biological Station (MLBS), Pembroke VA approximately 80 years ago. To our knowledge, this is the only human-introduced lungless salamander to have successfully established outside of its native range. Today, this nonnative salamander successfully coexists with several closely related species, including the highly abundant red-backed salamander (*Plethodon cinereus*). In the presence of competitors, other populations of red-backed salamanders have developed larger jaws to better obtain food, space, and other resources. We were interested in whether character displacement has occurred in *P. cinereus* in order to reduce competition with the newly established species. Using geometric morphometrics, we compared skull and jaw shape of *P. cinereus* from sites where *P. montanus* is either absent, introduced, or native. We predicted that skulls and jaws of *P. cinereus* would be larger in the presence of *P. montanus*. If this is the case, we expect that *P. cinereus* from the introduction site will represent a "transition" in skull and jaw morphology in response to the newly introduced competitor. The results of our study will shed light on the mechanisms underlying species coexistence, and will provide insight to the effects of novel species interactions caused by climate-related range shifts.

P2.169 BLAKE, S.*; DEL VALLE, L.; TSENG, Z.J.; Univ. of California, Berkeley, Univ. of Puerto Rico, Humacao, American Museum of Natural History; *savannah.b@berkeley.edu*

Cranial Biomechanics of Daphoenus (Carnivora, Mammalia): A Methods Case Study

The adaptive radiation of mammals has led to distinct cranial and dental morphologies that often correlate, across taxa, with feeding niches. Amphicyonids (colloquially called "bear-dogs") remain enigmatic in their paleobiology and taxonomy; it is the last clade with an unknown position in Carnivora. In this study, we use CT-based, 3D cranial finite element models of *Daphoenus* (Amphicyonid), *Tremarctos ornatus* (spectacled bear) and *Canis lupus* (gray wolf) to compare bite efficiency and skull strain energy to determine whether *Daphoenus* is more similar in biomechanical capability to Ursidae or Canidae. Finite element analysis in a phylogenetic context allowed for reconstruction of feeding specialization and tested for the influence of evolutionary history and diet on craniodental morphology. In prior studies using comparative finite element analysis, strain energy levels corresponded with taxonomic groupings rather than ecomorphology, while combined bite efficiency and strain energy measurements distinguished between hypercarnivores and generalists. A strain energy and bite efficiency comparison with *Canis lupus* tested for hypercarnivory in *Daphoenus* as compared to basal Caniformia. Comparison with *Tremarctos ornatus*, the earliest diverging living ursid, tested for generalist biomechanics in *Daphoenus* and symplesiomorphic biomechanical features suggested by retained ancestral traits. Comparison of bite simulation outputs shows similarities in biomechanical capability of *Daphoenus* to both *Tremarctos* and *Canis*. *Daphoenus* diverges from *Tremarctos* and *Canis* leaning toward an intermediary, and potentially plesiomorphic, type of skull mechanics distinct from attributes typically observed in hypercarnivores or omnivores.

P3.48 BLEVINS, B.*; CAUGHRON, J.; DAVIS, J.; Radford University; *bblevins6@radford.edu*

Cleaning House: Microbial ecology of passerine nest boxes in relation to environmental and nest constituent factors

Birds choose nest locations and construct nests out of varying materials for a variety of reasons, potentially including control of the microbial environment. Several studies have demonstrated that specific nesting materials may have antimicrobial properties, but the influence of nesting materials, nest location, and species influences on microbial populations remains relatively under-explored. In this study, bacterial samples were collected from bird boxes in southeastern Virginia in late summer, while recording various environmental features (orientation, age, construction materials, nest materials and type, and plants in the surrounding habitat). Bacterial samples were stored and analyzed using ethanol extraction and terminal restriction fragment length polymorphism (T-RFLP) assay to identify various microbial communities in relation to nesting materials. Here we describe our results, highlighting correlations between bacterial populations and features of the nest itself.

P2.189 BOERMA, D.B.*; VEJDANI, H.; TRESKATIS, T.L.; CHENEY, J.; BREUER, K.; SWARTZ, S.M.; Brown Univ., Westphalian Univ. of Applied Sciences; *david_boerma@brown.edu*

Aerodynamic and inertial contributions to recovery from aerial stumbles in Seba's short-tailed bat

When a flying animal experiences an unexpected change in orientation, its capacity to maintain and restore control is mediated by the complex interplay between wing morphology and wingbeat kinematics. For example, asymmetry in wingbeat kinematics can produce aerodynamic torques at the body, but kinematic asymmetry also redistributes wing mass, which imparts additional inertial torques at the body. If the wings are relatively massive, these inertial torques can be quite substantial. In bats, heavy materials, skin, muscle, and especially bone, of the hand, arm, and hindlimb, were coopted to evolve the wings, which comprise 25-30% of total body mass in our study species, *Carollia perspicillata*. This anatomical design may be especially suited to allow bats to take advantage of both aerodynamic and inertial torques to perform complex aerial maneuvers, maintain stable flight, and recover from aerial stumbles. Here, we investigated the relative contributions of aerodynamic and inertial torques for reorienting the body following an aerial stumble. We perturbed flight using a jet of compressed air (0.05 N, ~2.5 bodyweights) to the dorsal aspect of one wing, resulting in body roll toward the side of perturbation. Detailed wing and body kinematics of perturbation and recovery were recorded, then projected onto a reduced order 3D dynamical model of a bat. We estimated aerodynamic force using a quasi-steady blade element model, and analyzed the effect of the observed asymmetrical wing motions on the behavior of the model in the presence and absence of aerodynamic forces. Inertial torques from the relatively massive wings contributed substantially to the dynamics of reorientation.

P1.207 BOOTH, A.R.*; ZOU, E.; Nicholls State University, Thibodaux LA; *abooth2@its.nicholls.edu*

Impact of molt-inhibiting PBDEs on epidermal ecdysteroid signaling in Callinectes sapidus: an initial mechanistic look into disruption of crustacean molting

Polybrominated diphenyl ethers (PBDEs) are flame retardant chemicals that are pervasive in the environment and have been linked with endocrine disruption in a variety of organisms. In crustaceans, recent studies have demonstrated a molt-inhibiting effect by several PBDE congeners, but little is known about the specific mechanism through which molt-inhibition occurs. This study will examine the inhibitory effects of PBDEs on crustacean molting; specifically, whether these effects arise from the disruption of molting hormone signaling in the epidermis. In order to assess the effects of PBDEs on the molting process in our model crustacean, *Callinectes sapidus*, we partially sequenced cDNA of N-acetyl-&beta-glucosaminidase (NAG), a terminal enzyme in the molting hormone-signaling cascades. Using NAG gene expression as a biomarker for ecdysteroid signaling, *C. sapidus* epidermal tissue will be exposed to varying levels of PBDEs 28 and 47. The effects of these PBDEs will be measured by quantifying NAG gene expression in exposed tissues. The elucidation of a partial cDNA sequence for NAG in *C. sapidus* will facilitate further research into the molt disrupting effects of xenobiotics since NAG gene expression is a biomarker for crustacean molting. Study of the *in vitro* effects of PBDEs 28 and 47 will help illuminate the mechanisms for inhibition of crustacean molting by these two prevalent flame retardants. Ultimately, predicted findings of this study may contribute to a better understanding of the effects of PBDE contamination in aquatic environments, as well as mechanisms for the disruption of molting in crustaceans.

P2.25 BOWERS, ME; KAJIURA, SM*; Florida Atlantic University; *kajiura@fau.edu*

Migratory Behavior of the Blacktip Shark (Carcharhinus limbatus)

The migratory behavior of the blacktip shark (*Carcharhinus limbatus*) in the Western Atlantic has been anecdotally described but not empirically studied. The sharks are thought to migrate from nursery areas along the southeastern coast of the United States in the summer, to South Florida, where they remain in large aggregations (up to 800 sharks km^{-2}) from January to April before returning northward. The first recorded description of the blacktip migration states that they occur north of Cape Hatteras, North Carolina "only as a rare stray." Given that this description was published over 70 years ago, their range might have shifted poleward in response to warming ocean temperatures, as has been demonstrated in many other marine species. To investigate the current migratory pattern of this population, 27 blacktip sharks were instrumented with acoustic transmitters, while they overwintered in South Florida, and passively tracked along the eastern coast of the United States in cooperation with the Florida Atlantic Coastal Telemetry (FACT) and the Atlantic Cooperative Telemetry (ACT) networks. Eighteen of the 27 individuals (67%) were detected after instrumentation. Three of those 18 individuals (17%) were detected far north of the previously reported North Carolina boundary, off Delaware Bay, NJ (1) and Long Island, NY (2). Five individuals were detected at the original capture location in South Florida the following winter, including two of the sharks that were detected in Delaware Bay and Long Island. This study provides the first empirical evidence of blacktip sharks completing a full migration cycle and suggests that their northern distribution may have expanded poleward.

P1.202 BOYKIN, J.C.; Georgia Southern University; *jb09023@georgiasouthern.edu*

Physiological and Biochemical Consequences of Sleep Deprivation in Zebrafish (Danio rerio)

Sleep deprivation has been linked with various abnormal behaviours and negative effects on health in humans. Chronically elevated stress levels have been linked with serious health implications. The objective of the current study is to examine the physiological effects of sleep deprivation in a vertebrate organism, zebrafish (*Danio rerio*). Specifically, the physiological and biochemical response of sleep deprivation, as a result of prolonged light exposure, will be studied in. Previous research has demonstrated that fish do experience a "sleep-like" state defined as continuous intervals of immobility for ≥ 6 seconds. Preliminary behavioural analysis of sleep-like states in *D. rerio* (n=2) using an integrative tracking software (Ethovision XT, Noldus) has demonstrated that *D. rerio* exposed to control light exposure cycles (14 hr light/10 hr dark) spend 33.37% of their time in a sleep-like state during dark hours. Whereas fish exposed to an increase in light exposure (24 hr light/0 hr dark) demonstrated a 2.8 fold reduction in time spent in a sleep-like state. As such, the physiological effects of acute (24 hr light/0 hr dark) and chronic (4 weeks: 24 hr light/0 hr dark) sleep deprivation will be analyzed in *D. rerio* by analyzing mRNA expression levels of key genes that control the synthesis and release of glucocorticoids via the hypothalamic-pituitary axis and whole body cortisol and glucose levels. As corticosteroid production via the hypothalamic-pituitary axis is one of the most evolutionary conserved organismal responses to stress we propose that responses observed in *D. rerio* may provide insight into the stress effects of sleep deprivation in mammals.

P2.84 BRANDT, EE*; KELLEY, JP; ELIAS, DO; University of California, Berkeley; *eebrandt@berkeley.edu*

Temperature-Related Changes in Courtship Behavior in a Jumping Spider

In order to gain a complete understanding of how organisms behave in nature, their interactions with abiotic factors must be considered. In particular, temperature is critical to the lives of all animals, affecting many aspects of an animal's metabolism and behavior. Ectothermic animals (those that do not metabolically regulate their own body temperature) are particularly interesting in this context because they do not experience temperature in the same way as endotherms. Since they have no way to generate body heat, ectotherms' metabolic rates are directly tied to ambient temperature. Thermal physiology studies frequently address maximum and minimum temperatures under which these animals can sustain life or perform certain activities, but how such organisms modify complex behaviors in response to temperature changes within biologically relevant conditions is less well understood. In this study, we sought to understand how ambient temperature affects both male courtship signals and the mate choice patterns of females across natural temperatures. To investigate this, we used the species *Habronattus clypeatus*, an ectothermic desert-dwelling species of jumping spider to examine (1) how male visual and vibratory signals change with respect to temperature and, (2) how females respond to these changes in male signals. Temperature seems to play a key role in *Habronattus* mating systems, and has important implications for the study of behavior in ectotherms.

P3.167 BRIDGHAM, JT; University of Oregon, Eugene; *jamieb@uoregon.edu*

Evolution of glycoprotein hormone and receptor signaling

Glycoprotein hormones (GPH) and their receptors are classic models of protein co-evolution. Members of these heterodimeric hormone/receptor protein complexes evolved following gene duplication events to interact with specific protein partners and mediate hypothalamic - pituitary - peripheral gland endocrine signaling. Vertebrates typically have three functionally distinct GPH mediated endocrine signaling complexes, two gonadotropins, luteinizing hormone and follicle stimulating hormone, and one thyroid stimulating hormone. Each hormone is a heterodimer consisting of a common alpha subunit bound to one of three different beta subunits that recognize specific G-protein coupled receptors. This type of endocrine signaling originated at the base of the chordate lineage with agnathans having a subset of hormone subunits and receptors, recently characterized in the sea lamprey. Genome sequencing projects reveal that the cephalochordate, amphioxus, has a single receptor as well as single alpha and beta hormone subunits, and the holocephalan, elephant shark, genome encodes members of all three endocrine signaling complexes. These genome assemblies help define the historical intervals and gene duplication mechanisms by which the protein families have diversified. We use reporter gene based functional assays of the amphioxus and elephant shark receptors and their hormones to understand the molecular mechanisms by which these protein families have co-evolved to form specific partnerships. Our results characterize the early evolution of endocrine signaling complexes following gene duplication events that occurred prior to the divergence of Chondrichthyes from the chordate lineage.

P3.15 BROWN, K*; WEIGEL, E.G.; WERREN, J.W.; KOVACS, J.L.; Spelman College, University of Rochester; *kbrown87@scmail.spelman.edu*

Identifying candidate shared horizontally transferred genes in the kissing bug Rhodnius prolixus

Horizontal gene transfer also known as HGT, is the transfer of genetic material between different genomes by mechanisms other than common descent. Among bacteria and other prokaryotes, HGT is very common. Their genes can be transferred on plasmids, transposons, and integrons. However several recent studies have found genes that were horizontally transferred into the genomes of multicellular eukaryotes. Several cases of confirmed HGT of functional ecologically important genes have been confirmed in arthropods, including the coffee berry borer beetle, the two-spotted spider mite, aphids, and gall midges. Interestingly in several of these cases, the same phenotypically important gene has been independently transferred to two or more arthropod hosts. We were interested in examining how frequent, widespread, and important shared HGT is for the acquisition of ecologically important phenotypic traits in arthropods. In order to do do this, arthropods that share an ecological niche (blood-feeding) were analyzed to find functional shared candidate HT genes. Specifically, we used publically available ESTs from the kissing bug *Rhodnius prolixus* to look for genes shared with other blood-feeding insects (including *Aedes aegypti*, *Culex quinquefasciatus*, *Anopheles gambiae*, *Ixodes scapularis*, and *Rhipicephalus appendiculatus*), but missing from closely related non-blood feeding insects (including *Acyrthosiphon pisum*, *Bemisia tabaci*,*Tetranychus urticae*, *Diaphorina citri*, *Mayetiola destructor*, and *Drosophila melanogaster*). For selected candidate genes, we built phylogenetic trees to find anomalies and identify phylogenetic discordance. These candidate shared blood-feeding HT genes will be further analyzed and confirmed using techniques such as tissue-specific qPCR, PCR across animal-bacterial junctions, and fluorescent in situ hybridization.

P1.58 BROWN, C.A.*; VAN VALKENBURGH, B.; UCLA; *cbrown20@ucla.edu*

Skeletal Injury Distribution Reflects Hunting Behavior in Extinct Predators: a Novel Application of GIS Technology

The distribution of preserved skeletal injuries reflects behavior and perhaps the risks of activities such as hunting large prey. Here, we used Geographical Information Systems (GIS) to interpret injury patterns in two Pleistocene predators from pit 61/67 in the La Brea tar seeps, the sabertooth cat *Smilodon fatalis* (SF) and the dire wolf *Canis dirus* (CD). Using a previously diagnosed pathology collection, we mapped 1700 traumatic and chronic injuries on skeletons of CD and SF using ArcMap 10.2 (ESRI 2015) and analyzed their spatial distribution. The number of traumatic SF pathologies was 1.75x greater than that of CD. Optimized hotspot analysis revealed significant differences in injury distribution. Whereas SF had dense injury clusters on the scapula, lumbar and thoracic vertebrae, CD had clusters on the femur, olecranon, wrist, ankle, and cervical vertebrae. This distribution are consistent with hypothesized hunting modes. SF was an ambush predator that used a muscular back and forelimbs to pull down prey, whereas CD was a cursorial pack hunter that incurred limb injuries when in pursuit and neck strain during prey capture. Injury centroids were significantly more dispersed across the skeleton of *Canis dirus* than in *Smilodon*. Comparable numbers of each predator were found, thus differences in distribution likely reflect differing risks of each species' hunting mode. Our results suggest that *Smilodon* suffered more trauma than dire wolves, possibly due to a larger typical prey size or a longer life span. As a visualization tool, GIS excels in making large volumes of spatially-associated data accessible. In addition, the representations can be instantaneously filtered to examine subsets of data and aid interpretation using free QGIS software.

P2.139 BUCHHOLTZ, E/A*; GEE, J/K; JOHNSON, L/A; Wellesley College; *ebuchholtz@wellesley.edu*

Searching for Sacral in Cetaceans

Mammalian vertebral patterns are highly conserved: almost all mammals have five vertebral series and total precaudal counts of 29 or 30. Movements of *Hox* gene expression domains cause homeotic movements of precaudal series boundaries, while different rates of somitogenesis cause different caudal counts. Whales exhibit a rarer phenomenon without a known developmental cause: the apparent absence of a vertebral series. Reduction of the hind limbs in early cetaceans was accompanied by disarticulation of sacral vertebrae and of the innominate and sacrum, but vertebral counts were largely conserved. This conservation suggests that homologs of the four sacral vertebrae were retained, even if they are not currently recognized. We analyzed vertebral anatomy and vertebral ossification patterns in seven odontocete cetacean groups to search for morphological discontinuities that could signal the location of sacral homologs within the lumbar series. The morphology of adult vertebrae was documented using geometric morphometric analysis of 2D images. The first two principal components of this analysis were used in iterative piecewise regressions to identify the column location with the highest probability (minimal residual sum of squares) of a morphological discontinuity. We also documented fetal neural arch osssification size and density using AMIRA software analysis of CT scans. These analyses identified the four vertebrae immediately anterior to the precaudal / caudal boundary as sacral homologs in physeterids and ziphiids, indicating that they retain ancestral counts and column regionalization. In contrast, lumbar and caudal counts of delphinoids have been coordinately increased. We find that sacral homolog count has also increased proportionally, with the result that the location of the first sacral homolog occurs far anterior to the precaudal / caudal boundary.

P2.149 BURGOS, L.P.*; KARSTEN, K.B.; California Lutheran University ; *lburgos@callutheran.edu*

Is bigger better? Interpreting the role of male ventral patch size in intra- and intersexual contexts in S. occidentalis lizards

Sceloporus occidentalis, the western fence lizard, is considered a territorial lizard because it has the following traits or behaviors: it has site fidelity, it defends that site, and it holds a near exclusive use of that site. However, physical combat, which may be used to defend their site, carries significant risks. As a result, species often use displays to establish social dominance without physical confrontation, such as push-up behavior that displays blue ventral patches. We proposed that male *S. occidentalis* lizards with larger ventral blue patches would be in closer proximity to more females, be more distant from other, rival males, and possibly have stronger bite forces than males with smaller blue patches. We collected lizard locations from Ventura County, California with a Trimble GeoXH GPS unit accurate to 10 cm. We collected data for 16 males and 12 females from June-August 2014 and March-August 2015. We also captured some of the lizards and brought them to the lab to measure sprint speed, morphology, bite force, and to photograph the ventral patches. We also recorded spectral properties of each ventral patch with a spectrometer. From these data, we address the role of ventral patch size in both an intra- and intersexual context.

P3.199 BUSH, NA*; HAHN, TP; CORNELIUS, JM; Eastern Michigan University, University of California - Davis; *nbush4@emich.edu*

Seasonal patterns in hematocrit and red blood cell morphology in free-living red crossbills

Reproduction often requires large investments in time and resources and the body undergoes significant changes to meet these energy demands. Investments in survival can also be very energy costly and animals usually time reproduction to occur during the least challenging time of year (e.g., spring and summer). Blood physiology (e.g., hematocrit and red blood cells (RBC) size) may reflect such seasonal resource demands given that these factors probably affect oxygen delivery to working tissue; however, most organisms breed only when environmental parameters are comparatively benign. Some organisms, however, like the red crossbill, *Loxia curvirostra* breed in both summer and winter allowing the opportunity to compare differences between seasons and reproductive condition independently. We measured how blood physiology responds to environmental parameters and reproductive investment by looking at hematocrit and red blood cell size over seasons and various other physiological and environmental parameters. Our data suggest that crossbills have larger RBCs but lower hematocrit in spring compared with other seasons. There were fewer breeding birds in spring and the high levels of fat deposition coupled with known behavioral patterns suggest a migratory phase. Breeding was most prevalent in summer and winter when hematocrit was higher and cell size was lower - agreeing with the higher hematocrit and lower cell size in reproductively active birds independent of season. We discuss these results in light of behavioral ecology of crossbills, metabolic demand and oxygen delivery dynamics.

P3.10 CAHILL, AE*; LEVINTON, JS; Aix-Marseille Université, IMBE, Stony Brook University; *abigail.cahill@imbe.fr*

Genetic differentiation and reduced genetic diversity at the northern range edge of two gastropod species with different dispersal modes

Theory predicts that genetic variation should be reduced at range margins, but empirical support is equivocal. We used genotype-by-sequencing technology to investigate genetic variation in central and marginal populations of two species in the gastropod genus *Crepidula*. These two species have different development and dispersal types, and might therefore show different spatial patterns of genetic variation. Allelic richness was highest in the most central populations of both species, and lower at the margin. The species with low dispersal, *C. convexa*, showed high degrees of structure throughout the range that conform to the pattern found in previous studies using other molecular markers. The northernmost populations of the high-dispersing species, *C. fornicata*, are distinct from more central populations, though this species has been previously observed to have little genetic structure over much of its range. Although genetic diversity was significantly lower at the range margin, the absolute reduction in diversity observed with these genome-wide markers was slight, and it is not yet known if there are functional consequences for these marginal populations.

P1.60 CALEDE, J.J.*; SAMUELS, J.X.; CHEN, M.; University of Washington Department of Biology, John Day Fossil Beds National Monument, Smithsonian Institution National Museum of Natural History; *caledj@uw.edu*

A multi-proxy analysis of the locomotion of entoptychine gophers (Mammalia: Rodentia: Geomyidae) from the Oligocene of North America

Entoptychine gophers are a species-rich and abundant group of rodents from the Oligo-Miocene of North America representing over 30% of some faunas. Yet, little is known about the paleoecology of these rodents, which are often represented by isolated craniodental remains. Material from the John Day Formation of Oregon and articulated skeletons from the Cabbage Patch beds of Montana allow a comprehensive study of the ecomorphology of these animals. Using a geometric morphometric framework built from extant rodent species, we analyze the skull shape of five entoptychine species. We compare the results to analyses of linear measurements of their postcranial skeletons. Analyses of skull morphology suggest that all three species of the genus *Pleurolicus* studied were terrestrial to semi-fossorial, with a morphology similar to that of some ground squirrels, voles, and lemmings. Both species of the younger, more derived, genus *Entoptychus* were classified as fossorial, but *E. minor* was likely less specialized than *E. individens*, which closely resembles extant geomyines. These results are congruent with analyses of postcranial data. The forelimb morphology of *Pleurolicus* indicates digging abilities similar to those of the extant chipmunks, suggesting terrestrial to semi-fossorial locomotion. The larger *Entoptychus* is characterized by hypertrophied forelimbs that suggest a semi-fossorial to fossorial locomotion. Combined with differences in body mass and incisor morphology across taxa, our results suggest that the evolution of fossoriality in entoptychines may have been linked to changes in diet and body mass through time.

P3.3 CAMACHO, N.M.*; POWERS, D.R.; WETHINGTON, S.M.; George Fox Univ., Newberg, OR, HMN, Patagonia, AZ; *ncamacho12@georgefox.edu*

Environmental Impact on Heat Loss from Hummingbird Nests

Nestlings have narrow thermal tolerances (35-40˚C) and require nests with good insulation. Smaller nests might require relatively more insulation because of their high surface-to-volume ratio. Since hummingbirds build among the smallest nests, they are ideal for study of structural adaptations that enhance heat retention. We collected broad-billed (BBLH; *Cynanthus latirostris*) and black-chinned (BCHU; *Archilochus alexandrii*) nests near Patagonia, AZ after the nestlings fledged. Detailed morphometric measurements were made on all nests. To test nest insulation a sphere heated to hummingbird body temperature (41˚C) was placed in the nest cup to simulate incubation. Heating and cooling equilibrium times and temperatures of nest walls were recorded at air temperatures between 5-40˚C with thermocouples and infrared thermography. Nest dimensions did not vary between species. Nests were oval in shape due to stretching from incubation and nestling growth. The diameter along the longest axis of the nest cup was 22.1+/-7.1mm (inner) and 40.9+/-8.1mm (outer). Wall thickness ranged from 7-11mm. Temperature gradients between nest surface and ambient temperatures ranged from 9.8 ˚C (T_a=5˚C) to <1.0˚C (T_a=40˚C) in BBLH and 8.3 to <1.0˚C in BCHU. Cooling time ranged from 7.6-17.9 min in BBLH and 4.1-11.5 min in BCHU. Calculated surface specific conductance for BBLH nests (22.6 W $˚C^{-1}m^{-2}$) and BCHU nests (21.7 W $˚C^{-1}m^{-2}$) were similar. Total nest conductance for both BBLH nests (60.2 mW $˚C^{-1}$) and BCHU nests (58.8 mW $˚C^{-1}$) is 2-4 times less than that of bird species ranging in mass from 50-100g (90-200 mW $˚C^{-1}$). Longer cooling time in BBLH nests might suggest better insulation than BCHU nests. Lower conductance in hummingbird nests support greater relative insulation than in larger nests.

P1.196 CAMPBELL, KE*; NAVIS, C; CORNELIUS, JM; Eastern Michigan University; *kcampb27@emich.edu*

Investigating the influence of stress hormones on the differential migratory behavior of the American Goldfinch (Spinus tristis)

Differential migration is where individuals of a given species move to different latitudes depending on their specific age and sex classes. Compared to seasonal migration, where individuals of a species move similar distances with little or no distinct latitudinal variation, differential migration and its underlying mechanisms are less well understood. In migrants, hormones indicating high-energy costs or activity might help determine migratory status. The glucocorticoid corticosterone (CORT) has been documented in several seasonal migrants to increase during migratory avian behavior and is predicted to support the associated physiological and behavioral changes. We explored basal and stress-induced CORT in American goldfinches *Spinus tristis*; a known partial migratory species where the population consists of individuals that show both migratory and sedentary tendencies. In this species, females and adult males are known to migrate further south than do juvenile males. We therefore investigate a potential mechanistic role of CORT and determine if there are significant differences among age and sex classes. We predict that female and adult male goldfinches have higher CORT levels in comparison to juvenile males during the migratory period. This study contributes to a broader investigation of how glucocorticoids support seasonal life history stages of migratory avian species by comparing the different CORT levels across goldfinch age and sex classes. Understanding the behavioral ecology and physiological mechanisms of migration is important as human disturbance, climate change and other factors influence migratory activity - with implications for overall ecosystem management.

P1.43 CAMPBELL, K.M.*; SANTANA, S.; University of Washington, Seattle; *campbk86@washington.edu*

Do bite force differences enable dietary specialization in sea otters?

Intraspecific studies of morphology and performance are essential for understanding the factors that enable resource partitioning within ecological communities, yet these have received little attention in mammal ecomorphology. Sea otters (*Enhydra lutris*) is one of the few marine mammal species in which individual-level dietary specialization has been quantified and linked to competition and prey abundance, making them an ideal system to investigate the morphological basis of food resource partitioning. Here, we assess whether differences in cranial morphology and bite force predict dietary variation among sea otter populations. We use geometric morphometric analyses and two-dimensional bite force models to (1) estimate differences in cranial shape and bite force among the three sea otter subspecies groups, *E. l. kenyoni, E. l. lutris* and *E. l. nereis,* (2) evaluate the extent of sexual dimorphism in cranial morphology and bite force within subspecies, and (3) relate the variation in cranial morphology and bite force to available dietary information. Although some sexual dimorphism in cranial features exists, preliminary results do not show significant differences in bite force between subspecies or between male and female sea otters. These results suggest that resource-use variation may be linked to individual foraging behavior and not to differences in morphology in sea otters. However, unique cranial features leading to high bite forces may enable this species to have higher diet plasticity; higher bite force in sea otters allows for the consumption of a variety of hard-bodied prey items and allows for either generalized or specialized diets, depending on prey availability and competition.

P1.94 CAMPBELL, J., D*; PETERSEN, N.M., ; TOMANEK, L., ; California Polytechnic State University- San Luis Obispo; *jcampb09@calpoly.edu*

Proteomic responses of tidally-acclimated mussel congeners (Mytilus) to acute and chronic aerially-induced hypoxia exposure

Intertidal mussels of the genus *Mytilus* experience prolonged hypoxic and even anoxic conditions during aerial emersion (low tide), depending on the pattern of the semi-diurnal tidal cycle. Furthermore, mussels of *M. trossulus*, a native to the Pacific coast, are known to be more heat-sensitive than those of *M. galloprovincialis*, an invading species from the Mediterranean. It is presumed that heat-tolerance correlates closely with hypoxia tolerance, suggesting that *M. galloprovincialis* may be the more hypoxia-tolerant of the congeners, making it a successful invasive species . However, interspecific differences may also depend on the recent tidal history of the animals. Thus, to compare the proteomic responses of the two congeners, we acclimated both species to subtidal (constant emersion) and intertidal (6 h low: 6 h high tide) conditions for three weeks before exposing animals to 0, 6, 12, 24 and 120 h of aerial-induced hypoxia while also running a control under acclimation conditions. Changes in protein abundance in gill tissue collected during the experiment were analyzed with 2D GE and MALDI TOF/TOF. Preliminary analyses of the proteomic changes during hypoxia suggest that mussels greatly differ in how they modify the abundance of molecular chaperones of the endoplasmic reticulum (ER) and antioxidant proteins. The ER chaperones may be involved in the excretion of mucous by the gill tissue to capture food particles. Hypoxia may serve as a signal to the gill to reduce mucus production through down-regulation of ER chaperones. Protein expression patterns of tidally entrained mussels suggest a higher tolerance to hypoxia compared to their subtidally entrained counterparts.

P3.178 CARDILLO, C.*; WALKER, B.; BURGIO, K.; RUBEGA, M.; Fairfield University, UCONN, UCONN; *christian.cardillo@student.fairfield.edu*

Is A Hothead Stressed? A pilot assessment of thermal imaging as a tool for indexing glucocorticoids

Current techniques for measuring glucocorticoid levels in avian species are invasive, require displacing birds from their natural habitat, and are known to themselves elevate glucocorticoid levels, thus complicating measurement of biologically relevant stressors. Observations from poultry suggest that stress in birds may be accompanied by an increase in temperature of exposed extremities. Thus, we hypothesized that increases in glucocorticoid levels might be associated with measurable increases in heat output at unfeathered body parts in birds, e.g., the feet, eyes, and beak. If true, thermal imaging technology might make it possible to create an alternative field method for measuring stress in free-living wild birds without handling them. We investigated the correlation between corticosterone (secreted during times of stress) and thermal output by simultaneously sampling blood plasma and heat signatures from house sparrows (*Passer domesticus*) during a 60 min acute stress series protocol. Heat signatures were measured from sparrow beaks, eyes, and lores with an infrared camera. Our results suggest that development of a thermal measurement of stress will require further experimentation. House sparrow beak temperatures varied in complex ways with corticosterone levels over time; detectable heat output is probably complicated by multiple factors. We found no significant relationship between the temperature of the eye, or the lores, and corticosterone levels.

P1.178 CAREY, M. T.*; ROSTAL, D. C.; Georgia Southern University; *mc03167@georgiasouthern.edu*

Temperature effects on growth rates in Gopher tortoise, Gopherus polyphemus, hatchlings

Temperatures has been shown to have an effect on physiological functions of ectotherms. For example, different temperature regimes can affect growth rates as they can cause ectotherms to absorb the caloric energy of food at different rates. Growth rates can affect size and age at sexual maturity. Long term effects of climate change on adult size are unknown. Since most tortoise habitat has become fragmented, tortoises cannot move in response to environmental change. How tortoises will respond to temperature both behaviorally and physiologically is unknown. This study looks at the Gopher tortoise, a large herbivorous ectotherm under different temperature regimes to determine the effects temperature has on hatchling growth rate. Hatchlings were collected from wild nests at George L. Smith State Park and Fort Stewart Army Reserve in southeast Georgia. Hatchlings will be raised in controlled environments to avoid variances caused by environmental differences. Growth rates and metabolic rates will be monitored monthly. Previous studies conducted with tortoise hatchlings have shown similar growth rates between these two sites and that different diets can affect growth rates. Studying temperature effects on hatchling growth rates will add to the volume of work that has been done specifically on these animals and can help shed light on the possible effects of climate change on these as well as other large herbivorous ectotherms in the future.

P2.75 CARRELL, SC*; DAVIS, J; CAUGHRON, J; Radford University; *scarrell2@radford.edu*

Studying the Relationship between Social Patterning and Relatedness in Anelosimus eximius

Unlike most spiders, *Anelosimus eximius* from the Amazonian rainforest of Peru is a social, communally living, species. Groups of *A. eximius* appear to coordinate their foraging/hunting behaviors much like a pack of wolves or lions. They sleep together, hunt together, and thrive together. In turn, due to the large numbers of individuals in a single colony, and apparently low emigration rates, there is a high rate of inbreeding and therefore a high relatedness quotient within individual colonies. With this in mind, we hypothesized that relatedness will be inversely proportional to distance between colonies and that spiders would prefer to be closer to conspecifics from the same colony while avoiding those from different colonies, regardless of the distance between the colonies as well as the relatedness. In the experiment described here, we captured individuals from multiple colonies and placed them in closed containers for 36 hours, taking images and recording behavior at 3 hour intervals. Images gathered in this way were analyzed based on distance between individuals and general activity patterns. Genetic patterns from each spider colony were then tested to determine general relatedness of the spiders within and between colonies. Unexpectedly, we found that colony of origin had no impact on social behavior. We discuss this finding in light of relatedness and presumptive evolutionary factors.

P1.129 CARRIER, TJ*; COFFMAN, JA; KING, BL; RAWSON, PD; Univ. North Carolina, MDI Biological Laboratory, Univ. Maine; *tcarrie1@uncc.edu*

Resistance of echinoid larvae to starvation and harmful algae: may larval evolution be shaped by phytoplankton dynamics?

Benthic marine invertebrates with planktotrophic (feeding) larvae release embryos near the start of the spring phytoplankton bloom, maximizing the feeding period for growth towards metamorphosis. While planktonic, feeding larvae experience numerous stressors, including periods of starvation and encounters with harmful algal blooms. Starvation response by echinoid larvae is well characterized morphologically and more recent molecularly. On the other hand, responses to harmful algae by the same larvae are much less explored. In these respects, what remains unexplored is the gene expression associated with starvation and grazing dynamics on harmful algae. Larvae of the urchin *Strongylocentrotus droebachiensis* are highly plastic and their distribution and abundance patterns overlap in space and time with toxic dinoflagellate *Alexandrium fundyense* blooms. Using mRNA-Seq and qRT-PCR, we show that starved *S. droebachiensis* larvae down-regulate genes involved in growth and metabolic activity while up-regulating genes involved in lipid transport, environmental sensing, defense, and genes known to control aging and longevity in other animals. Furthermore, with respect to number of cells consumed and frequency that a larva consumed at least one *A. fundyense* cell, *S. droebachiensis* larvae consume *A. fundyense* cells in a density-dependent manner, which did not persist in the presence of a non-toxic microalgae. Additional observations reveal a 100% larval survival and that larvae cope with ingested *A. fundyense* cells in three ways: digestion, regurgitation, and defecation. Based on the adept resistance to phytoplankton-induced stressors, we hypothesize that echinoid larvae are tuned to cope with the biological variation in the patchy abundance and composition of the pelagic environment.

P3.148 CARRILLO-BALTODANO, A*; MEYER, NP; Clark University; *acarrillobaltodano@clarku.edu*

Isolated blastomeres reveal scenarios for neural specification in annelids

Early neural fate specification is relatively well-understood in vertebrate and insect model organisms, where a region of ectoderm receives extrinsic signals to become neural ectoderm. By studying the annelid *Capitella teleta* we can elucidate to what extent extrinsic versus intrinsic signals are involved in early neural fate specification in other metazoans. So far, only ascidians had been shown to require intrinsic and extrinsic signals to specify neural fate. We hypothesize that in *C. teleta* the potential to generate brain neural ectoderm is autonomously specified by factors that are asymmetrically segregated to the daughters of the first quartet micromeres (1q), while ventral nerve cord (VNC) neural ectoderm is conditionally specified in daughters of the 2d micromere by extrinsic signaling from surrounding blastomeres. Using mechanical and chemical protocols, we have successfully isolated blastomeres from 2- to 8-cell *C. teleta* embryos. Isolated blastomeres continue dividing for more than 3 days, enough time to assess neural fate via expression of homologs of proneural and pan-neuronal genes, and by immunohistochemistry. Daughters of isolated C blastomeres (fated to generate the right eye, right brain lobe, and cilia) generate an eye, an adjacent clearing in the tissue that resembles a brain lobe, and cilia. Preliminary results also suggest that daughters of isolated 1q cells express the pan-neuronal gene *Ct-elav1*, indicating a possible role for neural determinants in *C. teleta* brain formation. These and future experiments to examine the transcriptomic profile of isolated blastomeres should enable us to identify the type of signaling (intrinsic versus extrinsic) and putative genes involved in early neural specification in spiralians.

P2.157 CASTILLO, S*; HEDIN, M; UBICK, D; GRISWOLD, C; San Diego State University, CA, California Academy of Sciences, San Francisco, California Academy of Sciences, San Francisco; *stephcastillo.04@gmail.com*

Morphological analysis of short-range endemic Japanese and Californian harvestmen (Opiliones: Laniatores: Travunioidea)

Opiliones (harvestmen) are the third largest order of arachnids after the Acari (mites and ticks) and Araneae (spiders). Previous work shows that diversification of many groups of Opiliones is closely associated with historical geographic processes. Harvestmen typically have low dispersal capability and high endemicity, and are therefore excellent models for biogeographic studies. Phylogenetic data support Travunioidea as an early-diverging clade within the most diverse suborder of harvestmen, Laniatores. They are short-range endemic taxa distributed in east Asia, North America, and southern Europe. However, the current classification is problematic at higher levels, as it relies heavily on tarsal claw morphology that is argued to be homoplastic. Multilocus phylogenetic data indicate that travunioids are monophyletic and that the Californian genus, *Zuma*, is nested within a Japanese clade. As part of the SDSU-CAS joint project on species delimitation of Laniatores, homology and variation within this clade were assessed using a standard set of images of both male and female genitalia, as well as somatic morphology, using SEM. Both Japanese and North American travunioids have remained mostly unstudied since the 1970s and were never examined with SEM, which reveals that tarsal claw morphology can vary intraspecifically, and might not be a reliable character for species delimitation. Our morphological analysis will be used to increase confidence in clade support, resulting in phylogeny-based reclassifications of deeper phylogenetic nodes.

P3.17 CASTLEBERRY, A.M.*; ROARK, A.M.; Furman University; *alissa.castleberry@furman.edu*

A safe and cost-effective method of genetic fingerprinting via amplified fragment length polymorphism

Amplified fragment length polymorphism (AFLP), a technique for genetic fingerprinting based on polymerase chain reaction (PCR), can present financial and logistical challenges, as the use of radioactive isotopes and sequencing gels can be expensive and dangerous. The goal of our research was to optimize a protocol for the genetic fingerprinting of different clone lines of pale anemones (*Aiptasia pallida*) that did not require the use of these materials. DNA from individual anemones was extracted and digested with both *Eco*RI and *Mse*I restriction endonucleases. Adapters were ligated to these cut sites, and the resulting fragments were amplified via nested PCR using increasingly selective *Eco*RI- and *Mse*I-specific primers. In the final amplification step, *Eco*RI primers were labeled with 5(6)-carboxyfluorescein (FAM) tags instead of radioactive isotopes. The resulting DNA fragments were electrophoresed through pre-cast 8% tris-borate-ethylenediaminetetraacetic acid (TBE) polyacrylamide mini-gels rather than sequencing gels. To facilitate band scoring, a FAM-labeled ladder was run on these gels alongside the amplified DNA samples. Gels were photographed on a variable mode imager and bands were marked manually. Fragment lengths were determined using ImageQuant TL software by comparison to the FAM-labeled ladder run on each gel. Estimates of genetic similarity between each pair of fingerprints were then calculated using the Jaccard coefficient. Comparisons of sample replicates and individuals from the same clone line resulted in consistently larger Jaccard coefficients than comparisons of independent samples. Our AFLP technique facilitates DNA fingerprinting by student researchers, allowing for a broader application of genetic fingerprinting.

P3.5 CEJA, A.Y.*; ARMSTRONG, E.J.; STILLMAN, J.H.; San Francisco State Univ., Romberg Tiburon Center, Univ. of Berkeley, Romberg Tiburon Center; *aceja1@mail.sfsu.edu*

Exposure to Lowered pH and Acute Thermal Stress in Embryonic Porcelain Crabs

Ectothermic marine organisms are especially sensitive to decreased oceanic pH caused by increased atmospheric pCO_2 and increased frequency and severity of extreme heat events. Qualitative and quantitative effects of lowered pH and acute thermal stress on embryonic heart rate of the species *Porcellana platycheles* was investigated. Embryos taken from field-collected females (n = 6; 96 embryos/female) were reared until hatching (~27 days) under one of two pH treatment conditions (pH=8.0, pH=7.6). Embryos were exposed to one of four temperature treatments: constant ambient 20 °C, one hour exposure to 31 °C on Day 1, one hour exposure to 31 °C at start of heart beat, or both one hour exposure to 31 °C on Day 1 and start of heart beat. Videos of the embryos were filmed, and their average heart rate was determined by counting the heartbeats. The embryos were classified as having an arhythmic, unevenly spaced, or normal heart rate. Those embryos exposed to 31 °C for one hour on Day 1 and to both 31°C on Day 1 and at the start of heart beat had the greatest variance in heart physiology, suggesting that *P. platycheles* are likely to be negatively affected under predicted climate change scenarios.

P2.198 CATHCART, KJ; MILTON, JG; SHIN, S; ELLERBY, DJ*; Wellesley College; *dellerby@wellesley.edu*

Quantifying the field swimming performance of bluegill sunfish

Locomotion is essential to the survival and fitness of most animals. Detailed measures of locomotor performance, mechanics and physiology are generally obtained in the laboratory. To infer links between performance and fitness it is important that any performance measures are relevant to the repertoire of locomotor behaviors in the field. Bluegill sunfish (*Lepomis macrochirus*) vary in phenotype and swimming performance with respect to their habitat type. It is currently unclear whether phenotypic and performance variation reflect habitat-related differences in locomotor behavior in the field. An array of underwater video cameras with overlapping fields of view was used to record the swimming behavior of bluegill sunfish in Lake Waban, MA, USA. This enabled reconstruction of the three-dimensional trajectories of individual fish and detailed measurements of swimming performance and kinematics. Routine swimming behavior typically consisted of station holding or low-speed maneuvering interspersed by bouts of higher speed swimming. Low-speed maneuvering was powered primarily by the pectoral fins and higher speed swimming by the body and caudal fins. Speeds varied widely within and between individuals with limited evidence for a preferred swimming speed or speeds. The observed behaviors will be used to inform the development of laboratory based measures of bluegill swimming performance that are relevant to field behavior and fitness, and to test for habitat-related differences in locomotor repertoires.

P2.1 CHEN, S.*; SHIU, H.-J.; CHUANG, M.-H.; LIU, J.-N.; National Chiayi University, National University of Tainan, Aletheia University; *forestloversin@gmail.com*

The effect of agricultural land-use change on farmland green tree frog (Rhacophorus arvalis) in Chiayi area, Taiwan

With the growth of urbanization and an increase in agricultural development, the survival of some species has been threatened, in particularly species with low dispersal ability and high sensitivity to environmental changes. The Rhacophorus arvlis, an amphibian endemic to Taiwan is currently listed as Endangered under IUCN's red list. It prefers certain kinds of farmland such as bamboos as habitats. In recent years, the conversion of agricultural land-use such as from bamboo plantation to pineapple fields has increased, which might have negative effects on R. arvalis. The study aims to understand the effect of land-use change between 2006 and 2014 on the distribution and population R. arvalis of in Chiayi area, Taiwan. We used audio strip transects to locate the frogs in 2006 and 2014. The suitable habitat range in both years were predicted by the Maximum entropy (MaxEnt) model using land-use types and the distance from the river as the inputs of environmental factors. The land-use types include forest, grass, field, dry land, building and water. The result shows that the R. arvalis preferred forest habitat but avoided dry land and building. The total area of forest, however, had reduced. The suitable habitat for frogs accounted for 48.8% of total area surveyed in 2006 and 44.7% in 2014. The conversion of land-use not only caused the loss of habitat but also increased the isolation among frog populations. There is an urgent need to reduce the loss of habitat as well as increase the connectivity among habitats.

P3.153 CHIODIN, M.; RYAN, J. F.*; University of Florida; *marta.chiodin@whitney.ufl.edu*

Elucidating the function of the Multiple Endocrine Neoplasia type 1 (MEN1) gene using CRISPR/Cas9 genome editing in the sea anemone Nematostella vectensis

The MEN1 gene is an important regulator of patterning and cell growth during vertebrate embryogenesis. Mutations in human MEN1 cause tumors of the parathyroid, pancreas and anterior pituitary. The MEN1 gene encodes a protein that acts as a cofactor of the MLL protein, and together these proteins activate the expression of critical developmental genes and cell-cycle regulators including the homeobox transcription factors HoxA9 and Meis, as well as the cyclin-dependent kinase inhibitor p27. The Nematostella vectensis (Anthozoa, Cnidaria) genome encodes a single highly conserved ortholog of MEN1 (NvMEN1). The crystal structure for NvMen1 has been solved and shown to bind NvMLL. In an effort to develop N. vectensis as a model system for understanding the MEN1 gene regulatory network we have characterized the embryonic expression of NvMen1, NvMLL, Nvp27, NvMeis, and the Hox gene NvAx1a by whole-mount in-situ hybridization. We show that these five genes are expressed in partially overlapping spatial and temporal domains. Our data suggest that NvMen1 might share the same co-factors and targets as the vertebrate MEN1 gene. To functionally characterize NvMen1, we have used CRISPR/Cas9 genome editing to delete the gene from the N. vectensis genome. From this knockout we show phenotypic evidence consistent with a role of MEN1 in development and cell cycle. We also show the effects NvMEN1 knockouts on NvMLL, Nvp27, NvMeis, and NvAx1a. Our data show that N. vectensis is an up-and-coming model for studying MEN1 and has the potential for overcoming some of the technical difficulties that have hampered the study of this gene in traditional model systems.

P2.106 CHOW, MI*; LEMA, SC; Univ. of Washington, Cal Poly, San Luis Obispo; *slema@calpoly.edu*

Elevated water temperature alters gonadal steroidogenic gene expression in the desert pupfish Cyprinodon nevadensis

Gonadal sex differentiation in fishes can be influenced by environmental temperature, and prolonged exposure to high temperatures can impair gametogenesis or, in extreme cases, trigger gonadal sex reversal. Recently, we identified a population of *Cyprinodon nevadensis amargosae* pupfish that occupies a high temperature freshwater spring (Tecopa Bore) and exhibits reduced sexual dimorphism in morphology compared to *C. n. amargosae* in the nearby Amargosa River, a stream in the Death Valley region of California. Temperatures in this desert stream vary widely both diurnally and seasonally, but average nearly 15°C less than in Tecopa Bore. We hypothesize that exposure of fish to the consistently elevated temperatures of Tecopa Bore impacts gonadal steroid production to alter sexual differentiation of morphology in that population. To begin to test that idea, we examined how exposure to high temperatures under laboratory conditions influences gonadal steroidogenic gene expression. Adult male and female pupfish from both Tecopa Bore and the Amargosa River were collected from the wild and maintained in captivity under either 24°C or 34°C temperature conditions for 88 days. In males and females from both populations, gene transcripts encoding receptors for the gonadotropin hormones (GtH) follicle-stimulating hormone (FSH) and luteinizing hormone (LH) were depressed in fish of both sexes at 34°C. Tecopa Bore females exposed to 34°C also exhibited reduced transcript abundance for cytochrome P450 aromatase (cyp19a1) in the ovary. These findings suggest that exposure of pupfish to high temperatures may impair gonadal steroidogenic activity in pupfish both by reducing gonadotropin hormone (GtH) receptor abundance in both the testis and ovary, and also by depressing aromatase estrogen synthesis in the ovary.

P2.205 CLARK, AD*; PETERS, JM; COMBES, SA; Harvard University, Univ. of California, Davis; *andrewclark01@college.harvard.edu*

Foraging yellow jackets adjust body posture and wing kinematics to maintain stability during loaded flight

Like many species within the order Hymenoptera, the yellow jacket (*Vespula germanica*) forages for insect prey to provide protein for developing young in the nest. Flying while carrying prey requires additional force production and may lead to an off-axis loading problem if the prey is not carried directly beneath the center of mass, as is the case with the yellow jacket. The morphology of wasp abdomens is highly diverse, with some species displaying long, thin petioles separating the abdomen from the thorax and others displaying distinctive, large abdomens like that of the yellow jacket. This morphological variation suggests that wasps may employ their mobile abdomens, as well as their wings, to meet the challenge of maintaining stable flight while carrying a load. To investigate the role of abdominal position and wing kinematics in maintaining stable, loaded flight, we collected 15 individuals from a yellow jacket hive and filmed them ascending towards a light with high-speed cameras. We filmed each individual flying with no load, as well as with a small ball of solder, equal to 20% of the individual's total mass, glued to the dorsal thorax. We calculated body angle and abdominal flexion angle, as well as wing kinematics. Our analysis reveals that yellow jackets are able to compensate for flying with sizable additional loads through changes in body position and wing kinematics. These compensatory mechanisms have important implications for the design of MAVs capable of carrying variable loads, and point to intriguing evolutionary adaptions among predatory flying insects such as wasps.

P2.93 COBLENS, MJ*; SHOEMAKER, AK; ANDERSON, MR; BOYER, SL; Macalester College; *mcoblens@macalester.edu*

Does Size Matter? A study on mate preference in the harvestman Phalangium opilio

Phalangium opilio, a globally distributed species of daddy long-legs, is often referred to as the "common harvestman." Although it is a familiar animal, very little is known about its mating behavior. This study aimed to clarify the effect of male size on female mating preference. We collected *P. opilio* around the campus of Macalester College in St Paul, Minnesota. During mating trials, one male and one female were put into an acrylic "arena" that provided visibility and control over the trial conditions. We recorded each encounter as either a copulation, a rejection by the female, or a lack of interaction between the individuals. Each block of trials contained 3 males and 18 females all of which were paired with with each male in varying orders to control for potential effects of mating order. Each block contained one male of each different size class (small, medium or large) based on measurements of body and appendage length. Rstudio and JMP software were used to test for relationships between measurements of male size and likelihood of copulation, rejection or lack of interaction with females. This experiment strongly suggested that females do not have a preference in mate related to size. However, we found significant negative relationships between a male's likelihood of interaction and various measures of male size, suggesting that a smaller size leads to a greater likelihood of interaction with a female. Many aspects of the life history of *P. opilio* are currently unknown and understudied. Further research into the connections between size, ontogeny, and mating behavior will lead to a greater understanding of the reproductive biology of this common yet poorly understood animal.

P1.164 COLLETT, A.N.*; HUMBERT, J.S.; VANCE, J.T; College of Charleston, University of Colorado, Boulder; *collettan@g.cofc.edu*

Optomotor response to simulated egomotion during tethered flight in honey bees, Apis mellifera

Insects, such as honey bees, are capable of rapid maneuvers in response to turbulence and wind during flight. Although the visual system of bees is well-studied in the context of flight navigation, less is known about how vision is used for reactive flight control over short timescales. In this study, we investigated the frequency response of the visual system by tethering bees within a custom LED arena and simulating egomotion about the yaw-axis by presenting complex oscillating visual patterns. The visual stimuli were constructed using the sum of twenty different sine waves, generated at logarithmically-spaced frequencies of prime multiples of 0.05 hz, ranging from 2 to 35 Hz, and de-interlaced to present two separate patterns per bee. High-speed (5930 fps) videography recorded wing and head kinematics in the horizontal plane. The time-history of the kinematic record and the LED pattern were then transformed to the frequency domain to determine the bandwidth of the honey bee optomotor response. The power-spectral density (PSD) of wing asymmetry angle exhibited distinct peaks at each frequency presented by the sum-of-sines visual pattern; and, a strong response from 10 to 35 Hz was observed for angular velocity PSD. The head angular position PSD diminished prior to 10 Hz, with limited angular position and velocity power from 10 to 35 Hz. The high-frequency wing kinematics response suggests vision could mitigate flight perturbations approaching latencies observed during free-flight, while the low-frequency head kinematics response may reduce the effect of head phase lag and help maintain honest optic flow.

P1.19 COLLIN, R.*; FREDERICQ, S.; MASLAKOVA, S.; MIGLIETTA, M.P.; ROCHA, R.; RODRIGUEZ, E.; THACKER, R.W.; Smithsonian Tropical Res. Inst., Univ. Louisiana, Lafayette, Univ. Oregon, TAMU, Univ. Federal do Paraná, American Museum, SUNY Stony Brook; *CollinR@si.edu*

Increasing International Access to Vocabularies for Organismal Taxonomy

One of the greatest current threats to the study of biodiversity is the loss of taxonomic expertise. As the number of experts declines, it becomes increasingly difficult to train the next generation of taxonomists as well as to disseminate knowledge of the basic methods required to study poorly known taxa. One of the greatest challenges in learning the taxonomy of invertebrates and macroalgae is learning the complex vocabularies used to describe their morphologies. This task is complicated by the fact that documentation of the world's biodiversity is an international endeavour. English-speaking taxonomists often have difficulty understanding original species descriptions from the classical literature, which was often published in other languages. Modern taxonomists are more often based in non-English speaking countries and yet the modern literature is almost entirely in English. As a first step to confront these challenges, we have developed an illustrated multilingual glossary using the Symbiota Software Project's biodiversity platform for use as a translation tool for technical terms in taxonomy and systematics. The glossary has been seeded with terms and illustrations from macroalgae, tunicates, sponges, hydrozoans, anemones and nemerteans. Translations into 10 languages are underway. This poster presentation will demonstrate how SICB participants and their colleagues can contribute to this project.

P1.125 COLLIN, R; HARRISON, L*; Smithsonian Tropical Research Institute, Panama, University of Montana; *lillian.harrison@umontana.edu*

Seasonal dimorphism in gastropod hatchling size: What can we learn from eggmass morphology and deposition site conditions?

Egg size is one of the most important features of marine invertebrate reproduction because it provides insight into developmental patterns, offspring size, and adult investment per offspring. Intraspecific variation in egg size and the resulting hatchling size may depend on many factors including environmental and maternal conditions and geographic location. Therefore, both the season in which eggs are laid and the spatial heterogeneity of deposition sites may influence egg size and hatchling size. *Natica chemnitzii* deposits egg masses on sandy beaches along the coast of the Bay of Panama. During the wet (non-upwelling) season hatchling size is unimodal. However, monthly sampling in the same transect of beach shows that in the dry (upwelling) season hatchling size is bimodal with a peak at 136.5 microns, the normal hatchling size during the wet season and an additional peak at 152.9 microns. To determine if this bimodal pattern in hatchling size is due to either plasticity in one species or the concurrent seasonal reproduction of two species, we performed a more extensive survey of eggmass morphology and deposition site conditions at four sites around the Bay of Panama, during the dry season. Small hatchlings (< 145 microns) that appear in both the wet and dry seasons are produced from small to medium sized masses (30 to 70 mm diameter) and are abundant at all four sites. Large hatchlings (> 145 microns) which appear only in the dry season are produced from a wide distribution of eggmass sizes (> 20 mm diameter up to < 100 mm diameter), and only commonly occur at two sites. Hatchling size based on eggmass morphology and geographic location suggests that dimorphism in the upwelling season is due to two species. Sediment and DNA analyses are underway.

P3.186 COLOM SANMARTÍ, B.*; SPAULDING, J.; MILLER SIMS, V.; COHEN, S.; San Francisco State Univ.; *berta.colom92@gmail.com*

High fusion rates among sibling Botryllus schlosseri recruits

Chimerism, where two or more genetically distinct individuals are found within a single body, occurs across a wide variety of taxa. *Botryllus schlosseri* is one of the model organisms used to study the evolution of chimerism. However, natural rates of chimerism are still not well known. Field surveys in varying locations and population densities have established estimates of 10 to 20%. Lab fusions between pairs of siblings from a single clutch found a fusion frequency close to 50% (Scofield et al., 1982). A field monitoring study of *Botrylloides violaceus* found recruits in a single population fused at a rate of 73% (Westerman et al., 2009). Here, we report on a fusion rate experiment using gravid marina-fertilized *B. schlosseri* colonies that were redeployed in the field. In each of 3 replicates, we attached a single source colony to the center of 3 PVC plates tied together and hung from an exposed seawall in the San Francisco Bay. Recruits were monitored for over two months to track the total number of fusions between larval settlers from the experimental source colony. Genetic samples were taken before and after fusion and a subsample of fusions were confirmed using 6 microsatellite loci. Recruit numbers were high with between 80-100 recruits per plate. Mortality rates were low, approximately 20-25% of the recruits disappeared, primarily in the initial week. The mean fusion rate of 59% was comparable with field rates observed in *Botrylloides* and much higher than previous field survey rates for *Botryllus*. This study shows how local populations of botryllids may quickly build up closely related aggregations of conspecifics via high fusion rates and may easily dominate space given appropriate conditions.

P2.141 CONCANNON, M. R.*; WEBB, J. F.; ALBERTSON, R. C.; UMass Amherst, University of Rhode Island; *mrconcan@cns.umass.edu*

Developmental origins of a morphological novelty in African cichlids

The evolution of an exaggerated trait can lead to a novel morphology that allows organisms to exploit new niches. The molecular bases of such phenotypes can reveal insights into the evolution of unique traits, for example, whether a developmental or genetic constraint has limited the evolution of the trait. In the expansive adaptive radiation of cichlid fishes in East Africa's rift valley lakes, a rare craniofacial morphology has evolved in at least two distantly related lineages, once in Lake Malawi and once in Lake Tanganyika. Fish with this trait have a dramatically overhanging snout that folds in on itself to form a flexible flap that rests on the premaxilla, the tooth-bearing upper jaw bone. Here, we show through gross anatomy and histological staining that this flap appears to arise via hypertrophy of underlying fibrous tissue, mainly the intermaxillary ligament, which extends into and interdigitates with the surrounding connective tissue, forming a novel ligament-epithelial boundary. Through a combination of genetic mapping and comparative gene/protein expression profiles, we demonstrate that this trait is mediated, at least in part, by expression of ADAM12 and TGF- , which have both been implicated in organ fibrosis in humans and mice. Specifically, ADAM12 has been shown to regulate tissue invasion and extracellular matrix deposition, while TGF- is involved in important cellular functions such as proliferation, differentiation, and apoptosis and it is also known to induce tendon and ligament progenitor cells. Given these data, we begin to piece together the developmental origins of this unique craniofacial morphology.

P3.64 CONTE, A.N.*; WELLING, E.M.; KAVAZIS, A.N.; HOOD, W.R.; Auburn University; *anc0037@auburn.edu*

A test of the relationship between oxidative damage and energy expenditure in a passerine bird

Damage created by the leak of electrons from the electron transport chain and formation of reactive oxygen species (ROS) has been implicated as a possible mechanism for the tradeoff between energetically demanding life-history traits such as reproduction and longevity, yet this implication is based on the assumption that there is a positive correlation between ROS production and energy expenditure. Evaluation of mitochondrial bioenergetics suggests that this assumption is incorrect. To confirm this, we evaluated the relationship between energy expenditure and oxidative damage, as a proxy for ROS production, in the House Finch (*Haemorhous mexicanus*). We also evaluated the relationship between oxidative damage in blood and organs, as damage in the blood is commonly assumed to reflect processes occurring throughout the body. Finches were assigned to 1 of 3 cage sizes to simulate differences in activity and relative energy expenditure. Precise differences in energy expenditure are being evaluated using the doubly labeled water method. After at least 2 weeks in assigned cages, the birds were scarified and liver, pectoralis, and blood were collected. The relative concentration of protein carbonyls in each tissue was evaluated. Our results indicated that there is no correlation between oxidative damage to proteins and cage size for any of the tissues evaluated. In addition, we found no correlation between oxidative damage to proteins in the blood and oxidative damage to muscle or liver. Additional measures of oxidative damage will be presented. Our findings indicate that the assumptions that energy expenditure and oxidative damage are positively correlated and that blood accurately reflects oxidative damage throughout the body are both incorrect.

P3.207 COONEY, P*; TRACEY, E; PEREIRA, A; HUGHES, M; KOREY, CA; College of Charleston; *cooneypc@g.cofc.edu*

Variation in Autotomy and Claw Transformation in the Snapping Shrimp, Alpheus angulosus

The snapping shrimp (*Alpheus spp.*) exhibit extreme claw lateralization, presenting a large snapper and a small pincer, which are used for different behaviors. Like most crustaceans, the snapping shrimp is able to autotomize limbs when threatened, and through subsequent molts, regenerate the lost limb. Autotomizing a limb is therefore costly not only in terms of loss of function, but also in terms of limb re-growth; failing to autotomize a limb, however, could be deadly. Here we examine variation in latency to autotomize the snapper claw in *Alpheus angulosus*. We measured latency to autotomy of mature snapper claws in a large cohort of shrimp (nf=36, nm=36). After initial snapper autotomy, we also measured latency to autotomize the regenerating claw based on molt stage. We found autotomy to be based on threat type rather than duration among all shrimp, as a distinct pattern in latency to autotomize appeared in our data. We also found significantly longer latency to autotomize in males, suggesting a greater cost of snapper autotomy to males than females. Surprisingly, amount of investment in claw regrowth (as measured by molt stage) did not affect latency to autotomize. Regarding post-autotomy claw transformation, we have found that plunger/socket formation occurs rapidly, restoring snap behavior after the first molt, despite reduced claw size. Our analysis of sensory plasticity exhibits appearance and proliferation of a new setae type by molt two of transformation, suggesting that sensory setae follow behind snapping functionality and may be less important for shrimp fitness. Through these perspectives, we will present the evolutionary tradeoffs of autotomy and plasticity in the snapping shrimp.

P1.56 COPPENRATH, C.M.*; LEON, Y.M.; SALMON, M; Florida Atlantic Univ., Boca Raton, Grupo Jaragua, Dominican Republic; *ccoppenrath2014@fau.edu*

A morphological comparison between immature hawksbill and green sea turtles indicates different evolutionary strategies are employed to reduce the threat posed by predators

As hatchlings and posthatchlings, marine turtles are vulnerable to a wide variety of marine, terrestrial, and aerial predators. During their early stages of growth, each sea turtle species displays a variety of strategies to reduce that predation risk. This study investigated the morphological differences between immature hawksbill (*Eretmochelys imbricata*) and green (*Chelonia mydas*) sea turtles that occur sympatrically in a foraging habitat in the southwestern Dominican Republic. At a given straight carapace length (SCL) green turtles had a wider straight carapace width than hawksbill turtles. In addition, at a given SCL green turtles had a larger curved carapace length indicating that they had a larger body depth. Previous studies suggest that green turtles exhibit allometric growth early on, growing in width faster than they do in length. This growth pattern is advantageous as it helps them more rapidly exceed the gape of potential predators. Hawksbill turtles are narrower than green turtles of a given SCL, but possess sharp, pointed marginal scutes that could also assist in deterring predators by making the turtles more dangerous to handle. We hypothesize that these differences in growth and carapace morphology are indicative of the use of different evolutionary strategies as adaptations to reduce predation pressure.

P1.97 CORNELIUS, EA; REGIMBALD, L; PETIT, M; LOVE, O; VEZINA, F*; Univ. of Wisconsin-Madison, Univ. du Quebec a Rimouski, Univ. of Windsor; *ecornelius@wisc.edu*

Thermal physiology and body composition of temperate bird experiencing food unpredictability

During winter and extreme weather events, temperate residential birds may be faced with an unpredictable availability of food. This variability of resources might then have a negative impact on the bird's ability to divert resources equally to maintain all important biological functions; moreover, this could impose a trade-off between gaining body fat as a buffer and physiological maintenance (BMR) or thermogenic capacity (Msum). To test this idea we compared the thermal physiology and body composition of captive black-capped chickadees (Poecile atricapillus) with an excess and unpredictable food supply. Control birds received ad libutum food each day of the experiment; birds assigned to the unpredictable treatment received only 80% of their daily energy requirements on random days and ad libitum food on other days. During the course of the study we measured total body mass, fat and lean mass, basal metabolic rate (BMR) and summit metabolic rate (Msum). Treatment birds maintained higher mass over the course of the study and had significantly higher fat mass compared to control birds. First results indicate that Msum was dependent on body mass; however, despite this, Msum was not different between the two groups. Additionally, both groups were similar in their physiological maintenance (BMR). Resulting data from this experiment show that while food unpredictability may cause trade-offs with other biological function (ie. immune response); there does not appear to be a thermogenic cost associated with having an unsteady food supply.

P2.11 COTTON, R.E.*; IYENGAR, E.V.; University of Michigan, Ann Arbor, Muhlenberg College; *cottonr@umich.edu*

Impacts of an invasive terrestrial slug on ryegrass growth

The invasive slug *Arion rufus* is a prevalent garden pest along the Pacific Northwest coast, but the extent to which this slug affects local native grassland ecosystems is unknown. No native pulmonate in this ecosystem attains even an appreciable fraction of the size of *A. rufus*, so this newcomer may be an important addition to the herbivore/detritivore food webs. Previous work has shown that slugs can impact plant diversity and biomass production in grasslands, and that in forest ecosystems *A. rufus* limits plant growth through herbivory, but accelerates nutrient cycling. This study, conducted on San Juan Island, Washington State, sought to understand the impacts of the feces, mucus, and herbivory of *A. rufus* on biomass production of the annual ryegrass *Lolium multiflorum*. We exposed seedlings (100 per pot) in small isolated mesocosms to one of three treatments: live slugs, slug feces only, or no slugs. After a month of applying treatments, there was no significant difference across any of the treatments in seedling germination, seedling survival rate, or above- or below-ground biomass production (either wet or dry weight). Surprisingly, despite observable seedling herbivory within the first few days of germination in the live slug treatment, there was also no significant difference among treatments in blade length or average weight per blade at the conclusion of the experiment. These findings suggest that, despite processing large amounts of local primary production, the excrement contributed by *A. rufus* did not fertilize the surrounding ryegrass in a way that affected the growth of the plants.

P2.188 COUGHLIN, D.J.*; ROUSE, J.W.; Widener Univ.; *djcoughlin@widener.edu*

Do fish benefit from swimming in groups?

The literature suggests that fish swimming in schools save energy compared to fish swimming alone. Each fish swimming in a group is predicted to benefit from the vortices associated with thrust production by neighboring fish, allowing each fish to maintain a given swimming speed with lower energy consumption. This is similar in concept to the energetic benefit of entraining to flow near a stationary obstruction. We tested this prediction by measuring oxygen consumption in fishes swimming singly and in small groups in a respiratory swim tunnel. In addition, we compared energy consumption in these fishes in the presence and absence of an obstruction. Both goldfish (*Carassius auratus*) and rainbow trout (*Oncorhynchus mykiss*) benefitted energetically from the presence of an obstruction. Single fish or groups of fish showed lower tailbeat frequencies and lower rates of oxygen consumption when an obstruction was present. However, both species tended to show greater energy consumption and higher tailbeat frequency with increasing number of fish in the swim tunnel. The current results suggest that group swimming does not lead to energy savings during steady swimming.

P3.120 CREAGER, S.B.*; PORTER, M.E.; Florida Atlantic University ; *screager2012@fau.edu*

A Comparative Study on the Tensile Properties of Elasmobranch Skin

Shark skin has drag-reducing properties that increases swimming speed in some species and provides the inspiration for biomimetic materials. Previous research has shown that dermal denticle morphology varies regionally along the body and correlates with swimming performance across species. In sharks, the skin acts as an exotendon that is controlled by internal muscular pressures and skin stiffness. Our goal is to assess differences in skin tensile properties regionally in three species of shark (*Carcharinus limbatus*, *Sphyrna lewini*, and *Isurus oxyrinchus*) using a materials testing system. We hypothesized that there are differences in the tensile strength and stiffness of skin at different regions of the body in an individual and between species. Strength (MPa) is the maximum stress that can be applied to a material before it fails, and stiffness (MPa) is the ability of skin to resist deformation in response to stretching. Juveniles from each species were obtained and skin was dissected from the underlying fascia and muscle at seventeen anatomical landmarks. Skin samples were oriented along the collagen fiber angles and stretched at a strain rate of 2 mm/sec until failure. A stress strain curve was generated for each sample and maximum strength (MPa) and stiffness (MPa) were calculated. We used a two way ANOVA to determine regional and species differences. This study provides data on skin mechanics within and between species and will provide information on the role of skin on shark movement.

P1.29 CREAMER, KE*; SIMMONS, DK; MARTINDALE, MQ; University of Florida, Gainesville; *creamerk@kenyon.edu*

The role of BMP signaling in patterning both the primary and secondary axis of Nematostella vectensis

Bilaterians have known axis-patterning genes with interaction gradients and feedback loops that establish the dorsal-ventral and anterior-posterior axis. The bilaterality of animals likely evolved in the last common ancestor of cnidarians and their sister group, the bilaterians, which have been shown to have a primary and secondary axis. Past studies have shown asymmetric expression of conserved bilaterian axis specification genes along the body axis of the cnidarian model organism *Nematostella vectensis*. We used CRISPR/Cas9 gene editing via embryo microinjections to knock out ten asymmetrically expressed genes of interest, related to BMP signaling and Hox genes. We successfully established F0 populations of knockout animals, noted abnormal morphology in late planula and early polyp stages via fluorescent antibody staining, and observed disorganized and missing axes via in-situ hybridization of 13 axis marker genes in the knockout animals. We thus propose a new model for axis specification in *N. vectensis* via regulation by inhibition and promotion based on the altered expression patterns of the axis patterning genes in the knockout animals presented in this study.

P1.193 CROCKER-BUTA, S/P*; LEARY, C/J; University of Mississippi; *scrocker@go.olemiss.edu*

Social and Endocrine Factors Influence Mating Tactics in Male Treefrogs

Whether differences in hormone levels among males that alternate between mating tactics are a cause or a consequence of tactic expression is central to understanding the mechanisms regulating such behavioral decisions. This issue is particularly relevant in anuran amphibians where males switch between being callers or non-calling "satellites" because the social acoustic environment can mediate changes in both tactic expression and hormone levels. Hence, it is not clear whether males adopt different tactics in response to rival male signals, hormone levels, or both. We previously showed that acoustic signals produced by male green treefrogs, *Hyla cinerea*, can increase corticosterone (CORT) and decrease androgens in male signal receivers. These changes result in hormone levels similar to those found in satellite males in natural choruses. We now combined vocal playback experiments with measurement of circulating hormone levels. In response to vocal playbacks, 24% of calling males adopted a satellite tactic. These males previously produced less attractive calls than males that continued to call, but the two groups had similar CORT and androgen levels, suggesting that tactic decisions are based on the relative attractiveness of competing males and independent of any detectable differences in hormone levels. We then increased CORT levels in calling males to determine how acoustic stimulation of CORT production in rival males benefits male signalers. CORT injections reduced vocal attractiveness and induced satellite behavior. Thus, signal quality and hormone levels both can play a critical role in tactic decisions and different hormone levels in callers and satellites can be both a cause of tactic expression and a consequence of interacting with callers after adopting the satellite tactic.

P2.21 CRESTOL, KM*; MURRAY, IW; LEASE, HM; Whitman College, Walla Walla, University of the Witwatersrand, South Africa; *leasehm@whitman.edu*

Preferred body temperature of two ecologically distinct species of African lizards

In ectotherms, preferred body temperature (Tpref) is the temperature that an organism selects when uninfluenced by the demands of interacting with conspecifics, feeding, or evading predators, and is often measured in species-appropriate laboratory thermal gradients. Many species of lizards, in particular, manage to keep their body temperatures within a relatively narrow range of Tpref through active thermoregulation. However, increasing environmental temperatures may impose serious constraints on the ability of many lizard species to operate within their Tpref. Consequently, it is important to understand the thermal preferences of lizard species, particularly those dwelling in environments likely to experience significant climate change. We measured the Tpref of two species of burrowing African skink, that inhabit different habitat types. The sandfish, Scincus scincus, occurs on hot and arid sand dunes across much of northern Africa and parts of the Middle East. Sundevall's writhing skink, Mochlus sundevalli, occurs in scrubby woodland from South Africa north to Kenya. We found that the sandfish had a mean Tpref of 36.3+1.4°C and the writhing skink had a mean Tpref of 26.7±1.3°C. We discuss how the thermal biology of these two ecologically distinct skink species may affect their susceptibility to projected levels of climate change within their natural habitats.

P3.35 CRUZ, M.A.*; SCHIZAS, N.V.; Univ. of Puerto Rico; *mariel.cruzramos@gmail.com*

Population Structure of the Coral-eating Fireworm Hermodice carunculata in the Wider Caribbean, Atlantic and Mediterranean Sea

The bearded fireworm *Hermodice carunculata* is an important benthic invertebrate scavenger distributed in reefs worldwide. Fireworms are facultative corallivores and have been shown to transfer pathogenic agents between coral colonies. The effects of predation on coral species can be substantial. There is limited data on the genetic population structure of *H. carunculata* because of its cryptic nature and past studies resulted in ambiguous findings. Both morphological and molecular data suggest the presence of multiple fireworm sibling species but the morphological differences do not reflect the phylogeographic patterns of the species complex. *Hermodice carunculata* is an ideal species to use for genetic analysis to infer patterns of population structure and gene flow because of its biphasic life style with planktonic larvae and benthic adults. We collected 412 *H. carunculata* samples from over 20 locations in the Caribbean, Mediterranean Sea, Gulf of Mexico, Western and Eastern Atlantic Ocean. We sequenced two mitochondrial markers: Cytochrome C Oxidase subunit I (COI) and Cytochrome b (Cytb) from each specimen to examine the genetic diversity of *H. carunculata*. There is substantial genetic diversity within *H. carunculata* and preliminary evidence suggests the presence of at least two cryptic species in multiple locations. The presence of multiple species in bearded fireworms indicates our incomplete knowledge in one of the most important invertebrate scavengers in tropical and subtropical reefs.

P2.143 CULUMBER, ZW*; TOBLER, M; Kansas State University; *zculumber@ksu.edu*

Evolution of the thermal niche: functional physiology and gene expression across a genus of livebearing fishes (Poeciliidae: Xiphophorus)

Temperature is an omnipresent environmental variable influencing survival and reproduction of all living organisms. Understanding how and when species adapt to different thermal regimes can provide insight into the evolution and subsequent maintenance of reproductive isolation via natural selection. We investigated evolutionary patterns of the thermal biology across the genus *Xiphophorus* using a multifaceted approach. First, thermal niche evolution was reconstructed using phylogenetically-controlled niche modeling. The niche models were used to identify comparisons of interest which included the monophyletic platyfishes which are broadly distributed across a biogeographic divide and three replicated instances of speciation along elevational gradients. For these comparisons, we examined upper and lower thermal limits in common-garden fish to test for adaptive, heritable differences in functional physiology. Patterns of thermal tolerance were further complemented with gene expression assays of candidate genes. Collectively, these three approaches provide insight into adaptive shifts in functional physiology and gene expression that have enabled colonization and speciation across a broad range of environmental conditions (e.g., the platyfishes) as well as maintaining reproductive isolation along stream gradients from high to low elevation.

P1.46 CULUMBER, ZW*; TOBLER, M; Kansas State University; *tobler@ksu.edu*

Morphological diversification in livebearing fishes of the family Poeciliidae

The livebearing fishes of the family Poeciliidae represent an ecologically diverse group including over 270 species that are distributed throughout North, Central, and South America as well as the Caribbean. Some poeciliids have served as powerful models for investigating the roles of natural and sexual selection in phenotypic diversification and speciation. However, it remains largely unknown how natural and sexual selection interacted to shape diversification within the family. We analyzed morphological variation (body shape and fin morphology) across 133 species of poeciliid fishes, including representatives from all recognized genera. Using a time-calibrated phylogeny, distribution wide assessment of environmental variation, and metrics of sexual selection, we addressed the following questions: (1) What are the major axes of morphological diversification within the group and is there any evidence for convergence? (2) How do rates of morphological evolution vary across time and among different taxonomic groups? (3) How does variation in the environment, sexual selection, and reproductive biology shape phenotypic evolution in the family?

P2.86 CUNNINGHAM, G.B.*; NESTEROVA, A.; BONADONNA, F.; St. John Fisher College, Centre d'Ecologie Fonctionnelle et Evolutive, CNRS; *gcunningham@sjfc.edu*

King penguins (Aptenodytes patagonicus) can detect two odours associated with conspecifics, and appear to walk up-wind towards the colony

Many birds are able to use their sense of smell is to locate their nest. Although King penguins (*Aptenodytes patagonicus*) do not build a nest, islands and colonies may also contribute to the olfactory landscape and may act as an orienting map for these birds. To test sensitivities to a colony or personal scent we studied whether King penguins could detect the smell of sand (acting as a control), feathers or feces, by holding presentations beneath their beaks while they naturally slept on the beach. The response of penguins was greatest to the feathers and feces. We also noted that penguins tended to arrive downwind of the colony, particularly in the morning, and then walk towards the colony in an upwind fashion. Although our work here is only a first step in exploring a broader role of olfaction in this species, our results raise the possibility of olfaction being used by King penguins in three potential ways: 1) locating the colony from long distances (ie. out in the water or from downwind on the shore), 2) finding an area within the colony where a chick or partner may be found, or 3) recognizing individuals by scent, as in Humboldt penguins (*Spheniscus humboldti*). Future work will clarify how sensitivity to feathers and feces is adaptive in this species.

P3.77 CURLIS, J.D.*; COX, C.L.; COX, R.M.; Georgia Southern University, The University of Virginia; *jc12430@georgiasouthern.edu*

Sex-specific population differences in metabolism are associated with intraspecific variation in sexual size dimorphism in brown anole lizards

Sexual size dimorphism (SSD) can vary in both direction and magnitude among populations and species, but the extent to which this variation is associated with differences in metabolism is not well known. Mechanistically, variation in metabolism can be associated with differential investment of energy into maintenance, activity, reproduction, and growth. To address this, we compared resting metabolic rate (RMR) of male and female brown anole lizards (*A. sagrei*) from two populations (one from the island of Eleuthera and the other from the island of Great Exuma) with pronounced variation in the magnitude of male-biased SSD. Previous research in this system has shown that, whereas females from each population are similar in growth and body size, males from Great Exuma grow more quickly and attain larger body sizes than males from Eleuthera, and this occurs in the wild, under common garden conditions in the lab, and in lab-raised progeny. Thus, we predicted that any population differences in RMR would be more pronounced for males than females. We used stop-flow respirometry to examine how RMR varies with temperature and time of day for males and females from each population. Consistent with our prediction, we found that RMR of males from Eleuthera was significantly higher than that of males from Great Exuma at 25°C and 30°C, and marginally higher at 35°C. In contrast, RMR of females did not differ between populations at any temperature. This research indicates that the smaller body size of males on Eleuthera can be partially explained by their higher RMR, compared to Great Exuma. More broadly, our work suggests that differential allocation of energy into resting metabolism versus growth can be linked to intraspecific variation in the magnitude of SSD.

P3.78 DAHLHOFF, EP*; SARGENT, BA; DAHLHOFF, VC; OTEPOLA-BELLO, D; GRAINGER, C; RANK, NE; Santa Clara University, Sonoma State University, Sonoma State University; *edahlhoff@scu.edu*

Getting chased up the mountain- high elevation may limit performance of a montane insect

Climate change is expected to shift species distribution as populations grow in favorable habitats and decline in harsh ones. For montane animals, the ability to escape hot, dry conditions at low elevation may be limited by low oxygen availability at high elevation. The willow beetle *Chrysomela aeneicollis* lives along steep elevation gradients (2400-3600 m) in the Sierra Nevada mountains of California and populations are sensitive to climate- they are found at low elevation following wet winters and retreat to high elevation during drought. Beetles living at high elevation have higher mitochondrial concentrations and develop more slowly than those found at low elevation. In these populations, mitochondrial Cytochrome c Oxidase II varies with latitude to a much greater extent than many other genes, one form predominating in the north (COII-1), another in the south (COII-2). To examine the role this genetic variation plays in effects of elevation on performance, we collected hatchlings from populations where frequency of northern and southern COII is equal and reared them under common garden conditions in the laboratory at high and low elevation. We found that larvae possessing COII-2 developed equally well at high and low elevation, while COII-1 larvae developed much slower at high elevation. Once larvae reached the 3rd instar, running speed was measured before and after heat treatment. Larvae reared at low (but not high) elevation ran slower after heat treatment, and the effect was greater for individuals possessing COII-1. These data suggest that low oxygen may limit growth and performance of a small insect, and that elevations just above beetles' current range may reduce performance of individuals possessing "northern" mitochondria.

P2.78 DAKIN, R.; MCCROSSAN, O.; HARE, J. F.; MONTGOMERIE, R.; KANE, S. A.*; University of British Columbia, Drexel University, University of Manitob , Queen's University, Haverford College; *samador@haverford.edu*

The biomechanics of an audiovisual courtship display: how peacocks shake their feathers to produce a coordinated signal

Courtship displays involving exaggerated ornaments are often costly and may serve as signals of male motor performance, a sign of male quality. To evaluate both the costs and signal content of these displays, we need to understand their underlying biomechanics. We used a combination of high-speed field video recordings, in vitro experiments, and detailed studies of feather morphology to describe how peacocks generate a coordinated audiovisual courtship display involving their large elaborate train. Peacocks were found to court females by vibrating their trains at remarkably consistent frequencies ranging from about 24-27 Hz, driven by the tail feathers strumming against the elongated tail covert feathers. Field recordings show that this stridulation produces coherent motion of the green feather barbs that form the visual background, as well as a broadband pulsating acoustic signal with harmonics at 26 Hz and 52 Hz. The peacock's display frequencies fall within the range for optimal detection of both visual flicker and acoustic signals found for other bird species. This display frequency is also higher than expected given the scaling relationship between vibrational frequency and body mass found for other bird and mammal shaking behaviors, suggesting that the peacock's display is an extreme motor behavior. To understand how peacocks are able to achieve coordinated motion of an array of feathers with the >160 multicolored eyespots remaining nearly stationary, we measured the resonant vibrational spectra of peacock tail and eyespot feathers. Our results demonstrate that peacock eyespot feathers achieve a novel scaling of frequency vs. length, with biomechanical properties that facilitate the performance of this extreme display.

P1.74 DANOS, N.*; WAGENBACH, C.O.; ANKARALI, M.M; COWAN, N.J; TYTELL, E.D.; Tufts Univ., Johns Hopkins Univ., Johns Hopkins Univ,; *nicole.danos@tufts.edu*

How lamprey muscle responds to perturbations during rhythmic motions: Phase-dependent system identification via harmonic transfer functions

Animals can move robustly through unpredictable and complex environments. This work seeks to determine how the muscular system of the lamprey, *Ichthyomyzon unicuspis*, responds to deviations from a steady rhythm. In particular, we aim to understand how the muscle itself, separately from the nervous system, can react to and compensate for perturbations during periodic motion. We dissected a small section of axial musculature, approximately 5-10 mm in length, and performed standard work loop methods. We imposed a baseline sinusoidal length change to the muscle while measuring the force produced. To mimic muscle activation by motor neurons we electrically stimulated the muscle at one of four phases in the cycle. Afterwards we performed a similar test but added small sinusoidal length perturbations. We analyzed the data using a new system identification technique based on harmonic transfer functions that addresses the system identification problem in the frequency domain. This technique allows us to determine how the muscle responds during its cyclic motion to external perturbations at a range of different frequencies and at different phases during the periodic motion. Preliminary results indicate that both the effective stiffness and damping properties of the muscle change within a cycle. We will also present results that show how these properties, and in fact the entire harmonic transfer functions, differ for muscle when it is activated during lengthening compared to when it is activated during shortening.

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The Use of Dynamic Time Warping to Reduce Inter-trial Variability in Gait Data

The timing of salient features in gait parameter varies among gait trials. When gait data are averaged, some of the standard error associated with this inter-trial variability can obscure important gait features unless normalization is carried out beforehand. A functional data analysis technique referred to as dynamic time warping registers or aligns prominent curve features for each curve, $x_i(t)$, by appropriate monotone transformation functions, $h_i(t)$, so that the analyses are carried out on the registered curves $x_i(h_i(t))$. The objective of this study was to determine how dynamic time warping can reduce inter-trial variability in human gait data, while maintaining the characteristics of the original curves. The iWalk BiOM is a powered ankle-foot prosthesis that uses a motor to assist the user through the gait cycle. Gait data were collected from the BiOM's internal torque and ankle angle sensors. Thirty gait cycles were collected from one person with an amputation (PWA) during level walking. Dynamic time warping was applied to ankle angle, anterior and posterior muscle torques, net ankle torque, and current. After registration of these curves, the standard error decreased. Prominent curve features were also maintained when the registered curves were averaged, while they were obscured when the unregistered curves were averaged. Dynamic time warping is thus a suitable technique to apply to gait data from animals and humans to achieve more accurate representation. Supported by NSF, IIP-1237878, and IIP-1521231.

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Hormonal and behavioral correlates of reproductive "decision-making" in a biennial breeder

In species with limited opportunities for reproduction and feeding, females are generally unable to recover sufficient energy stores to reproduce in consecutive years. Body condition has been used as a proxy for recent reproductive history in such species. We showed that hormonal responses to capture stress and receptivity to mating vary with body condition in female red-sided garter snakes (*Thamnophis sirtalis*), a species with limited breeding opportunities. These data suggest that reproductive history influences both stress responsiveness and mating behavior, although no study has directly examined if body condition accurately predicts reproductive history. We hypothesized that females that did not give birth during the previous summer would have higher body condition, lower stress responsiveness, and higher likelihood of mating during the spring breeding season. We collected unmated females and measured hormonal responses to capture stress and recorded latency to copulate for each female. Mated females were then housed in the lab to determine which females became parturient over the summer. Mated females that did not give birth were assumed to have given birth the previous summer and were deemed post-parturient. We found that parturient and post-parturient females did not differ significantly in body condition or hormonal stress responses, but parturient females mated more quickly. We also found that receptive females had a smaller stress response, were more likely to be in positive body condition, and were more likely to give birth than unreceptive females. These data suggest that variation in the sensitivity of the hypothalamus-pituitary-adrenal axis is related more to reproductive history than body condition and may contribute to reproductive "decision making."

P1.6 DE CARVALHO, M*; HAMDEN, J; DELUCA, R; DAVIS, J; CAUGHRON, J; Radford University, Radford University ; *mdecarvalho@radford.edu*

Using Bacteria Killing Assay to Test Immune System Efficiency in Birds

Being able to accurately measure the immunocompetence of free living, non-model animals would be of great value; making it possible to make comparisons across species, niche, sex, and life-history stage. However, currently it is very difficult to measure even just one aspect of immunocompetence. The methods currently used for determining innate immune capacity (phytohemagglutinin assay (PHA) and bacteria killing assays (BKA)) are problematic and often don't work for non-model species (Martin et. al., 2004). We have developed a variation on a traditional BKA technique that can accurately and efficiently assess immune capabilities of birds by exposing static bacteria to the antibodies and complement contained in small volumes of blood plasma by observing bacterial growth using a spectrophotometer. In principle, the greater the cell death caused by plasma, the lower the final bacterial cell number will be following exposure to complement in bird plasma. Our variation on the traditional BKA takes a relatively short amount of time to conduct, is cost effective compared to plate count assays, and utilizes a minimal amount of plasma making it useful for small vertebrates and potentially even invertebrates. Here we present results utilizing this technique to determine complement-mediated killing in various passerine groups, in comparison with heterophil:lymphocyte ratio. The heterophil:lymphocyte ratio technique and traditional bacterial plate counts were used to validate the data observed in the use of our novel BKA.

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Structured Light 3D Surface Reconstruction of Bird Wings

Birds fly effectively through complex environments, and in order to understand the strategies that enable them to outperform current drones, we need to determine the shape and movement of their wings. The dynamic morphing of the wing's upper surface is of particular interest, because it determines the boundary layer's sensitivity to flow separation during undisturbed flight. Previous studies focused on measuring general kinematics parameters such as wing stroke, but the actual shape and twist of the wing has not been fully resolved. We developed a high-speed camera and projector system to reconstruct the 3D surface of a bird wing at 3200 Hz. This is accomplished by projecting time-coded striped patterns onto the bird, which allows us to match corresponding stripe edges between the projected and recorded images. Using this system, we quantify how birds morph their wings while flying between perches using parameters such as surface area, wing orientation, and curvature which are difficult or impossible to measure with different approaches. Ultimately, the analysis of how birds change their wing shape will serve as inspiration for novel morphing wing designs.

P1.133 DEFINO, R*; OLIVA, KD; SPRAYBERRY, JDH; Muhlenberg College; *rd247297@muhlenberg.edu*

Odor Association and Proboscis Extension Reflex in Bumble Bees (Bombus impatiens)

Bumblebees are critical pollinators in both natural and agricultural ecosystems; they are effective pollinators of crops such as cranberries, blueberries, cucumbers, and numerous native flowering plant species. Their generalist floral preferences, ability to tolerate cold, ability to forage at high altitudes and "buzz" pollination contribute to the important role they play in pollination ecology. In contrast to honeybees, bumblebees do not directly communicate resource location to their nestmates. Therefore, individual foragers will often be searching out foraging patches. As previous work has shown that bumblebees can use olfaction to navigate in laboratory settings and are capable of associating specific odors with food rewards, it is likely that bumblebees can use floral odors to help locate resources in a field setting. However, in the field bumblebees will not be experiencing unpolluted floral odors; rather floral scents exist within a mélange of environmental odors. We are interested in understanding how olfactory pollution does, or does not, impact associative olfactory learning in bumblebees. To that end, this study uses Pavlovian conditioning and the proboscis extension reflex (PER) to train bees to associate lavender with a sucrose reward. The scent is then contaminated with biologically relevant odors; some that are structurally similar to lavender, and others that are markedly different. This will allow us to determine how similar, or dissimilar, a polluting odor needs to be in order to disrupt the bumblebees' olfactory association. Given past work on the negative effects of agrochemical odor pollution on bumblebee foraging behavior, this study should shed light on the mechanistic underpinnings of behavioral changes due to odor contamination.

P3.188 DELANEY, DM*; WARNER, DA; JANZEN, FJ; Iowa State University, Auburn University; *dmdelane@iastate.edu*

Nesting stage and distance to refuge, but not distance to predators, influences terrestrial nesting behavior in an aquatic turtle

Reproductive activities often expose individuals to predators, yet behavioral decisions can minimize predation and may depend on many variables. For example, terrestrial nesting can be risky for aquatic turtles, and a female's decision to flee from a predator may be a function of her distance from safe habitat. We monitored nesting painted turtles (*Chrysemys picta*) to examine their response (continue to nest vs. flee) to a human observer (potential predator) depending on the (1) distance between the turtle and the observer, (2) distance between the turtle and the water, and (3) reproductive stage at the time of the encounter (i.e., searching for a site to nest vs. excavating a nest). We found that females were less likely to flee as the distance to water increased, and that turtles already excavating nests were more likely to continue nesting than those still searching for nest sites. We found no evidence that the distance to the observer influenced whether turtles nested. Females that traveled farther from water and that had begun excavation may have continued nesting because they had invested more energy and were closer to finishing their nesting activities. In addition, fleeing farther from water or while excavating a nest may be more costly and/or less effective compared to fleeing while closer to water or while searching for a nest site. Our study suggests that investment in nesting activity influences flight decisions of painted turtles during this important and potentially vulnerable period of reproduction.

P3.187 DHOONMOON, A.*; COTHRAN, R.D.; Southwestern Oklahoma State University; *rickey.cothran@swosu.edu*

Cost of Courtship: Effects of Male-Male Competition on Harm Experienced by Females in Hyalella Amphipods

Sexual conflict over mating is common in nature and arises because males and females have clashing interests over whether, when, how often and for how long to mate. In some cases, these conflicts may result in significant costs to females, which can have negative consequences on the health of a population. One factor affecting sexual conflict is the intensity of male-male competition in the environment. We hypothesized that females are more harassed and thus harmed in more densely populated areas. We also hypothesized that females would be harassed more in populations composed of male-biased sex ratios. We used freshwater amphipods in the genus *Hyalella* to test these hypotheses. In amphipods, there is sexual conflict over the duration of pre-copulatory mate guarding. Males prefer to pair for a longer period than females. We set up populations of amphipods and manipulated the relative proportion of the two sexes. The sex ratio commonly found in nature (40% male) was used as a control. Other populations were either female or male biased. Separately, we also varied the size of the container to manipulate amphipod density. We used female survival as our response variable to assess the costs associated with sexual conflict. As the percentage of males increased from 40% to 60% in populations of the same density, female survival decreased from 82% to 15%. Contrary to our predictions, females survived better at the higher of the two densities. As number of females in a population decreases, the population has less genetic diversity and hence a greater risk of local extinction. It can be concluded that sexual conflict has a negative effect on population health.

P3.11 DEYARMIN, J.S.*; ROBERTS, K.; WHEAT, C.; DAHLHOFF, E.P.; RANK, N.E.; Sonoma State University, University of California Berkeley , Stockholm University, Santa Clara University, Sonoma State University ; *deyarmin@sonoma.edu*

Geographic variation of the mitochondrial genome in a montane ectotherm

Many organisms in montane environments live in isolated populations along environmental gradients. If gene flow among populations is restricted, small populations may become adapted to local environmental stressors. *Chrysomela aeneicollis*, are leaf beetles living at high elevation (2400-3600 m) in the Eastern Sierra Nevada mountains of California, which experience large diurnal temperature fluctuations during the summer growing season. Allele frequency variation is unusually high for three genes associated with central metabolism in these populations: phosphoglucoisomerase (PGI), Cytochrome Oxidase II (COII), and Succinate Dehydrogenase (SDH), and these genes vary greatly along a 75 km latitudinal thermal gradient. Prior studies suggest that PGI and COII genotype affect physiological and reproductive characters. Our initial results suggested that all mutations of COII are synonymous. However, using next-generation sequencing and Pool-Seq analysis, we were able to conduct larger-scale comparisons of the mitochondrial genome for these willow beetle populations. We identified single nucleotide polymorphisms (SNPs) and across the mitochondrial genome. With these data, we have discovered additional synonymous as well as non-synonymous substitutions in protein coding genes in the mitochondria, and found sequence variation within tRNA genes that may be influenced by temperature. These data will help us understand the genetic basis for mitochondrial differences in performance and fitness characters in future studies.

P1.75 DICK, TJM*; WAKELING, JM; CLEMENTE, CJ; Simon Fraser University, BC, University of the Sunshine Coast, QLD; *tjd3@sfu.ca*

Scaling of muscle architecture: from world's smallest to world's largest Monitor lizard

Here, we present a comprehensive dataset on the scaling of musculoskeletal architecture in varanids, providing information about the phylogenetically constrained adaptations that allow functional diversification across locomotor muscles in sprawling tetrapods. The effects of size and the fundamental selective pressures associated with it has been recognized for nearly 4 centuries. If animals were geometrically scaled up versions of themselves, increases in body size would result in an increase in musculoskeletal stresses, a result of the geometric scaling of mass and area. This becomes a problem for large animals, where stresses come dangerously close to failure points. In this study, we quantified the architectural properties of 22 lower limb muscles in 27 individuals from 9 species of varanid lizards (from 7.6g *Varanus brevicauda* to 40000g *Varanus komodoensis*). Results suggest that larger varanids increase the relative force-generating capacity of the femur abductors and adductors, and ankle extensors with greater scaling exponents than geometric similarity predicts for muscle mass, PCSA or pennation. In addition, muscle mass in the swing phase knee flexors scale with values > M^1, which may reflect additional muscle mass required to move a heavier limb. Thus varanids mitigate the size-related increases in stress by increasing muscle mass and PCSA rather than adopting a more upright posture with size as shown in other animals.

P1.61 DICKSON, K.*; TAYLOR, C.; MARTIN, K.; YASUMASU, S.; California State University, Fullerton , Pepperdine University, Malibu, CA, Sophia University, Tokyo; *kdickson@fullerton.edu*
Identification of hatching gland cells in embryos of the California grunion, Leuresthes tenuis
Adults of the California grunion spawn on beaches during spring high tides, and embryos develop within the sand until triggered to hatch by wave action during a subsequent spring high tide. Hatching involves digestion of the chorion from within, and must occur very rapidly in grunion. We have previously identified putative hatching gland cells in embryos while within the chorion and after manual removal from the chorion, but not after embryos are stimulated to hatch. These cells form a distinctive pattern along the length of the embryo, starting anterior-dorsally near the head and continuing down the length of the body at the lateral midline. In this study, we have identified the cells that contain the choriolytic enzyme required for hatching. Grunion gametes were stripped from adults collected while spawning, and eggs were fertilized and maintained in laboratory incubators set at 20°C for up to 30 days post-fertilization (dpf). Embryos and hatched larvae were examined by light microscopy, transmission electron microscopy, and immunohistochemistry using antibodies specific for the high choriolytic enzyme (HCE) of medaka. Cells located dorsally in the embryo, posterior to the developing brain, stained for HCE at 3 dpf. At 4-5 dpf, cells along the body midline also stained for HCE. The membrane of individual hatching gland cells contacts the embryo surface and therefore the cells can release the choriolytic enzymes into the peri-vitelline space to act directly on the inner chorion. These numerous cells are unicellular hatching glands similar to those that have been described in several other fish species.

P1.64.5 DIER, MJ*; SCHREIBER, AM; TEMKIN, MH; St. Lawrence Univ; *mtemkin@stlawu.edu*
Characterizing the Structure and Growth of Xenopus laevis Lungs
The lungs of *Xenopus laevis* start forming at an early premetamorphic stage and continue developing into the adult form well after metamorphosis has occurred. Similar to other animals, lung development in *X. laevis* involves both endodermal and mesodermal derivatives to establish efficient respiratory structures. Here, we examine the growth of both the endodermal and mesodermal components of *X. laevis* lungs from premetamorphic to postmetamorphic stages (NF47 to NF 66). Tadpoles at NF stages 47, 49, 54, 60, 64, and 66 were anesthetized in 0.1% MS-222 and rinsed in 1X PBS. Before the lungs were removed by dissection, an area of the ventral surface, that included the region of the abdomen and heart, was measured in order to standardize values among individuals of different body size. Lungs, in 1X PBS, were maximally inflated with air using a syringe needle inserted into the laryngotracheal groove. Lung inflation was viewed from the dorsal side and digitally recorded. Measurements of lengths and widths were made using ImageJ and individual video frames of maximally inflated lungs. Measurements of right and left lungs were averaged for each individual. These measurements were used to calculate parameters such as surface area, cross-sectional area, and volume. Our results indicate strong correlations between the measured ventral surface area and the growth of both the endodermal and mesodermal derivatives of the lung. Stage specific comparisons standardized for body size suggest that lung volumes increase over the entire range of the developmental stages included in our study. The vascularized mesodermal component of the lung increased significantly as the tadpoles approached metamorphosis.

P3.33 DIXON, GB*; MATZ, MV; SIDIK, Alfire; Univ. of Texas, Austin; *grovesdixon@gmail.com*
Small-scale spatial selection in massive broadcasting corals
Efforts to manage and conserve coral reefs are hindered by a fundamental and as yet unanswered question—What makes a coral good at living in its particular environment? Reciprocal transplant experiments have improved our understanding of local adaption. Corals are indeed often better at living in their 'home' environment than alternate ones. But it remains unclear to what extent this results from genetic adaptation as opposed to developmental (canalized) plasticity, a question that could impact success or failure when recolonizing degraded reefs. Here we use genome-wide genotyping (2bRAD) to test for evidence of spatially varying selection between proximate (< 10km apart) but environmentally distinct reefs. We sampled juvenile (less than 2 years old) and adult individuals of two bouldering corals *Siderastrea siderea* and *Montrastraea cavernosa* to examine how allele frequencies change through time at the alternate reefs. Specifically we test the hypothesis that purifying selection leads to genetically distinct adult populations. If this is the case, adult colonies should display elevated structure compared to juvenile counterparts because purifying selection among the young juveniles is largely incomplete. Analyses of FST across the genome indicate that adults indeed display generally higher FST between reefs than juveniles. More importantly, adults show higher incidence of extreme FST values, suggestive of genetic regions under local selection. The results indicate the potential importance of small-scale spatially varying selection in producing locally adapted coral populations.

P2.19 DOBKOWSKI, KA*; BIGHAM, KT; CROFTS, SB; DOBKOWSKI, Katie; Univ. of Washington; *kdobkows@uw.edu*
Feeding Patters of Pacific Northwest Crustacean Consumers
Bull kelp (*Nereocystis luetkeana*) is ecologically important to primary production, supply of detrital material, and creation of 3D habitat in Salish Sea nearshore subtidal ecosystems. Crustaceans are found in kelp bed food webs but feeding electivities and trophic impacts can be challenging to quantify. To assess the potential for *Pugettia producta* (the Northern Kelp Crab) to exert top-down control on kelp bed species, we first quantified feeding electivities and preferences in laboratory feeding trials on a range of prey items. In all trials, kelp crabs consumed more bull kelp than any other macroalga tested and elected to eat fresh kelp over aged; they showed no significant preference between kelp and snails (p=0.363). To determine if morphology influenced this feeding electivity, we compared claw morphology of *P. producta* with three other crab species: *Glebocarcinus oregonensis*, *Oregonia gracilis*, and *Chionoecetes bairdi*. Morphological measurements included number of denticles, radius of curvature of denticles and the distance that denticles extend along the claw. Foods tested in choice and no-choice feeding trials were bull kelp, snails, and non-kelp detritus (shelled shrimp). Kelp crabs (*P. producta*) have multiple denticles and frequently elect to eat bull kelp but also consumed snails and detritus in much smaller quantities. Decorator crabs (*O. gracilis*), another "spider" crab, have fewer denticles and rarely elect to eat kelp, eating mostly detritus. *G. oregonensis* had multiple denticles and consumed the widest variety of food. *C. bairdii* had the largest number of denticles and consumed detrital material almost exclusively. These results indicate that the serrated, multi-denticulate claws of *P. producta* may confer an advantage in handling both kelp and detrital matter, suggesting generalist, not strictly herbivorous, feeding patterns.

P2.73 DODGEN, R.E. *; IYENGAR, V.K. ; Univ. of California, Santa Barbara, Villanova University; *rose_dodgen@umail.ucsb.edu*
Influential Interactions: Group Dynamics of the Maritime Earwig, Anisolabis maritima
Dispersion patterns within a group can reveal important aspects about social interactions and sexual selection within a species. We examined the distribution patterns of the maritime earwig *Anisolabis maritima*, an insect well-suited for studies of aggression and sociality (both sexes live in close proximity and possess weaponry) and sexual selection (males possess asymmetrical, curved forceps whereas females have straight forceps). We first examined single-sex and mixed-sex groups of 18 earwigs in large enclosures to determine whether they had random, uniform, or clumped distributions. Similar to our field observations, males tended to form aggregations similar to leks whereas females were distributed uniformly, a pattern indicative of territoriality. Mixed-sex groups were initially uniform and then become clumped, and patterns suggest that females behave consistently across contexts while males alter their behavior in response to females. We also conducted trials among three earwigs with limited access to shelters to determine how intra- and intersexual interactions at the individual level may influence overall distribution patterns. In single-sex trios, we found that females exhibited stronger size-based intrasexual aggression than males, as small females were more likely to be excluded from shelters than large females whereas males were more likely to cohabitate with other males. In mixed-sex trios, we found that individuals of both sexes tended to cohabitate with the smaller of two different-sized opposite sex partners. However, a closer examination of the participants suggests different mechanisms driving this similar pattern, which further reflects sex and size-based differences in aggression that may influence the mating system.

P1.143 DONOHUE, M.W.*; CARLETON, K.L.; CRONIN, T.W.; Univ. of Maryland, Baltimore County; *willard3@umbc.edu*
Behavioral and molecular evidence for opsin-based extraocular photoreception in stomatopod crustaceans
Stomatopod crustaceans possess extraordinary visual systems and other unique adaptations. Stomatopod eyes contain dozens of opsins, the protein portion of a visual pigment. Until now, no studies have identified extraocular light detectors or explored opsin diversity in non-ocular stomatopod tissues. Extraocular light detectors are prevalent across animal phyla and are important for many functions, including circadian function, photolocomotory responses, and reproduction. Here, we provide behavioral and molecular evidence for extraocular photoreception in stomatopods. Sighted and blinded stomatopods flip, walk, and/or swim when illuminated more frequently than in the dark. Blinded animals responded more slowly to a light stimulus, indicating the extraocular light detectors control processes that occur on a different timescale than ocular light detectors. In a search for photopigments that could be responsible for light detection outside the eyes, we obtained transcriptomes from three separate regions of the central nervous system (CNS) of the stomatopod, *Neogonodactylus oerstedii*. Our transcriptome analyses and RT-PCR suggest that at least four opsins are expressed in the CNS. These data indicate that stomatopods probably possess opsin-based extraocular photoreceptors. Future work will explore the location and possible electrophysiological photoresponses of these putative photoreceptors.

P2.210 DONOUGHE, S.*; HOFFMANN, J.; NAKAMURA, T.; RYCROFT, C.H.; EXTAVOUR, C.G.; Harvard University; *donoughe@fas.harvard.edu*
Fluid mechanics and collective movement within an egg: Using light sheet microscopy and long term cell tracking to understand how a well-ordered insect embryo is built
In the majority of insect lineages, development begins with a series of nuclear divisions and movements within a single shared cytoplasm. First, the nuclei move through the viscous fluid of the cytoplasm, becoming a single layer around the yolk. Then, the nuclei undergo coordinated flows at the periphery of the egg, physically segregating distinct lineages of tissues. Such pre-blastoderm nuclear movements are poorly understood, even in the well-studied *Drosophila melanogaster*. Moreover, those aspects of post-blastoderm dynamics that have been elucidated in *Drosophila* are unlikely to be representative of all insects. We are therefore examining these developmental events in an insect that branches basally with respect to the most well-studied model species. We use light sheet microscopy to live-image transgenic embryos of the cricket *Gryllus bimaculatus* with high temporal resolution. We automatically detect and track nuclei, and then quantitatively characterize early divisions and movements of thousands of nuclei in 3D space for up to 12 hours at a time. This has enabled us to uncover early differentiation of cellular behaviors in the absence of gene expression information. We also describe how the geometric organization of nuclei changes over time, prefiguring the spatial arrangement of newly formed embryonic cells. Lastly, we use injected fluorescent beads to characterize the flow of cytoplasm, and chemical disruptors of the cytoskeleton to probe the mechanistic basis of early nuclear dynamics. Taken together, this work sheds light on how early nuclear movements and fluid mechanics contribute to the formation of the insect embryo.

P1.124 DOOLEY, T.C.*; CHOI, C.; PIRES, A.; PECHENIK, J.A.; College of Charleston, Dickinson College, Tufts University; *dooleytc@g.cofc.edu*
The effect of acidification on settlement and metamorphosis in response to adult cues in an invasive gastropod
The average pH of ocean surface waters has dropped by about 30%, due to absorption of anthropogenic CO_2 emissions. In the past decade, much research has been conducted examining the effect of this "ocean acidification" on marine organisms. Larvae seem especially sensitive. Acidification has been shown to affect chemosensory mechanisms and behavior of clownfish larvae, but little is known about how acidification may affect the sensory biology of marine invertebrate larvae. Like many marine invertebrates, the gastropod *Crepidula fornicata* settles and metamorphoses in response to chemical cues associated with favorable habitat for juveniles. Other studies on marine invertebrates have found decreased settlement and metamorphosis at lower pH, but none have measured how pH affects settlement and metamorphosis in response to cues from adult conspecifics. We tested the effect of pH on settlement and metamorphosis of four broods of larvae of *C. fornicata* that were derived from different parents. pH had a significant overall effect on both settlement and metamorphosis in the presence of adults, but not in the direction expected. Larvae settled and metamorphosed at higher frequency at pH 7.5 and 7.7 than at pH 8.0. While this pattern was seen in three of the four broods tested, response to pH treatment varied between broods. Further research is needed to determine if differences between broods remain consistent throughout the larval period, and might therefore reflect adaptations to variable pH regimes in estuarine environments. In separate experiments, pH had no significant effect on frequency of ciliary arrest (a correlate of settlement behavior), nor did it affect metamorphosis in response to elevated K^+.

P1.150 DRISCOLL, RMH*; RENN, SCP; HURD, PH; Reed College, University of Alberta; *rosdrisc@reed.edu*

"Aromatase genes and their enhancers in P. pulcher, a cichlid species with environmental sex determination"

Sex determination mechanisms vary greatly across the teleost fishes. In fact the process of, and environmental influences on, sexual differentiation often show a striking degree of phenotypic plasticity within a species. In the African cichlid fish *Pelvicachromis pulcher*, sex determination is influenced by pH, with a male bias at lower pH and a female bias at more neutral pH. Furthermore, male phenotypic morph and reproductive tactic is also influenced by pH. This species thus provides the opportunity to examine the mechanisms of environmental sex determination and differentiation both between and within the sexes. To this end, we have fully sequenced the upstream enhancer region of both the A and the B copies of the aromatase gene, cyp19a1, which convert testosterone to estrogen primarily in the gonads (A) and brain (B) respectively. Methylation levels and patterns in the gonadal (A) form of the gene have been linked to environmental sex determination in other species. The highly repetitive sequence in the upstream enhancer region is likely responsible for much interspecies variation, including the 400bp deletion found in P. pulcher relative to other cichlid species, as well as for intraspecies variation detected between P. pulcher individuals. We identified conserved putative transcription factor binding sites and CpG sites that play a potential role in the regulation of gene expression through methylation. While cyp19a1A, expressed primarily in gonads, includes a canonical CpG island ~1200 bp upstream from the start site, cyp19a1B, expressed primarily in the brain lacks a canonical CpG island.

P3.24 DRUMM, D.T.*; BIRD, G.J.; EcoAnalysts, Inc., Independent; *ddrumm@ecoanalysts.com*

New deep-sea Paratanaoidea (Crustacea: Peracarida: Tanaidacea) from the northeastern Gulf of Mexico

Tanaidaceans are a poorly known group of small (averaging 2-5 mm in length) peracarid crustaceans. Most of the 1000+ species live at depths exceeding 200 m, and, in some deepwater environments, Tanaidacea are the most diverse and abundant members of the fauna present.There are currently 46 species known to occur in deep waters (>200m) in the Gulf of Mexico. The present study adds an additional four species, bringing the total to 50 species. The tanaidaceans studied here came from an environmental baseline survey. One new genus is erected and four new species of paratanaoidean tanaidaceans are described from deep waters in the northeastern Gulf of Mexico: one in the genus *Collettea*, one in *Tanaella*, one in *Pseudomacrinella*, and one as a new genus in the family Anarthruridae. Keys to species in the genera *Collettea*, *Tanaella*, and the genera of the Anarthruridae will be provided.

P1.187 DUARTE-GUTERMAN, P*; MERKL, A; RILEY, L; GEISSLER, DB; EHRET, E; University of Ulm; University of British Columbia, Vancouver, University of Ulm; *duarte.paula@gmail.com*

Brain aromatase increases with parental experience and behavior in male mice

In mammals, maternal care is universal and its neural bases well-studied, whereas paternal care is much rarer and less well understood. In house mice, paternal care is gained with experience. Naïve males ignore and often kill pups, and only display parental behaviour after several days' exposure to pups. This delay coincides with altered neuroendocrinology; injection of estrogen helps naïve males become parental and experience with pups increases estrogen receptor content in limbic brain areas. Here, we asked whether locally produced estrogen (via aromatase) may contribute to becoming paternal, by quantifying limbic brain aromatase levels (number of Arom+ cells) in naïve males (M0, no pup contact); fathers co-caring their first litter of pups with a female partner for 5 days (M5, 5 days of pup exposure); and males co-caring with a female partner their first litter of pups until weaning and their second litter of pups for 5 days (M27, 27 days of pup exposure). Only males with previous pup experience retrieved lost pups back into the nest (% males retrieving pups; M0: 0%; M5: 83%; M27: 92%). The number of Arom+ cells increased in M5 and M27 relative to M0 in the lateral septum, amygdala, piriform cortex, and ventromedial hypothalamus. There were, however, no significant changes in nuclei associated with maternal care (medial preoptic area, bed nucleus of the stria terminalis, nucleus accumbens). Our results show increased paternal performance coincides with increased Arom activity in brain areas that regulate emotional/motivational and olfactory signal processing and learning. We suggest local estrogen is involved in a paternal brain network that is different from the network regulating the maternal instinct in females.

P1.188 DUDEK, A.M*; SCHOENLE, L.A.; ST. JOHN, P.; KERNBACH, M.; GONG, S.; VAN TOL, A.; BONIER, F.; MOORE, I.T.; Virginia Tech, Virginia, Queen's University, Ontario, Queen's University, Ontario; *alana33@vt.edu*

Caught in a trap and can't flap out: how do trapping methods and individual condition influence when a female bird returns to her nest?

Capturing animals is a common component of studies in wildlife behavior, ecology, and physiology. However, capture can be stressful to the animal, altering their behavior and/or physiology. If an individual's response to capture varies with another trait, such as age, hormone profile, or condition, then the effects of capture could affect the outcome of a study. We investigated the effect of capture with two trapping methods on incubation behavior in female red-winged blackbirds (*Agelaius phoeniceus*). We trapped females in either mist nets, positioned 1-3 meters from the nest, or a single-celled potter trap placed directly on top of the nest. We then measured the length of time for a female to resume incubating her eggs after capture. In addition to trapping method, we determined if individual variation in glucocorticoid hormones, hematocrit, or body condition predicted time away from the nest. We found substantial among-individual variation in the time taken by females to resume incubating (range: 28 to 251 minutes after capture). Females caught in potter traps on the nest tended to take longer to resume incubation than females caught in mist nets. However, mass seems to have no effect on return rates. In conclusion, capturing females disrupts incubation, leaving their nests vulnerable to predation and alters a behavior that influences the phenotype and survival of offspring. Our results suggest that investigators should be cautious capturing females right at the nest as it has the potential to have deleterious effects on subsequent incubation behavior and ultimately offspring survival.

P3.168 ECHEVERRIA, V; GONZALEZ-GOMEZ, PL*; KRAUSE, JS; ESTADES, CF; WINGFIELD , JC; LEVS, U Chile, UC Davis, IFICC, UC Davis, UC Davis; *plgonzalezgomez@gmail.com*
Feather quality and stress levels, a relation mediated by environmental conditions?
Considering the magnitude of global change, understanding the mechanisms involved in how organisms cope with this phenomenon is urgent. Species and individuals in highly xeric and unpredictable environments could show a variety of strategies to handle the predictable and variable conditions imposed by climate change. Rufous-collared sparrows (*Zonotrichia capensis*) living in the fertile agricultural valleys in the Atacama Desert, and in the semiarid Fray Jorge National Park in the north of Chile offer a particularly interesting group in which to examine the relation between feather quality and stress levels. Although we did not find differences in baseline or stress-induced levels of corticosterone between both localities during the molting period, preliminary results show that feather's quality is negatively affected by baseline levels of corticosterone but not by stress-induced levels. However, this effect is weaker in the desert locality where birds experience almost complete aseasonality, unlimited food supply and water and the molt period overlaps largely with breeding stages. These findings could suggest that the effect of corticosterone on feather quality could depend on the energetic challenges that individuals experience more than the absolute corticosterone levels.

P1.8 EDGAR, A.*; ROSTON, R.; Duke University; *ae75@duke.edu*
Telling a Three-Dimensional Tale to Primary School Students
Many children struggle with spatial reasoning and 3-dimensional geometry. However, these subjects are particularly amenable to hands-on exploration and visualization, and have numerous practical applications. These qualities can be a hook for students who believe they are "not good at math" to challenge that belief. We present a series of outreach activities derived from our own research interests in imaging and morphology aimed at 6th-grade students in North Carolina public schools. These activities are about biological subjects, but in fact satisfy several curriculum standards for mathematics. Students generate and test hypotheses using real, common objects to develop their geometrical intuition. Students have had a great time with these activities, which we have refined in consultation with practicing primary school teachers. Detailed lesson plans will be available at the poster session under a share-and-share alike license model - that is, take the lessons home to use, share, and modify for your own outreach!

P1.139 EDDINGTON, S.A.*; MUSCEDERE, M.L.; Hendrix College; *eddingtonsa@hendrix.edu*
Effects of body size and brain neuromodulators on olfactory learning in carpenter ants (Camponotus americanus)
Ants are extremely ecologically successful due in large part to an efficient division of labor among workers based on age and size. While differences in learning ability and responsiveness to environmental stimuli likely generate variation in worker behavior, few studies have addressed how variation in learning and memory ability among workers might impact colony division of labor, or how variation in neurophysiological mechanisms known to regulate division of labor could affect learning ability. The biogenic amine neuromodulators, including dopamine, serotonin, and octopamine, are particularly interesting in this context because they are widely implicated in learning across vertebrates and invertebrates and they have independently been linked to division of labor in multiple social insect species. Using workers of the carpenter ant species *Camponotus americanus*, in which division of labor is heavily influenced by body size, we performed behavioral observations to assess worker foraging behavior, experimentally measured learning ability in workers of different sizes, and used HPLC to determine neuromodulator levels in the brains of these workers. While larger workers were overrepresented outside the nest, they were found much closer to the nest entrance than smaller workers, which appear to be more active foragers. Smaller workers had better learning abilities and, after correcting for brain size differences, significantly higher brain amine levels than larger workers. Together, these findings suggest that variation in learning ability may help generate size-related division of labor in *C. americanus*. Future work will involve experimental manipulations of brain neuromodulator levels to directly test whether higher aminergic activity improves learning performance.

P2.101 EDWARDS, P.D.*; BOONSTRA, R; University of Toronto; *phoebe.edwards@mail.utoronto.ca*
Reduction of High Cortisol Levels During Pregnancy in an Arctic Mammal
Glucocorticoid (GC) hormones play important roles during pregnancy. They induce steps in fetal development, modulate energetic tradeoffs, and provide a signal to the fetus of the quality of the environment it will enter, adaptively altering its physiology. GCs circulate either bound to the carrier protein corticosteroid-binding globulin or unbound and biologically active ("free"). In many mammals, including humans and laboratory rodents, free GCs increase during pregnancy. However, this does not reflect the potential diversity in GC changes during pregnancy across Mammalia. We found that arctic ground squirrel (*Urocitellus parryii*) females emerge from hibernation with very high levels of free cortisol (51% unbound) but this is reduced markedly during pregnancy and lactation (5% and 10% unbound) due to an increase in corticosteroid-binding globulin. Total cortisol levels remained consistent across emergence and reproduction. We postulate that the high free cortisol just prior to visible pregnancy is related to the physiological changes or mobilization of body reserves involved in transitioning from hibernation to pregnancy. Thereafter, increased corticosteroid-binding globulin may shield the developing offspring from the negative effects of cortisol overexposure. These findings reveal a novel pattern in GC changes during pregnancy and underscore the importance of measuring corticosteroid-binding globulin levels in addition to total hormone concentrations.

P2.207 EKLOF, J.F.*; PEPPER, R.E.; University of Puget Sound; *jeklof@pugetsound.edu*

The Importance of Seed Characteristics in the Dispersal of Splash Cup Plants

Splash cup plants disperse their seeds by exploiting the kinetic energy of raindrops. The splash cup of the plant is a 3-5 mm vessel that holds seeds. When raindrops impact the splash cup, seeds are projected up to 1 m away from the parent plant. This study focused on the conical splash cups of the genera Chrysosplenium (golden-saxifrage) and Mazus. A systematic experimental study conducted by Amador et al. (2013) found a 40° cone angle maximized dispersal distance when seeds were not present. Our study used a 40° cone angle with the addition of seeds of varying characteristics. We 3D-printed the conical fruit bodies of the splash cups using UV curable resin and then used high-speed video to find splash characteristics such as angle and velocity of seeds and splashing drops as they exited the seed cup. Dispersal distance was calculated by measuring the distance from the model to the final resting position of the seeds and droplets. Splash characteristics and dispersal distances of seeds with differing characteristics such as size, shape, texture, density, and hydrophobicity were compared to one another, as well as to the case of having no seeds present. Our data showed that the presence of seeds dramatically decreased dispersal distance and altered splash characteristics. In addition, our data showed that seeds with different characteristics yielded splashes with differing dispersal distance and splash characteristics.

P1.198 ELDERBROCK, E.K.*; SMALL, T.W.; SCHOECH, S.J.; University of Memphis; *kldrbrck@memphis.edu*

Nestling experience predicts long-term phenotype in Florida scrub-jays

Environmental factors, such as sibling competition, parental care, food availability and weather conditions, can influence the development of altricial young. These factors may "program" an individual's organizational pathways to best match the conditions it experiences, thus shaping behavioral and physiological phenotypes that persist over the long-term. Altricial nestlings signal their parents by begging, although it remains unclear whether begging is an honest signal of nutritional need or if it is driven by parental behavior and/or competition with siblings. In this study we monitored a free-living species, the Florida scrub-jay (*Aphelocoma coerulescens*), as nestlings and across the first few years of life to investigate whether nestling begging behavior predicts an individual's future physiological and behavioral phenotype. We monitored nestling growth, begging rate and bout duration across the nestling period, as well as an individual's physiological stress response at 11 days of age. We subsequently assessed all individuals' physiological stress responsiveness (i.e., corticosterone response to capture and handling) at nutritional independence (~70 days of age), one year of age, and annually thereafter. At each stage we also tested all individuals' neophobic response to a novel object in their home territory. Although nestling corticosterone levels (baseline and stress-induced) do not correlate with begging or with the adult stress response, a strong positive correlation exists between an individual's begging rate at 11 days of age and its physiological stress response at both nutritional independence and one year of age. This result exists for multiple cohorts, suggesting an individual's experience as a nestling plays an integral role in shaping its future phenotype.

P3.107 ELDRIDGE, ML*; SPERANDO, D; GLAZER, A; MASS, SM; State University of New York, New Paltz; *N02377336@hawkmail.newpaltz.edu*

Comparative Ambystomoid Gait Kinematics

Axolotls *(Ambystoma mexicanum)* are neotenic salamanders that do not typically complete metamorphosis and remain aquatic when they reach sexual maturity; however, some axolotls may undergo spontaneous metamorphosis. Tiger salamanders *(Ambystoma tigrinum)* are non-neotenic terrestrial salamanders that normally complete metamorphosis and are within the same genus as axolotls. This study investigates the kinematics of the salamander gait cycle in order to compare movement of the metamorphosed axolotl to the tiger salamander during walking. By digitizing the movements of these salamanders during their gait cycle with slow-motion video, the motion and position of specific body parts were tracked, measured and compared.

P1.95 ELOWE, CR*; TOMANEK, L; California Polytechnic State University, San Luis Obispo; *celowe@calpoly.edu*

Circadian and Circatidal Rhythms of Protein Abundance Changes in the California Mussel Mytilus Californianus

The intertidal zone is a dynamic environment that fluctuates with the 12.4-h circatidal and 24-h circadian cycle to predictably alter food availability, temperature, air exposure, wave action, oxygen partial pressure, and osmotic conditions. Intertidal sessile bivalves exhibit behavioral or physiological changes such as adjusting gaping behavior and heart rate to cope with the persistent challenges of fluctuating environmental conditions. To date, transcriptomic studies on mussels' baseline circadian and circatidal rhythms indicate that the circadian rhythm exerts a dominant entrainment of transcriptional patterns. However, as proteins reflect the basic molecular phenotype of the cell and their abundance may differ greatly from that of mRNA, transcriptional methods could fail to detect important cyclical changes in the proteome that cope with the regular stress of tidal rhythms. For this study, intertidal *Mytilus californianus* were acclimated to four treatment combinations of circadian (12:12 h light/dark cycle) and circatidal (6:6 h tidal cycle) conditions using a tidal simulator with identical feeding schedules. Following acclimation, mussels were sampled from each treatment every 2 h for 48 h and gill tissue was dissected and frozen for proteomic analysis using 2-D GE and MALDI TOF-TOF mass spectrometry. Preliminary data suggest that tidally-entrained mussels differ in antioxidant and NADPH-producing proteins, primarily near tidal transitions, as well as a shift to a new metabolic state with changing tides. This high-resolution time course of protein abundance patterns under differing circadian and circatidal cues is providing insights into the endogenous responses to tidal and circadian rhythms of the proteome.

P3.5.5 ELSHAFIE, S.J.*; HEAD, J.J.; Univ. of California, Berkeley, Univ. of Nebraska, Lincoln; *selshafie@berkeley.edu*

Paleogene temperature estimates from body size in glyptosaurine lizards (Squamata: Anguidae) for the interior of North America

Poikilothermic vertebrates such as lizards can offer viable proxies for terrestrial climate based on measurable relationships between environment and body size. Ambient temperature constrains body size in extant lizards, but this relationship has not been tested in extinct forms through geologic time. In this study, we estimate mean annual paleotemperature (MAPT) based on hypothesized physiological requirements for glyptosaurine lizards (Squamata: Anguidae) according to body size. We show that these MAPT estimates correspond to known floral and isotopic records of continental climate change through the Paleogene of the Great Plains and the Western Interior. We modeled the relationship between skull length and snout-vent length (SVL) for extant anguimorphs and used these models to estimate SVL in glyptosaurines based on fossil cranial material. We then applied the model relationship between mass-specific metabolic rate, maximum SVL and minimum mean annual temperature for extant *Heloderma*, the largest North American anguimorph, to body size estimates of glyptosaurines to estimate paleotemperatures through the North American Paleogene. We find that maximum body size remained approximately constant among the largest glyptosaurines through the Eocene, with estimated MAPT of about 19 - 21°C in the Great Plains and Western Interior during this interval. Our estimates indicate that maximum body sizes of Oligocene glyptosaurines were less than half of those of the largest Eocene glyptosaurines, corresponding to a significant cooling period in the same region. Our results are consistent with other local proxies for the Paleogene of North America, indicating that body size in fossil lizards can be a useful proxy for estimating terrestrial paleotemperatures over geologic timescales.

P3.2 ELTING, R.L.*; POWERS, D.R.; George Fox Univ., Newberg, OR; *relting13@georgefox.edu*

How much can hummingbirds increase nectar consumption during extreme energetic demand?

Hummingbirds might be limited in their ability to increase nectar consumption because most water consumed is absorbed and processed through their kidneys. If water processing imposes a cap on feeding rate, then increasing energy intake during periods of extreme energy demand could be difficult. We measured maximum feeding rate in four hummingbird species by sequentially feeding them nectars that decreased in sucrose concentration (10-2%). Feeding rate in broad-billed (3.2g) and magnificent (7.5g) hummingbirds peaked at 4% (0.55 and 0.53 g_s $g^{-1}h^{-1}$, respectively) whereas black-chinned (3.0g) and blue-throated hummingbirds (8.0g) peaked at 6% (0.77 and 0.55 g_s $g^{-1}h^{-1}$, respectively). Maximum water consumption occurred at 4% for broad-bills and magnificents (0.53 and 0.51 mL $g^{-1}h^{-1}$, respectively), and at 6% for black-chins and blue-throats (0.72 and 0.51 mL $g^{-1}h^{-1}$, respectively). Maximum energy consumption occurred at 8% for all species (0.50-0.79 kJ $g^{-1}h^{-1}$). Further nectar dilution past the point of peak feeding rate appeared to result in reduced activity, presumably to compensate for reduced energy intake. Species differences in consumption was not related to body mass. All species except black-chins maintained mass for the duration of the experiment. Mass loss in black-chins might suggest higher energy demand or lower assimilation efficiency than the other species. The unusually high water consumption of black-chins could indicate lower intestinal water absorption. Since hummingbirds appear to be able to meet daily energy demands by consuming 2-3 times their body weight in nectar per day, our data predict that in periods of extreme energy demand compensatory feeding can be substantially increased if nectars contain typical amounts of sugar.

P3.73 EMERY, K.Q.*; DEAROLF, J.L.; AVERY, J.P.; PLATT, K.M.; PEARSON, K.J.; Hendrix College, Conway, AR, Univ. of North Florida, Jacksonville, FL, Univ. of Kentucky, Lexington, KY; *emerykq@hendrix.edu*

Effects of perinatal exercise on the enzymatic properties of neonatal mouse diaphragms

Female mice that exercise during pregnancy have offspring that show improved overall glucose disposal when compared to offspring from sedentary dams, and skeletal muscles are one of the major organs involved in glucose metabolism. Therefore, the goal of this study was to measure oxidative enzyme activity in muscle, specifically the diaphragm, in the offspring of exercised and sedentary mice. To achieve this goal, pregnant female mice were separated into two groups, sedentary and exercise. Sedentary dams did not have access to a wheel during pregnancy, while exercised dams were placed into controlled exercise wheel systems for one hour a day. Diaphragm samples were then collected from the two-day-old neonates of dams in both groups. The citrate synthase (CS) activities of these samples were measured with a microplate reader under the following conditions: 50 mM imidazole, 0.25 mM DNTB, 0.4 mM acetyl CoA, and 0.5 mM oxaloacetate, and pH 7.5 at 37°C. The rate of change of the assay absorbance (at 412 nm) at the maximum linear slope (Vmax) was used to calculate the CS activities of the diaphragms. The average CS activity of the diaphragm of pups of sedentary dams was 28.26 (±1.25) micromoles/min*g, and the average for pups of exercised dams was 31.59 (±1.40) micromoles/min*g. This result demonstrates that exercise led to a slight increase in CS activity in the mouse pup diaphragms, and the increase in the oxidative activity of this muscle may contribute to the improved glucose disposal of the pups of exercised mothers. However, since the increase in CS activity was so small, this effect of perinatal exercise cannot be the main driver of changes in pup glucose metabolism.

P2.206 ENAYET, NS*; WALDROP, LD; Univ. of North Carolina at Chapel Hill, Univ. of California, Merced; *lwaldrop@ucmerced.edu*

Effects of the finger-like lunules of rotulid sand dollars on lift and drag in steady flow

Rotulid sand dollars have a uniquely shaped test: instead of the classic round outline with smooth edges, they have small indentations that create finger-like lunules on about a third to a half of the distal margin's circumference. The function of these lunules, if any, is unknown. In this study, we test the hypothesis that the finger-like lunules provide the same lift-reduction benefits as the hole-like lunules of the *Mellita* spp. by measuring lift and drag forces and visualizing flow using particle image velocimetry on dynamically scaled physical models of tests of a rotulid sand dollar (*Heliophora orbiculus*) and a keyhole sand dollar (*Mellita quinquiesperforata*). Average and peak lift forces, lift-to-drag ratios, and flow visualization on the tests of the rotulid and keyhole sand dollar tests will be presented. Flow visualization shows that the patterns of flow around the rotulid sand dollar resemble a flat plate than the patterns around the keyhole sand dollar. The rotulid tests were also more unstable than those of the keyhole sand dollar, showing higher peak lift forces. It is likely that the finger-like lunules of rotulid sand dollars do not provide the same benefit, or the same extent of benefit, of lift reduction as the hole-like lunules of keyhole sand dollars.

P2.20 ENGLISH, P.A.*; GREEN, D.J.; NOCERA, J.J.; Simon Fraser Univ., Burnaby BC, Ontario Ministry of Natural Resources & Forestry and Trent Univ., Peterborough ON; *penglish@sfu.ca*

Flying down the food web? Diet change of an aerial insectivore revealed by museum specimen isotopes

Aerial insectivores, dietary specialists that rely on flying insects, are exhibiting some of the steepest population declines of any group of birds in North America. One hypothesis for the decline is a change in food availability; however long-term data on insect abundances and avian diet are generally lacking. The eastern whip-poor-will (*Antrostomus vociferous*) is a nocturnal aerial insectivore that eats moths and beetles. We look for evidence of temporal change in the diet of Ontario's eastern whip-poor-wills using museums specimens collected between 1880 and 2000, and samples from breeding individuals in 2012. Nitrogen isotope ratios (δ15N) are known to increase with trophic level and diet quality. We compare temporal changes in δ15N of whip-poor-will tissues grown in winter (claw) and during breeding season (feather) with δ15N of 3 potential prey insect species (*Biston betularia, Phyllophaga anxia, Colymbetes sculptilis*) collected from the same region and time period. We found significant declines in δ15N in both winter and summer tissues of adults and in nestlings over the past 100 years. Nitrogen isotopes of both winter-grown claws and summer- molted feathers did not differ between sexes or breeding sites. Nestlings have lower feather δ15N levels than adults. None of the insect prey species sampled show any temporal trend in δ15N suggesting that the pattern found in bird tissues is not the result of broad-scale changes in N fertilizer inputs. These results are consistent with the hypothesis that aerial insectivore populations are declining due to changes in abundance of high quality, higher trophic level prey.

P3.34 ENZOR, L.A.*; HANKINS, C.; BARRON, M.G.; U.S. Environmental Protection Agency; *enzor.laura@epa.gov*

Ocean acidification effects on Caribbean scleractinian coral calcification using a recirculating system: A novel approach to OA research

Projected increases in ocean pCO_2 levels are likely to affect calcifying organisms more rapidly and to a greater extent than any other marine organisms. The effects of ocean acidification (OA) has been documented in numerous species of corals in both laboratory and field studies. However, the majority of laboratory studies have utilized flow-through exposure systems. Challenges of a recirculating system include effectively off-gassing carbon dioxide from waste water and accounting for the compounding effects of CO_2 from acidifying treatment water and organismal respiration. We developed a recirculating coral exposure system that allows precise pCO_2 control using a combination of off-gassing measures including: aeration, water retention devices, venturi injectors, and algal scrubbing. The system is being utilized in a comparative study to identify changes in skeletal weight and tissue growth in three major reef-building corals of the Caribbean: *Pseudodiploria clivosa*, *Montastrea cavernosa*, and *Orbicella faveolata* exposed to either present-day pCO_2 levels or 1000 µatm (IPCC A1F1 scenario). Preliminary results indicate that OA-induced reductions in scleractinian coral growth is species specific. Combining photogrammetric analysis (tissue growth) and advances in the buoyant weight technique provide an area density that can be used to infer the rate of calcification and erosion. The recirculating exposure system can provide laboratories without access to flow-through systems to contribute to the growing field of coral OA discovery.

P3.177 ERNST, DK*; LYNN, SE; BENTLEY, GE; Univ. of California, Berkeley, Univ. of San Francisco, The College of Wooster, Univ. of California, Berkeley; *dernst@usfca.edu*

Corticosterone measurements differ in plasma sampled from a wing vein and trunk vessels

Hormone levels are not necessarily uniform throughout the circulatory system, and thus estimates of circulating hormone concentrations may vary depending on the location or type of blood vessels from which samples are collected. Such variation may be of critical importance, both for understanding the dynamics of hormone action across tissues, and for appropriately designing experiments. We investigated whether levels of corticosterone (CORT) differed in blood samples collected from zebra finches (*Taeniopygia guttata*) using two common methods: wing venipuncture and trunk blood collection following decapitation. CORT changes rapidly and substantially during periods of stress; thus, we subjected finches to 60 min of restraint to elevate CORT. We collected blood from a wing vein after 60 min of restraint, and then two minutes later euthanized birds and collected trunk blood. Plasma CORT was lower in blood from trunk vessels than in blood from the wing vein ($P = 0.01$), an effect that was driven by males. Because the nature of trunk blood collection prevented alternating sampling order, we used a second group of finches to control for the possibility that this difference in CORT could have been caused by the order in which samples were collected. In this group we collected blood from a wing vein after 60 min of restraint and again two min later. Plasma CORT did not differ between these two successive wing bleeds ($p=0.90$), and was not related to the time between blood samples ($p=0.783$). In sum, CORT concentration differed depending on the source of the blood collected, suggesting that sampling methodology should be considered carefully when designing experiments and when drawing comparisons across studies.

P2.100 ESCALLóN, C.; MOLINA, J.; BELDEN, L.K.; MOORE, I.T.*; Virginia Tech, Universidad de los Andes; *itmoore@vt.edu*

The cloacal microbiome in a wild bird: the role of reproduction and sex

The microbial communities that reside on animals are dynamic and can be affected by the behavior and physiology of the host. These microbial communities provide critical functions to their host, but can also represent health costs if they are pathogenic. In birds, bacteria residing in the cloaca form a complex community because it is composed of transient gut bacteria as well as sexually transmitted bacteria. During the breeding season there is an increase in physical contacts among individuals, testosterone levels increase in males, and there are additional energetic demands, all of which can increase exposure to bacteria or facilitate infection. As such, we hypothesized that cloacal bacterial communities would be more diverse during the breeding season than in the non-breeding season, males would have more diverse cloacal bacterial communities than females, and that individuals would accumulate bacterial species across breeding seasons. We surveyed the cloacal microbial communities in free-living male and female rufous-collared sparrows (Zonotrichia capensis) through sequential breeding and non-breeding seasons. We found that the cloacal microbiome was different between the sexes, and that in males, but not in females, the bacterial community became more diverse with the onset of reproduction, increasing its phylogenetic diversity and OTU richness, and then decreased its diversity as they transitioned to a non-breeding condition. Individuals sampled across sequential breeding seasons did not accumulate more bacterial species or change their community composition compared to their previous season. Among males, those with higher testosterone levels during their breeding season, had a more phylogenetically diverse cloacal microbiome. This study showed that the cloacal microbiome in birds is dynamic and responsive to breeding condition and sex of the host.

P2.8 ESQUIVEL, CA*; WATSON, CM; Midwestern State University; *christianesquivel@rocketmail.com*

Comparison of Moisture and Caloric Content of Leaf Tissue Among Multiple Milkweed Species (Genus Asclepias) Commonly Eaten by Monarch Butterfly Larvae.

Milkweeds in the genus *Ascleipas* are the primary food source for monarch butterfly (*Danaus plexippus*) larvae which specialize upon, and derive their own chemical defense from, this toxic plant. Monarch butterfly numbers are decreasing with a steady annual reduction in numbers reaching their overwintering sites in central Mexico. While there are many contributing factors proposed for this reduction, one consideration consistently cited is reduced native food availability and increased planting of tropical milkweed in northern regions. This, coupled with global climate change, causes latency in migration and increases the instance of protozoan parasite infection, thereby contributing to reduced monarch butterfly numbers. Here we investigate the moisture and caloric content of multiple species of native temperate milkweed for comparison to the tropical species. These data provide a baseline for future plant-animal interaction studies while also documenting variation of these measures among members of a closely-related group of organisms with direct conservation implications. These data are also part of an ongoing study that links milkweed species to growth and development rate and digestive efficiency of monarch butterfly larvae feeding upon them.

P2.53 FALSO, PG*; MARSHALL, LV; ZAJAC, JM; GUSTAFSON, KL; FALSO, MS; STRAIN, SR; Slippery Rock University; *paul.falso@sru.edu*

Implications of Exposure to a Neonicotinoid Pesticide on Amphibian Immunity

Chemical contaminants and disease present immediate threats to amphibian populations worldwide. Previous research on the effects of chemical contamination on amphibians has focused on the lethal effects of high-use pesticides. However, there is a noticeable lack of information regarding the neonicotinoid insecticides, despite their increased importance in pest control. Further, less information is available on sublethal endpoints that may influence organism success in altered habitats, such as immunity. Imidacloprid is a commonly used neonicotinoid pesticide and has been found to contaminate aquatic environments yet little information is available on the effects of imidacloprid exposure on aquatic animals. This study assessed the effects of imidacloprid exposure on immunity in a laboratory model amphibian, the African clawed frog (*Xenopus laevis*). Adult male (*X. laevis*) were exposed to environmentally relevant concentrations of imidacloprid by immersion for 48 days. White blood cell differentials and (*in vitro*) plasma antimicrobial activity were examined from samples collected under baseline and handling-stressed conditions. This study provides insight into the sublethal effects of an emerging environmental contaminant on aquatic life, with implications for amphibian resistance to pathogens associated with population declines.

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Fractal dimensionality as a measure of occlusal enamel complexity in Equidae (Mammalia: Perissodactyla)

Enamel patterns on the occlusal surfaces of equid teeth are asserted to have tribal-level differences. The most notable example compares the Equini and Hipparionini, where Equini have higher crowned teeth with less enamel-band complexity and less total occlusal enamel than Hipparionini. While previous work has successfully quantified differences in enamel band shape by dividing the length of enamel band by the square root of the tooth surface area (Occlusal Enamel Index, OEI), we have discovered that OEI only partially removes the effect of body size. Because enamel band length scales allometrically, body size still has an influence on OEI, with larger individuals having relatively longer enamel bands than smaller individuals. Fractal dimensionality (*D*) can be scaled to any level, so we have used it to quantify occlusal enamel complexity while completely eliminating the effects of scaling from body size. To test the hypothesis of tribal-level complexity differences between Equini and Hipparionini, we digitally traced a sample of 58 teeth; 18 Hipparionini and 40 Equini. We restricted our sampling to the P3-M2 to eliminate the effect of tooth position. After calculating the D of these teeth with the fractal box method, we performed a nested two-way analysis of co-variance (ANCOVA) with taxonomy as a nested independent factor, true occlusal area (TOA) as a continuous independent factor, and D as the dependent factor. The ANCOVA indicates that tribe (p=0.0002), genus nested within tribe (p=0.0219), and species nested within genus and tribe (p=0.0030) are significant. TOA (p=0.2968) is not significant. Our results suggest that, as expected, *D* is independent of body size and that complexity is the product of evolutionary relatedness and differs from previous analyses where the tribal level was not significant.

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Physiological Responses of Phyllaplysia taylori to Future Climate Change Scenarios

As climate change continues to impact marine organisms, it is essential to understand the effects of temperature and salinity increases in San Francisco Bay on the ecologically important marine mollusk *Phyllaplysia taylori*. *P. taylori* is sea hare that lives on the eelgrass beds of the Pacific coast, composed of eelgrass species *Zostera marina*, and is an integral part of eelgrass bed ecology, consuming epiphytes from eelgrass blades and allowing *Z. marina* leaves to photosynthesize successfully. It is hypothesized that *P. taylori* individuals exposed over multiple weeks to predicted future average temperatures will have lower respiration rates, indicating lower metabolic stress, when exposed to extreme temperature fluctuations, such as those seen during low tide, than individuals exposed to mean current temperatures. This phenotypic plasticity was observed in *P. taylori* after a two-week exposure to future average temperature scenarios, with lower respiration rates when exposed to extreme temperatures than individuals exposed to current average temperatures. An affect of handling was observed which increased respiration rates regardless of temperature, with rates returning to normal over the course of 4 hours post-handling. The combined effects of exposure to both current and future average temperature and salinity will be assessed by examining more respiration rates, epiphyte consumption, and reproductive output. With a full picture of the affects on physiological performance, it will be possible to understand how climate change might impact the overall fitness of *P. taylori*, which plays a large role in determining the resilience of eelgrass restoration in San Francisco Bay.

P2.79 FERGUSON, SM*; SCHOECH, SJ; Univ of Memphis; *s.ferguson@memphis.edu*

A dual-speaker playback experiment in a non-duetting, co-defending passerine

Studies of vocal behavior in temperate passerines are typically biased toward males, which are generally more vocal and aggressive than female conspecifics. 'Duetting species,' in which females are more vocal and active in territory defense, use highly cooperative displays that make each individual's participation in aggressive interactions difficult to compare. Although not technically a duetting species, in Florida scrub-jays (*Aphelocoma coerulescens*; FSJs), males and females participate jointly, but independently, in territorial disputes using largely sex-specific calls (i.e., while both sexes use 'weep' calls, up to 90% of female calls are the sex-specific 'rattle' call), suggesting different roles in defense. Previous work with a single-speaker playback protocol showed that males and females defend equally against intruders, regardless of their sex (Ferguson, unpubl. data); however, similar to the cooperative vocalizations of duetting species, FSJs rarely engage rivals alone. We used a dual-speaker playback design to better test the roles of males and females in territorial encounters, with each speaker simultaneously playing the call of either an unfamiliar male or female FSJ to simulate an intrusion by an unknown pair. In general, males and females were equally aggressive and neither showed any bias toward male or female playback. Females, however, showed a nonsignificant tendency to call earlier in the encounter ($p = 0.095$) and called more ($p = 0.019$) than males. Some 70% of calls given by females were the rattle call. Our results further support the existence of a shared defense strategy in FSJs, but suggest an additional role for female vocalizations. Use of sex-specific vocalizations may serve to alert opposing pairs to multiple participants or as a signal to family group members in this cooperatively breeding species to recruit additional defenders.

P1.181 FINTON, CJ*; WILLIAMS, CT; BARNES, BM; LOREN, CL; Indiana University, Bloomington, Northern Arizona University, University of Alaska, Fairbanks; *cjfinton@indiana.edu*

Snapping back to rhythm: phase-shifted arctic ground squirrels rapidly entrain their circadian clocks under the midnight sun

Circadian rhythms are ~24h-long endogenous cycles of physiology and behavior that are thought to be principally entrained by external light cues of dawn and dusk. Constant sunlight during the arctic summer leads to the loss of circadian rhythmicity for some resident animals. Arctic ground squirrels, however, maintain daily rhythms despite constant light during the polar day. We investigated the capacity of arctic ground squirrels to re-entrain their circadian rhythms under conditions of constant daylight after their circadian clocks were phase-shifted by an artificial light:dark cycle while temporally in captivity. Control animals were maintained in an environmental chamber for 28 days with lights on between 8:00 and 21:00, when they are typically aboveground. In contrast, experimental animals received two 6h phase delays such that lights were on between 20:00 and 9:00 for the 14 days prior to their release. Control animals remained entrained to the light cues while in the chamber and after release whereas rhythms of body temperature (Tb) in experimental animals free-ran with a period <24h until they were ~12h out of phase with controls. Within 3d of their release back into the natural environment, however, experimental animals had shifted their rhythms of Tb and behavior (time aboveground and movement) to match that of controls. Our results demonstrate that arctic ground squirrels are able to rapidly resynchronize their rhythms of physiology and behavior after a phase shift despite exposure to constant sunlight.

P1.107 FISCHER-COSIO, N.A.*; FRENCH, J.D.; BACHMAN, R.E.; MOORE, B.C.; Sewanee: The University of the South, Louisiana Tech University; *fischna0@sewanee.edu*

X-ray Fluorescence Microspectra Analysis of Metal Bioaccumulation in Spotted Gar Otoliths

Metal contamination of aquatic habitats can pose long-lasting effects that hinder the fitness of aquatic organisms. Top predatory fish are more prone to metal bioaccumulation than animals lower on the food web. Spotted gar (*Lepisosteus oculatus*) collected from Felsenthal Reservoir NWR in southern Arkansas displayed high concentrations of mercury (Hg) and selenium (Se) in muscle and liver (up to 70 ppm). In association, otolith (ossified structure of the inner ear) ring counting was used to age the collected fish. This study asks if those otoliths also provide a marker for metal exposure across the fish lifespan and if those metals measured in the otoliths correlate with tissue metal concentrations at the time of fish collection. We employed radioisotope X-ray fluorescence (XRF) to analyze the elemental spectra of otoliths and compared these microchemistry spectra to those measured in muscle and liver tissues of the respective fish. Here we present the correlations and discuss how otolith metal bioaccumulation may serve as a measure of life-long exposures. Further, we explore if finer resolution analysis (tighter beam diameter) of individual otolith ring elemental spectra may yield high-resolution data of the variation in lifetime exposures.

P2.48 FLANAGAN-ROBINSON, T/F*; TRACY, C/R; California State University Fullerton; *darktman@csu.fullerton.edu*

Heating and cooling rates of piebald giant chuckwallas, Sauromalus varius

Many species of lizards heat more quickly than they cool. This is important because it allows them to stay at preferred body temperatures for longer periods during the day, and therefore allows lizards longer periods to perform various activities, like foraging. This phenomenon has been well studied in iguanid lizards, and the difference is particularly big in large-bodied lizards. We tested to see if the piebald chuckwalla, *Sauromalus various*, a large bodied iguanid, had control over the rate of change in body temperature by measuring the amount of time needed to heat or cool by 10 C, between 25 C and 35 C. We found that these desert iguanids had a ratio of heating to cooling rate of 0.654±0.063 and heated from 25 to 35 C in 6.2±0.9 minutes, while cooling from 35 to 25 C in 9.1±1.6 minutes. The ratio of these rates is similar to other desert iguanids, including the smaller, common chuckwalla, *S. ater*. Thus it appears that these desert iguanids have some physiological control over body temperature changes, that allows them to stay at a preferred temperature as long as possible.

P3.50 FLIES, E.J.*; FLIES, A.S.; WEINSTEIN, P.; WILLIAMS, C.; University of South Australia, University of Tasmania, Adelaide University; *Emilyj77@gmail.com*

Reassessing Ross River virus ecology: uncovering new urban and rural reservoirs using bloodmeal analysis

Ross River virus (RRV) is the most common mosquito-borne pathogen in Australia. Decades of seroprevalence and experimental infection studies have identified macropods (kangaroos and wallabies) as the major reservoir hosts. However, transmission ecology varies with reservoir and vector abundance across the country and recently, infections in urban areas have prompted the question of what animals are acting as reservoirs in cities and regions where macropods are scarce. In South Australia (SA), human infection rates for RRV vary greatly by region as do vector and reservoir abundance. We hypothesized that mosquito abundance and feeding patterns will vary in different regions of SA and may help explain divergent human case rates. To test our hypothesis, we extracted and amplified bloodmeals from mosquitoes trapped in four main ecoregions of SA and matched DNA sequences using a BLAST search in NCBI. The results are surprising: from 206 extracted, amplified and identified bloodmeals, none were acquired from macropods. Possums (marsupials) comprised a larger proportion of meals from urban regions and may be acting as reservoir hosts in cities. Domestic livestock animals (cows and sheep) made up the vast majority of bloodmeals from a rural region with the highest human infection rate. Livestock are generally not considered to be important reservoir hosts for RRV but here we discuss their potential role in transmission ecology. In the context of these findings, we reassess the long-standing idea that macropods are the main reservoir host for RRV and instead we propose that diverse transmission ecologies occur, depending on vector and reservoir availability.

P2.90 FLORES, V.*; PAGE, R.A.; University of Chicago, Smithsonian Tropical Research Institute; *vflores@uchicago.edu*

The role of chemical signals in sexual selection: a novel trait in fringe-lipped bats (Trachops cirrhosus)

Studies of sexual selection in vertebrates have focused on visual and auditory signals; however, olfactory cues can also effectively communicate an individual's condition, particularly in mammals. Bats are excellent subjects in which to study the evolution of olfactory signals because many species are nocturnal, live in social groups, and do not rely on visual cues. We investigated a possibly sexually selected trait in fringe-lipped bats (*Trachops cirrhosus*). Adult male *T. cirrhosus* produce a previously undescribed odorous orange crust on their forearms. We conducted behavioral observations of reproductive and non-reproductive males in captivity and at natural roosts to determine how this crust is produced. We found that the crust is produced through complex, stereotypic behaviors only observed in reproductively active male *T. cirrhosus*. We also investigated whether the crust is correlated with body condition (body mass/forearm length) to determine its potential as a signal of male quality. We found that males with a crust had a significantly higher body condition than males with no crust. This study aids our understanding of the evolution of chemical traits under sexual selection. Given that the majority of animals do not primarily rely on visual cues, further study of chemically/olfactory-based systems are necessary to understand the dynamics of sexual selection and sexual signaling.

P3.25 FLOWERS, N.*; THORNTON, A.N.; ISMAIL, N.T.; KOVACS, J.L.; Spelman College; *nflowers@scmail.spelman.edu*

Using DNA metabarcoding to identify pollen in environmental samples

Being able to quickly and accurately identify plant species in a particular geographic region based on environmental pollen samples would be useful for a wide variety of fields including biogeography, ecology, paleontology, and forensics. Currently, microscopy is the most common technique used to identify pollen in environmental samples, but microscopy is a time-consuming task and requires extensive training. The purpose of this research project is to assess the usefulness of high throughput next generation DNA sequencing and metabarcoding for pollen identification and forensic geolocation. We extracted DNA from environmental soil samples and performed DNA metabarcoding using four different primers, two nuclear barcoding primers, *ITS* and *ITSi*, and two chloroplast barcoding primers *rbcL* and *matK*. This allowed us to evaluate the utility of the different primers for the identification of local plant species from environmental samples. Additionally, we wanted to know how informative metabarcoding sequence data would be for forensic geolocation. To do this, we compiled a list of "informative" plant species for the state of Georgia using the publicly available USDA PLANTS list. Informative plants were plants that were either identified as being found only in Georgia or only in the southeast United States. We were then able to compare the plants identified from the soil sample metabarcode sequencing to the list of informative plants generated from the USDA PLANTS list. By determining which primers are the most efficient at identifying plants in a mixed environmental sample, we can begin to more broadly apply DNA metabarcoding for pollen identification.

P2.125 FRIESEN, CR*; UHRIG, EJ; MASON, RT; BRENNAN, PLR; University of Sydney, Oregon State University, Mount Holyoke College; *christopher.friesen@sydney.edu.au*

Female behavior and the interaction between male and female genital traits mediate copulatory success.

Natural selection, sexual selection and sexually antagonistic coevolution contribute to genital diversification. Fundamental first steps in understanding how these processes shape the evolution of specific genital traits are to determine their function experimentally and to understand the interactions between female and male genitalia during copulation. Our experimental manipulations of male and female genitalia in red-sided garter snakes reveal that copulation duration, copulatory plug deposition, as well as total and oviductal/vaginal sperm counts are influenced by the interaction between male and female genital traits and female behavior during copulation. By mating females with anesthetized cloacae to males with spine-ablated hemipenes, we identified significant female-male copulatory interactions and found that females prevent sperm from entering their oviducts by contracting their vaginal pouch. Furthermore, these muscular contractions limit copulatory plug size, while the basal spine of the male hemipene aids in sperm and plug transfer. Our results are consistent with a role of sexual conflict in mating interactions and highlight the evolutionary importance of female resistance to reproductive control.

P2.171 FUERTE-STONE, J.J.*; CLARK, A.J.; UYENO, T.A.; University of Washington, College of Charleston, Valdosta State University ; *jjfuerte@uw.edu*

Assessing muscle function in the Pacific hagfish feeding apparatus

Hagfish are marine chordates that, despite lacking jaws, are able to feed on large, tough carcasses with the protraction and forceful retraction of a toothplate. In this study, the function of feeding apparatus muscles in Pacific hagfish *Eptatretus stoutii* was compared to that of previously studied Atlantic hagfish *Myxine glutinosa*. In this study, we observed the effects of stimulating each of the four major feeding apparatus muscles (deep protractor, sphincter, perpendicular, and retractor). Superficial muscles were first stimulated, *in situ*, as the apparatus was exposed in euthanized animals by a ventral incision. The head and apparatus were then excised in order to access deeper musculature. Each muscle group was stimulated tetanically (80V, 60Hz, 1ms duration). Trials involving five animals were filmed at 120 frames per second and analyzed with ImageJ. Results show that stimulating only the medial heads of the deep protractor muscle resulted in toothplate protraction, while individual stimulations of the perpendicular, sphincter, and retractor muscles induced toothplate retraction. This is similar to what had been previously determined in *M. glutinosa* using electromyography. In both species, the toothplate was shown to protract because of active contraction of the deep protractor muscle causing the cylindrical feeding apparatus to decrease in length and increase in diameter. In *E. stoutii*, differences in strain were found between *in situ* and excised feeding apparatuses. Transverse strain, or normalized change in width, was greater *in situ* by .05 while longitudinal strain, or normalized change in length, was greater for excised muscles by .03. Over all, total strain was approximately equal. This suggests that the loose connections to the body wall still constrain muscle displacement.

P1.209 FULLER, R.G.*; HUNT, K.E.; STIMMELMAYR, R.; GEORGE, J.C.; SUYDAM, R.S.; ROLLAND, R.M.; Tufts Univ., New England Aquarium, Dept. of Wildlife Mgmt, North Slope Borough, AK, Dept. of Wildlife Mgmt, North Slope Borough, AK; *rory.fuller@tufts.edu*

Steroid Hormones in Baleen: Optimizing Extraction and Characterizing Distribution within Baleen Plates

Despite great public and scientific interest, research into the physiology and life histories of large cetaceans presents significant obstacles due to the difficulties inherent in safely acquiring tissue samples from free-swimming animals of immense size. As an example, little is known about seasonal hormone cycles of large whales. We recently showed that steroid hormones can be extracted from baleen, keratinized tissue plates most large whales employ for feeding. Because baleen plates grow over the course of years, analysis of hormone levels along the length of the plate could give a continuous record of hormonal activity in bowhead or right whales over a decade or more. Still, many questions remained about the optimum techniques for hormone extraction from baleen and the variation in hormone deposition within a single plate. Employing bowhead baleen, we tested a suite of solutions and protocols to determine optimal conditions for efficient steroid hormone extraction (cortisol and progesterone). We then evaluated if there are substantial differences in hormone deposition across the face of the plate, that is, along putative "growth lines" representing distinct periods of growth. We found that 70% EtOH provides superior extraction in as little as two hours. Cortisol values in growth lines peaked in the central area along the test plate, typically dropping 25-50% in samples closer to edges. Progesterone showed the opposite pattern, edge higher than center, with similar 50% drops from peak value. Our results provide a flexible protocol for future steroid hormone work in baleen.

P2.145 FUNKHOUSER, CR*; WALSH, MR; University of Texas at Arlington; *collin@uta.edu*

Predator driven morphological evolution in Trinidadian killifish: genetic or environmental differences?

The physical appearance (i.e. body shape) of a species is both a target of selection and ecologically important. Investigating body shape variation along environmental gradients lends itself to understanding the factors that exert selection and drive evolutionary changes in morphology. *Rivulus hartii*, a species of killifish, is found across a gradient in predation and competition in streams on the island of Trinidad. Previous work using field specimens revealed phenotypic differences, with high predation populations having an unsteady body shape and more fusiform body shape in *Rivulus* only populations. We tested for a genetic basis underlying phenotypic differences in body shape. Second-generation lab reared *Rivulus* from divergent predation and competition regimes were reared till maturation on two levels of food that mimic naturally occurring variation in the wild. Body shape was analyzed using landmark geometric morphometrics with 19 landmarks. We found that body shape differed as a function of river of origin and food availability; individuals reared on low food levels exhibited a broader head and slightly narrower body, indicating a potential investment in a larger mouth to increase resource acquisition. Importantly, difference in body shape among populations from contrasting predator communities paralleled previous phenotypic trends but were weaker in magnitude. Our results reveal important roles for genetic and environmental effects on the expression of morphological characteristics.

P3.170 GABOR, C. R.; FORSBURG, Z. R.*; VöRöS, J.; BOSCH, J.; SERRANO-LAGUNA, C.; Texas State University, Hungarian Natural History Museum, Museo Nacional de Ciencias Naturales, CSIC; *zrf5@txstate.edu*

Does exposure to Batrachochytrium dendrobatidis via an infected overwintering salamander have greater costs (stress, mortality, and infection levels) to Bombina variegata or Hyla arborea tadpoles?

Batrachochytrium denrobatidis (Bd) is a fungus that causes the disease chytridiomycosis (chytrid) and is associated with widespread amphibian declines. Recently, in Hungary, *Bombina variegata* have been found to be infected with chytrid, yet their susceptibility to chytrid has not been well studied. Even less research has been performed on *Hyla arborea*, a species believed to be a reservoir for chytrid. We tested the hypothesis that overwintering *Salamandra salamandra* larvae are a vector for Bd by exposing *B. variegata,* and *Hyla arborea* tadpoles to Bd positive overwintering larvae or young of year larvae that were Bd negative. Bd is known to induce a stress response in amphibians resulting in an increase of corticosterone (CORT). We explored CORT release rates using a non-invasive waterborne hormone technique, Bd loads, growth and development. We found that tadpoles of *B. variegata* had higher Bd loads and greater proportion of individuals infected than *H. arborea*. Tadpoles of both species exposed to Bd positive larvae had elevated CORT release rates compared to tadpoles exposed to Bd negative larvae. Based on our findings, *S. salamandra* is a vector for Bd and *B. variegata* appear to be more susceptible to infection than *H. arborea* based on measured Bd loads.

P2.117 GADEKEN, K*; DORGAN, K; MOORE, J; BERKE, S K; Dauphin Island Sea Lab & the University of South Alabama, Dauphin Island Sea Lab, Florida Museum of Natural History, Siena College; *kgadeken@disl.org*

Applications of ecophylogenetics to benthic communities in the Northern Gulf of Mexico: Do functional traits follow phylogeny?

Evolutionary relationships may shed light on observed patterns of diversity and functional traits when viewed through the lens of phylogeny. The potential for phylogenetic information to be used to explain patterns in community structure, such as niche partitioning and responses to stress, is extensive. Differential distributions of related species with similar functional traits suggests niche partitioning, and local redundancy in functional traits may indicate the potential for interspecific competition. In this study, we investigated phylogenetic and functional diversity as a function of habitat for sites with varying levels of oil contamination in the Northern Gulf of Mexico. Our study was conducted in a shallow benthic community at the Chandeleur Islands, a group of uninhabited barrier islands. Infauna were sampled from seagrass (*Halodule wrightii*) and bare sediment at three sites along the island chain that experienced variable levels of oil impact from the Deepwater Horizon oil spill. Individuals were preserved and 18S and COI genes sequenced, and a phylogenetic tree was constructed of the local community using maximum likelihood. Phylogenetic diversity and evenness were quantified. Ecologically important functional traits were then compiled into respective distance matrices, evaluated through different functional diversity indices, and assessed for correlation with the phylogeny. This integration of functional and phylogenetic diversity has the potential to provide greater insight into factors driving community structure than either metric alone. Determining relevant metrics of diversity is critical to understanding the ecological effects of major disturbances such as oil spills.

P1.103 GAMBOA, MP*; GHALAMBOR, CK; FUNK, WC; SILLETT, TS; Colorado State University, Smithsonian Migratory Bird Center; *mgamboa@rams.colostate.edu*

Hot Islands, Big Bills: The effect of gene flow and climate on morphology

Natural selection across heterogeneous environments may favor locally adapted ecotypes, but identifying the mechanisms that underlie adaptive variation in natural populations remains a challenge. Disentangling the environmental and genetic underpinnings of phenotypic variation requires systematic sampling of populations across different environments and under varying degrees of isolation. Climatic variation is increasingly appreciated as a strong selective pressure on morphological characters. In birds, the bill may be used as a tool for thermoregulation by dissipating excess heat and, consequently, is under selection from climate. On the Northern California Channel Islands (Santa Cruz, Santa Rosa, San Miguel, and Anacapa), song sparrows (*Melospiza melodia graminea*) occupy a distinct east-to-west climatic gradient ranging from hot and arid on Santa Cruz Island to cold, wet, and windy on San Miguel Island. We genetically sampled and measured bill characteristics from song sparrows distributed on Santa Cruz, Santa Rosa, and San Miguel Island from 2014-2015. As predicted, bird bills were significantly larger on hotter islands (Santa Cruz) than those found on colder islands (Santa Rosa, San Miguel). STRUCTURE analysis and DAPC of thousands of SNPs reveal low F_{ST} values and distinct clustering by island suggesting population structure despite gene flow. Thus, climate may drive local adaptation and must be considered in the development of conservation management strategies, particularly of insular populations.

P3.104 GARNER, A.M.*; STARK, A.Y.; THOMAS, S.A.; NIEWIAROWSKI, P.H.; The University of Akron, The University of Louisville, The University of Akron, Integrated Bioscience, The University of Akron, Integrated Bioscience; *amg149@zips.uakron.edu*

Geckos go the distance: water's effect on gecko locomotor performance

The gecko adhesive system has been subject to widespread investigation for many decades, but few studies explore environmentally relevant conditions that geckos likely face in their natural habitat. Recent evidence suggests that after *Gekko gecko* takes more than three steps on certain wet substrates, shear adhesion is significantly lower than adhesion on dry substrates, a result that is somewhat unexpected given *G. gecko* is native to wet tropical habitats. Interestingly, some evidence suggests that when geckos are engaged in dynamic adhesion, locomotor performance is not affected by wet substrates over a distance of 1 m. We followed up on these results by testing whether gecko locomotion would be impaired over larger distances. To answer this question, we investigated the locomotor performance of two species of geckos, *G. gecko* and *Chondrodactylus bibronii*, measured on wet glass and acrylic substrates over a distance of 2 m. We found that neither water nor substrate type had a significant effect on the average sprint velocity of either species. Furthermore, the frequency of slipping on a vertical surface, a behavior that would be expected to reduce velocity, was dependent on substrate type and species, although no significant decrease in average sprint velocity was observed. Our findings suggest that geckos are able to effectively sprint on wet surfaces up to two meters in length without a reduction in locomotor performance. These results highlight the plasticity and versatility that makes gecko adhesion such a popular biomimetic model.

P3.137 GAUDREAULT, B.N.*; DAS, S.; OATMAN, S.R.; MYKLES, D.L.; Colorado State University, Fort Collins; *gaubrini@gmail.com*

Expression levels of nuclear receptors EcR, RXR, E75, and HR3 during cell differentiation and proliferation of limb regenerates in the blackback land crab Gecarcinus lateralis

Many decapod crustaceans including the blackback land crab *Gecarcinus lateralis* (*G. lat.*) are able to regenerate limbs. In *G. lateralis*, autotomy of five or more walking legs induces molting. Completion of the molting process is required for successful limb regeneration, suggesting that molting and limb regeneration are regulated in tandem. Cell division and differentiation of the blastema occur during basal growth, which takes place during intermolt, when ecdysteroid levels in the hemolymph are low. During premolt, rising ecdysteroid titers stimulate limb bud growth. Both molting and limb regeneration are regulated by steroid hormones that bind to the nuclear heterodimer receptor EcR and RXR. Ecdysteroids are synthesized in and released from the molting gland, or Y-organ (YO), and bind to EcR/RXR, regulating transcription of downstream genes that direct development, differentiation, and growth. Two genes of interest are the early response gene E75 and the early-late gene HR3. E75 can repress the activity of HR3 by heterodimerization. In *Drosophila*, expression of *HR3* is required for successful embryogenesis and is also an inhibitor of ecdysone production by the prothoracic gland. Full-length sequences of *Gl-EcR*, *Gl-RXR*, *Gl-E75*, and *Gl-HR3* were identified in a YO transcriptome constructed from the *de novo* assembly of RNA-seq data. The four genes were expressed in limb regenerates. Real-time PCR is being used to quantify gene expression during blastema differentiation at 4, 6, 10, and 15 days post-autotomy and during premolt limb bud growth. Supported by NSF (IOS-1257732).

P1.14 GAYER, W*; REID, A; LINDGREN, A; Portland State University, Australian Museum Research Institute; *wgayer@pdx.edu*
Systematics and Population Distribution of the Australian Giant Cuttlefish, Sepia apama
The Australian giant cuttlefish, *Sepia apama*, is the world's largest cuttlefish species. Known for its bright color displays, *S. apama* comprises populations that are found near the rocky reefs, kelp forests, sea-grass beds, sand and muddy seafloors of Southern Australia to a depth of up to 100 m. Their typical breeding behavior involves pair or small groups. However, the population that occupies the Upper Spencer Gulf area is known to breed in large aggregations, which has led to speculation that this population may be a separate species or sub-species. Given that the conservation status of *S. apama* is near threatened, it is essential to determine the number of species present. This study uses molecular and phylogenetic tools to investigate the relationships between different populations and determine if new species designations are warranted. Tissue samples from 17 cuttlefish were collected in 4 distinct geographical locations: in and around the Sydney Harbor, from Upper Spencer Gulf, from Geographe Bay, and from Houtman Abrolhos (islands). We obtained genetic sequence data for the mitochondrial CO1 and 16S rRNA gene regions and used this data to build phylogenetic trees and calculate % sequence differences across individuals from all populations. Preliminary analyses distinct groups: one along south and southeastern Australia from the Upper Spencer Gulf in the north to Geographe Bay in the southwest and a second in western Australia off of the Houtman Abrolhos. These findings suggest that individuals of S. apama, with the exception of those found in Western Australia, are somehow overcoming geographical distance and their poor swimming abilities to intermix. Further morphological examination is warranted to determine the taxonomic rank of the distinct western population.

P1.172 GÜELL, BA*; WARKENTIN, KM; University of California, San Diego, Boston University; *bguell@ucsd.edu*
When and where to hatch? Red-eyed treefrog embryos use light cues
Hatching timing is under strong selection and environmentally cued in many species. For eggs in masses, the spatial orientation of hatching may also matter. *Agalychnis callidryas* lay gelatinous egg masses on leaves over ponds in Central America. Individual eggs are closely packed; most have <50% of their surface exposed to air and strong internal oxygen gradients. Embryos orient their external gills, and heads, towards the air and are thus positioned to escape from the clutch upon hatching. Submerged embryos experience hypoxia, and hatch prematurely to escape, but their first response to flooding is to change position many times, disrupting their outward-facing orientation. Nonetheless, in whole-clutch flooding experiments most embryos hatched correctly; <3% hatched into the jelly, which can be lethal. However, when we flooded individual embryos with similar surface exposure in glass cups, 26% hatched poorly oriented, into the glass. We hypothesized that in flooded clutches embryos use light cues to orient their hatching. To test this, we positioned eggs in close-fitting tubes, with one end illuminated and the other dark, then flooded them and recorded the direction of hatching. Most embryos hatched toward the light, thus using light as a directional cue. To elucidate the role of light in diel hatching patterns of mature embryos, we recorded hatching timing for siblings distributed across three light environments: continuous light, continuous dark, and a natural 12h photoperiod. Continuous light delayed hatching, suggesting light is a hatching inhibitor. Embryos exposed to a photoperiod hatched the most synchronously, soon after dark, suggesting the onset of darkness may stimulate hatching. Overall, our results show that *A. callidryas* embryos use light cues in at least two contexts, informing both when and where to hatch.

P2.123 GENEREUX, O; GIBSON, G*; Acadia University; *glenys.gibson@acadiau.ca*
Bisphenol A (BPA) disrupts regeneration in Pygospio elegans (Annelida)
BPA is a common environmental contaminant that is known to disrupt development as, for example, in mice where BPA acts as both an endocrine disruptor and also by demethylating DNA. This raises the question of what effect BPA has on the development of estuarine invertebrates as most estuaries are exposed to BPA in wastewater discharge. Also, recent work has found that BPA bioaccumulates in some marine species. We tested the effects of BPA on regeneration in *Pygospio elegans*, a spionid polychaete that is abundant in estuaries and tidal flats of the North Atlantic. *P. elegans* exposed to BPA had delayed blastema formation and growth, relative to controls, and preliminary results suggest this is due to inhibition of mitosis (Click-It Plus Edu cell proliferation kit). Subsequent treatment with folate/ vitamin B12 ‘rescued' blastema development leading to complete regeneration. These results suggest that BPA disrupts regeneration by inhibiting typical cell cycles, but also, that these effects may be reversed in early blastema formation by exposing the worms to a different environment.

P2.66 GEORGE, E M*; NOONAN, M; Indiana University, Canisius College; *georgee@indiana.edu*
Underwater Bubbling in Beluga Whales (Delphinapterus leucas): Rates of Production as a Function of Age, Sex, and Bubble Type
Although the production of underwater bubbles has been documented in a number of cetacean species, an understanding of this category of behavior in terms of ecological, cognitive, and social contexts is only beginning to emerge. The present study focused on underwater bubbling behavior in a captive population of beluga whales (*Delphinapterus leucas*), with the goal of characterizing the extent of bubble production as a function of age, sex, and bubble type. Bubbles were recorded as stemming from both the blowhole and the mouth, and were categorized as conforming to four main shapes (Burst, Stream, Drips, and Rings). Nearly all bubbles fell into four source-shape combinations, or types (Blowhole Bursts, Blowhole Drips, Blowhole Streams, and Mouth Rings). A GLMM analysis revealed a significant three-way interaction of sex, age, and bubble type on rates of production. For Blowhole Bursts, the rate per minute in adults was higher for females than males, but in juveniles was higher for males than females. Blowhole Streams were produced at higher rates by males across both age categories. Both Blowhole Drips and Mouth Rings were produced more frequently by females than by males and by juveniles than by adults. The results of this study confirm that underwater bubbling is a common and widespread behavior in all sexes and age classes of the population studied, but suggest that roles played by bubbling do vary with age, sex, and bubble type.

P3.122 GEORGE, MN*; PEDIGO, BD; EDELSWARD, M; BOCCAMAZZO, R; NEWCOMB, LA; CARRINGTON, E; Univ. of Washington, Seattle; *mngeorge@uw.edu*

Characterizing the seawater environment provides new insights into the formation, maturation, and function of mussel byssus adhesive

In hydrodynamically turbulent marine environments, the settlement and survival of marine organisms depend on a strong attachment to the ocean floor. Marine mussels achieve this by anchoring themselves to rocks with stretchy, collagen-like fibers (known as byssal threads) that are tipped with a natural adhesive. Synthesized in seawater the glue that mussels' use is a biomechanical marvel due to its unique ability to adhere to a variety of conventionally challenging surfaces, all while in the presence of water, salts, and polar organic molecules. However, despite the adhesive's notoriety little is known about how the glue "cures" in natural environments and under what seawater conditions this process is either accelerated or retarded - information that could be ecologically and economically relevant as seawater conditions change as a result of ocean acidification, the expansion of hypoxic zones, and increases in sea-surface temperatures predicted by climate models. Here we describe laboratory experiments wherein mussels made byssal attachments to mica sheets that then matured in a range of different temperature, dissolved oxygen, and seawater pH conditions for up to two weeks and were then pulled to failure using a materials testing machine. We then coupled these results with protein separations from mussel adhesives using 2D gel electrophoresis to look for bulk changes in the mussel adhesive proteins that were present. Results from these assays provide insights into which environmental factors promote strong byssal attachment and inform commercial aquaculture facilities about which seawater variables should be monitored to better identify and adapt to unfavorable growing conditions.

P3.101 GERALD, GW*; WASS, ED; SCHUMACHER, AJ; Nebraska Wesleyan University; *ggerald@nebrwesleyan.edu*

Examining how individual performance quality influences the detection of locomotor trade-offs in snakes

Different performance tasks can impose conflicting demands on the behavioral, skeletomuscular, and biochemical mechanisms underlying locomotor performance, resulting in trade-offs. However, when studying animal locomotion, performance trade-offs are often difficult to detect because of large variation in the quality, health, and motivation among individuals. There are likely many traits that enhance various types of performance without hindrance to others (e.g., larger muscle mass or increased metabolic efficiency), thereby making potential trade-offs between different performance tasks more difficult. We aimed to determine if locomotor trade-offs exist in snakes with and without taking individual performance quality into account. Using cornsnakes (*Pantherophis guttatus*), we quantified locomotor performance during 10 different locomotor modes/ecological situations. We hypothesized that functional trade-offs among pairs of locomotor modes/situations would be detected only after accounting for individual quality. We also expected to detect a generalist-specialist trade-off with quality-corrected speed data. We found no significant trade-offs among performance measures that were not corrected for quality. After taking individual quality into account, cornsnakes exhibit a specialist-generalist trade-off across all locomotor performance measures. We found a positive correlation between terrestrial lateral undulation and swimming. Significant negative correlations between lateral undulation and concertina, as well as between several measurements of arboreal performance, were found only after individual quality was accounted for. These results strongly suggest that locomotor performance should be corrected for individual quality before making comparisons among modes and species.

P3.51 GERVASI, S.S.*; BURGAN, S.C.; BURKETT-CADENA, N.; UNNASCH, T.R.; MARTIN, L.B.; University of South Florida; *steph.gervasi@gmail.com*

Vector consequences of feeding preferences in the West Nile virus system

In vector-borne parasite systems, transmission dynamics depend on interactions within and between hosts and vectors. For example, host behavior and physiology mediate exposure to vectors and susceptibility to parasites. Host traits also impact vector-feeding preferences and thus ultimately influence which individuals contribute to the spread of infections. However, we still know very little about the consequences of vector preferences on vector-specific traits. Variation in blood meal quality and quantity could impact both reproductive success and survival of female mosquitoes and their progeny. Disproportionate feeding on certain hosts could thus influence transmission dynamics directly (through the propensity of adult mosquitoes to survive to bite subsequent hosts post-reproduction) and indirectly (through the quantity and quality of offspring produced). We have previously shown that glucocorticoid stress hormones mediate variation in vector choice of avian hosts. When given a choice of control and corticosterone-manipulated zebra finches, a cosmopolitan vector (the southern house mosquito, Culex quinquefasciatus) consistently preferred to feed on birds with elevated stress hormone levels. Here, we examined the consequences to mosquitoes of feeding on hormone-manipulated zebra finches. Mosquitoes that fed on birds with experimentally elevated corticosterone levels laid eggs more rapidly but also experienced greater total mortality over a 30-day trial compared to mosquitoes that fed on implant-control birds. Our findings suggest that vector preferences may have important consequences for short-term and long-term epidemiological and ecological dynamics including pathogen spread and persistence, vector density, and the spatiotemporal distribution of vectors and parasites, especially in anthropogenically-modified habitats where stressors are often more common.

P2.174 GIAMMONA, F.F.*; GIDMARK, N.J.; BLAIS, J.; Friday Harbor Laboratories, University of Washington; *ffg4@cornell.edu*

Quantifying differences in musculo-skeletal morphology of the feeding apparatus across Pacific Salmon species

In the Pacific Northwest United States, multiple salmon species exist, each with different feeding habits and ecological niches. Learning how the anatomical differences between these species equate to their discrete environmental roles is of paramount importance to both functional morphologists and fisheries researchers alike. Here, we compare several aspects of muscular and skeletal morphology in the feeding apparatus of the primarily piscivorous King Salmon (*Oncorhynchus tshawytscha*), omnivorous Chum Salmon (*Oncorhynchus keta*), and planktivorous Pink Salmon (*Oncorhynchus gorbuscha*). We quantified mandible architecture, jaw muscle architecture (specifically of the adductor mandibulae), compared tooth morphology, and modeled muscle contractions for all three species to understand how each utilizes different prey resources. Overall, significant differences were found in every facet of adductor mandibulae analysis, especially concerning muscle fiber lengths. King Salmon tend to have shorter fiber lengths while Pink Salmon have the longest fibers. Our models suggest that King Salmon have the largest maximum gape and absolute percent muscle length change, while Pink Salmon have the smallest. The fact that the Pink Salmon have this small absolute gape and muscle length change combined with long fiber lengths means that individuals can produce a large amount of force across nearly all possible gapes. This is opposite to the shorter fiber lengths and larger gapes present in King Salmon, which indicate that individuals can produce an optimal force only for a specific range of gapes. This study demonstrates how closely related species can functionally specialize muscle anatomy to allow for vast differences in feeding habits.

P1.47 GILLESPIE, SG*; MINICOZZI, M; GIBB, AC; Northern Arizona University; *shannon.gillespie93@gmail.com*

Is variation in vertebral column morphology associated with variation in axial musculature in killifishes?

The axial musculature of fishes is characterized by distinctive, "W"-shaped myomeres; however, myomere morphology varies across taxa and little is known about the evolutionary and developmental factors that influence axial morphology. Our long-term goal is to determine if variation in caudal peduncle morphology influences locomotor performance in the killifishes (Cyprinodontiformes). As a first step, we survey axial muscle and vertebral anatomy in the peduncle region of four cyprinodontiform fishes to test the a priori prediction that myomere variation mirrors vertebral column variation. For example, if the neural and hemal spines of the vertebrae form shallower angles (more posteriorly oriented angles) relative to the vertebral column in one species relative to another, then we expect the "W" shaped myomeres will also display shallower angles and form a more compressed "W" shape. We dissected individual myomeres from the axial musculature of the caudal peduncles in *Gambusia affinis, Poecilia mexicana, Jordanella floridae* and *Kryptolebias marmoratus* and compared myomere angles to measurements of the vertebral column in cleared and stained individuals. Variation in peduncle morphology is associated with variation in vertebral spine angles: as the neural and hemal spines "bend" toward the posterior vertebral centra (to form a shallower angle), the angle of the anterior cone relative to the vertebral column also decreases. In addition, cyprinodontiform fishes with smaller caudal peduncles appear to have shorter myomeres when normalized to body length. Although there is a point when the sclerotome and myotome separate in embryology, it is likely that the bony and muscular elements of the axial skeleton are linked developmentally because the vertebrae and axial musculature both form during somitogenesis.

P1.16 GIRARD, M.G.*; SMITH, W.L.; University of Kansas; *mgirard@ku.edu*

The Intra- and Interspecific Relationships of sculpins in the genus Icelinus

The genus of sculpin *Icelinus*, described by Jordan in 1885, contains eleven species of phylogenetic and biogeographic interest. The phylogenetic placement of *Icelinus* has been inconsistent in previous molecular and morphological analyses, with sister taxa being *Chitonotus*, *Stlengis*, *Antipodocottus*, or a mixed clade of psychrolutids. In addition to the disparity in sister taxa, the use of molecular or morphological data yields contradicting placement of *Icelinus*. Most morphological analyses place the genus sister to Eastern Pacific psychrolutids while molecular analyses, in addition to a subset of morphological studies, place the genus sister to Western Pacific psychrolutids. However, all previous studies have not taken Western Pacific *Icelinus* species into account. Biogeographically, *Icelinus* is one of few cottoid genera that are trans-Pacific, with multiple species residing on each side of the Pacific. Despite being one of the few trans-Pacific genera, an unusual distribution of species occurs; with nine species in the Eastern Pacific and two in the Western Pacific. In this study, we combined a novel molecular and morphological dataset to test the previous competing hypotheses about the limits and relationships of *Icelinus*, focusing on its relationships amongst close allies and the relationships between Eastern and Western Pacific species of *Icelinus*. Our results show the non-monophyly of *Icelinus* in addition to placing *Antipodocottus* in a phylogenetic context for the first time.

P2.38 GIVENS, J.L.*; KELLEY, A.L.; SLEADD, I.M.; University of North Alabama, University of California, Santa Barbara; *jgivens@una.edu*

Heat-Shock Protein Expression During Temperature and Salinity Stress in the Antarctic Nemertean Worm Parborlasia corrugatus.

In recent years the Antarctic Peninsula has experienced a significant increase in annual temperature that is expected to continue over the next several decades. The coastal marine environment in this part of the world has previously been extremely cold and stable, and as a result many Antarctic species appear to have lost the ability to elicit a heat shock response, thus making them ill-equipped to tolerate elevated temperatures. The cold-adapted nemertean worm *Parborlasia corrugatus* is a benthic scavenger and predator found throughout Antarctica and the Antarctic Peninsula. Despite its ecological significance, to our knowledge no research has been previously conducted to analyze *P. corrugatus*'s cellular response to heat and salinity stress. Consequently, it is unclear the effect that global climate change will have on these important organisms. The goal of this study was to investigate HSP70 expression using western blotting. Specimens were collected from the Ross Sea and experiments were conducted at McMurdo Station, Antarctica. Animals were exposed to acute heat stress (10°C) or salinity stress (24ppt or 28ppt) and protein levels of the crucial molecular chaperone HSP70 were determined. Here, we present our findings and discuss their implications in the context of global climate change.

P2.56 GOESSLING, JM*; MENDONCA, MT; Auburn University; *goessling@auburn.edu*

Seasonal contexts of acute immune responses in gopher tortoises (Gopherus polyphemus)

Physiological function, and specifically immunological function, in ectothermic vertebrates is often constrained by thermal environments that may negatively affect performance. North American tortoises (genus *Gopherus*) have been the source of numerous studies investigating baseline immunological parameters (specifically related to upper respiratory tract disease, URTD), yet little is known regarding the nature of acute immune responses and how immune responses are constrained by thermal environments in this taxon of high conservation concern. Herein, we measured immune responses in gopher tortoises (*Gopherus polyphemus*) to simulated acute bacterial infection (lipopolysaccharide, LPS). We performed assays in *G. polyphemus* that had been acclimated to two different seasonal (and thus thermal) acclimation states of winter and summer to test the hypothesis that seasonal context determines the scope of an immunological response. We measured body temperature, bactericidal ability (BA), plasma iron, total and relative circulating leukocyte proportions, and baseline corticosterone in response to LPS injection in tortoises acclimated to winter and summer conditions. We found that LPS caused a significant increase in BA and the number of circulating heterophils, and a decrease in plasma iron. However, we did not find that *G. polyphemus* increased their set body temperature, a pattern which would be consistent with behavioral fever. The lack of behavioral fever in this species is similar to earlier studies in testudinids in which tortoises were not shown to increase body temperature in response to acute infection. In general, we found that the immune responses were not affected by seasonal acclimation state, and that both winter- and summer-acclimated tortoises generated significant immune responses to LPS.

P3.118 GOUGH, W.T.*; FISH, F.E.; BART-SMITH, H.; West Chester University, University of Virginia; *wgough@wcupa.edu*

Physical properties of the sub-dermal fibrous layers in cetacean tail flukes

During swimming, cetaceans generate hydrodynamic thrust with dorso-ventral oscillations of flexible tail flukes. These flukes do not contain rigid skeletal structures. Instead, they are mainly comprised of densely packed collagenous fibers. A structural analysis was performed to determine the internal structure and orientation of these fibers. Fluke specimens from common dolphins (*Delphinus delphis*), bottlenose dolphins (*Tursiops truncatus*), and harbor porpoises (*Phocoena phocoena*) were obtained from stranding centers. Dissection of the flukes distinguished two distinct fibrous layers. The inner layer (thick layer) originated from the leading edge and was found to contain thin fibers angled with respect to the chordwise axis that displayed greater flexibility along the chordwise axis and less flexibility along the spanwise axis. The outer layer (thin layer) originated from the tail stock and was found to contain thick fibers angled along the spanwise axis of the fluke that displayed flexibility opposite to the manner of the thick layer. The arrangement of the fibers gave the flukes anisotropic properties. The two-dimensional orientation of the fibers within the fibrous layers was determined using 1.5mm slices which were oriented in the chordwise direction and examined with a stereomicroscope under polarized light. Fibers in the thick layer in the parasagittal plane displayed a crisscross arrangement with fibers oriented at an average of either 70° or 111° in relation to the chord line. Fibers in the thin layer were found to be oriented in the same direction on a one-fiber-thick plane. The two fibrous layers constitute the main structural support for the cetacean fluke. The differences in flexibility, fiber orientation, and thickness help the flukes to maintain their shape while being flexible during swimming.

P1.13 GOWACKI, WA*; BELL, SS; PIERCE, SK; Univ. of South Florida; *gowacki@mail.usf.edu*

Confusion in a Redescription of a Kleptoplastic Slug: Elysia patina (Marcus 1980) Ortea et al. (2005) is really Elysia papillosa (Verrill 1901)

Sacoglossan sea slugs have a well-known ability to sequester photosynthetically active chloroplasts from their algal food source within specific digestive cells (= kleptoplasty). Many species also utilize the photosynthetic products from the stored chloroplasts. This phenomenon has been examined in several sacoglossan species, but detailed life histories are only known for a few large and charismatic slugs. We have recently begun studying a comparatively smaller-sized, enigmatic kleptoplastic slug from seagrass/rhizophytic algal beds in Tarpon Springs, FL, as well as the Florida Keys, which consumes the algae *Penicillus capitatus* and *Penicillus lamourouxii*. We initially identified the slug as *Elysia patina* (Marcus 1980) based on a redescription by Ortea *et al*. (2005) (*Vieraea* 33: 495-514). However, we now report that Ortea *et al*.'s (2005) classification of *E. patina* was incorrect based on the following: 1) dorsal surface vascular morphology, 2) scanning electron microscopic examination of radular teeth, and 3) careful comparisons of Ortea *et al*.'s (2005) anatomical descriptions with the original literature. In fact, we found that Ortea *et al*.'s (2005) description of *E. patina* exactly matches the original descriptions of *Elysia papillosa* (Verrill 1901) as well as the anatomy of the Tarpon Springs slugs. Therefore, the Tarpon Springs slugs should be identified as *E. papillosa*. In turn, the redescriptions of both *E. patina* and *E. papillosa* in Ortea *et al*. (2005) are incorrect and neither description should be used.

P3.196 GRACE, R.C.*; SCHWEIKERT, L.E.; GRACE, M.S.; Florida Institute of Technology; *jingoztheamazing@gmail.com*

Shining Light on the Blind: Neuroanatomy, Physiology and Behavior in a Micro-Vertebrate, the Brahminy Blindsnake (Ramphotyphlops braminus)

The subterranean brahminy blindsnake (*Ramphotyphlops braminus*) is among the smallest vertebrate animals on Earth. Among reptiles, snakes have very small eyes, but the fossorial *R. braminus* has extremely small eyes that are located underneath the skin and scales, and completely invisible from the exterior. This study is part of a comprehensive analysis of what may be the simplest nervous system in any terrestrial vertebrate on the planet, the goals of which are (1) to assess the cellular architecture of the *R. braminus* eye, (2) to produce an atlas of the *R. braminus* brain and determine the central targets of retinal projection, (3) to determine whether the R. braminus eye responds physiologically to light, and (4) to determine how light exposure may modify *R. braminus* behavior. Scanning electron microscopy and visible light microscopy revealed an eye-like structure underneath the skin and scales of the head, the cellular architecture of which was examined by histological and immunofluorescence approaches. Electroretinography showed that the snakes respond to light using their apparently rudimentary eyes. Finally, a series of behavioral experiments revealed that these snakes may not respond to the appearance of shadows from above, but may navigate with the aid of light (via negative phototaxis). This work provides new understanding of the anatomy, physiology and behavior of one of the world's smallest vertebrate animals, provides a better concept of the fundamental components of central neuroanatomy required for vertebrate animals to perform complex behavior, and provides new insight into the evolutionary adaptations of micro-vertebrate life.

P1.88 GRADY, K.O.*; BOURGEON, A. ; HARDY, K.M.; California Polytechnic State University, San Luis Obispo; *kogrady@calpoly.edu*

Effect of oxygen limitation on skeletal muscle metabolism in the giant acorn barnacle, Balanus nubilus

Crustacean muscle fibers are some of the largest cells in the animal kingdom, with fiber diameters in the giant acorn barnacle (*Balanus nubilus*) exceeding 2 mm. Sessile animals with extreme muscle sizes and which live in the intertidal zone - like *B. nubilus* - represent ideal models for probing the effects of oxygen limitation on muscle cells. We aimed to investigate the metabolic response of *B. nubilus* muscle to fluctuating oxygen conditions over both acute (6h) and chronic (2 week) time periods. We exposed barnacles (n=9) to either: normoxic immersion, aerial emersion, or anoxic immersion. After a 6-hour exposure, tergal depressor (TD; fast twitch, glycolytic) and scutal adductor (SA; slow-twitch, oxidative) muscles were excised, flash frozen and processed for citrate synthase (CS) activity and lactate dehydrogenase (LDH) activity. CS activity did not show any significant treatment effect in either muscle; whereas LDH activity in the TD muscle was significantly higher in the animals exposed to the air. Furthermore, we uncovered a strong tissue effect, whereby SA muscle had significantly higher CS activity, and TD muscle had significantly higher LDH activity. Thus far, our findings indicate that *B. nubilus* can metabolically support aerobic activity in these giant muscle cells over short-term, low oxygen bouts, but there is some upregulation of LDH activity during air exposure in the more glycolytic TD muscle, presumably to support an increased reliance on anaerobic metabolism. We aim to supplement these findings by comparing our acute data to the same measurements collected after a chronic exposure period. By examining the effects of environmental oxygen limitation on metabolic patterns in giant *B. nubilus* muscles, we hope to further unravel the fundamentals of cellular design.

P2.94 GRAHAM, J.L.*; MADY, R.; KETTERSON, E.D.; GREIVES, T.J.; North Dakota State Univ., Towson Univ., Indiana Univ.; *jessica.l.graham@ndsu.edu*

Behavior as a mechanism underlying trade-offs between immune system activation and nest success in the dark-eyed junco

Activation of the immune system requires individuals to allocate limited energy toward immunity, perhaps at the expense of reproduction. For example, a strong acute immune response may promote adult survival, but during the breeding season this may compromise offspring survival by interfering with parental behavior. To our knowledge, no studies have asked whether changes in parental behavior, such as visitation rate and brooding time, during an immune challenge may underlie a trade-off between immune function and offspring survival in free-living populations. We hypothesized that females experiencing immune system activation during reproduction would redirect their behavior away from offspring care, reducing offspring survival. To test our hypothesis, we injected 48 female dark-eyed juncos (*Junco hyemalis*) over the course of 2 breeding seasons at Mountain Lake Biological Station with a mild antigen (KLH) or a saline control. Females were injected during incubation to induce a robust immune response by 10 days post-injection, during the nestling phase when demands of brooding and feeding are high. Juncos are ground-nesting birds that are highly vulnerable to nest predation and time spent on or away from the nest may play a critical role in nestling survival. We video monitored nests 3d post-hatch to record visitation rate, feeding rate and time spent brooding. We also recorded fledging success. The data presented will shed light on whether activation of the immune system interacts with parental behavior to create a trade-off between immune response and offspring care.

P3.26 GRAHAM, AM*; PRESNELL, JS; Univ. of Miami; *graham.allie@gmail.com*

Major transcription factor binding domains: does their evolution correlate with avian biodiversity?

A long-standing question has been whether changes in gene regulation or protein sequence has made a larger contribution to phenotypic diversity seen between species. It is commonly believed that changes in cis-regulatory systems more often underlie the evolution of morphological diversity. These cis-regulatory elements typically regulate gene transcription by functioning as binding sites for transcription factors. Transcription factors (TFs) are proteins that bind to DNA in a sequence-specific manner and enhance or repress gene expression. Although, transcription factor binding domains are very well conserved, the other associated domains, largely responsible for protein-protein interactions, readily diverge among homologs. Therefore, the structure and function of transcription factors are inherently modular. This attribute is thought to allow gene-regulatory networks to evolve via transcription factor changes, and could account for the seemingly large phenotypic difference between closely related groups. Although transcription factor diversity has been correlated with increased complexity across the eukaryotic lineage, no study has been able to measure such transcription factor diversity within a specious, but highly related, clade. One of the most diverse vertebrate lineages is that of birds, and is also the tetrapod class with the most living species. Not only do birds live worldwide and range in size, but also they vary widely in morphology, physiology and behavior. Recently, 48 avian genomes representing all the major families have recently been published. In this study, we identify the major metazoan TF families and domain architectures in these genomes, as well as reptiles. We also highlight differences in TF DBD composition between birds and reptiles as well as their putative functional similarities.

P1.59 GRAY, BL*; WILLIAMS, KA; MILES, DB; Ohio University; *bg022811@ohio.edu*

Intraspecific variation in wing shape and flight performance in the hooded warbler Setophaga citrina

Primary and secondary flight feathers are the principal morphological elements which determine wing shape in flying birds. Variation in wing shape has been shown to impact measures of flight performance such as flight speed and maneuverability in passerines. The hooded warbler (*Setophaga citrina*) is a neotropical migrant which exhibits sex-specific differences in spring arrival dates to the breeding grounds and in habitat preference. In order to determine whether differences in ecology are explained by variation in morphology and flight performance, we measured wing loading and wing shape and assessed flight performance in two wild populations of hooded warblers breeding in southeastern Ohio and measured wing shape in additional specimens from northern and southern breeding populations. Each individual holding territory within our study sites was uniquely color banded and followed throughout the 2014/15 breeding seasons to obtain individual reproductive success. We did not detect differences in wing morphology between hatch year (HY) males and females, but after hatch year (AHY) males exhibited a narrow and pointed wing morphology; a morphology linked to rapid flight speeds and is common in long distance migrants. AHY females exhibited a broader, more rounded wing morphology than males; possibly allowing for greater maneuverability in the dense understory where the females nest and forage. Studies linking variation in morphology to variation in performance and, subsequently, linking performance to reproductive success will improve our understanding of the adaptive nature of various wing morphologies as well as provide insight into how hooded warblers, and perhaps other migratory species, may respond to novel selective pressures encountered in a changing environment.

P1.15 GREEN, B*; GOSLINER, T; California Academy of Sciences; San Francisco State Univ., California Academy of Sciences; *bgreen@calacademy.org*

Uncovering Cryptic Diversity in Flabellina, a Genus of Nudibranchs

Flabellina is a large and diverse genus of aeolid nudibranchs, containing over 60 recognized species. Several new species of *Flabellina* have been described in the past decade, and undiscovered diversity likely remains within this group. Several *Flabellina* species exhibit morphological variability over large geographic ranges and may constitute cryptic species complexes. Using the molecular mitochondrial markers 16S, cytochrome oxidase subunit I (COI), and the nuclear marker 28S, we have found preliminary evidence for cryptic species complexes within three widely distributed, morphologically variable taxa. Identification of these potential cryptic species indicates the need for further research into differences in morphology, ecology, and geographic distribution. An improved understanding of species diversity and differences in natural history within *Flabellina* enables further investigation into their evolutionary history and enhances their usefulness as bioindicators of change in ocean climate and reef health.

P2.103 GREIVES, TJ*; NEEDHAM, KB; North Dakota State Univ.; *timothy.greives@ndsu.edu*

Testosterone as a 'trait': relationship between daily endogenous testosterone profiles, GnRH-induced testosterone and fitness-related traits

Testosterone, through its pleiotropic effects, plays a crucial role in regulating and coordinating morphology, physiology and behavior. While much has been learned through the use of manipulative experiments, determining the relationship of natural variation in testosterone profiles with other phenotypic traits related to fitness is necessary going forward. The hypothalamic-pituitary-gonadal (HPG) axis, with gonadotropin-releasing hormone (GnRH) initiating the endocrine cascade, regulates testosterone secretion. Circulating testosterone, however, varies over the course of the day and in response to other internal or external stimuli, potentially making it difficult to relate testosterone sampled at any one-time point with fitness-related traits. Over the past decade, researchers have begun to utilize the administration of exogenous GnRH to elicit a testosterone response in order to generate a standardized testosterone 'phenotype' to relate to other traits. While this has provided useful insight, it has remained unclear if and how this exogenously stimulated activation of the HPG axis is related with endogenously regulated testosterone capable of influencing testosterone related traits. Here, we ask how endogenous diel variation in testosterone profiles relates to GnRH-induced testosterone secretion, as well as how the relationship between these two measures relate with fitness-related traits in a songbird, the house sparrow (Passer domesticus). Specifically we associated testosterone measures with badge size and sperm concentration and function in captive house sparrows. Data presented will elucidate the usefulness of GnRH-induced testosterone as a 'phenotypic trait' in studies aimed at understanding individual variation and selection on testosterone phenotypes.

P1.2 GROGAN, KE*; EISEN, A; HAYNES, JK; EATON, D; Emory University, Morehouse College; *kathleen.e.grogan@gmail.com*

Fellowships in Research and Science Teaching (FIRST): An integrative postdoctoral experience that generates effective researchers and educators

The Fellowship in Research and Science Teaching (FIRST) at Emory University is a three-year postdoctoral training program designed to provide a quality foundation for successful careers in academia. Supported for 16 years by an Institutional Research and Career Development Award (IRACDA) from the NIH, FIRST combines interdisciplinary research training with instruction in teaching pedagogies, classroom technology, course development, and undergraduate mentoring. As with traditional postdoctoral positions, fellows work under the direction of research mentors at Emory University, a nationally recognized research institute. As a crucial addition, however, fellows also receive training in innovative pedagogical methods like active learning and technology-based teaching. Fellows apply these skills by teaching and mentoring students at one of three Historically Black Colleges or Universities in Atlanta: Morehouse College, Spelman College, and Clark-Atlanta University. FIRST also aims to increase the overall representation of minority scientists within the biological/biomedical sciences, and thus inspire minority undergraduates to pursue the same path. In 16 years, FIRST has trained ~170 fellows. In comparison to their peers in traditional postdoctoral fellows, FIRST fellows publish at the same rate, receive comparable external funding, and importantly, are more successful at obtaining academic positions after completion of postdoctoral training. Of 145 alumni, 64% are faculty at research intensive, liberal arts, or minority serving institutions. By combining teaching and research training, FIRST produces scholars who are successful, independent researchers and effective educators that will inspire the next generation of scientists.

P3.71 GROOM, DJE*; TOLEDO, MCB; WELCH JR, KC; University of Toronto, Universidade de Taubate; *derrick.groom@mail.utoronto.ca*

Maximum metabolic capacities during hovering flight challenges in hummingbirds

Hummingbirds differentially modify hovering flight kinematics depending upon body size and the type of challenge imposed. Flight in hypodense air is accomplished with increases in wingbeat frequency and stroke amplitude. Increases in angular velocity of the wing may be facilitated by lower air density and, thus, the costs of accelerating the wing and overcoming drag. Hovering failure occurs at an amplitude of 180° suggesting a morphological or mechanical constraint. Conversely, sustained weight lifting is achieved by increasing stroke amplitude (up to 160°), with only relatively large species increasing wingbeat frequency. We hypothesize that metabolic constraints play a greater role in limiting performance during weight lifting. We predict that aerobic hovering scope available for flight, calculated as the ratio of oxygen consumption rate near failure to unweighted, normodense hovering flight, would be higher during weight lifting than during air density reduction trials, as weight lifting would illicit metabolic rates closer to maximal limits. Hovering metabolic rates were recorded from four species of hummingbird at three elevations in Brazil while undergoing sustainable weight lifting trials. Metabolic rates increased with increasing elevation and mass, but max-recorded rates were invariant across elevations within each species. Aerobic hovering scope was greater during weight lifting than during previously reported air density reduction trials. Thus, in support of our hypothesis, sustained weight lifting is more limited by constraints on metabolic power of lift production while failure during hypodense flight trials occurs when metabolic rate is still lower than can be achieved.

P2.110 GRUNWALD, J.T.*; RAMOS, S.A.; PROPPER, C.R.; Northern Arizona University ; *jtg84@nau.edu*

Exposure to environmentally relevant arsenic levels affects estrogen sensitive tissues in an adult aquatic vertebrate

Inorganic arsenic is a common environmental toxin found in many ground and surface water resources around the world. Recent evidence suggests that arsenic disrupts estrogenic pathways and may affect reproductive health in rodent and human systems. However, little is known regarding how arsenic may effect estrogen-dependent reproduction in non-mammalian systems. Because aquatic vertebrate populations, in particular, may be exposed to inorganic arsenic in surface water, understanding the effects of arsenic on reproductive measures may be important to both water and wildlife management. For this study, 60 adult female and 38 adult male *Xenopus tropicalis* were exposed to environmentally relevant concentrations of sodium arsenite at 0, 0.1, and 1.0 uM for 14 days. Tissues were collected and analyzed for effects on organ morphology. Although the exposure had no effect on the males, we observed significant outcomes in estrogen-sensitive tissues in exposed females. Arsenic exposure had little effect on most non-reproductive endpoints, but there was a significant decrease in both oviduct/ovary weight and oocyte diameter suggesting that environmentally relevant exposure to arsenic may affect female reproduction in aquatic vertebrates possibly through disruption of estrogen signaling processes. Our results suggest that monitoring of aquatic vertebrates in regions of high arsenic concentrations, whether from naturally occurring resources or from point or non-point pollution sources, could provide information regarding reproductive health of exposed populations.

P1.197 GUINDRE-PARKER, S.*; RUBENSTEIN, D.R.; Columbia University; *slg2154@columbia.edu*

What physiological traits allow tropical passerines to cope with climatic uncertainty?

Global warming is increasing extreme and unpredictable weather events globally, yet it is unclear how environmental uncertainty may adversely affect organismal physiology. One way to approach this problem is to determine how organisms that have evolved under naturally unpredictable environments have adapted to these conditions. Three main physiological traits are shown to help vertebrates to cope with environmental stressors, including (i) immune function, (ii) glucocorticoid hormones and (iii) oxidative stress. Differences in physiology among species correlate with global environmental gradients, demonstrating there is a relationship between physiology and habitat conditions. However, life-history differences among species can confound these analyses, thus it remains unclear which physiological traits can help individuals within a species cope with environmental uncertainty. We explore how populations of superb starlings (*Lamprotornis superbus*) that have naturally evolved in unpredictable habitats cope physiologically with differences in total annual rainfall and uncertainty in rainfall within Kenya. Specifically, we compare physiology among 9 populations of superb starlings that experience drastic differences in rainfall. Preliminary results indicate that glucocorticoids are elevated in birds living in habitats where rainfall is unpredictable (including baseline, stress-induced and ACTH-challenged glucocorticoid levels). These results suggest that elevated glucocorticoids allow superb starlings to live under unpredictable environmental conditions. This research demonstrates how species cope physiologically under diverse and variable environments, enhancing our ability to predict how vertebrates facing environmental unpredictability due to global warming may respond.

P1.116 GUISE, E*; O'BRIEN, S; Radford University, Radford VA; *guise.emily@gmail.com*

The Ecologically Relevant Effects of Trenbolone on Gambusia holbrooki

Trenbolone, a testosterone mimic that is often used in the cattle industry, has potential to act as an endocrine disrupting chemical affecting wildlife near cattle feed lots. With three times the bonding affinity as testosterone and a nine month half-life, trenbolone has been found in the runoff and waste of cattle feed lots (Orlando 2004, Bartelt-Hunt 2012). The continued use of trenbolone in the cattle industry could pose a threat to the freshwater environment of the mosquitofish, which are often placed in ponds near cattle as an alternative mosquito control method. Our previous research has show that Trenbolone, at the ecologically relevant levels of 5ng/L and 10ng/L, to have significant effects on the eastern mosquitofish *Gambusia holbrooki* in a laboratory setting. These effects include changes in mosquitofish mating behavior and masculinization of the female reproductive tract. Here we show replicated results of the influence trenbolone has on morphological changes, mating behavior, and female masculinization of the reproductive tract, with the addition of the effects of trenbolone on same-sex interactions.

P1.45 GUSSEKLOO, S.W.S.*; HEINEN, R.; CERKVENIK, U.; Experimental Zoology Group, Wageningen University; *Sander.Gussekloo@WUR.nl*

Adaptations to substrate properties in the ovipositors of parasitic wasps (Ichneumonoidea)

Parasitic wasps of the superfamily Ichneumonoidea use ovipositors to lay eggs in or on arthropod hosts which are often hidden in substrate. The physical properties of the substrate can differ significantly. Some hosts use soft substrates, such as rotten fruit, and others use hard substrates, such as wood. Field observations show that ichneumonoid species prefer single host species often found in a specific substrate. It may be assumed that during evolution the ovipositor adapted to the physical properties of the specific substrate. For 113 species we obtained morphologies and host preferences from literature, and used these to find morphological adaptations for specific substrates. The egg-laying preferences were categorized in six classes varying from drilling in hard substrate to non-penetrating egg-laying on exposed hosts. We used morphological characters relevant for ovipositor stiffness and internal stress reduction, which limit buckling and avoid breaking of the ovipositor. The ovipositors consisted of three moving parts, which are linked via a tongue and groove (aulax-rachis) mechanism. A multivariate discriminant analysis showed that the largest differences between animals in different substrate classes are in this tongue and groove mechanism. The mechanism is large when hard substrates are used, and smaller in species that use exposed larvae. This indicates that drilling creates stress on the sliding mechanism, and that the valve movement might be important for drilling. Other parts of the morphology seem less affected by substrate characteristics, but might be affected by other functions such as egg transport or sensory functions.

P2.209 GUTIERREZ, E*; LENTINK, D; Stanford University; *eguti007@stanford.edu*

Predicting Weight Support Based on Wake Measurements of a Flying Bird in Still Air

The wake of a freely flying Pacific Parrotlet (*Forpus coelestis*) was examined in still air. With positive reinforcement, the bird was trained to fly from perch to perch through a laser sheet while wearing custom-made laser safety goggles. This enabled a detailed study of the evolution of the vortices shed in the wake using stereo particle image velocimetry at 1000 Hz in the plane transverse to the flight path. The instantaneous lift force that supports body weight was calculated based on the velocity field, using both the Kutta-Joukowski and the actuator disk quasi-steady model. During the first few flaps, both models predict an instantaneous lift that is close to the weight of the bird. Several flaps away from the laser sheet, however, the models predict a decline of the lift to about 50% of the bird's weight. In contrast to earlier reports for bat wakes in wind tunnels, these findings for bird wakes in still air suggest that the predictive strength of quasi-steady force calculations depends on the distance between the flying animal and the laser sheet.

P2.104 HAHN, TP*; BRAZEAL, KR; CORNELIUS, JM; Univ. of California, Davis, Univ. of Nebraska, Lincoln, Eastern Michigan University; *tphahn@ucdavis.edu*

Managing the breeding-plumage molt transition in an opportunistic breeder, the red crossbill, Loxia curvirostra.

For temperate zone birds, the trade-off between reproduction and self-maintenance is exemplified by the transition from breeding to plumage molt. In most temperate zone species, at most the earliest stages of primary (flight) feather molt overlap with reproductive competence. Crossbills (*Loxia* sp.) are temperate zone birds with flexible breeding schedules, reputed to breed in all seasons if conifer seeds (their primary food) are common. How they fit molt - essential to long-term survival - into such a reproductive schedule is a puzzle. Our nearly 30 years of field data show an "autumn hiatus" in reproductive competence, even in years with good seed crops. Primary feather molt overlaps extensively with persistent reproductive competence, but body molt coincides with reproductive collapse. Thus, unlike zebra finches, which overlap reproductive competence with a slow, protracted molt, crossbills molt seasonally and segregate the most demanding molt stages from breeding. This pattern may relate to sex steroid sensitivity. Although field data suggest that male crossbills with the highest testosterone (T) levels do not molt, captives with experimentally elevated T do eventually molt. T implants delay primary molt compared with controls, and the effect of T on timing and rate of body molt is greater than on primary molt. Thus, crossbill molt onset appears relatively insensitive to high sex steroids, so molt can proceed while circulating sex steroids are still above breeding baseline. Body molt, which is more sensitive to T, is delayed further if T remains high, so molt completion is facilitated by reproductive collapse, which leads to the decline of T below breeding baseline levels.

P2.163 HALL, MR*; BERG, O; MULLER, UK; California State University Fresno; *umuller@csufresno.edu*

Prey capture efficiency of the carnivorous plant Utricularia vulgaris and cost of carnivory

Several lineages of plants have adapted to low-nutrient and acidic environments by carnivory, which makes up for the lack of phosphorus and nitrogen. Reliance on carnivory is expected to exert evolutionary pressure for increased prey capture efficiency: the more specialized and active the trapping mechanism, the higher the success rate must be in order to offset the cost of developing and setting such traps. The bladderwort *Utricularia vulgaris*, for example, is a free-floating aquatic plant, which forms small (approximately 1- 4 mm) bladders to suction capture zooplankton. The suction traps are structurally intricate and energy-intensive, hence the expectation that their capture efficiency (captures per feeding strike) is high. By combining imagery of captured prey and acoustic recording of feeding strikes, we are able to measure the capture efficiency of bladderwort for the first time. The data further document the role of trap size and trap age in the life history of *U. vulgaris*. Our measurements of the capture mechanism complement published studies of its genetic basis, making this species an excellent case study of rapid adaptation to a specialized niche.

P1.151 HARRIS, R.M.*; FENTON, A.A.; HOFMANN, H.A.; Univ. of Texas, Austin, New York University; *rayna.harris@utexas.edu*

Enhancing Discovery-based Training in the Neural Systems & Behavior Course

The Neural Systems & Behavior course at the Marine Biological Laboratory is the premier discovery-driven training opportunity for neuroethologists and systems neuroscientists. These fields have increasingly benefited from integrating data across spatial and temporal scales as well as levels of organization to understand the neural basis of behavior. We have enhanced and expanded the course by integrating molecular and genomic approaches with behavioral, electrophysiological, and evolutionary analyses to study complex problems in neuroscience. For instance, we have developed an interdisciplinary research program aimed at understanding the behavioral, electrophysiological, and molecular mechanisms of learning and memory. We employ a hippocampal-dependent learning paradigm to assess how well laboratory mice can learn and remember to associate spatial cues with a stimulus. We then use ex vivo slice physiology to quantify the levels of synaptic plasticity that are indicative of a memory trace. Finally, we isolate discrete hippocampal regions and single neurons to identify changes in gene expression related to variability in behavior and synaptic plasticity. We find that active place avoidance training causes widespread input-specific changes in hippocampal synaptic network function that accompanies memory persistence. Ongoing research aims to identify transcriptome-wide changes in neural activity that are indicative of memory persistence and synaptic plasticity. Understanding how the brain stores memory is still poorly understood, but our integrative approach sheds new light on the neuromolecular mechanisms at play. This integrative approach can be applied to many unsolved questions about neural function and animal behavior.

P1.42 HARRISON, J.S.*; HIGGINS, B.A.; MEHTA, R.S.; Univ. of California, Santa Cruz; *jasaharr@ucsc.edu*

Oral Tooth Morphology and Growth of the California moray eel (Gymnothorax mordax)

Oral teeth are important structures for the acquisition of prey. Tooth morphology has been used to provide insights into the dietary habits and even the ontogenetic shifts in diet for many predatory species. In this study we analyzed tooth morphology and the ontogeny of tooth growth in the oral jaws of the California moray eel (*Gymnothorax mordax*), which can attain lengths of up to 1.5 m total length (TL). We sampled individuals ranging from 455-850 mm TL, 54-106 mm head length (HL). To quantify tooth morphology, the length and width of each tooth was measured for the following five regions: inner maxillary, outer maxillary, ethnovomerine, vomerine and dentary. Within the oral jaws the anterior most teeth were found to be significantly larger in length. Of these five regions, the vomerine teeth, while fewest in number, were the longest. To detect changes in scaling patterns throughout growth, teeth located in the anterior portion of each region were corrected for size using the skeletal feature along which they were located. We then took the ratio of these relationships and regressed them against HL. We found that both length and width of the anterior teeth in all regions scaled isometrically with HL indicating that tooth shape and relative size is maintained throughout ontogeny. These isometric patterns in tooth shape suggest that *G. mordax* does not undergo an ontogenetic shift in diet. Stomach contents of *G. mordax* individuals collected (n=49) from Santa Catalina Island, California, correspond with these scaling patterns and further support a generalist diet throughout ontogeny.

P2.107 HART, CE; HUNTER, CS; LEMA, SC; HARDY, KM*; Cal Poly - SLO; *kmhardy@calpoly.edu*

Effects of nonylphenol on the immune response of the Pacific oyster, Crassostrea gigas to a Vibrio campbellii bacterial infection

The endocrine disruptor nonylphenol (NP) is a pervasive aquatic pollutant whose detrimental effects on marine organisms (e.g., growth, reproductive, developmental and metabolic impairments) can be attributed to both its estrogenic activity, as well as other unrelated toxic properties. The goal of this study was to determine how exposure to NP influenced immune function in the Pacific oyster (*Crassostrea gigas*) by measuring total hemocyte counts (THC) and immune-gene expression following a bacterial infection. We exposed oysters to NP at high (100µg/L), low (2µg/L) or control doses for 7d, then experimentally infected oysters with *Vibrio campbellii*. After 24h, hemolymph samples were collected for immediate determination of THC, whereas gill, mantle and hemocyte tissues were collected for the subsequent qPCR analysis of nine immune genes (*bigdef1-3, bpi, galectin, lectin, lysozyme, transglutaminase* and *timp*). We found that bacterial infection resulted in a significant increase in THC in the control oysters, but this response was abated in both low and high NP exposure groups. We also confirmed that a number of genes were significantly responsive to bacterial injection (in all tissues: *lysozyme* and *timp*; hemocytes: *bigdef2*; mantle: *galectin, transglutaminase, bigdef2* and *bpi*); and of these, infection-induced expression changes in *galectin* and *tranglutaminase* (in mantle tissue) were also repressed by low dose NP exposure. Other times NP alone caused significant changes in the relative mRNA levels (i.e., *bpi, lectin* and *bigdef1* in the mantle, and *bpi* and *galectin* in the gill tissue). Our results suggest that exposure to NP (and particularly the low dose) does have the potential to alter the cellular and transcriptional level immune response to bacterial infection in *C. gigas*.

P3.98 HARVEY, R.J*; ROSKILLY, K; HUBEL, T.Y; EVANS, H.E; WILSON, A.M; Royal Veterinary College; *rjharvey@rvc.ac.uk*

A Snapshot of the Domestic Cat's Daily Life in Different Environments

The Domestic cat (Felis catus) is one of the most common pets kept in the UK and worldwide. In an increasingly urbanised world it is of importance to understand how the lack of green space and increase in density of conspecifics affects the ranging and activity patters of domestic cats. To understand this we studied cats from three different environments: rural farm, village and inner city. Each cat was fitted with custom-made high accuracy, high rate GPS-IMU collars and monitored for 4 separate 24-hour periods. There was a difference in the overall activity between the areas with the Farm cats being most active and City cats being the least active, Farm cats also showed a more nocturnal pattern of activity whereas City and village cats were more diurnal. Home range size and distance travelled per day varied in the three environments with farm cats having much larger ranges than village and city, and village having larger ranges than city. The distance travelled per day was shorter in the City cats, however Village and Farm cat travelled similar distances despite differences in range area.

P3.134 HARVEY, TA*; BENES, J; VELAZQUEZ-ARMENDARIZ, E; PRUM, RO; Yale University, Charles University, Prague, Autodesk, Inc.; *todd.harvey@yale.edu*

Tetrahedral color vectors in 3D: Visualizing plumage patterns without human color bias

The color phenotype of an organism consists of a complete description of the variation in spectral reflectance over the entire organismal surface. Because many organisms use color in communication and crypsis, the color phenotype should be described over the visible spectrum of the organisms themselves or ecological interactors. New tools are needed to enable humans to visualize the extended spectral sensitivity and third color dimension of avian vision without human bias. Computer Graphics compensate for the limits of human color vision, simulating for humans what birds see with their enhanced color vision. Using physiological models of tetrachromatic avian color vision, we calculate avian color and brilliance vectors across the entire surface of a 3D virtual model of bird plumage, and project these vectors back on to the model to create a virtual plumage color vector field. The origins of the color vectors are positioned on the object's surface with some vectors pointing inside and others pointing outside. The graphical user interface of our vector visualization tool presents a bi-directional approach to interacting with data. Two use cases dominate: the user may select vectors on the surface to highlight points in the chromaticity diagram and vise versa. The Cartesian coordinate system of the color vectors on the surface is actively linked to the Cartesian coordinate system of the chromaticity diagram. Application workflow enables the user to independently spin the chromaticity diagram and the organismal surface to (1) orient the vectors on the surface and (2) view the spatial variation of color phenotype over the entire organismal surface. Our technological innovation has the real potential to transform the way biologists quantify, analyze, and study the color phenotypes of multicellular organisms.

P2.49 HARWELL, F. S. *; MITCHELL, A.; BERGMANN, P. J. ; Clark University , Clark University; *Fharwell@clarku.edu*

Effects of dehydration on thermoregulation and hydroregulation in three species of frogs

Amphibians are ectotherms with water-permeable skin, and so they must thermoregulate and hydroregulate to cope with a variable environment. Amphibians must maintain body temperatures and hydration levels that allow for adequate organismal performance of daily activities. Recent work suggests that temperature and moisture effects can interact, thus moisture availability may affect thermoregulation and body temperature may affect hydroregulation. For our study, we examined thermal and moisture preferences in two species of ranid frogs (*Lithobates clamitans* and *L. sylvaticus*), and one species of bufonid toad (*Anaxyrus americanus*). These species provide informative comparisons, as the two ranids are closely related, but *L. sylavaticus* and *A. americanus* are predominantly terrestrial, frequenting drier habitats than the hydrophilic *L. clamitans*. To determine thermal and moisture preferences of the frogs, we used thermal and moisture gradients. The thermal gradient was kept either dry or moist with temperatures ranging from 5 to 35°C. The moisture gradient had peat moss ranging from dry to extremely wet, and was kept at 10°C, 20°C, or 30°C. In both gradients, frogs were either dehydrated to 80% standard mass or fully hydrated. In the thermal gradient, dehydrated frogs of all three species preferred lower body temperatures than hydrated frogs, suggesting that frogs select body temperatures that minimize water loss. In the moisture gradient, *L. clamitans* preferred wetter conditions when dehydrated, as expected, but the two terrestrial species either did not differ in their moisture preferences or preferred wetter conditions when hydrated. This may suggest that hydroregulation is more important in aquatic species that may have lower capacity to cope with dehydration.

P2.51 HASKINS, D.L.*; HAMILTON, M.T.; FINGER, J.W.; JONES, A.L.; BRINGOLF, R.B.; TUBERVILLE, T.D.; University of Georgia, Savannah River Ecology Lab, Auburn University, University of South Carolina, Columbia, University of Georgia, Warnell School of Forestry and Natural Resources, Savannah River Ecology Lab; *david.haskins@uga.edu*

Immunological costs of trace element contaminants in Yellow-bellied sliders (Trachemys scripta scripta)

In modern ecosystems, industrial processes have caused contaminants to become pervasive, especially in aquatic environments. Coal combustion is a major source of contamination globally, and causes deposition of elements such as selenium (Se) and mercury (Hg) into the environment. Coal combustion wastes (CCWs) are typically placed into artificial settling basins which then attract a variety of wildlife. Turtles have many characteristics that put them at risk of accumulating significant body burdens: they are long-lived, have small home ranges, and occupy middle to upper trophic levels within the ecosystem. The goal of this study was to discern if contaminant loads affected the immune status of Yellow-bellied sliders *Trachemys scripta scripta* on the Savannah River Site (SRS) in Aiken, SC. Furthermore, we also sought to determine if parasite loads differed across varying contaminant burdens. Trace element contaminants, such as selenium, pose a risk to biota and little is known about the sublethal effects of contamination on reptiles. This study aimed to evaluate (1) the accumulation of trace elements in *T. scripta* across reference and contaminated sites, (2) potential immunological effects of contamination, and (3) differences in turtle parasite loads across sites. A total of 88 turtles were collected from CCW-affected and reference wetlands located on the SRS. Immune responses were measured via bacterial killing assays (innate immunity) and phytohemagglutinin assays (cell-mediated immunity). In preliminary findings, turtles from reference sites exhibited lower immune responses than individuals from contaminated areas. In this presentation of data, I will describe further analysis regarding accumulation trends, parasite loads, and immune effects of contamination status.

P3.160 HATEM, NE; WANG, Z*; NAVE, KB; KOYAMA, T; SUZUKI, Y; Wellesley College, Instituto Gulbenkian de Ciência; *zwang@wellesley.edu*

Juvenile hormone mediates trade-off between developmental speed and body size

In insects, fitness tradeoffs exist between maximizing body size and developmental speed. In the tobacco hornworm, *Manduca sexta*, growth is dependent on two size assessment points, the critical weight and the threshold weight. In *Drosophila*, the insulin/TOR signaling pathway has been shown to affect metamorphic timing and the size-assessment point. In this study, insulin/TOR signaling was inhibited by feeding rapamycin to JH-deficient and wild type *Manduca* larvae. Critical weight was not affected by rapamycin treatments although the final body size was significantly increased in rapamycin-treated JH-deficient larvae. Our study demonstrates that both a nutrient sensitive pathway, mediated by insulin/TOR pathway, and a size sensing pathway, mediated by the JH pathway, exists in *Manduca*, and that JH overrides the role of insulin/TOR signaling to maximize body size. The mechanism underlying the threshold weight is presently under investigation.

P1.146 HAVENS, L.T.*; SPEISER, D.I.; University of South Carolina; *lukethavens@gmail.com*

Visual processing centers of scallops: structural characterization and comparison to mushroom bodies

There appear to be a limited number of ways that image-forming eyes can be designed, but it is not clear how many ways the processing centers that are associated with them can be formed. Scallops (Family Pectinidae) are bivalve mollusks with dozens of eyes along the edges of their valves. Although the anatomy of their eyes has been studied, little is known about the processing centers that accompany them. It is known that the optic nerves of these eyes project to the dorso-lateral lobes (DLL) of the parieto-visceral ganglion (PVG), a nerve center that is situated on the adductor muscle and separate from the cephalic ganglion. Further, the optic nerves appear to maintain a somatotopic arrangement as they project to globular neuropil in the DLL termed glomeruli. These glomeruli exist in relatively equal number to the eyes and are spaced along the length of the DLL. This system may be an example of visual processing that has evolved separately from the cephalic visual processing centers found in other bilaterians. Furthermore, it is not known if or how scallops integrate images collected separately by their dozens of eyes. Here, we use immunohistochemistry and confocal imaging to study the structure of the DLL and glomeruli in bay (*Argopecten irradians*) and sea (*Placopecten magellanicus*) scallops. In addition, we investigate the morphology of single neurons within the glomeruli using Golgi-Cox silver impregnation. The glomeruli of scallops are then compared to the mushroom bodies of other sighted invertebrates via the comparison of individual cell morphologies and the organization of neuropil. Through this comparison, we will evaluate whether these separately evolved structures may serve a similar purpose to the mushroom bodies of other invertebrates.

P2.69 HAYDEN, N*; RUVINA, K; ANDRINGA, R; BERGMAN, D; Grand Valley State University; *haydenn@mail.gvsu.edu*

Intrinsic and Extrinsic Influences on the Aggressive Behavior of Female Crayfish, Orconectes propinquus

Several influences have been identified as important in determining aggressive (i.e. agonistic) hierarchy formation in male crayfish, however these influences on females are under represented in the literature. This study compares several aggressive influences, including previous winning or losing experiences, prior shelter possession, starvation, olfaction obstruction, and control treatments to determine which of these factors affect aggressive interactions to the greatest extent. The analysis will reveal which of these effects is strongest when directly confronted against one another. Each female crayfish received one of the above treatments and then interacts with another size-matched crayfish that received a different treatment. All trials were recorded and then analyzed using a blind analysis scheme. Trials of each experimental treatment versus a size-matched naive female crayfish have been completed to date, and the cross-comparison trials are currently in progress.

P1.99 HEBERT, S*; CAUGHRON, J; DAVIS, J; CLOSE, M; Radford University; *shebert3@radford.edu*

Amphibian diversity and the occurrence of Batrachochytrium dendrobatidis in the Las Piedras watershed of the Madre de Dios region of Peru during the dry season

Batrachochytrium dendrobatidis (Bd) has been implicated as a major cause of amphibian population declines throughout the world. *Bd* is a water spread pathogen that infects frogs through their skin leading to metabolic disruption and eventually death. Due to the remote and rarely visited location of Las Piedras river and the lack of recent studies, neither amphibian species diversity nor their level of potential infection with *Bd* are known. Given the level of isolation we hypothesized that amphibians in this area would exhibit no indication of infection. We conducted surveys of our study site in May-June 2015. Amphibians from 10 species were hand captured, measured, photographed, swabbed and weighed, and samples were later assayed using PCR to detect the presence of *Bd*. Here we discuss the findings of the project, as well as overall interactions between species, body condition and *Bd* infection state. Finally, we discuss possible correlations with *Bd* distribution and habitat.

P1.20 HENRIQUEZ, SA*; TATTA, CM; MARTINEZ-ACOSTA, VG; The Atonement Academy, Alamo Heights High School, Univ. of the Incarnate Word; *vgmartin@uiwtx.edu*

The effect of caffeine on regeneration and stem cell migration in Lumbriculus variegatus.

We utilize *Lumbriculus variegatus*, an aquatic oligochaete, to determine the effect of caffeine on the cellular and molecular mechanisms of regeneration. Utilizing bromodeoxyuridine (BrdU) labeling coupled with behavioral testing and segmentation, we determined the effects of short-term exposure to 2.5mM caffeine on epimorphic and morphallactic regeneration. Worms in both non-regenerating and regenerating populations were fed BrDU in an agarose and spirulina paste for one week before dissection to investigate stem cell migration. Regenerating populations of worms were then exposed to 2.5mM caffeine or left in Ozarka water as per Drewes, 1999. Total number of segments regenerated were determined over a three week period. Behavioral analysis was also carried out along the anterior to posterior body axis as evidence for morphallaxis and dissections were completed for stem cell migration analysis. Immunohistochemistry was performed on tissue samples with anti-BrDU and Lan 3-2 antibodies to track stem cell migration and upregulation of a glycoepitope marker of neural morphallaxis (Martinez et al., 2004). Preliminary data suggests that short-term exposure to 2.5mM caffeine reduced the number of head segments regenerated but did not appear to affect behavioral recovery along the anterior-posterior axis. Stem cell migration and Lan 3-2 expression patterns also appeared unchanged. Thus, caffeine exposure appears to reduce epimorphic regeneration but not morphallactic regeneration. With concern regarding the increased consumption of caffeine, Lumbriculus may prove to be valuable tool in fully understanding caffeine and its effects on a developing system.

P1.41 HEDRICK, BP*; MITCHELL, P; CORDERO, SA; KASSUTTO, M; MONGE, J; DUMONT, ER; Univ. of Massachusetts Amherst, Amherst, Univ. of Pennsylvania, Philadelphia, Hitchcock Center for the Environment, Amherst; *bphedrick1@gmail.com*

Disparity in the Cross Sectional Geometry of Limb Bones in Birds and Bats

Flight evolved independently in bats and birds, but in spite of this convergence on the same locomotion mode birds occupy a wider range of niches. Bird forelimb morphology is associated with a vast array of flight modes (e.g., soaring, diving, highly-maneuverable flight, flightlessness), and variation among birds' hindlimbs reflects specializations for other locomotor functions (e.g., perching, grasping prey, swimming). In contrast with birds, almost all bats are limited to flapping flight and use their hindlimbs primarily to hang in their roosts. Given the differences between how birds and bats use their hindlimbs, we tested the hypothesis that bat humeri are stronger relative to their femora than birds' and that birds have greater disparity in cross-sectional parameters. We assessed relative strength of the femur by calculating humeral/femoral ratios from measurements derived from the cross-sectional geometry of the bones: relative cortical bone area (RCA), polar section modulus (Z_{pol}), second moment of area (I_{max}/I_{min}). Using phylogenetic comparative methods, we found that the birds (18 orders) and bats (7 families) sampled do not differ in any of their cross-sectional geometry metrics. Larger samples that include mammalian quadrupeds may shed light on whether and how this similarity relates to the evolution of flight. As expected, birds and bats do differ in the coefficient of variation for the humerus/femur RCA ratio (2.9 times higher in birds), and the humerus/femur Z_{pol} ratio (18 times higher in birds). This is a clear validation of the wider range of humeral and femoral morphologies observed in birds relative to bats.

P1.201 HENSON, J.R.*; SIMS, C.G.; SCHOECH, S.J.; University of Memphis, University of Arkansas Monticello; *jrhenson@memphis.edu*

Effects of Hunting on Waterfowl Body Condition and Stress Physiology.

Waterfowl face a multitude of stressors while in the Mississippi Alluvial Valley (MAV). These stressors include energetic demands associated with life history stage, weather, habitat availability, and waterfowl hunting seasons. Many studies have examined the effects of hunting on waterfowl, but very few have focused on how hunting affects the stress physiology of waterfowl. Any stressful stimulus will elicit a physiologic stress response and activate the sympatho-adrenal system culminating with the release of epinephrine and corticosterone (CORT). These hormones aid in survival and recovery over the short-term, but if CORT is elevated over a long period it can lead to decrements in health. Importantly, maintenance of body condition is well known to affect future reproductive potential. The aim of this ongoing study is to determine whether hunting and duration of hunting alter body condition and stress physiology of mallards (*Anas platyrhynchos*) while in the MAV. Mallards were collected before, during, and after the waterfowl hunting season in eastern Arkansas. Only clean, one-shot killed birds were sampled, thus eliminating confounds of wounded highly stressed samples. A blood sample was taken immediately, and then morphometrics and a breast fat score were recorded for each bird. Blood samples were analyzed for plasma triglycerides and baseline CORT levels. We hypothesized that baseline CORT levels and body condition would change as the season progressed. Thus far, our data do not support the hypothesis and indicate that neither hunting per se, nor the duration of the hunting season alter baseline CORT or body condition.

P1.34 HERAS, J.*; GERMAN, D.P.; Univ. of California, Irvine; *herasj@uci.edu*

The monkeyface prickleback (Cebidichthys violaceus) genome: a source for understanding biology in a complex environment

We sequenced the genome of the intertidal, herbivorous fish, *Cebidichthys violaceus* (Teleostei: Stichaeidae), to elucidate the genetic underpinnings of dietary specialization and intertidal existence in this species. *C. violaceus* is part of a phylogeny that showed independent intertidal invasion and evolution of herbivory in comparison to other herbivorous stichaeids (e.g., *Xiphister mucosus*). A juvenile individual collected from San Simeon, California was used to sequence the *C. violaceus* genome, and the genome was generated with Illumina and Pacific Biosciences (PacBio) datasets with 107X and 9X coverage, respectively. From our genomic datasets, we conducted a de novo assembly of the Illumina reads and then a hybrid assembly with both Illumina and PacBio datasets. With bioinformatic tools, we estimated the genome to be 526,436,767 base pairs with a N50 scaffold size of 542 kilobases. The *C. violaceus* genome provides a multitude of opportunities to link genomic information to ecological and nutritional physiology. We are using this data set to better understand the multitude of processes that allow a fish to be herbivorous and to tolerate the vagaries of intertidal existence (e.g., temperature fluxes, and breathing water and air). Moreover, what we learn from *C. violaceus* will be used to inform analyses of other fishes in the family Stichaeidae, which features dietary diversity, ontogenetic dietary shifts (including a shift from carnivory to herbivory in *C. violaceus* and other taxa), and large biogeographic ranges spanning the eastern and western Pacific Ocean. This will be one of the most robust non-model system, vertebrate genomes available to date and will expand our understanding of the biology of fishes and beyond.

P2.185 HERNANDEZ, A.V.*; GERVAIS, C.R.; RUMMER, J.L.; PORTER, M.E.; Florida Atlantic University, James Cook University; *ahernandez2013@fau.edu*

Comparing submerged walking and swimming kinematics in epaulette sharks

The transition from swimming to walking was an important event in the evolution of tetrapods. To understand this transition, researchers have studied movement in many extinct and extant aquatic and semi-aquatic species. The epaulette shark *Hemiscillum ocellatum* uses slow-to-medium walking, fast walking, and swimming forms of aquatic locomotion. We described kinematic differences between the three gaits in neonate (n=6) and juvenile (n=6) sharks hatched and reared in the laboratory. Neonates retain nutrition from an internal yolk until they develop a consistent feeding schedule (~35d post-hatch). They are then classified as juveniles, foraging for worms, crustaceans, and small fish. We hypothesized that changes in diet and feeding habits would affect gait performance between neonates and juveniles. Using video tracking software and 13 anatomical landmarks along the fins, girdles, and body mid-line, whole body velocity, duty factor, fin frequency, girdle rotation, and body curvature were calculated to identify characteristic movements of the gaits for each shark. Velocity was greater in neonates when compared to juveniles across all gaits; however, both groups increased velocity from walking to swimming. Regardless of gait, pelvic girdles had a greater range of motion than pectoral girdles for both neonates and juveniles. In juveniles, regardless of gait, the contralateral sides of the pectoral and pelvic girdles were synchronized during lateral excursions. Neonates, however, exhibited overlapping of ipsilateral sides of the girdles. Understanding the transition from neonate to juvenile locomotory forms in this species could provide insight on the water to land transition of tetrapods.

P2.173 HERNANDEZ, LP*; MCCALLEY, M; George Washington University; *phernand@gwu.edu*

Secrets of a menace: How the cypriniform palatal organ has become greatly modified to allow silver carp to thrive in eutrophic environments

Silver carp, as well as a number of other Asian carp, have garnered recent interest as invasive species well-established within several American rivers and menacing to enter the Great Lakes. Part of the reason for their overwhelming success has been their capacity to feed so efficiently within eutrophic environments. While previous research has described the structure and function of the epibranchial organ (a snail-shaped structure comprised of highly modified branchial arches used to concentrate material filtered from the water column) other aspects of their feeding anatomy have been ignored. Although concentration of phytoplankton is important for efficient feeding, the actual filtration mechanism at the level of the gill rakers has not been investigated within a functional context. This is a particularly glaring omission given that silver carp possess highly derived gill rakers that interdigitate with extended ventral folds of the palatal organ. The palatal organ is an important structure located on the dorsal pharyngeal roof. Previous work has shown that it is important in a specialized type of feeding that characterizes goldfish and carp, in which particulate matter is captured by localized protrusion of this muscular structure. Recent work in our lab has revealed that the overwhelming majority of cypriniform species examined have a muscular palatal organ, however the specialized nature of the palatal organ of the silver carp rivals anything previously described. It has been suggested that the large palatal organ is simply used as a piston pump to drive water through the gill rakers. Given the complex muscular architecture of each palatal fold this proposed mechanism seems overly simplistic.

P3.129 HICKS, M.*; LINKEM, C.; TRUONG, L.; SUMMERS, A.; DITSCHE, P.; University of Washington, University of Hawaii at Manoa, Wellesley College; *mhicks12@uw.edu*

An easy and applicable method to measure roughness in the marine intertidal

Many animals that make their living in the rocky intertidal cope with the forces of crashing waves by securing themselves to the surface of hard substrates such as rocks in which surface roughness has a crucial impact on the animal's ability to attach. Northern clingfish inhabits the rocky intertidal and have been shown in lab studies to have the remarkable ability to stick to surfaces with a large range of surface roughness by means of their ventral suction disc. To compare this ability to the range of roughness encountered in its natural habitat we had to overcome several methodological problems. Clingfish can be found in the lower and lower middle intertidal zone causing short term access to rocks during low tide. To overcome this problem we molded the surface of the rocks where we found clingfish with a precise and fast hardening dental wax, allowing the molds to be analyzed later in the lab without time pressure and without removing rocks from the habitat. Technical devices for roughness measurements such as optical or contact profilometers, often designed to measure roughness of technical surfaces at a very fine scale, were not appropriate for this study, so we developed a simple method to measure roughness with inexpensive equipment in the range of coarser roughness orders. The roughness parameters used in this study were the maximum distance between the highest and lowest points in a segment per mold (RmaxDIN) and the total average distance between the highest and lowest points in all segments per mold (RzDIN). The results generated from this method show that the natural substrates in the rocky intertidal cover, and in few cases exceed, the range of roughness Northern clingfish can attach to.

P1.50 HIDALGO, F*; LIEU, V; TABUTOL, N; HAAK, K; MULLER, UK; California State University Fresno; *umuller@csufresno.edu*

Quadrupeds and biped appendicular bones scale differently

Size matters: the bones of small animals support less weight than those of large animals. Scientists have argued that larger animals should have thicker bones to support their larger mass. To keep the load on the bones the same across sizes, animals need to scale elastically: larger animals need to have relatively thicker and shorter bones. In contrast, when larger and smaller animals differ only in size but not shape, their size is said to scale geometrically. Previous studies found a wide range of scaling exponents. In this project, we measured the long bones from more than 50 mammal, marsupial, and bird species in the vertebrate collection of the Fresno State Biology Department as part of a course in Comparative Vertebrate Morphology. The objective of this study is to quantify how the bones scales in the arms and legs of walkers and flyers. To determine how length and diameter scale with mass, we measured the humeri, femurs, tibias, and ulnas. Consistent with previous findings on quadrupeds, we expected that the back legs of the quadrupeds and legs of the bipeds would scale geometrically since they serve the same purpose. For the arm, we expected the quadrupeds to scale geometrically and the bipeds to scale elastically due to the different purpose of each limb. Our data on quadrupeds agree with past research. However, quadrupeds and non-flying bipeds appear to scale differently, and birds differ from quadrupeds. Also, upper and lower limb bones scale differently in both quadrupeds and bipeds. Many of the explanations put forward in the literature about the scaling of long bones do not integrate well across all the available data and they do not explain the differences between scaling coefficients for bones within the same limb or for how length versus diameter scales with mass.

P3.152 HIDAYAT, A.S.*; MINOR, P.J.; LOWE, C.J.; University of Washington, Seattle WA, Hopkins Marine Station, Pacific Grove, CA; *ahidayat@uw.edu*

Conserved Hox gene expression during larval stages in the bat star, Patiria miniata

Hox genes constitute an essential and ubiquitous mechanism in the construction of the animal body. Despite the diversity in bilaterian body plans, every member of this clade utilizes these key genes in patterning the anteroposterior axis, with one potential exception - radial echinoderms. As adults, members of Echinodermata are characterized by a highly derived radial body plan, however, most species develop indirectly, beginning their lives as bilateral larvae that undergo a radical metamorphosis into a radial adult. A broad understanding of echinoderm development is still lacking, and it is unknown how classically bilateral patterning genes like *Hox* are involved in setting up these very different life stages. To resolve this, *in situ* hybridizations of four *Hox* genes present in the bat star, *Patiria miniata* in its larval stages were performed. *P. miniata* exhibits indirect development, and is an excellent model in which to characterize the usage of conventional AP axis patterning genes to compare with that of bilateral organisms. *Hox* expression was observed in larval forms in a collinear fashion analogous to the expression patterns in other animals. These results suggest that, despite a greatly divergent radial body plan, echinoderms use many of the same developmental mechanisms found in bilateral organisms to pattern their larval stages prior to metamorphosis. This research represents the beginning of studies on *Hox* genes in asteroids, and provides evidence for rethinking our assumptions about the evolutionary transition from bilateral to radial symmetry in early echinoderms.

P2.196 HIGHTOWER, B. J.*; LENTINK, D. ; Stanford University; *bhightow@stanford.edu*

Acoustic Analysis of an Aerodynamic Force Platform for Animal Flight Studies

In order to draw inspiration from birds for improving the design of flying robots, we need accurate time-resolved force measurements of flying birds *in vivo*. A new system developed by our lab, an aerodynamic force platform (AFP), has been used to measure the vertical lift forces of hovering Anna's hummingbirds and Pacific parrotlets. The AFP is a control volume that encloses the bird and integrates the Navier-Stokes equations mechanically to measure the aerodynamic force generated by the bird with force sensors attached to the ceiling and floor. Like all measurement systems, there is inherent noise due to the natural frequencies in each component. The structural and acoustic resonance of the volume determine precision, as in terrestrial force plates. Currently it is not fully understood how the coupling between the structural and acoustic resonance can be optimized to improve precision. We study a linearized small-amplitude acoustic model (Helmholtz Equation) of the air volume coupled with models of the top and bottom force plate of the volume (harmonic oscillators). This simplified model, which ignores essential momentum terms in the Navier-Stokes equations for calculating force transfer, enables us to derive design principles. It shows how the resonances need to be decoupled to reduce small amplitude noise and improve precision of *in vivo* measurements. To determine the validity of the design principles derived based on this simple model we compare our simulations with experiments.

P2.119 HILLIARD, J.*; SCHULZE, A.; Texas A&M University at Galveston; *jhilliard@tamu.edu*

Species Delineation in the Capitella Species Complex: Geographic and Genetic Variation

Capitellid polychaetes (Annelida) are common members of the marine benthos that superficially resemble earthworms. Morphological synapomorphies that define them include a thoracic region with mostly capillary chaetae and an abdominal region with hooded hooks. Generic and specific designations are often made with this chaetal formula, hooded hook morphology, and the presence or absence of other structures, e.g. genital hooks, anal cirri, and branchiae. Having so few characters has likely led to erroneous designations. Further confounding the topic is the *Capitella* cryptic species complex. *Capitella capitata* is commonly used as a biological indicator species due to its ubiquitous distribution and ability to tolerate high concentrations of pollutants. However, it was discovered in the 1970s that what is traditionally considered *C. capitata* is actually a group of several sibling species on the Massachusetts coast alone, with the number continually growing worldwide. Our research aims to delineate boundaries within this species complex using genetics and morphology. We sequenced mitochondrial markers for individuals of *C. capitata* and *C. aciculata* collected from Texas and Florida and analyzed them in conjunction with data available in GenBank. Our results indicate the presence of a Gulf of Mexico (GoM) clade that is distinct from populations in Canada and India. They also show that clades are defined more by location rather than by morphology, that is that there is more divergence intraspecifically GoM-wide than there is interspecifically in one location.

P1.108 HINSON, J.R.*; WELCH, A.M.; CORY, W.C.; DAVILA, S.C.; College of Charleston; *hinsonjr@g.cofc.edu*
Effects of two antidepressants, fluoxetine and sertraline, and their photodegradants on southern toad (Anaxyrus terrestris) tadpoles
Pharmaceuticals and personal care products (PPCPs) are commonly used throughout the developed world and enter natural water systems due to incomplete removal during wastewater treatment. When exposed to UV radiation in sunlight, many pharmaceuticals degrade into related compounds that may be more toxic than the original compound. In addition, continual release of PPCPs in daily use can maintain elevated levels in the environment despite rapid degradation, a phenomenon known as pseudo-persistence. Fluoxetine (Prozac®) and sertraline (Zoloft®) are widely prescribed antidepressant medications, which are frequently documented in surface waters and sewage effluent. Although effects of these pharmaceuticals have been shown for various aquatic organisms, very little is known about the effects of their degradants. *Anaxyrus terrestris* (southern toad) tadpoles were used to investigate acute and sub-lethal effects of sertraline, fluoxetine, and their UV-photodegradants. Sertraline was more toxic to tadpoles than fluoxetine. A sertraline solution was exposed to UV radiation for different amounts of time, and tadpoles were exposed to the resulting solutions. The sertraline solution decreased in toxicity as UV exposure time increased, as the photodegradants themselves rapidly degraded in the exposed solutions. We are currently conducting similar tests with fluoxetine to understand how its toxicity is affected by UV degradation. Our research underscores the importance of understanding the effects and fate of pharmaceutical degradants as well as the pharmaceuticals themselves within the environment.

P1.68 HOLT, NC*; AZIZI, E; UC Irvine; *natalie.c.holt@gmail.com*
The effect of muscle compliance on the relationship between activation level and optimum length
The relationship that exists between muscle length, and the force that it can produce, is a defining feature of skeletal muscle. It is widely accepted that this relationship, where maximum force is produced at an intermediate length (the optimal length), is a result of the overlap between the contractile proteins actin and myosin. However, optimum length increases with decreasing muscle activation level suggesting that there are additional determinants of the force-length relationship. We have previously suggested that at the level of the whole muscle, the amount of internal work that must be done to overcome compliance within the muscle and allow force to be effectively generated. Therefore, at lower activation levels, where less work is done by cross-bridges, muscles may be able to produce more force at longer lengths due to reduced internal work requirements. Muscle ergometry and sonomicrometry were used in frog plantaris muscles to determine the effect of activation level on optimum fiber length in whole muscles and muscle fiber bundles. The fiber bundles will have reduced structural complexity and no in-series compliance thereby decreasing internal work requirements compared to whole muscles. We test that hypothesis that at lower levels of activation, optimum length will shift to significantly longer lengths in the whole muscle compared to the fiber bundle. Understanding the effect of internal compliance and muscle shortening on the force-length relationship will not only highlight other determinants of the force-length relationship, but will also provide insight into this relationship *in vivo*.

P1.177 HOPE, S.F.*; BECK, M.L.; KENNAMER, R.A.; HOPKINS, W.A.; Virginia Polytechnic Institute and State University, University of Georgia, Savannah River Ecology Lab; *shope@vt.edu*
The effect of incubation temperature on Wood Duck duckling behavior
Incubation temperature is a critical parental effect that influences offspring quality in egg-laying animals. Unlike most other oviparous species, avian parents regulate incubation temperature through behavior, allowing parents to shape offspring phenotype. For cavity nesting wood ducks (*Aix sponsa*), slight temperature changes (<1°C) affect duckling morphology and physiology, but it is unknown whether incubation temperature affects offspring behaviors that may be crucial to survival. To investigate this, we incubated wood duck eggs at three different temperatures (35, 35.8, 37°C) and assessed duckling behavior with multiple repeated behavioral trials between 1-15 days post-hatch. We found that incubation temperature affected several behavioral traits. On day 1, fewer ducklings incubated at the lowest temperature successfully exited a nest box in response to wood duck hen call recordings compared to those incubated higher temperatures, which would likely lead to abandonment by the mother in the wild. Additionally, ducklings incubated at the lowest temperature spent more time calling while alone in an unfamiliar environment and were more likely to emerge from a shelter into an unknown environment than those incubated at higher temperatures. These behaviors may help maintain close associations between the mother and her offspring, but may also increase predation risk. Our study provides evidence that the early developmental environment has an effect on avian neonate behavior and offers insight into how non-genomic factors may provide directional selective pressure for behaviors important to early survival.

P2.9 HOPKINS, CH*; KUCHTA, SR; ROOSENBURG, WM; Ohio University; *ch183014@ohio.edu*
Amphibians on the road: potential impacts of roadway mortality and ecopassage utilization on populations along a two-lane highway
Roadways kill tens of thousands of amphibians annually in the United States and this mortality is likely to increase as over 13,000 additional miles are constructed annually. Roadways depress amphibian population sizes, disrupt connectivity, and degrade habitat. Barriers and ecopassages are increasingly being implemented to mitigate roadway impacts. Barriers limit access to roadways and may direct animals toward ecopassages, which are corridors designed to conduct animals safely over or under the roadway. The effectiveness of these mitigation measures remains poorly studied. The Nelsonville bypass, completed in 2013, bisected the largest tract of continuous forest in Ohio, including wetlands and associated amphibian migration routes. The Ohio Department of Transportation installed mitigation measures and views this as their flagship effort, upon which future projects will be based. We quantified levels of roadway mortality, ecopassage use, and amphibian populations, in order to assess the effectiveness of a barrier-ecopassage system. We monitored wildlife deaths along a 2.6km stretch of two-lane highway, used camera traps in two ecopassages, examined drift fence effectiveness, and surveyed surrounding habitat to obtain population estimates. In the spring of 2015, 6,311 amphibians were found dead along the roadway, two individuals were seen using the ecopassages successfully, and 104 individuals were trapped trying to circumvent the drift fence. Preliminary population estimates and growth models indicate populations may not be large enough to sustain additive mortality. This suggests that the barrier-ecopassage system in place is not effective. Future work will evaluate alternatives to the current mitigation design.

P3.94 HOU, JJ*; CORNELL, A; WILLIAMS, TD; Simon Fraser University ; *jha165@sfu.ca*

How developmentally mature are chicks at fledging? Variation in hematology during a critical life-history transition

Body condition at life-history transitions, or "developmental milestones", is known to affect fitness across a wide range of taxa. In passerines, the immediate post-fledging stage is marked by high levels of mortality and the transition from sedentary nestling to free-flying fledgling might therefore be a critical determinant of fitness. Numerous studies have shown positive relationships between somatic development (nestling mass or growth) and survival but very little is known about the *physiological* components of chick quality or phenotype at fledging. Here we present data on individual variation in a range of hematological measures (hematocrit, hemoglobin, and proportion of young red blood cells or reticulocytes) in European Starling chicks (*Sturnus vulgaris*) just prior to, and at the fledging stage (day 17 and day 21, post-hatch). Since there are well-documented "cohort" effects in offspring survival we first test for annual variation in hematological traits (relative to values in adults), and somatic development across three years (2013-2015) which varied in breeding productivity. Second, since post-fledging survival decreases with hatch date we compare physiological development of hematology for chicks in 1st and 2nd broods. Preliminary analysis shows a) rapid increase in hematocrit and hemoglobin and rapid decrease in proportion of reticulocytes just before fledging, b) lower hematocrit, hemoglobin, and reticulocyte levels in second brood chicks compared to first brood chicks, c) lower hematocrit, hemoglobin, and reticulocyte levels in years with lower overall breeding success. Our ultimate goal is to understand how the individual variation in hematology of chicks and fledglings might relate to the inter-annual variation in reproductive success.

P2.22 HUANG, MH*; SEGER, JM; CRESTOL, KM; HSU, ER; MURRAY, IW; LEASE, HM; Whitman College, Walla Walla, University of the Witwatersrand, South Africa; *leasehm@whitman.edu*

The thermal dependence of sprint speed for two species of African lizards: Mochlus sundevalli and Scincus scincus

Current work suggests that many lizard populations are experiencing negative impacts from ongoing climate change, possibly mediated through the reduction of time available to accomplish life activities such as foraging and breeding, as a result of warming environmental temperatures. Part of better understanding the mechanisms behind how lizards are impacted by climate change involves estimating how ecologically relevant metrics of performance are affected by temperature. We examined the thermal dependence of sprint speed for two species of African skink about which little is known: Sundevall's writhing skink (Mochlus sundevalli) and sandfish (Scincus scincus). We acclimatized the lizards to 7 different temperatures (24, 27, 30, 33, 36, 39, and 42°C), and then used a high speed video system to record lizard sprinting down a linearly demarcated track. Here we present thermal optimal performance curves for these two ecologically distinct African lizard species, which can help inform models of lizard extinction risk in the face of global climate change.

P2.12 HUDSON, D.M; CARDONA, L.F; CORTES MUNAR, J.S; PHILLIPS, G.D; SMITH, Q.M*; CAMPOS, M.R; Atlanta Metropolitan State College, Atlanta, Georgia, USA;Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogotá, Colombia, Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogotá, Colombia, Georgia State University, Atlanta, Georgia, USA, Atlanta Metropolitan State College, Atlanta, Georgia, USA; *quandasmith08@gmail.com*

Spatial competition between the native Colombian freshwater crab, Neostrengeria macropa , and the invasive red-clawed crayfish, Procambarus clarkii

Abstract : The endemic Colombian freshwater crab, *Neostrengeria macropa*, has recently encountered an invasive species in *Procambarus clarkii*, the Louisiana red- clawed crayfish. This Louisiana crayfish species has been identified across the United States, Central and South America, Europe and Asia. *P. clarkii* competes with *N. macropa* for shelter and likely for food as well as other characteristics that can define their ecological niche space. To predict which species will best compete for shelter resources, a series of behavior experiments were performed to determine the role of direct competition for shelter. This included individual behavior for space and shelter usage, competition within species for shelter usage, as well as between the two species. Preliminary data results, pending further video analysis, show that *P. clarkii* will outcompete *N. macropa* for shelter space. Conclusions that could be extrapolated from these data may include the types of behaviors that will lead crayfish to outcompete freshwater crabs native to Colombia and be used as a model in other geographical locations in the region. The invasive crayfish, which has spread to a vast geographical reach, may hinder the ecological function of other native species in freshwater waterways in Colombia if they outcompete members of this group of crab.

P1.31 HULETT, R.E.*; CHAN, D.K.; WETZEL, L.A.; KING, N.; University of California, Berkeley; *ryanehulett@gmail.com*

A rosette by any other name: Identifying cell type markers in the choanoflagellate S. rosetta

Choanoflagellates, the closest living relatives of animals, are a group of microeukaryotes found ubiquitously in aquatic environments. As the sister group to Metazoa, studying choanoflagellates may provide insight into the origins of animal multicellularity. The choanoflagellate, *Salpingoeca rosetta*, has an intricate life history and can transition between several unicellular and multicellular cell types. These cell types include attached thecate cells, slow swimmers, fast swimmers, chain colonies, and rosette colonies. Rosette colonies are robust (cannot be easily separated by mechanical force) clusters of at least three cells with organized polarity that develop through serial cell divisions. The complex life history of *S. rosetta* provides an excellent model to study the transition to multicellularity. However, while many *S. rosetta* cell types are morphologically distinct, we understand very little regarding the molecular mechanisms underlying these life history transitions; thus, it is necessary to identify molecular markers for distinct cell types in order to characterize these transitions. We tested a myriad of antibodies to identify markers that either differentially stain or localize within single cells and rosettes. Based on our initial screen, the following candidates seem promising for further investigation: procollagen, maIE, and pMLC.

P2.82 HUMFELD, SC*; MARSHALL, VT; SCHWARTZ, JJ; University of Missouri, University of Scranton, Pace University; *humfelds@missouri.edu*

Different call timing preferences in closely related species of gray treefrogs

In a variety of animal taxa, females often show preferences based on the relative timing of sexual advertisement signals produced by different males. Such preferences may be important selective forces on communication systems, leading to phenomenon such as synchronous displays or avoidance of overlap. We examined the preferences of female gray treefrogs, *Hyla versicolor* and *H. chrysoscelis*, for calls broadcast with different timing relationships by systematically modifying the interval between the onset of calls. At the longest intervals (900 and 1300 ms), calls did not overlap but exhibited a distinctive leader-follower timing relationship. At the shorter delays (25 and 250 ms), calls overlapped in time. In general, females of both species preferred the leading call. However, there were differences between the species as a function of call delay. Females of *H. chrysoscelis* maintained a preference for leaders over a greater range of delays than *H. versicolor*. However, at the very shortest delays (25 ms), females of *H. chrysoscelis* appeared unable to localize either sound source while females of *H. versicolor* exhibited strong preferences for leading calls. We discuss the species differences in the context of species-specific call structures and the possible action of the precedence effect.

P3.110 HUNT, N*; JINN, J; ROBIN, A; LEE, C.Y.; FAJARDO, I; HUANG, J; JACOBS, L.F.; FULL, R.J.; University of California, Berkeley; *nathaniel.hunt@berkeley.edu*

Squirrel parkour: wall-jump maneuver adds intermediate control point to ballistic trajectories

Targeted leaping across large gaps is a fundamental skill in arboreal environments where errors carry considerable risk. Animals lacking the ability to generate aerodynamic forces move along a ballistic trajectory towards a landing point. The center-of-mass trajectory is predetermined at initial take-off, because animals are unable to make mid-flight corrections. We found that free ranging fox squirrels (*Sciurus niger*) jumping from a launching beam to a landing perch, both attached to a wall, selectively established an additional control point mid-leap using a parkour-like wall-jump maneuver. In this maneuver, animals re-oriented some or all of their legs toward the vertical surface, generating substrate reaction forces to alter their trajectory before landing. We hypothesized that squirrels use the wall-jump maneuver for longer leaps. To test this, we systematically varied the horizontal distance between the launching beam and landing perch (0.5, 1.0, 1.5 m). We also varied vertical position (± 20 cm) at each perch distance along an isocline of constant impulse. Squirrels consistently used the wall-jump maneuver for medium and long leaps (ranging 3-5 body lengths), but not for short leaps (about 1.5 body lengths). Vertical variations in perch position did not affect the proportion of trials exhibiting the wall-jump maneuver. When squirrels used the wall-jump maneuver to reach lower perch heights, they generally decelerated during wall contact phase, leading to a reduction of horizontal velocity upon landing. During leaps to level and high height perch positions, the direction of acceleration varied significantly. Future manipulations may allow us to predict possible creative biomechanical solutions to maneuvering in complex environments.

P3.54 HUSAK, J. F*; ROY, J. C.; Univ. of St. Thomas; *jerry.husak@stthomas.edu*

Trade-offs among performance, growth, and immune function in juvenile lizards

Life history trade-offs result from differential allocation of acquired energetic resources to phenotypic traits. In adults this often manifests as a trade-off between traits promoting survival versus current reproduction. However, the nature of trade-offs may be age-specific, and this age-specificity may be sex-specific. We determined how several life-history traits that are key to survival and future reproduction trade off in juvenile green anole (*Anolis carolinensis*) lizards. Specifically, we examined trade-offs among locomotor performance (endurance), growth, and immune function. Previous work on adult green anoles showed that forced allocation to performance, via endurance training, resulted in dramatic performance enhancement but at the cost of decreased immune function. Training enhanced growth. There were also sex differences, with females having a stronger response to training but lower immune responses. We extended this approach to juveniles where resource allocation priorities should be different. Most resources should be allocated to growth, especially for males, and little to reproduction, but survival-enhancing traits should also be important. Captive male and female green anole lizards were either endurance trained on a treadmill or exposed to handling stress over the course of nine weeks. We measured endurance capacity, growth, and immune function (bacterial killing capacity of plasma and swelling response to phytohemagglutinin) at the end of the experiment to determine the nature of trade-offs. We also examined whether trade-offs and allocation priorities were similar to those seen in adults, testing which trait(s) took priority over others and whether there were sex differences in trade-offs or priorities.

P3.195 IBANEZ, G.G.*; JAYNE, B.C.; University of Cincinnati; *ibanezgg@mail.uc.edu*

The effects of size and shape of holes on the choice of refuge by snakes

A key feature of the ecology of many species of snakes is that when they are not active, they often hide beneath objects and within a wide variety of crevices and holes. Despite this well-known habit of snakes, experimental data are lacking regarding how the visual attributes of openings may affect their attractiveness for snakes seeking a refuge. Hence, we performed laboratory experiments with twelve boa constrictors to test whether variation in the dimensions of two dark holes affected where the snakes chose to take refuge. We initially placed the snakes so that their head was in the center of a large octagonal chamber, 2 m in diameter, with holes in the middle and bottom edge of each of two walls that were located at 45 degrees to the left and right of the initial position of the head of the snake. A total of six treatments included the following pairs of holes with variable width by height (WxH): 1) 1x1 vs. 1x2, 2) 1x1 vs. 2x1, 3) 1x2 vs. 2x1, 4) 1x1 vs. 2x2, 5) 1x2 vs. 2x2, and 6) 2x1 vs. 2x2. No significant preferences occurred in treatments 1-3. Hence, we did not detect a significant effect of the orientation of the long axes of the rectangular openings. For treatments 4-6 the snakes significantly preferred the large square opening compared to all of the other alternatives. The most significant preference ($P<0.001$) occurred for the large versus the small square, which was also the treatment with the greatest difference between the areas of the two openings. Thus, rather than preferring a tight-fitting openings, the preferences that we observed may have resulted mainly from an increased conspicuousness associated with a very large difference in the area of the openings.

P2.159 IMHOFF, V.E.*; GALLANT, J.; MULLEN, S.; Stephen F. Austin State University, Michigan State University, Boston University; *imhoffve@sfasu.edu*

Wing pattern evolution in North American Admiral butterflies

The evolution of wing patterning diversity in North American Admiral butterflies (*Limenitis spp.*) has been marked by the continued and often widespread hybridization between both species and different wing pattern races. Recent findings have identified variation in WntA is linked to mimetic wing pattern shifts in the *Limenitis arthemis* species complex. Previous work examining patterns of mitochondrial and genomic sequence divergence in admiral butterflies has shown strong support for a monophyletic North American lineage. However, the historical relationships of *Limenitis arthemis* subspecies have been difficult to characterize due to ongoing hybridization. For hybridizing taxa, phylogenetic relationships are complicated by genealogical discordance in most regions of the genome except those regions linked to genes responsible for species differences. In an attempt to better characterize the historical relationships among wing pattern races in the *Limenitis arthemis* species complex we present a nuclear phylogeny using variation in genes linked to wing patterning in *Limenitis, Heliconius*, and other butterfly species.

P3.124 INGLE, D.N.*; PORTER, M.E.; Florida Atlantic University, Boca Raton; *dingle2014@fau.edu*

Yield Strengths and Elastic Moduli of Vertebral Bodies in Cetaceans (Kogiidae and Delphinidae) and Sirenians (Trichechidae)

In fully aquatic mammals, the axial skeleton is a key anatomical feature powering locomotion. Previous research showed that mechanical behavior of the vertebral column partially mediates body deformation during axial locomotion, and that these behaviors vary regionally. Assessing mechanical properties of vertebral bodies provides insight on how bone of aquatic species responds to forces. The three goals of the present study are to (1) assess mechanical properties, yield strengths (MPa) and elastic moduli (MPa), in the axial plane of vertebral bodies, (2) compare yield strength and elastic moduli taking into account functional location and type of vertebrae, (3) compare mechanical properties of aquatic animals from this study with terrestrial mammalian bone from bovine models. Three vertebrae from the thoracic, lumbar, and caudal regions were sampled the following species: West Indian manatee (Trichechus manatus), common bottlenose dolphin (Tursiops truncatus), and pygmy sperm whales (Kogia breviceps). All soft tissue and bone projecting from the vertebral body were removed with a bone saw and sander. Vertebral bodies were tested under a compressive load at a displacement rate of 2mm/min until the material transitioned from the elastic to plastic region indicating yield. Yield strengths (MPa) were quantified as the maximum stress the vertebral body can withstand before being permanently deformed. Elastic moduli (MPa), the material's ability to resist compression, were calculated from the linear portion of the stress-strain curve. Density measurements were taken after the mechanical test to give a coarse estimate of microarchitecture of each vertebral body.

P1.80 ISLAM, KN*; BELOTT, CJ; CONSTANTINESCU, D; WIEGAND, A; MENZE, MA; Eastern Illinois University; *kislam@eiu.edu*

Concurrent expression of group 3 and 6 LEA proteins using multicistronic vector constructs in Drosophila melanogaster Kc167 cells

Adaptations in animals to survive severe desiccation (anhydrobiosis) are multifaceted and include expression of highly hydrophilic polypeptides termed late embryogenesis abundant (LEA) proteins. Several classification schemes for LEA proteins have been proposed. However, the brine shrimp, *Artemia franciscana*, is the only known animal that naturally expresses LEA proteins from three different classification groups (groups 1, 3, and 6). We hypothesized that proteins from groups 1 and 3 may function to aid cells in entering the anhydrobiotic state, while group 6 LEA proteins may be required to prolong viability in the dry state, or to ameliorate cellular damage during rehydration. To test our hypothesis, cell lines that transgenically express combinations of different LEA proteins have to be developed. We utilized Kc167 cells from the desiccation sensitive organism *Drosophila melanogaster* to express LEA proteins belonging to groups 3 and 6 concurrently from the same multicistronic vector construct by employing viral derived cis-acting hydrolase element peptides. Proteins encoded on the same mRNA strand are separated during translation in a process described as ‘ribosome-skipping'. Despite bacterial recombination of vector constructs during cloning of plasmids, our protein immunoblots illustrated that concurrent expression of multiple LEA proteins is possible in Kc167 cells. Experiments to investigate the effect of different combinations of LEA proteins belonging to group 3 and 6 on viability of Kc167 cells after rapid desiccation and rehydration are currently underway. Supported by NSF *IOS-1457061/IOS-1456809*.

P1.17 JACOBS, J.L.*; HUTTER, C.R.; GLOR, R.E.; California State University, Long Beach, University of Kansas Biodiversity Institute; *jjacobs228@gmail.com*

Phylogenetic Analysis of the Mantidactylus lugubris Complex with the Description of a New Species Endemic to Madagascar.

The frog family Mantellidae is endemic to Madagascar and the Comoros Islands and includes 207 described species. Recent research suggests a similar number of species remain undescribed. The *Mantidactylus lugubris* complex consists of two species of medium-sized stream-dwelling frogs, and six candidate species. Populations of *Mantidactilus cowanii* from Ranomafana National Park and the nearby area may represent a third species, *Mantilidactylus sp. 48*. We test the hypothesis that this population represents a distinct species using morphological and multilocus molecular phylogenetic data. Bayesian and maximum likelihood analyses of genes, 16S, POMC and RAG2 show that *Mantilidactylus sp. 48* is a monophyletic group that we propose to be elevated to species status. This research was supported in part by the National Science Foundation- Grant #DBI-126795

P1.81 JANIS, BR*; HAND, SC; MENZE, MA; Eastern Illinois University, Louisiana State University; *bjanis@eiu.edu*

A computational analysis of LEA proteins from Artemia franciscana

Embryos of the brine shrimp, *Artemia franciscana*, employ a set of highly hydrophilic polypeptides, termed LEA proteins, to survive severe desiccation. Most LEA proteins belong to a larger group of intrinsically disordered proteins (IDPs), which have little or no well-defined secondary structure at physiological water concentrations. However, LEA proteins become more ordered at low water concentrations during desiccation. Unlike other anhydrobiotic animals which only express group 3 LEA proteins, *A. franciscana* expresses proteins from multiple groups; groups 1 (AfrLEA1.3), 3 (AfrLEAI, AfrLEA2, AfrLEA3m), and 6 (AfrSMP). By employing a number of bioinformatics approaches, we assess potential folding patterns at low intracellular water concentrations as well as potential functions based on predicted secondary structures. According to MeDOR analysis, group 1 LEA proteins, do not appear to become very ordered, even at low water concentrations. In contrast, group 3 LEA proteins exhibit about 50 - 60% of ordered regions, often forming alpha helices. Using Heliquest and DeepView, we predict that some of these alpha helices are amphipathic, which implies a potential for membrane interactions. Additionally, AfrLEAI has a unique spacing of proline residues (~44-40 aa apart) surrounded by hydrophobic residues that separate the predicted helices. Furthermore, GlobPlot analysis suggests three regions of coiled-coil structure in AfrLEAI. PONDR analysis suggests that AfrSMP is an atypical LEA protein, which becomes more disordered as the cell desiccates. Transgenic expression and purification of AfrLEAI, AfrLEA1.3, and AfrSMP are currently underway, and experiments to support these predictions will be performed when isolated proteins become available. Supported by NSF *IOS-1457061/IOS-1456809*.

P2.92 JAWORSKI, KE*; HICKERSON, C-AM; ANTHONY, CD; Christopher Newport University, John Carroll University; *kortney.jaworski@cnu.edu*

Male mate choice as a potential mechanism for assortative mating in a polymorphic salamander (Plethodon cinereus)

Color polymorphism is often associated with variation in ecological and behavioral traits which may affect individual fitness. For traits involved in mate acquisition, this association could promote non-random mating and isolation among morphs. The redbacked salamander (*Plethodon cinereus*) exhibits a color polymorphism that involves two discrete dorsal-pattern morphs, striped and unstriped. Both morphs co-occur across much of the species' range, and several studies have revealed ecological and behavioral differences between morphs. Additionally, recent studies support that male and female *P. cinereus* associate assortatively by color, suggesting that they may also mate nonrandomly. However, the mechanisms contributing to this behavior remain unclear. Although many studies focus on female mate choice, male mate choice may be a more appropriate candidate for driving assortative mating in this species, particularly because males of this species display a swollen vomeronasal organ during the breeding season and striped males tend to associate with large, striped females. Here we sought to determine 1) whether males preferentially associate with females with respect to color, body size, or both, during the breeding season and 2) whether female traits are evaluated via visual or chemical cues. To investigate these questions, we conducted two experiments which examined striped male behavior toward olfactory and visual cues of striped and unstriped females. We used a Bradley-Terry tournament-style model to reveal that female morph and body size predict male mate-preference. These results provide evidence for a role of assortative male preference in the non-random mating associations observed in this population of *Plethodon cinereus.*

P3.18 JAY, KR*; OBERSKI, JT; COBLENS, MJ; SHARMA, PP; BOYER, SL; Macalester College, Univ. of Wisconsin, Madison; *kjay@macalester.edu*

Six new species of mite harvestmen from Australia's Wet Tropics biodiversity hotspot

Mite harvestmen are a globally distributed suborder of tiny cryptic arachnids (2-5 mm in length) that inhabit leaf litter and cave habitats. They are highly dispersal-limited, making them ideal for fine-scale historical biogeographic studies. The mite harvestman genus *Austropurcellia* is distributed throughout tropical rainforests along the eastern coastline of Queensland, Australia, with the majority of its diversity found within the Wet Tropics of northeast Queensland, a region known for its exceptionally high biodiversity and endemism. Due to their limited capacity for dispersal and their ability to persist even in small rainforest fragments, mite harvestmen in the Wet Tropics can provide insight into the role of climatic changes such as rainforest contraction in shaping rainforest biodiversity patterns. In recent years, *Austropurcellia*'s range has been thoroughly surveyed through examination of field and museum collections and there are currently 19 described species within the genus, including 15 species from the Wet Tropics. For the current study, male specimens were dissected and mounted on stubs for scanning electron microscopy (SEM) in order to assess morphological differences and determine species identities. Morphological analyses support the finding of six new species of mite harvestmen from the Wet Tropics rainforests, and are corroborated by molecular data from three loci (COI, 18S rRNA, and 28S rRNA). Emerging biogeographic patterns within *Austropurcellia* show concordance between geographic distribution, morphology, and phylogeny; distinct clades are distributed in different regions within the Wet Tropics, supported by a phylogeny using Bayesian inference analyses as well as by similarities in morphology within clades.

P3.68 JIMENEZ, A.J.*; BURNETT, L.E.; BURNETT, K.G.; College of Charleston, SC; *alessjjimenez@gmail.com*

Effects of bacterial exposure on predator escape response in Atlantic brown shrimp, Farfantepenaeus aztecus

In crustaceans, hemocytes rapidly aggregate and bind bacteria that breach the exoskeleton. These aggregates can become lodged in gill microvasculature and impair O_2 uptake, decreasing aerobic metabolism. In shrimp, tail-flipping is a predator escape response fueled by anaerobic energy stores. When depleted by activity, these stores are replenished aerobically. We hypothesized that exposure to bacteria would impair recovery from muscle fatigue in Atlantic brown shrimp *Farfantepenaeus aztecus*. Shrimp were injected with saline or a sublethal dose (2.5×10^5 g^{-1}) of bacterium *Vibrio campbellii*. At 4 or 24 h after injection, shrimp were repeatedly induced to tail-flip to fatigue (initial tail-flips). After 20 min recovery in well-aerated water, shrimp were induced to tail-flip to fatigue again. Recovery from fatigue was expressed as the number of tail-flips in the second bout of activity as a percentage of initial tail-flips. Contrary to expectation, bacterial exposure had no significant effect on recovery from fatigue. However, in the 4 h but not the 24 h group, shrimp exposed to bacteria performed significantly more initial tail-flips than saline-injected controls (mean 50.86 ± 3.62 SEM and 35.25 ± 3.62 tail-flips, respectively; $p = 0.005$). We speculate that shrimp exposed to bacteria upregulate arginine kinase, an enzyme essential to the creation of anaerobic energy stores, driving an increase in initial tail-flip activity. These results suggest that predatory escape behavior in shrimp as measured here is resilient to fluctuations in aerobic metabolism (NSF DBI-1359079, IOS-1147008).

P2.179 JIMENEZ, Y.E.*; LAURENCE-CHASEN, J.D.; CAMP, A.L.; BRAINERD, E.L.; Brown University; *yordano_jimenez@brown.edu*

Where does the vertebral column bend during suction feeding in fishes? A comparative study of axial bending during cranial elevation

During suction feeding, many fishes use their epaxial muscles to generate a substantial amount of power to produce cranial elevation. When the muscles contract they reduce the angle between the head and body, causing the axial skeleton to bend dorsoventrally. Without axial bending, cranial elevation would be limited and feeding performance would decrease. The goal of this study is to locate where the vertebral column bends during suction feeding and relate this to the axial morphology of different species. We collected and analyzed live feeding data from three species (largemouth bass, pacific staghorn sculpin, and striped surfperch) using 3D animation techniques. CT scans were also analyzed with a focus on the shapes and spacing of the vertebrae, neural spines, and pterygiophores. Each of the three species had unique axial skeletons comprising differently shaped and spaced vertebrae, neural spines, and pterygiophores. We hypothesized that the axis of rotation for each species is located in the anterior-most region of the vertebral column, specifically between the vertebrae with the greatest space between the neural spines and pterygiophores. Preliminary data suggest that bending at the intervertebral joints (IVJs) is fairly consistent within a species, although different species bend at different IVJs. Given the great deal of interspecific variation of the axial skeleton, it is important to investigate the role of these different morphologies in suction feeding.

P2.102 JOERSZ, WB*; DAYGER, CA; WHITEMAN, R; LUTTERSCHMIDT, DI; Portland State Univ, OR; *wjoersz@pdx.edu*

Blocking corticosterone synthesis increases androgens but not spermatogenesis in red-sided garter snakes, a dissociated breeder.

Glucocorticoids fuel energetically demanding life-history stages, but can also suppress reproduction. In many taxa, reciprocal hormone-behavior interactions make it difficult to assess the effects of glucocorticoids on gonad function independently from changes in reproductive behavior (e.g., sexual experience itself can alter sex steroids). In this study, we used a dissociated breeder, red-sided garter snakes (*Thamnophis sirtalis parietalis*), to determine if glucocorticoids alter two measures of testis function: sex steroid hormone synthesis and spermatogenesis. Because males mate during the spring and undergo spermatogenesis during the summer, the influence of glucocorticoids on gonad function can be determined independently of breeding activity. As in our prior studies, we manipulated glucocorticoids with subcutaneous elastomer implants mixed with corticosterone, metyrapone (a glucocorticoid synthesis inhibitor), or no hormone. Blood samples were collected at 0, 3 and 6 wks post-implant treatment; a subset of snakes in each group was euthanized at 3 and 6 wks post-treatment and the testes were sliced on a cryostat and counterstained. Seminiferous tubule diameter was measured for 25 tubules per snake as an indirect assessment of spermatogenesis. Similar to previous studies, plasma corticosterone did not differ significantly among groups, indicating strong endogenous control of corticosterone. However, androgens increased over the course of the experiment and were significantly elevated in metyrapone-treated snakes. Seminiferous tubule diameter did not differ among groups despite the differences in androgens. These data suggest that corticosterone suppresses gonadal sex steroid synthesis but not spermatogenesis in this dissociated breeder.

P1.170 JOCQUE, H.L.*; BUBAK, A.N.; RENNER, K.J.; SWALLOW, J.G.; University of Colorado Denver, University of Colorado Denver-Anschutz Medical Campus, University of South Dakota; *harperjocque@gmail.com*

Influence of chronic exposure to an SSRI on stalk eyed fly (Teleopsis dalmanni) locomotion, brain monoamines, and morphology

Fluoxetine, used as an antidepressant and anti-anxiety drug and branded as Prozac, Sarafem, and Rapiflux, is a common pharmaceutical contaminant in waterways. In this study the stalk eyed fly (*Teleopsis dalmanni*) was used to explore the possible impacts on insect behavior, morphology, and neurotransmitters by chronic exposure to fluoxetine. Fluoxetine is a selective serotonin reuptake inhibitor (SSRI) which increases the serotonin available to bind postsynaptic cells. Serotonin is a conserved biogenic monoamine found primarily in the central nervous system and enteric nervous system in both invertebrates and vertebrates. Serotonin influences such diverse processes as cognitive function, locomotion, and appetite. During the *T. dalmanni* larval stage, nutrient intake contributes to ultimate adult size. Adult males have significantly longer eyestalks than females, and males with greater eye-spans succeed more often in aggressive conflicts over resources. Serotonin mediates larval locomotion and light response in other dipterans, and brain serotonin levels play an important role in determining *T. dalmanni* contest outcomes. This study examined the influence of fluoxetine on *T. dalmanni* larvae and adults across behavioral, morphological and neurochemical measures. Larvae experienced chronic oral dosing of 0.2 mg/g fluoxetine or received control food lacking any drug. Third instar larvae locomotion and phototaxis were quantified. Adult eye-span, body length and locomotion were measured. Both larval and adult brain monoamine levels were analyzed. Results suggest that fluoxetine influences the development and behavior of *T. dalmanni*. These will be discussed in the context of the serotonergic system and the presence of pharmaceuticals in the environment.

P1.69 JOHNSON, E.S.*; ALLEN, J.J.; SWARTZ, S.M.; Brown University; *elissa_johnson@brown.edu*

Life on the Trailing Edge: Muscle and Elastin Structure in Bat Wings

Bat wings contain muscle and elastin fibers embedded in thin, compliant membranes. These structures are present in all bat species studied to date and are thought to affect the extensibility and camber of the wing during flight. Determining the structure and arrangement of these fibers is critical to understanding the aerodynamic performance of the membrane. Using histological techniques, we examined the trailing edge of Seba's short-tailed fruit bat, *Carollia perspicillata*. In this species, the spanwise, caudalmost edge of the armwing comprises two layers of collagen surrounding an array of muscle cells and a large elastin fiber, composed of small fibrils. We examined the arrangement of the muscle cells and elastin fiber along the length of the trailing edge of the armwing, and investigated the mode of attachment of both tissue types at its proximal (hind limb) and distal (digit V) ends. Many muscle cells originate at the tibia, run spanwise along the trailing edge, and insert within the membrane. The large elastin fiber at the trailing edge widens (35µm to 265µm) rostrocaudally as it extends distally. The presence of muscles near the trailing edge suggests that *C. perspicillata* has some active control of this part of the wing membrane. The muscles might provide proximal stiffness when contracted or reduce skin looseness during upstroke. The large elastin bundle could act as a "hem" that prevents tearing while providing stability and durability. It may also help fold the wing during upstroke or keep the trailing edge taut, reducing flutter throughout the wingbeat cycle. Studying the morphology of the trailing edge of bat wings can inform our understanding of how skin is modified for flight and improve the design of compliant, membranous materials that encounter aerodynamic forces.

P3.19 JOHNSON, JE*; IMAGAWA, M; SHARMA, PP; BOYER, SL; Macalester College, Univ. of Wisconsin, Madison; *jjohns21@macalester.edu*

A new armored harvestman species from Queensland, Australia identified using morphology and DNA

A new armored harvestman species from the Wet Tropics of Queensland, Australia is identified using morphology and DNA. This new species from the genus *Zalmoxis* is described and illustrated using light microscopy and scanning electron microscopy (SEM). Shape of the body, coloration of carapace, and ornamentation of the body and legs are used in preliminary assessment of the morphologically distinct characteristics in this species. Light microscopy and SEM images were taken of specimens and were used to compare with each other and images from morphological descriptions in published literature. We sequenced the mitochondrial gene cytochrome oxidase 1 (CO1) and nuclear gene histone-3 (H3) and used the data to generate a maximum likelihood phylogeny in RAxML. The resulting tree strongly supported the monophyly of *Zalmoxis* n. sp. nested within *Zalmoxis*, and the monophyly of all Australian Wet Tropics (AWT) *Zalmoxis* species. ArcGIS was used to map the known distribution of *Zalmoxis* n. sp., which is limited to the central Wet Tropics, south of the Black Mountain Corridor and slightly overlapping the range of *Z. cardwellensis*. The morphological, molecular, and geographical data support the discovery of this new species of *Zalmoxis* from the Wet Tropics although further work needs to be done to explore the diversity of this genus and address unresolved phylogenetic relationships within *Zalmoxis*.

P1.208 JOHNSON, K.M.*; LEMA, S.C.; Cal Poly State Univ., SLO; *kaitlin.johnson24@gmail.com*

Nonylphenol disruption of osmoregulation in the gill of the estuarine arrow goby Clevelandia ios

Recent evidence indicates that some of California's coastal estuaries are contaminated with the chemical 4-nonylphenol (4-NP). The compound 4-NP is a well-established endocrine-disrupting chemical with estrogenic properties, and exposure to 4-NP has been found to alter estrogen hormone signaling in many marine organisms. In fish, estrogen itself can modulate osmoregulatory function and we hypothesize that estuarine fishes exposed to 4-NP in California's estuaries might suffer deleterious impacts due to impaired osmoregulatory abilities in the rapidly changing salinity conditions of coastal estuaries. The aim of our study is thus to determine if 4-NP interrupts the ability of the estuarine arrow goby (*Clevelandia ios*) - a benthic fish abundant on the mud flats of California's estuaries - to osmoregulate under changing salinity conditions. Adult mixed-sex arrow gobies were exposed in seawater (33 ppt) to either high dose 4-NP (100 ug/L), low dose 4-NP (10 ug/L), 17 -estradiol (50 ng/L; positive control), or ethanol vehicle only (negative control) for 12 days. Fish were collected from each treatment tank at times representing either a baseline (0 hrs; all fish at 33 ppt salinity) sample, or at 6 hrs or 24 hrs time points following transferred to tanks containing water of 33 ppt (control), 20 ppt, or 5 ppt salinity. Gills tissue was dissected from each fish for evaluation of Na+/K+ ATPase enzyme activity, and for quantification of relative gene expression levels for several ion and water transport proteins (e.g., sodium-hydrogen exchanger-3, nhe3; aquaporin-3, aqp3) critical for maintaining osmotic balance during seawater to fresh water salinity transitions.

P2.74 JOHNSON, S.P.*; FERREE, E.D.; Pitzer College, Pitzer, Scripps, and Claremont McKenna Colleges; *sjohnson@students.pitzer.edu*

Group formation in the facultatively aggregating spider, Nephila clavipes

Although the vast majority of spiders are solitary, several species are strictly colonial, while others, such as the orb weaver *Nephila clavipes*, variably aggregate or remain solitary. These latter species can provide insights into the conditions favoring social behavior in spiders. We have found that clustering in *N. clavipes* is generally most favorable for small spiders, which have reduced predation rates if clustered than if solitary, but that temporal variation in predator and prey abundance correlate with the trade-offs and frequency of clustering. In this study we documented the formation of clusters in *N. clavipes*, testing the prediction that small spiders should drive cluster formation, particularly in years when predators are abundant. Assuming groups provide protection, spiders experiencing a previous predation attempt might also be motivated to cluster. We assessed how spider size and leg autotomy related to the order in which spiders moved into and out of a cluster. We observed 400 webs in each of three years, finding that in the year of highest predation, small spiders were three times more likely to create a two-spider cluster than were medium spiders, but that small and medium spiders left clusters with the same frequency. We discuss variation among the study years and implications for the evolution of social behavior in spiders.

P3.115 JOHNSON, L.E.*; SCHMITT, D.; University of Arizona - College of Medicine Phoenix, Duke University; *lauraejohnson@email.arizona.edu*

Limb kinematics during vertical clinging and grasping in eight primate species

An animal's ability to maintain a vertical clinging or grasping posture against gravity is constrained for species without claws or adhesive pads. These animals must in theory use cheiridial anatomy, body geometry, and muscles to generate enough force normal to the vertical support to avoid slipping or rotating away from the substrate. Available models predict changes in posture and grip to maintain position based on body mass, substrate diameter, and locomotor mode, yet little empirical data exist to test these models. Within primates, strepsirrhines are an ideal group to study as species span a range of body masses and include species of many locomotor modes with some specialized for vertical clinging and leaping. Eight species with a range of body masses (150-4000g) and locomotor modes were prompted to vertically cling or grasp on three substrates of increasing diameter. Individuals were filmed by two videocameras in order to calculate limb joint angles in three dimensions. These data indicate that there is a differentiation in the functional role between the forelimb and hindlimb. The forelimb joint angles are similar between species, where mean elbow angles for all species on all substrates is 77°, with a minimum mean of 61.1° and maximum mean of 90.8°. In contrast, hindlimb joint angles are more complex. Hindlimb angles differ between species, with locomotor mode explaining much of the variance. Variance in knee angles for all species on all substrates was high, with a mean of 65.8° and a minimum mean of 17.5° and a maximum mean of 101.6°. These results support previous notions of the different functional role of the fore- and hindlimb in primates and may play a role in the unusual hindlimb-dominant weight support pattern in strepsirrhines.

P1.24 JONES, B.M.*; SIKES, J.M.; Univ. of San Francisco, Univ. of San Franciso; *bmjones@usfca.edu*

Cellular and molecular regeneration dynamics in an acoel flatworm

Regeneration abilities are present in a variety of Metazoan taxa, but the mechanisms underlying regeneration have only been characterized in select model organisms. Acoels are highly regenerative, small marine worms with a contentious phylogenetic position as basal bilaterians. While regeneration is common among acoels, the developmental patterns of regeneration have only been thoroughly investigated in a single species. In this study, we have characterized the cellular and molecular dynamics of regeneration in *Convolutriloba longifissura*, a derived large-bodied acoel with an extensive population of neoblasts and robust regeneration abilities. Transverse and longitudinal amputations resulted in both epimorphic and morphallactic regenerative mechanisms. During both anterior and lateral regeneration, *C. longifissura* undergoes high levels of cell proliferation resulting in blastemas that later differentiate while posterior regeneration occurs largely through tissue remodeling with limited cell proliferation. We are currently investigating the neoblast dynamics that allow for *C. longissura*'s extensive regenerative abilities by elucidating the spatiotemporal expression of *piwi* and other stem cell-related genes during all stages of the regeneration process.

P1.204 JOSEFSON, CC*; BENTZ, AB; HOOD, WR; WADA, H; Auburn University, University of Georgia; *ccj0011@auburn.edu*

Epigenetic and neuroanatomical changes associated with early-life exposure to exogenous corticosterone in Eastern Bluebird (Sialia sialis) nestlings

Mounting evidence from both field and laboratory studies suggest that the perinatal environment can have permanent effects on adult physiology. The avian brain is particularly vulnerable to hormonal fluctuations during the first few months post-hatch due to rapid neurodevelopment, particularly in telencephalic song nuclei. Past literature has found that elevated corticosterone (CORT) during this sensitive post-hatch period is correlated with decreased song quality. To date, few studies have examined mechanisms behind this physiological modification associated with changes in the developmental environment. One possibility is that CORT alters the epigenetic status of the neural glucocorticoid receptor (GR) via DNA methylation. Changes in methylation status may alter gene expression, thus leading to downstream changes in both neuroanatomy and phenotypic expression. Here, we examine the effects of the administration of oral CORT to wild Eastern Bluebird nestlings on the volume and area of telencephalic song nuclei. Further, we are assessing the methylation status of the GR promoter using bisulfite sequencing. Our results have the potential to help elucidate a mechanism behind physiological priming during development.

P1.173 JUNG, J*; KIM, SJ; GUELL, BA; COHEN, KL; WARKENTIN, KM; Boston Univ, Univ of California, San Diego; *jungj@bu.edu*

Ontogeny of escape hatching in red-eyed treefrogs: onset of response to flooding and attack cues

Arboreal embryos of *Agalychnis callidryas* hatch prematurely to escape from both egg predators and hypoxic conditions, which kill eggs too young to hatch. To assess the developmental timing of response onset and potential limiting mechanisms, we tested embryo hatching-responses in developmental series of 11 sibships. Every 3 h, we tested 2 eggs per clutch by submerging them in hypoxic water or manually stimulating them with a simulated attack cue. Immediately after trials, we decapsulated unhatched embryos and photographed animals to assess development. To examine the potential role of otic mechanoreception in hatching for attack-cued individuals, we measured the roll-induced vestibulo-ocular reflex (VOR), in which eyes roll counter to body roll based on vestibular sensory input. We used confocal fluorescence microscopy with phalloidin staining to assess ear development across the onset of attack-cued hatching and of VOR. Across sibships, hatching responses to hypoxia began on average at 84 h, 8 h before attack-cued hatching. Also response consistency increased more rapidly and onset timing showed less variation across clutches, compared with responses to attack cues. Hatching ability is clearly not the sole constraint on the developmental onset of escape-hatching responses to attacks. The onset of hatching in response to attack cues coincided with the onset of VOR. Based on initial confocal images, stereociliary bundles start to appear in simple otic capsules shortly before the onset of VOR and attack-cued hatching, and there is substantial ear development across the onset of the hatching response. Ontogenetic coincidence of the appearance of inner ear mechanosensors, VOR, and hatching in response to simulated attack supports a role for developing ears in the perception of predator cues.

P2.81 KAATZ, I. M.*; STEWART, D.J.; LOBEL, P. S.; unaffiliated, SUNY ESF Syracuse NY, Boston University, Boston MA; *imkaatz@yahoo.com*

Vocal ridge morphology of callichthyid catfishes: variation within and similarities across species of the Corydoradinae

Callichthyid catfishes produce sounds by pectoral spine stridulation in agonism and reproduction. Vocal ridge shape can be acute and rounded within individuals for the subfamily Corydoradinae and is similar across species. Dorsal process ridge width and inter-ridge distance is similar across species. To determine whether species' mechanisms are convergent or have diverged we counted dorsal process ridge number for adult specimens (17 species, four genera) using scanning electron and dissecting microscopes. Scleromystax ridges ranged 34 to 45 (39 + 4 SD, n = 6 individuals). Aspidoras ridges ranged 19 to 44 (36 + 9, n = 6). Brochis ridges ranged 59 to 81 (68 + 8, n = 6). Corydoras pooled species ridges ranged 38 to 76 (55 + 9, n = 70). Ridge number correlated with body size (SL) for Corydoras species pooled ($r2 = 0.2293$, $p < 0.00002$). Total ridges per species for 14 Corydoras species (n = 4 to 9 individuals/species) positively correlated with body size (SL) for three species ($r2 = 0.6834$ to 0.9772, $p<0.04$ to 0.001). Specimen standard length was similar (4.0 cm + 0.8 SD, 2.3 - 7.5 cm, n = 89). The presence of vocal ridges in all specimens suggests that both sexes could vocalize. Correlation of ridge number with body size for some species and the similarity in adult size for many species in the Corydoradinae suggests that if species differ in vocal communication signals this would have to be accomplished by variation in vocal muscles, their origins or insertions and neural control.

P2.176 KACZMAREK, E. B.*; GIDMARK, N. J. ; University of Washington, Friday Harbor Laboratories; *elskabette@gmail.com*

The force-length relationship of skeletal muscle as a biomechanical adaptation to trophic niche in salmonid fishes

Specialized feeding behavior is generally reflected not only in skeletal anatomy (as has been the major focus of functional morphology literature) but also in muscular morphology and physiology. We show that this is the case for salmon feeding mechanics of king and pink salmon. King salmon (*Oncorhynchus tshawytscha*) eat small, fast fish, and pink salmon (*Oncorhynchus gorbuscha*) primarily filter feed on planktonic organisms by keeping their mouths open while swimming. Salmon close their jaws using the adductor mandibulae, which, like all skeletal muscles, is constrained by a strict relationship between muscle length and force. Muscles that are over-stretched or over-shortened exert weaker forces than they do at optimal length, and muscle length corresponds to gape. We compared king and pink salmon by measuring the force-length curves of their adductor mandibulae and demonstrated that in king salmon, maximum bite force is achieved close to maximum gape (67% of max gape, n = 3). This may allow them to take advantage of optimal muscle length, and thus greater force production, when eating large or elusive prey. In pink salmon, the force-length curve is centered at a smaller relative gape that is closer to mid-gape (43% of max gape, n = 6). This may facilitate filter feeding, allowing reasonably high forces at all gapes. The optimal gapes of each species were significantly different with a p-value of 0.0282. The different feeding preferences of these species may have put different pressures on the evolution of jaw muscle physiology, resulting in distinct optimal solutions to the force-length constraint.

P2.27 KAJIURA, SM*; TELLMAN, SL; Florida Atlantic University; *kajiura@fau.edu*

Seasonal Shark Abundance in South Florida

Southeast Florida experiences an enormous seasonal influx of upper trophic level marine predators each year as blacktip sharks (*Carcharhinus limbatus*) form massive aggregations in nearshore waters. The narrow shelf and close proximity of the Gulf Stream Current to the Palm Beach County (PBC) shoreline constrain tens of thousands of sharks to the shallow, coastal environment. This natural bottleneck provides a unique opportunity to estimate abundance. Over a four year period, a biweekly aerial survey was flown along the length of PBC and the number of sharks within 200m of shore was directly counted. Shark abundance peaked in the winter (January-March) at over 12,000 individuals, and declined to nearly zero in the summer months. This corresponds to a maximum density of over 800 sharks km^{-2}. Because these numbers represent only the sharks immediately adjacent to the shoreline, they are a gross underestimate of the total number of sharks present. Shark abundance was inversely correlated with water temperature with sharks found in large numbers only when water temperatures were less than 25°C. These baseline abundance data can be compared to future studies to determine if shark population size is changing and if sharks are restricting their southward migration as global water temperatures increase.

P1.100 KAHN, A.S.*; LEYS, S.P.; University of Alberta, Edmonton, Canada; *kahn@ualberta.ca*

Feeding and carbon flow through glass sponge reefs, or, how and where sponge reefs catch their food

Filter feeding by glass sponges, especially in dense communities such as reefs, is an important process that couples a pelagic microbial food supply - typically not an accessible food source to other animals - with benthic communities. Filtration of bacteria supplies carbon to sponge reefs, but given high densities and feeding rates in reefs, how do sponges capture enough food and what is the flow of carbon that passes through the reefs? We studied the feeding behavior, from particle capture to excretion, of *Aphrocallistes vastus* fed 0.1 µm, 1 µm beads, and bacteria using scanning electron microscopy and tracking ^{13}C-labeled bacteria. At 15 minutes post feeding (mpf) bacteria and beads were in canals and actively phagocytized into the primary and secondary reticulum. However, 60 mpf, phagocytic vesicles full of undigested bacteria were visible in other tissues distant from flagellated chambers. By 8 hours pf (hpf), larger phagocytic vesicles were visible in the primary reticulum. By 24 hpf, phagocytized particles were seen in vesicles in the trabecular syncytium. Pulse-chase feeding of ^{13}C-labeled bacteria showed a rate at which carbon consumed by the sponge passed through its body and how much remained in its tissue. The water that washes over sponge reefs comes from deep and surface water, from the nearby Fraser River, and from sediments resuspended among sponges. Stable isotope data show that different reefs feed on distinct food sources, which supports previous findings that reefs require trophic subsidies from currents and which may explain their ability to form dense reefs. Reef sponges, which live at densities of up to 46 m^{-2}, manage to sustain themselves through highly efficient particle capture and by growing in regions with a variety of food inputs.

P1.7 KANE, E. A. *; BRODER, E. D.; WARNOCK, A. C.; BUTLER, C. M.; JUDISH, A. L.; ANGELONI, L. M.; GHALAMBOR, C. K.; Colorado State University, College of Natural Sciences Education and Outreach Center, Colorado State University, College of Natural Sciences Education and Outreach Center, Colorado State University; *emily.kane@colostate.edu*

Using self-guided "guppy kits" to teach adaptation and evolution with authentic science

The concept of evolution is central to our understanding of organismal biology, but the United States has a poor understanding and acceptance of evolution compared to other countries, which is potentially influenced by the limited availability of evolutionary biologists that can assist teachers when covering this subject. We want to fill this gap by making our knowledge and resources easily accessible to teachers. Additionally, we want to use authentic science and hands-on experimentation to reach students who are not comfortable with the concept of evolution. We have designed a self-guided activity that utilizes live Trinidadian guppies (*Poecilia reticulata*) to explore adaptation, selection, and evolution. These "kits" include a video introduction by the researchers, activities observing differences in color and survival between 3 populations (domesticated and wild caught low- or high-predation), and a booklet providing guidance on the formation of hypotheses and conclusions. These kits can be used by the researchers for outreach events sponsored by the university, but can also be borrowed by local K-12 teachers to be performed independently, thereby enhancing the ability to reach a greater number of students while maintaining the benefits of a small-scale program. Similar activities performed previously demonstrate an increased retention compared to traditional lessons. Therefore, our goal is to use these kits to supplement local K-12 education, particularly at schools with under-represented populations.

P2.146 KARAN, EA*; WAINWRIGHT, DK; COLLAR, DC; Harvard University, Christopher Newport University; *e.annekaran@gmail.com*

A comparative study of damselfish scale morphology

Fish scales show tremendous morphological diversity, but relationships between scale morphology, ecology, and evolution are largely unknown. We use damselfish (Pomacentridae) to investigate the evolution of fish scale morphology and how scale shape changes with body shape and ecology in a comparative context. Pomacentrids are the third most diverse family of reef fish with close to 400 species. We collect 3D, 2D, and linear scale morphology data for 59 species of pomacentrids, using three to five individuals per species and sampling two areas of the body for each individual. Using published datasets and phylogenies, we investigate patterns between scale and body shape, as well as scales and feeding ecology. Our data show that anemonefish have smaller scales compared to other damselfish, perhaps tied to their association with anemones. Qualitatively, closely related damselfish seem to have similar scales compared to distantly related species, with the exception of species with extreme body shapes. We use data from a three-dimensional surface imaging system to compare scale morphology with modern methods for the first time, providing a framework for future studies in comparative scale morphology.

P2.105 KASSAB, H.D.*; ABOLINS-ABOLS, M.; KETTERSON, E.D.; Indiana University, Bloomington; *hkassab@iupui.edu*

MELANIN-BASED FEATHER ORNAMENTS IN BIRDS: AN INVESTIGATION OF HORMONE RECEPTOR SENSITIVITY

According to the honest signaling hypothesis, signal reliability depends on cost such that only high quality individuals can afford to signal. To assess cost, the mechanisms that link ornaments and individual quality must be understood. Bird feathers are one of the most striking examples of variation in nature. Importantly, some of the variation in ornaments have been shown to act as signals of the quality of an individual and enhance fitness by increasing the probability of attracting a mate. In some instances feather size and color are mediated by the steroid hormones testosterone and corticosterone, which can bind directly to feather follicles and have been associated with immune competence. We examined whether the size of a specific melanin-based feather ornament used in attracting mates and signaling status - the white outer tail feathers of Dark-eyed junco (*Junco hyemalis*) - is mediated by hormonal signaling. In particular, we investigated the abundance of androgen receptor (AR) and estrogen receptor (ER) in feathers, and compared receptor abundance among males of varied ornament size and between different feathers from the same individual. We hypothesized that white tail feathers would be more sensitive to hormonal regulation than white-black or black tail feathers. Preliminary results indicate that dark inner tail feathers have higher expression of AR than white outer feathers. However, feathers show a negative relationship between AR expression and percent-dark area. We found no significant relationship between ER expression and feather color. Future directions for study include investigating the location of AR in the developing feather tissue to further elucidate the role of testosterone in mediating ornament size.

P3.27 KELLER, E.L.*; CAFFRAY, T.E.; BERKE, S.K.; DORGAN, K.M.; BELL, S.S.; ROBERTSON, A.; BALTZER, K; CLEMO, W.C.; GADEKEN, K; Siena College, Dauphin Island Sea Lab, University of South Florida; *skberke@gmail.com*

Oxygen fluxes in Gulf of Mexico sediments

Quantifying the linkages between individual organisms, communities, and ecosystem function is of fundamental importance for ecology. In shallow water marine systems, biogeochemical fluxes at the sediment-water interface are an especially important component of ecosystem function. We seek to link oxygen fluxes to community composition in the northern Gulf of Mexico while simultaneously examining the effects of oil exposure on community structure and function. Sediment metabolism was measured in vegetated and unvegetated shallow subtidal habitats in Tampa Bay and in the Chandeleur Islands. The Chandeleurs are a chain of uninhabited barrier islands that experienced variable oiling during the Deepwater Horizon spill; Tampa Bay, in contrast, experienced minimal oiling. Measurements were made in 6-inch cores, which were subsequently sieved for infauna. Emerging patterns suggest that oxygen uptake by sediments is generally higher in seagrass habitats than unvegetated ones, an effect which persists even when aboveground seagrass biomass is removed. Substantial variability exists among sites, however, and may well be explained by the community composition within cores and/or by the history of oiling from the Deepwater Horizon spill at each site. Together, these data will provide further insight into linkages between communities and ecosystem function in benthic habitats, while also providing a baseline for understanding how ecosystems are affected by anthropogenic events such as oil spills.

P2.85 KELLEY, M.D.*; MENDONCA, M.T.; Auburn University; *mdk0014@auburn.edu*

Contribution of sensory modalities on courtship in the Gopher tortoise Gopherus polyphemus

Communication, a product of sensory perception, is key to individual relationships, especially when organisms are spatially far apart in an increasingly fragmented environment. The Gopher tortoise *Gopherus polyphemus*, a recent species of special concern, is a long-leaf pine specialist often spread far apart from conspecifics. Distance between mating individuals could reduce the number of mating opportunities, a serious concern in a declining species. Currently, little is known about tortoise sensory perception and how individual tortoises locate each other for mating. In this study, a total of 33 paired trials (11females and 22males) in the months of April and June were conducted to address sensory perception in tortoise interactions. In Experiment 1, males and females were unable to see each other to allow for chemical detection without vision of conspecifics, whereas in Experiment 2, males and females were allowed to interact (experienced visual and olfactory cues). Behavior was observed during each ten-minute trial, categorized, and timed. Behavior categories included: regulatory, stress-related, and awareness of conspecifics. Males and females did not differ in total numbers of behaviors regardless of category observed in either experiment type ($p=0.40$ for non-visual trials; $p=0.80$ for interaction trials), indicating captive conditions did not affect the sexes differently.When analyzing behavior categories, males were more likely to spend time performing awareness behaviors in the non-visual trials than interaction trials (221.7+72.68 vs. 66.0 +6.5; $p=0.0001$), and both males and females exhibited more sniffing behavior in the non-visual trials versus the interaction trials (168.06+33.33 vs. 71+21.96; $p=0.007$). A possible explanation for higher sniffing behavior in non-visual trials could be that tortoises are using olfaction to compensate for lack of visual cues.

P1.98 KELLEY, J.F.*; SMITH, T.; DAVIS, R.; PODAR, M.; RAGHAVAN, R.E.; STOTT, M.B.; REYSENBACH, A.-L.; Portland State University, Oak Ridge National Laboratory, GNS Science; *jokelley@pdx.edu*

Preliminary analysis of New Zealand hot spring Nanoarchaeota and Korarchaeota metagenomes

The *Nanoarchaeota* and *Korarchaeota* represent two poorly characterized, deep-branching archaeal phyla, with very few sequenced genomes. Both lineages have been detected globally in terrestrial and marine high temperature environments but have been very difficult to cultivate in the laboratory. All cultivated *Nanoarchaeota* form symbiotic/parasitic associations with crenarchaeal hosts, while no *Korarchaeota* have been grown in pure culture. In order to further characterize their phylogenetic position in the Tree of Life and obtain additional insights into their potential lifestyle, we analyzed the metagenomes of environmental and enrichment cultures containing *Korarchaeota* and *Nanoarchaeota* from a New Zealand (NZ) hot spring. Metagenomic libraries were sequenced from the sediment of a hot spring at Tikitere and two enrichment cultures from the same sample. The metagenomes were co-assembled and binned using a differential coverage program, GroopM. The nanoarchaeote draft genome is about 0.55Mb across 55 contigs, with an estimated genome completeness of 86%. The 1.38Mb NZ *Korarchaeota* draft genome has an estimated completeness of 89% across 151 contigs. The NZ nanoarchaeote genome differs from the marine *Nanoarchaeum equitans* and is more similar to the other terrestrial nanoarchaeote from Yellowstone National Park, in that it lacks an apparent ATP synthase and appears to be capable of gluconeogenesis amongst other shared features. The draft NZ korarchaeote shares many of the genomic features of *Candidatus* Korarchaeum cryptofilum. The draft metagenomes provide further evidence to the potential hosts for the NZ nanoarchaeote and possible metabolic capabilities of the NZ korarchaeote.

P1.190 KELLEY, RA*; MABRY, KE; New Mexico State Univ., New Mexico; *rakelley@nmsu.edu*

Physiological Stress Response and Behavior in a Drought-Affected Species

Early life experiences can alter social behavior, physiology, and life history trajectories of individuals by serving as a predictor for the environment an animal will experience as an adult, potentially affecting the development of plastic traits. In particular, stress experienced during development has been implicated in the modulation of the adrenocortical stress response, affecting the robustness and responsiveness of the physiological response to stressors later in life. The physiological stress response may be a mechanism underlying behavioral traits such as anxiety or boldness that are important in coping with stressors. An individual that develops under stressful conditions may have an elevated physiological stress response and altered behavioral responses in novel or stressful situations. We investigated the relationship between corticosterone levels and individual variation in anxiety and boldness behaviors in a population of wild brush mice (*Peromyscus boylii*) experiencing severe drought conditions in northern California. Preliminary data suggest there is a relationship between fecal corticosterone and boldness behavior in adult male brush mice that developed under stressful drought conditions. Mice with both high and low fecal corticosterone levels behaved more boldly, while mice with intermediate corticosterone levels behaved less boldly. As global climate change alters and increases the stressors populations face, it is imperative that we understand how organisms will respond physiologically and how the behavioral patterns important to coping with the stress will be shaped.

P2.28 KELTY, J/D*; PAGE, V/E; PALMER, T/A; HIMES, H/M; Central Michigan University; *kelty1jd@cmich.edu*

Rapid cold hardening affects phototaxis in Drosophila

For decades brief pre-treatment with moderate low temperature has been used to induce a rapid cold hardening (RCH) response that protects against a) cold shock injury otherwise incurred during brief treatment with more severe low temperature and b) interruption of various behaviors ranging from the simple (e.g., clinging) through the complex (e.g., courtship and mating). If RCH provides protection at a cost to a particular organism, those costs may be subtle. Rapid cold hardening causes little, if any, effect on early fecundity, lifespan or the behavioral repertoire of *Drosophila melanogaster*. Here we describe a subtle effect of a commonly used RCH treatment (1 h at 2 °C) on the phototaxis response of *D. melanogaster*. Adult (48 h post-eclosion) flies were maintained at 23°C or cooled to 2 °C for 1 h (2 °C flies), then maintained at 23 °C for an additional 1 - 2 h before transfer to a phototaxis testing chamber. Each chamber consisted of a pair of 13 X 100 mm glass culture tubes connected at their openings, with one tube covered in aluminum foil and a fiber optic light source positioned at the far end of the uncovered tube. In tests initiated with flies placed on the dark side of the chamber control flies almost always moved to the lighted end of the testing chamber. By contrast 2 °C flies remained in the darkened side of the chambers. In tests initiated with flies in the lighted side, nearly all control flies remained within 10 mm of the lighted end but all 2 °C flies moved away from the light, positioning themselves 5.4 ± 0.3 cm from the lighted end. These data provide an example of a subtle effect associated with an RCH treatment that itself may be diminished by RCH during treatment with even less severe low temperature.

P3.184 KENDALL, D.A.; Radford University; *dkendall@radford.edu*

The Biogeography of Nutrient Preference in Tropical Wasp Species

The Biogeography of Nutrient Preference in Tropical Wasp Species Often, the geographical location of a population can determine what composes their diet. But to what extent? This study explores the relationships between biome type, nutrients and the resulting catches to understand feeding habits of wasp species in the Amazon River Basin. Specifically, traps were placed in varying sub-biomes (varying in temperature, humidity and overall plant community features) and with varying lures and were sampled multiple times to determine how these factors impacted species visitation patterns. The traps were tested with standard European wasp/yellow jacket bait, copoazu fruit slurry (a fruit indigenous to the region), non-native fruit slurry and a solution of distilled water and poultry scraps. Traps were recovered daily and their contents surveyed. The results indicated that while some wasp species exhibited a constant preference for a given nutrient, several wasp species exhibited a much broader preference profile. In addition, some were only found in specific combinations of site and nutrient. We discuss our results and how further studies could bring to light the deeper biogeographical connections between location and food preference in hymenopteran species.

P2.208 KENNY, M.C.*; TEGELMAN-MALABAD, P.; MILLER, L.A.; SOCHA, J.J.; Virginia Tech, Giles High School, University of North Carolina, Chapel Hill; *mck66@vt.edu*

Development of a 3D model of the beetle heart to understand flow production

The dorsal vessel is a small tube that acts as the primary pumping organ of the insect circulatory system. Posteriorly, the dorsal vessel consists of a muscularized heart which contracts using a peristaltic motion of the heart wall. This motion, which occurs with small amplitudes and without full occlusion of the walls, can produce flows in two directions in some species. However, the mechanics of how the heart pumps are not well understood. To understand how insects create flows within the heart, we are using morphological data from the beetle *Zophobas morio* to inform new computational models of the dorsal vessel. Geometric characteristics of the dorsal vessel were quantified using dissection and scanning electron microscopy. Initial measurements from 26 specimens indicate that the dorsal vessel (length = 21.5 ± 1.2 mm) occupies 90.1% of the length of the body, with the heart (length = 12.4 ± 0.7 mm) comprising 57.7% of this length. The heart has 6 serially-oriented chambers, with an average chamber length of 1.79 mm (n=5). These findings were used to generate a 3-dimensional model of the insect dorsal vessel using Autodesk Inventor software. Flows within the dorsal vessel were simulated using the immersed boundary method over a range of contraction amplitudes of the modeled heart wall. Peristaltic pumping through flexible tubes at low Reynolds numbers is generally understood to rely on almost full occlusion of the tube walls to generate pulsed flows and net fluid transport. Our model allows us to quantify the net flow of hemolymph and to understand how flows are produced without complete constriction of the vessel. Supported by NSF 1301037 to JJS and NSF 1151478 to LAM.

P3.21 KILGORE, K.*; SCHWARTZ, M.; University of Washington, Tacoma; *megansc@uw.edu*

Circumpolar Genetic Connectivity of Pilidiophoran Ribbon Worms via Teleplanic Pilidia Larvae in the Southern Ocean (Phylum Nemertea)

Pilidiophoran ribbon worms (phylum Nemertea), characterized by the planktotrophic, iconic pilidium larva, figure prominently among the biota of the Southern Ocean. We report on pilidiophorans collected by the British Antarctic Survey in the Weddell, Amundsen, and Bellingshausen Seas, as well as the Antarctic Peninsula and Scotia Arc, and by the New Zealand National Institute of Water and Atmospheric Research in the Ross Sea and Chatham Rise. Samples were collected by epibenthic sled or Blake trawl between 100 to 2100 meters and preserved in 95% ethanol. Of the 354 nemerteans collected, we generated 163 16s ribosomal DNA and 75 cytochrome oxidase subunit 1 DNA sequences and continue our sequencing efforts. The order Pilidiophora is represented by 62% of the sequences. Phylogenetic analyses reveal 10 distinct pilidiophoran lineages, including *Baseodiscus antarcticus* and two probable new species of *Baseodiscus*. Haplotype network analysis reveals that four of these 10 lineages have circumpolar distributions, of which one can be identified by proboscis morphology as *Oligodendrorhynchus hesperides*, whereas the others require further study. These four species match pilidial larval sequences deposited in GenBank by previous NIWA research that barcoded zooplankton. Pilidia of the Southern Ocean differ from those of other oceans in attaining unusually large sizes (up to 2 mm), and one species, *Parborlasia corrugatus*, is known to have a long larval phase. The pilidia have unusual morphological adaptations of the episphere and lappets that may favor long distance dispersal. Taken together these data suggest planktotrophic pilidia larvae are able to drift with the currents of the Southern Ocean and maintain genetic connections between vastly separated populations.

P3.163 KIM, O*; YAP, KN; WILLIAMS, TD; Simon Fraser University, British Columbia; *ork@sfu.ca*

Validation of the use of erythropoietin and anti-erythropoeitin for experimental manipulation of hematocrit and hemoglobin in zebra finches, Taeniopygia guttata.

Aerobic capacity has been long assumed to be one of the key determinants of individual performance. Since hematocrit (Hct) and hemoglobin (Hb) are often assumed to be the main predictors of oxygen carrying capacity, many studies have tried to manipulate hematology to alter aerobic capacity and thus, individual quality. Given that phenylhydrazine (PHZ) injection, one of the most popular methods to manipulate hematology in birds, is problematic when trying to manipulate aerobic capacity due to its side effects, development of new techniques to manipulate Hct and Hb is essential. We propose using chicken erythropoietin (EPO) and anti-erythropoietin (anti-EPO) to manipulate hematology. EPO plays a critical role in erythropoiesis and is relatively well studied in mammals. However, it is unclear whether EPO modulates erythropoiesis the same way in birds. Furthermore, unlike PHZ, EPO is more specific in its action and is present endogenously in birds. We sought to investigate the effects of EPO and anti-EPO on Hct and Hb in captive zebra finch, *Taeniopygia guttata*. We ran two experimental trials. In trial 1, we measured baseline Hct and Hb at day 0 in 19 male zebra finches. At day 7, we assigned birds to 3 groups: EPO (n=5; 400pg), Saline (n=9), and anti-EPO (n=5; 12µL). We measured Hct and Hb at day 10, 3 days after EPO and anti-EPO injection, and again at day 17. We conducted trial 2 using the same protocol, except we changed the dose of EPO to 800pg and the dose of anti-EPO to 10µL. Preliminary analysis suggested that there was a 5.6% increase in Hct in the EPO group, and a 5.4% decrease in Hct in the anti-EPO group. Thus avian EPO and anti-EPO treatment might be an effective method for experimental manipulation of Hct.

P3.176 KIM, DS*; GABOR, CR; EARLEY, RL; Texas State Univ., Univ. of Alabama; *dianakim@txstate.edu*

Identifying the normal reactive scope of female sailfin mollies in different reproductive states

Individuals vary in circulating baseline levels of stress hormones (predictive homeostasis) and in their response to a stressor (reactive homeostasis). However, variation in normal reactive scope - predictive and reactive homeostasis combined - may be particularly important in females when in different reproductive states, such as gestating versus non-gestating females. The normal reactive scope of an individual is measured as the increase in glucocorticoid (GCs) hormones above baseline levels. We performed an adrenocorticotropic hormone (ACTH) challenge on females of the live-bearing fish species, *Poecilia latipinna*, at different reproductive states and measured stress responses using water-borne hormone collection methods. We measured cortisol, the primary GC in teleosts, to obtain baseline release rates prior to injection with either ACTH or saline. Then we measured cortisol release rates at three time intervals post-injection. Females were then sacrificed to determine the presence embryos. We found that non-gestating females had higher baseline cortisol release rates than gestating females, which suggests that baseline cortisol may be suppressed during gestation. Additionally, all ACTH-injected females, whether gestating or not, had higher release rates of cortisol during the second hour post-injection than females that received a saline control injection. These results provide insight into individual variation of the reactive scope and how individual reproductive states may affect that variation.

P1.180 KIM, SJ*; JUNG, J; PÉREZ ARIAS, SM; MCDANIEL, JG; WARKENTIN, KM; Boston University; *sujink@bu.edu*

Shake and roll: testing the ontogenetic correlation of vibration-cued hatching and otic mechanoreception in red-eyed treefrogs

Vibrations cue red-eyed treefrog (*Agalychnis callidryas*) embryos to hatch and escape in attacks by egg-eating snakes. We hypothesize that inner ear mechanoreceptors serve a key sensory role in this process. As a first step to testing this, we used the roll-induced gravitational vestibulo-ocular reflex (VOR) to assess the ontogeny of ear function. VOR generates eye movements that compensate for head movements to stabilize the visual field, and depends critically on vestibular function. To measure VOR, we placed newly hatched *A. callidryas* in a horizontal water-filled tube and rolled them around their body axis for 180° in both directions, in 15° increments. We photographed their faces at each angle, used ImageJ to measure eye and body angles, and fit sine curves to calculate the peak-to-peak amplitude of eye motion. Embryos begin escaping from predators early in Gosner stage 23 (usually age 4.3 d) with an initially weak response, which strengthens and becomes more consistent over the next day. We found a similar, temporally matched ontogenetic pattern of VOR. Next, we quantified hatching responses in vibration playbacks to clutches across the period of VOR onset and increase, and tested the VOR of 3-6 individuals per clutch immediately following playback. Our vibrational stimulus was 0-60 Hz noise, resembling snake vibrations, played in an intermittent temporal pattern that elicits nearly 100% hatching of older embryos. All embryos that hatched in playback showed VOR, consistent with a critical role for otic mechanoreceptors in vibration-cued hatching. However, across clutches showing VOR, the hatching response ranged from 0-88% and was not correlated with VOR magnitude, suggesting that additional factors contribute to the variation in embryo response.

P3.62 KIM, A.R.*; KIM, H.W.; KIM, K.R.; KANG, H.E.; LEE, J.H.; YOON, T.H.; LEE, S.R.; Pukyong National University; *tass5910@naver.com*

Molecular characterization of adiponectin receptor homolog in white shrimp, Litopenaeus vannamei

Adiponectin and its receptor (AdipoR) plays pivotal role in carbohydrate and fatty acid metabolism in vertebrates. We identified the full length cDNA encoding mammalian AdipoR homolog (Liv-AdipoR) from the shrimp, *Litopenaeus vannamei*. The full length Liv-AdipoR (1245 bp) encoded a protein with 415 amino acid residues. Liv-AdipR exhibited the conserved 7 transmembrane domains (7 TMs) and its predicted topology showed that Liv-APidoR belongs to the Progestin and adipoQ receptor (PAQR) family members. Based on the obtained sequences, only single AdipoR gene appear to exist in arthropods, while it has been evolved into two paralogs, AdipoR1 and AdipoR2 in vertebrates. Major production sites for Liv-AdipoR were the hemocyte, hepatopancreas, gonad and muscle and its expression was upregulated in those without feeding, which suggest that Liv-AdipoR may play a primitive role in carbohydrate and lipid metabolism as single gene. In order to estimate the function of Liv-AdipoR, dsRNA was designed and injected. After 72 hours of 50 pmol Liv-AdipoR dsRNA injection, its transcription levels decreased in thoracic muscle and deep abdominal muscle by 93% and 97%, respectively. Transcriptomic analysis showed that 804 contigs were upregulated and 212 contigs were down-regulated by the knockdown of Liv-AdipoR in deep abdominal muscle. Chronic effects of Liv-AdipoR dsRNA injection was the increased motalities suggesting function of Liv-AdipoR appears to be essential for survival of *L. vanammei*.

P2.40 KING, EE*; GUNDERSON, AR; STILLMAN, JH; California State University, Monterey Bay, San Francisco State University; *emiking@csumb.edu*

Do interspecies interactions trigger the cellular stress response in porcelain crabs?

Global climate change may compress the amount of suitable thermal habitat for an organism in present distribution ranges. As a result, species distributions may shift causing novel species interactions. Behavioral interactions between predator and prey species can cause physiological stress; but whether competing for space causes physiological stress is unknown. Based on present temperatures and thermal performance, warming will likely cause *Petrolisthes cinctipes* to shift its distribution from the upper intertidal zone to the lower intertidal zone habitat of *Petrolisthes manimaculis*. Therefore, increased interactions are expected to occur between the porcelain crabs *P. cinctipes* and *P. manimaculis*. We hypothesized that crabs are more interactive in interspecific assemblages and that interactivity increases expression of cellular stress response genes. Interactions were observed in single and mixed species assemblages. Physiological stress was measured by the differential expression of six biomarkers for the cellular stress response (CSR). Crabs were more interactive in interspecific assemblages, but there was no relationship between interaction frequency and CSR. Contrary to our expectations, 100% of crabs in conspecific groups showed increased CSR as compared to 20-40% of crabs in interspecific groups. Interspecific competition for space may not induce the CSR in either species. Other physiological indicators, such as long-term injury and reproductive output, may better predict the indirect consequences of climate change on interspecific interactions and organismal stress.

P2.89 KINGWELL, CJ*; WCISLO, WT; Cornell University, Smithsonian Tropical Research Institute; *callumkingwell@gmail.com*

The evolutionary origins of social insect queen pheromones: honesty and dynamics of fertility signal production in a socially polyphenic Halictid bee.

Pheromones produced by queens are central to maintaining the characteristic reproductive division of labor seen in social insect societies. The workers who make up the bulk of these societies typically respond to queen 'fertility signals' by suppressing their own reproductive potentials and instead contributing to that of their queen(s), yet the evolution of these signaling channels given the potential for destabilizing dishonest signal production remains somewhat unclear. Fertility signal evolution may be at a nascent stage in primitively social insect societies, and the mechanisms enforcing signal honesty may be more readily apparent in these less derived species. However, little is known concerning the identity and production dynamics of chemical fertility signals in these species relative to their highly social relatives. We first identify putative fertility signals in a Halictid bee (*Megalopta genalis*) exhibiting facultative eusociality, a level of organization considered representative of the earliest stages in the evolution of complex insect social behaviour. We then examine the ontogeny, caste differentiation, and antennal sensitivity of bees to these compounds to assess their utility as reliable signals of queen reproductive potential. Finally, we compare socially-nesting versus solitarily-nesting queens from a single population to examine whether these compounds represent true, actively-produced signals or are instead constitutively produced cues of fertility.

P1.119 KITSON, S.R.*; ROOSENBURG, W.M.; Ohio University, Athens, OH; *sk616712@ohio.edu*

Performance of Malaclemys terrapin Hatchlings: Variations in Seasonal Emergence

In temperate regions, the emergence of hatchling turtles from their nests varies among species and generally follows one of two patterns: fall emergence or delayed spring emergence. Diamond-backed Terrapins (*Malaclemys terrapin*) in temperate latitudes follow a facultative strategy in which one population will have both fall and spring emergence. On average, 55% of nests on the Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island, MD display fall emergence, 25% overwinter and emerge the following spring, with the remaining 20% of nests failing to produce hatchlings. Survivorship was calculated for fall and spring emergent terrapins using recapture data since 2008. Though delayed spring emergence is less common in this population, the best fit model indicated that there is an 8% higher chance of survival for spring emergent hatchlings in the first two years of life (during which juvenile terrapins are semi-terrestrial in contrast to the aquatic adults). To investigate this survivorship difference on Poplar Island, fall and spring emergent hatchlings from the 2014 nesting season were collected to examine individual hatchling performance between these two emergent strategies. Righting behavior, as well as aquatic and terrestrial burst speed and endurance were used as fitness proxies that may correlate with the calculated survivorship differences. Trends in the gathered data indicate that spring emergent hatchlings may perform better than fall emergent hatchlings, which could increase survivorship due to factors such as aiding in foraging or predation avoidance. This comparison between emergent season performance may provide insight as to why a less common strategy has greater survivorship.

P2.64 KLOSTERMEYER, K.M.*; HAHN, D.C.; IGL, L.D.; FASSBINDER-ORTH, C.A.; Creighton University, Omaha, NE, Patuxent Wildlife Research Center, Laurel, MD,, Northern Prairie Wildlife Research Center, Jamestown, ND; *kmk68071@creighton.edu*

Passive Immunity Components in the Albumen and Yolk of New World Blackbirds

Immune traits evolve to fit the species' niche, and each species has an adaptive portfolio of immune defenses that reflect its life history and ecological niche. We conducted a multi-species comparison of passive immunity components in eggs of six species of birds in the family Icteridae and examined how traits differ among these closely related species. First, an enzyme-linked immunosorbent assay (ELISA) was performed on polyethylene glycol-extracted albumen and chloroform extracted yolk to determine total immunoglobulins (Ig) levels, and also lipopolysaccharide (LPS)-specific Ig levels. Second, lysozyme and ovotransferrin assays were performed on the albumen. Distinctive patterns of differential investment in components of passive immunity were apparent for several of the species. For example, while the common grackle exhibited significantly higher total Ig in the yolk than all other species, it exhibited significantly less ovotransferrin activity than most other species tested. These distinctive patterns of immunological investment are likely reflective of the life history of the species and their unique microbial interactions.

P2.15 KLEMPAY, B.L.; LIM, I; MALLULA, M.L.*; OLSEN, A.M.; PARK, K.E.; SILVA, D.H.; GONZALEZ, V.H.; HRANITZ, J.M.; PETANIDOU, T.; BARTHELL, J.F. ; Yale University, Williams College, University of Kansas, University of Michigan, Pomona College, St. Mary's University, University of Kansas, Bloomsburg State University, University of the Aegean, University of Central Oklahoma; *jbarthell@uco.edu*

The Effect of Introducing Differing Color Floral Morphs on Bee Visitation in a Native Population of Vitex agnus-castus on the Greek Island of Lesvos

At least two distinct color morphologies of the Mediterranean chasteberry bush, *Vitex agnus-castus* L., occur on the Greek island of Lesvos near Kalloni Bay: blue and white. A transplant experiment was conducted to detect whether introducing an inflorescence from an alternately colored bush within an experimental host bush would cause perturbations in visitation by foraging bees; these introductions occurred within adjacent blue and white bushes. Twenty paired comparisons were used per bush, with one inflorescence serving as a control and the other as a manipulated treatment by having an introduced (opposing colored) inflorescence (in a floral water pick) attached immediately next to it on its stem. Bee visitation rates between the respective inflorescence types (manipulated and control) did not significantly differ according to a Wilcoxon Rank Sum Test over the course of the day and nor did the level of nectar standing crop as measured immediately after the last forager censusing period (ca. 18:00) using a Wilcoxon Pairwise Test. These results suggest that floral colors (blue versus white) do not strongly influence bee foraging behavior at the level of the inflorescence. However, the nectar flow dynamics of this species at the level of *V. agnus-castus* populations may still influence foraging patterns of bees among individual bushes (regardless of color).

P1.12 KNIGHTSTEP, G.; MCBRIDE, S. A.*; WILLIS, R. E.; Midwestern State University; *sarah.mcbride@mwsu.edu*

The Molecular and Morphological Determination of Valid Subspecies of Canyon Lizard (Sceloporus merriami merriami, Sceloporus merriami annulatus and Sceloporus merriami longipunctatus) in the Chihuahuan Desert of West Texas

Since its description, relatively few studies have examined the morphology and phylogeny of the canyon lizard, *Sceloporus merriami*, and its subsequent subspecies, Merriam's canyon lizard (*Sceloporus merriami merriami*), the Big Bend canyon lizard (*Sceloporus merriami annulatus*), and the Presidio canyon lizard (*Sceloporus merriami longipunctatus*). Geographical ranges of these subspecies are centered in southwestern Texas. In this study, the Dalquest Desert Research Station and the surrounding areas were explored to capture and examine the canyon lizard subspecies. From April to October of 2015, *S. merriami* were captured from rock facings within the canyon systems of the Trans Pecos area. Lizards were captured, weighed, photographed, and several morphological characteristics were measured and recorded. Preliminary morphological data shows little variation in physical characteristics such as weight, snout to vent length, head length, body length, limb length, and ventral scale coloration and patterning. Initial observation of the paravertebral scale coloration and patterning on the dorsal surface yielded different results. Shapes of the paravertebral patches ranged from those typical of *S. m. longipunctatus* and *S. m. annulatus* to patterns unlike those previously described. The lizards were then analyzed for genetic variation. Examined sequences show little variation between subspecies at this time. These data may indicate a possible intergradation zone between the Big Bend canyon lizard and the Presidio canyon lizard and the differences between the three subspecies may be explained as natural variation within one species rather than attributed to their being classified as separate subspecies.

P3.39 KOHL, K.D.*; BRUN, A.; MAGALLANES, M.; LASPIUR, A.; ACOSTA, J.C.; BORDENSTEIN, S.R.; CAVIEDES-VIDAL, E.; Vanderbilt Univ., Univ. Nac. San Luis, Argentina, Univ. Nac. San Juan, Argentina; *kkohl78@gmail.com*

What's the scoop on lizard poop?: Insights into the gut microbial ecology of lizards

Vertebrate hosts maintain complex associations with a diverse community of microbes living in their guts. Our understanding of the ecology of these associations is extremely limited in reptiles. Here, we conducted an in-depth study into the microbial ecology of gut communities in three syntopic lizard species in the Southern Andes of Argentina (two omnivorous species: *Liolaemus parvus* and *L. ruibali*, and an herbivorous species: *Phymaturus williamsi*). All three species are viviparous (live-bearing). We used 16S rRNA sequencing to inventory the microbial communities of the lizard gut and many other sources (plant material in nature, diets in captivity, etc.). We found that in nature, a considerable portion of the fecal communities of lizards (25-50%) overlapped with microbiota found on plant material, and little overlap with soil or invertebrate microbiota (< 4%). Captivity significantly altered the gut microbial community structure of lizards, though species retained distinct microbial signatures. Microbial communities differed significantly across gut regions (stomach, small intestine, hindgut, and feces), though fecal communities were found to be accurate representations of the hindgut communities. Lizards that were born in captivity and separated from their mothers within 24 hours harbored communities that were distinct from their mothers', lacked a host species-specific signature, and were more similar to the microbiota in their food. Our results enhance our understanding the microbial ecology of gut communities in lizards, but also have implications for conservation, especially captive breeding.

P2.54 KOLER, SA*; GOESSLING, JM; MENDONCA, MT; Auburn University; *goessling@auburn.edu*

Seasonal lag of in vitro humoral immune responses in gopher tortoises (Gopherus polyphemus)

The gopher tortoise (*Gopherus polyphemus*) is a declining keystone species of the southeastern United States Coastal Plain ecosystem. While numerous anthropogenic sources of mortality have been attributed to *G. polyphemus* declines, disease has been hypothesized to be a significant source of adult mortality in this species. Climate change, and specifically climatic variability, has been shown to cause negative effects on disease resistance in ectothermic vertebrates. Herein, we investigated the role that rapid temperature change has on humoral immune responses in *G. polyphemus* by experimentally testing the seasonal lag hypothesis. Acclimated to seasonal states of both winter and summer, we manipulated temperatures experienced by *G. polyphemus* to simulate short-term temperature increases and decreases, respectively. At both baseline acclimation states and temperature-altered states, we measured *in vitro* cellular humoral responses. Whole blood samples were collected and circulating leukocytes were isolated using a histopaque density gradient; antibody production was measured in response to negative controls as well as lipopolysaccharide (LPS) using an Enzyme-linked immuno spot assay (ELISpot). Our results indicated a strong response of *G. polyphemus* lymphocytes to spontaneously secrete antibody. Using this assay, we evaluated whether long-term seasonal acclimation, as well as short-term seasonal lag effects can account for changes in humoral immune responses. Data from this study indicated a lag effect in the immune response in which we did not detect a change in response as a result of the thermal manipulation. We further discuss the constraints that climatic variability may impose on ectothermic immune responses, and how this may represent one mechanism of increased disease in *G. polyphemus*.

P2.200 KOTHARI, A.R.*; BURNETT, N.P.; Univ. of California, Berkeley; *adit.kothari@berkeley.edu*

Effect of herbivore damage on broad leaf motion in wind

Terrestrial plants regularly experience wind that imposes aerodynamic forces on the plants' leaves. Passive leaf motion (e.g. fluttering) and reconfiguration (e.g. rolling into a cone shape) in wind can affect the drag on the leaf. In the study of passive leaf motion in wind, little attention has been given to the effect of herbivory. Herbivores may alter leaf motion in wind by making holes in the leaf. Also, a small herbivore (e.g. snail) on a leaf can act as a point mass, thereby affecting the leaf's motion in wind. Conversely, accelerations imposed on an herbivore sitting on a leaf by the moving leaf may serve as a defense by dislodging the herbivore. In the present study, we investigated how point masses (>1 g) and holes in leaves of the tuliptree affected passive leaf motion in turbulent winds of 1 and 5 m s^{-1}. Leaf motion was unaffected by holes in the leaf surface (about 10% of leaf area), but an herbivore's mass significantly damped the accelerations of fluttering leaves. These results suggest that an herbivore's mass, but not the damage it inflicts, can affect leaf motion in the wind. Furthermore, the damping of leaf fluttering from an herbivore's mass may prevent passive leaf motions from being an effective herbivore defense.

P1.11 KOWALSKY, M.S.*; WILLIAMS, G.C.; University of Maine, Orono, California Academy of Sciences, San Francisco; *makaila.kowalsky@umit.maine.edu*

Phylogenetic analysis of gorgonian and pennatulacean corals from the Verde Island Passage, Philippines

Octocorals are distributed around the world and are found in habitats from shallow coral reefs to the deep sea. Phylogenetic relationships of octocorals have previously been understudied and much of their systematics remains unknown. Using molecular techniques, we investigated the phylogenetic relationships of individuals representing seven genera in six families of octocorals collected during the 2015 CAS Philippine Biodiversity Expedition in the Verde Island Passage. The goal of this study was to determine if there is congruence between molecular and previously published morphological phylogenies for the gorgonian and pennatulacean groups. Examination of color, branching patterns, and sclerite morphology allowed identification of the specimens to genus. Mitochondrial protein coding genes [NADH-dehydrogenase subunits 2 (ND2) and 6 (ND6) and mutS homolog (msh1)] as well as the non-coding intergenic spacer region (COI-COII intergenic spacer) in the mitochondrial genome were sequenced to derive a phylogeny of the seven genera. The molecular results of this study suggest that ellisellid gorgonians and pennatulaceans are sister taxa, which is in contrast to the current classification. Previous studies had mentioned similarities in the morphology of these two taxa. Molecular analysis of additional material from these families must be conducted in order to further test these newly discovered relationships.

P2.197 KRASKURA, K*; NELSON, J.A.; OUFIERO, C.E.; RICCI, K; Towson University ; *k.kraskura@gmail.com*

Allometry and repeatability of gymnotiform swimming performance in black ghost knifefish (Apteronotus albifrons)

Recently, abundant interest concerning gymnotiform locomotion has emerged, but research has focused on kinematics, hydrodynamics and robotics. Very little is known about the swimming abilities and performance of fish that use gymnotiform locomotion. In this study we explored the allometry and repeatability of two swimming performances in black ghost knifefish of several sizes. Individual fish were subject to repeated sprint and constant acceleration tests within a single day and across a period of 4 weeks. A sprint chamber with computer-controlled laser detection system was used to find maximal sprint speeds of each individual. Endurance performance was tested using a constant acceleration test (CAT) increasing velocity in the swim tunnel at the rate of 3 cm s^{-1} min^{-1} until fish fatigued (U_{max}). Both tests were significantly repeatable within a day and across 4 weeks. Swimming performance was analyzed with respect to size, growth over the 4 week interim period and with respect to several morphological measurements. Surprisingly, there was no effect of fish body size on either endurance or sprint swimming performance. These results suggest consistent performance in a gymnotiform swimmer, but little effect of size based on our sample.

P3.204 KROHMER, R. W.*; JURKOVIC, J.; Saint Xavier University, Chicago, IL; *krohmer@sxu.edu*

Neuronal Plasticity in the Forebrain of the Male Red-Sided Garter Snake: Effect of Season and Hormonal Status on Dendritic Spine Formation

Numerous studies have reported seasonal variations in regional morphology in the brains of seasonally breeding vertebrates. In many cases, this neural plasticity has been found to be in response to changes in circulating sex steroid hormone levels and occur within pathways essential for the control of reproductive behaviors. Male red-sided garter snakes (*Thamnophis sirtalis parietalis*) exhibit a dissociated reproductive pattern where mating is initiated at a time when the gonads and steroidogenesis are inactive. The current study examined seasonal and hormonal influences on the density and morphology of dendritic spines within regions shown to be critical for the regulation of reproductive behaviors. In many seasonally breeding species, alteration of dendritic spine density and/or morphology appears to be an active process within neural regions regulating reproductive behaviors. In male red-sided garter snakes, dendritic spines on neurons within pathways controlling reproductive behaviors are dramatically denser during spring mating than in fall collected non-mating individuals. In addition, animals maintained under conditions of low temperature dormancy (LTD) exhibited increasing spine density the longer animals were maintained in LTD. Animals receiving either testosterone or estradiol exhibited greater density of dendritic spines than control animals. These results add to the increasing amount of evidence suggesting that testosterone may play a critical, although indirect, role in the regulation of reproductive activity in an animal exhibiting a dissociated reproductive pattern.

P3.174 KUCERA, A.C.*; NEEDHAM, K.B.; GREIVES, T.J.; HEIDINGER, B.J.; North Dakota State University; *aurelia.kucera@ndsu.edu*

Sperm telomere dynamics in response to an immune challenge in captive house sparrows

Although it has long been assumed that exposure to stressors hastens aging, recent studies have found that these effects can span more than one generation. Stressors experienced by parents often have negative long-term consequences for offspring health and longevity. However, the underlying mechanisms remain poorly understood. Telomeres are highly conserved, repetitive DNA sections at chromosome ends that are involved in cellular aging. Telomere dynamics (length and loss rate) may be an important mechanism underlying the transmission of stress effects from parents to offspring. Stressors experienced by parents may directly influence germ cell telomere length prior to fertilization, which may then be transferred to offspring. Here we experimentally exposed 14 captive male house sparrows (*Passer domesticus*) to an ecologically relevant stressor, an immune challenge (lipopolysaccharide injection), or a control treatment (vehicle only injection) and examined the effects on the telomere length of red blood cells and spermatozoa using qPCR. Results of this study will be discussed within the context of life-history theory.

P2.121 KUDENOV,, J.D.*; BORDA,, E.; DESBRUYERS,, D.; Univ. of Alaska Anchorage, Texas A&M Univ. at Galveston, Centre de Brest de l'IFREMER; *jdkudenov@uaa.alaska.edu*

Novel morphology in a new genus of deep-water Amphinomidae (Annelida: Amphinomida) from the eastern Pacific

Amphinomidae represent a diverse group of polychaetes that include some large and highly colorful coral reef-dwelling taxa. When irritated, amphinomids are generally well-known among divers and snorkelers for their ability to impart painful stings (due to a trimethylamine) whenever contact is made with the worm's sharp, detachable notochaetae. Anatomically, amphinomids are unique among annelids in possessing a suite of traits that includes: calcareous chaetae, a well-developed prostomial caruncle, two pairs of ventral nerve chords, and an unarmed muscular ventral pharynx. Besides the five prostomial appendages generally present in every known species of this family, no other antennae or tentaculate appendages have ever been described. We describe the presence a novel structure in the Amphinomidae that is newly described here for the very first time: a pair of retractile grooved oral tentacles that arise from within the anterior digestive tract that protract through the mouth. The structure of these canaliculate tentacles is described along with their surmised function, and compared with similar structures present in other families of polychaetes.

P3.126 KUO, S.*; MIDDLETON, K.M.; University of Missouri; *sharon0kuo@gmail.com*

Estimating mechanical properties of penguin wing feathers

The size, shape, and distribution of feathers are important indicators of differences in flight adaptation among birds. Comparatively less is known about the role that feather mechanical properties play in flight. Penguins have transitioned from aerial to aquatic flight and have highly modified feathers that are thought to be adaptations to an extreme environment and the viscous fluid through which they fly. Thus penguin feathers offer an interesting test case for feather hydrodynamic and thermodynamic adaptations. Previous research has compared feather rachis stiffness in a range of avian taxa to quantify the variation in bending and tensile properties. Here we extend these studies to include penguin wing feathers. To study the effects feather specialization has on mechanical properties of the rachis, we conducted tensile tests of wing feathers from five penguin species. Whole feathers (n = 2-10 per species) were dissected free of the flipper connective tissues, secured by grips, and loaded in tension cyclically and then to failure. Raw load and displacement curves were converted to stress-strain curves. Young's modulus was calculated both from external caliper measurements and from the cross sectional area based on histological sections of the penguin rachises. These tensile tests reveal that the moduli of feather rachises in the penguin species studied fall within the range of moduli found in previous studies testing tensile rachis stiffness in other avian taxa. Despite extreme modifications of penguin feathers, including increased homogeneity and thermodynamic insulation, the mechanical properties of penguin flight feather rachises are indistinguishable from those of other birds. These results indicate that feather morphology, specifically the reduced rachis length and overlapping orientation, may play a greater role in the transition to underwater flight than a change in material properties of the feathers themselves.

P1.122 LAHONDÈRE, C.*; VINAUGER, C.; OKUBO, R.; RIFFELL, J.A.; University of Washington; *lahonder@uw.edu*

What makes mosquitoes attracted to Platanthera orchids?

Female mosquitoes not only feed on blood to produce eggs but they also use carbohydrates to sustain their metabolism. In nature, flowers provide a good source of carbohydrates and some plants such as *Platanthera* orchids take advantage of these visitors to get pollinated by the mosquitoes during their nectar intake. Although several observations have been made of mosquitoes pollinating these bog orchids, the signals used by the plant to attract both male and female mosquitoes remain unknown. We first performed non-destructive headspace volatile collections in the field to study the scent of several *Plathantera* species, and analyzed these scent samples using Gas-Chromatography coupled with Mass-Spectrometry (GC-MS). Adult mosquitoes of different species and some of them carrying *pollinia* were also caught and identified in field sites where orchids were present. Then, using Electro-Antennogram coupled with Gas-Chromatography (GC-EAG), we evaluated to which specific compounds from the orchid scents the mosquitoes are responding to. Delivering pulses of specific chemicals (EAGs) to the mosquitoes also provided a better understanding of the way orchids attract and use the mosquitoes to get pollinated. Interspecific differences among orchid species and mosquito species will be discussed.

P2.138 LAINOFF, AJ*; MOUSTAKAS-VERHO, JE; HU, D; KALLONEN, A; MARCUCIO, RS; HLUSKO, LJ; UC San Francisco, University of Helsinki, UC Berkeley; *alexis.lainoff@ucsf.edu*

Differences in odontogenic gene expression between toothed and toothless amniotes

A well-known tenet of murine tooth development is that BMP4 and FGF8 antagonistically initiate odontogenesis, but whether this tenet is conserved across amniotes is largely unexplored. Moreover, changes in BMP4-signaling have previously been implicated in evolutionary tooth loss in Aves. Here we demonstrate that *Bmp4*, *Msx1*, and *Msx2* expression is limited proximally in the red-eared slider turtle (*Trachemys scripta*) mandible at stages equivalent to those at which odontogenesis is initiated in mice, a similar finding to previously reported results in chicks. To address whether the limited domains in the turtle and the chicken indicate an evolutionary molecular parallelism, or whether the domains simply constitute an ancestral phenotype, we assessed gene expression in a toothed reptile (the American alligator, *Alligator mississippiensis*) and a toothed non-placental mammal (the gray short-tailed opossum, *Monodelphis domestica*). We demonstrate that the *Bmp4* domain is limited proximally in *M. domestica* and that the *Fgf8* domain is limited distally in *A. mississippiensis* just preceding odontogenesis. Additionally, we show that *Msx1* and *Msx2* expression patterns in these species differ from those found in mice. Our data suggest that a limited *Bmp4* domain does not necessarily correlate with edentulism, and reveal that the initiation of odontogenesis in non-murine amniotes is more complex than previously imagined. Our data also suggest a partially conserved odontogenic program in *T. scripta*, as indicated by conserved *Pitx2*, *Pax9*, and *Barx1* expression patterns and by the presence of a *Shh*-expressing palatal epithelium, which we hypothesize may represent potential dental rudiments based on the Testudinata fossil record.

P3.1 LAM, E.K. *; YOU MAK, K.T.; GUNDERSON, A.R.; STILLMAN, J.H.; San Francisco State Univ.; *ek3lam@gmail.com*

Thermal Preference and Avoidance Behaviors in the Porcelain Crab Petrolisthes cinctipes

Increased frequency of severe high temperatures is expected to increase with global climate change, and as a result shifts in species distributions are expected to intensify. Characterizing the temperatures at which animals will move is therefore an important element of predicting the consequences of ongoing warming. For example, thermal microhabitats of the intertidal zone porcelain crab, *Petrolisthes cinctipes*, can reach lethal levels, but at what temperature the crabs migrate to cooler locations is unknown. The thermal preference of this species is indicative of their optimal temperature range and the set-point at which crabs exhibit avoidance behavior will, thus, inform ecological predictions regarding emigration. Thermoregulatory behavior was examined by placing crabs in an aquatic thermal gradient and recording water temperature at the location of the crab over time. Thermal avoidance behavior was measured as the temperature at which crabs exited a temperature chamber during a thermal ramp. We hypothesized that characteristics such as sex and size will influence thermal preference and avoidance behaviors. The mean preferred temperature was 15.1°C ± 1.7. During thermal ramps, where temperature increased at a rate of 1.1°C/min, crabs exhibited avoidance behavior at a mean temperature of 23.5°C ± 5.3. In the field we have observed habitat temperatures that exceed these thresholds. We saw no significant difference in sex or size in either experiment. Ultimately, these data will provide insight to how future temperatures may cause migratory behavior away from microhabitats that are no longer within a physiologically permissive range. Such movement may have consequences for increased intra- and interspecific interactions that can cause cellular stress and potentially reduce fitness.

P3.136 LAMEYER, T.J.*; PASCUAL, M.G.; STANHOPE, M.E.; CHI, M.; SHEA, D.N.; MARDER, E.; SCHULTZ, D.J.; DICKINSON, P.S.; CHRISTIE, A.E.; Bowdoin College, Brunswick, ME 04011, University of Hawaii at Manoa, Honolulu, HI 96822, University of Missouri, Columbia, MO 65211, Brandeis University, Waltham, MA 02454; *tlameyer@bowdoin.edu*

In silico discovery of the first putative receptors from the American lobster, Homarus americanus

The molecular components of peptidergic signaling systems in nervous systems include both neuropeptides and peptide receptors. In the lobster, *Homarus americanus*, numerous neuropeptides have been identified and characterized. In contrast, nothing is known about the identity of neuropeptide receptors in this species. Here, known peptide receptors, primarily ones from the fruit fly, *Drosophila melanogaster*, were used to mine a H. americanus neural transcriptome for sequences encoding homologous proteins. Via this strategy, over 40 putative receptor-encoding transcripts were identified. The proteins deduced from these receptors include putative adipokinetic hormone-corazonin-like peptide, allatostatin A, allatostatin C (AST-C), bursicon, CCHamide, corazonin, crustacean cardioactive peptide, diuretic hormone 31, diuretic hormone 44, ecdysis-triggering hormone, FLRFamide, insulin-like peptide, leucokinin, myosuppressin, neuropeptide F, pigment dispersing hormone, proctolin, pyrokinin, red pigment concentrating hormone, SIFamide, sulfakinin and tachykinin-related peptide receptors. For many peptide groups, multiple receptor subtypes appear to exist in the lobster. For example, three distinct proteins showing homology to known AST-C receptors were discovered. Structural analysis of the full-length proteins showed the majority of them to possess complements of structural motifs consistent with their proposed function as peptide receptors, *e.g.* seven membrane spanning regions, and, in some cases, hormone-binding domains.

P3.169 LANDRY, DW*; BREUNER, CW; METCALF, LC; University of Montana; *devin.landry@umontana.edu*

Recreational aviation and wildlife impacts: The physiological stress response in ungulates and associated user perceptions

Backcountry aviation is a popular form of recreation throughout the Northern Rocky Mountains; however, it is unclear whether this seasonal disturbance has adverse effects on wildlife. Using stress physiology techniques provides a mechanistic understanding of the effects of disturbance on free-living populations. The analysis of fecal glucocorticoid metabolites (FGM) is an increasingly useful tool in conservation biology as it provides a non-invasive measurement of circulating stress hormones (e.g., cortisol) deposited into the feces. We quantified aircraft activity and human presence in concert with collecting white-tailed deer (*Odocoileus virginianus*), mule deer (*O. hemionus*), and elk (*Cervus elaphus*) fecal samples from six backcountry airstrips and six control sites (n=12) located in national forests and wilderness areas throughout western Montana and north-central Idaho. By correlating FGM levels against aircraft activity, we can evaluate the impacts of backcountry aviation on deer stress physiology within the greater context of recreation on public lands. We are also surveying recreational pilots who frequent backcountry airstrips in the study region. The main objectives of this human dimensions analysis are to 1) measure attitudes of pilots toward seeing various wildlife species at backcountry airstrips 2) evaluate scenarios under which pilots might alter their recreational behavior in order to mitigate potential impacts and 3) determine how they, as stakeholders, perceive the impacts of recreational aviation on wildlife. This research represents the first attempt to model the endocrine profile of wildlife populations exposed to recreational, backcountry aviation while also providing social science data on current attitudes regarding this topic.

P1.182 LANGE, A. P.*; ARTEAGA, E.; BAINS, N. K.; MOHAMED, A.; LENT, D. D.; California State University, Fresno; *alange1@mail.fresnostate.edu*

The Effect of Local Flower Distribution on the Foraging and Communication Behavior of the Common Eastern Bumblebee, Bombus impatiens

Bumblebees are able to obtain information both through personal experience, i.e. personal information, and from their conspecifics, i.e. social information, however it is unknown how bumblebees weigh information to make the best decisions. This ability to weigh decisions and act on the one with the highest value would allow the bees to make the most of the resources within the territory of their colony, as they would not be wasting time and energy obtaining resources from less valuable sources. Foraging situations were created in which individual bumblebees were confronted with social information that conflicted with their personal information and their responses were monitor and analyzed. Bumblebees were presented with an arena where the values of food resources were controlled by altering the sugar concentration within artificial flowers and the number of fresh flowers present at the feeders. The foraging patches that bees choose, the behavior of the bees after they return to the nest and communicate with their nest mates, and the subsequent foraging choices bees made after social information was assessed was be monitored. Data suggests that the bees respond to the initial change in food distribution by increasing the number of foragers out at any one time. The foragers would consistently visit both feeders, but foraged at the feeder with the greater amount of food. The number of foragers decreased to control levels on the second day of uneven food distribution, but time spent foraging remained high. It is unknown 'if' or 'how' bumblebees are evaluating information and then acting upon this evaluation, but this assay provides a new way to study communication and information processing in bumblebees.

P2.87 LAPLANTE, PM*; WOFFORD, SJ; MOORE, PA; Bowling Green State University , BGSU; *philipl@bgsu.edu*

The smell of victory or defeat: The role of chemical signals in fight escalation and resolution

The role of chemical communication in animal behavior is a rising subject in sensory ecology; however, detailing the effect of chemical signals on the mechanics of agonistic behaviors has just begun. The purpose of this study is to correlate agonistic behavior with chemical release events in order to determine the mechanistic role that chemical communication plays in contest escalation, resolution, and possibly assessment. A fluorescent dye was used to visualize a chemical signal (urine) known to play an important role in crayfish contests. In order to observe this phenomenon, crayfish (Orconectes rusticus) were injected with the fluorescent dye and then paired randomly with a contestant of the same or opposite sex. We examined same sex as well as mixed sex interactions due to the limited knowledge on female and mixed sex contests. Contest videos were first analyzed to confirm urine release. Further analysis was used to determine if escalation, de-escalation, or no change in fighting occurred between contestants. We also examined how these urine release events played a role in fight outcome. It appears that chemical signals are critical in determining rates of escalation within fights and that different crayfish pairings had different chemical signal use.

P2.175 LAURENCE-CHASEN, J.D.*; JIMENEZ, Y.E.; KNORLEIN, B.J.; BRAINERD, E.L.; Brown Univ.; *jd_laurence-chasen@brown.edu*

Video Reconstruction of Moving Morphology (VROMM) for studies of suction feeding in ray-finned fishes

Suction feeding in ray-finned fishes is a highly kinetic behavior. Musculoskeletal components are arranged in linkages, which move in complex, 3-dimensional ways. In order to precisely measure the 3-D rotations and translations of bones during suction feeding, we developed a new imaging method called Video Reconstruction of Moving Morphology (VROMM). VROMM combines bi-planar high speed video with 3-D mesh models from CT scans to create highly precise animations of real-life motions. As a test-case for the VROMM method, we evaluated the opercular linkage for lower jaw depression by measuring the rotation of the lower jaw and the operculum at the quadratomandibular and operculohyomandibular joints, respectively. We filmed two species of sculpin, *Leptocottus armatus* and *Hemilepidotus hemilepidotus*, during suction feeding, and also filmed a post-mortem manipulation where we pulled straight up on the operculum to simulate the dorsal rotation described by the classic 4-bar linkage. In the manipulated trials, the measured kinetic transmission (KT) for *Leptocottus* and *Hemilepidotus* was 2.3 and 2.0 respectively. The measured KT for the live *Leptocottus* was 4.0, and, notably, the operculum reached maximum rotation significantly before the lower jaw. These data suggest that in *Leptocottus*, operculum rotation is responsible for initial jaw depression, while other linkages subsequently drive the rest of mouth opening.

P3.203 LAUX, RH*; WINTERS, GC; BOTSWICK, CJ; KOHN, AB; MOROZ, LL; Humboldt State U., Whitney Lab & Neuroscience Dept, U. Florida, Whitney Lab, U. Florida, McKnight Brain Institute, Whitney Lab & Neuroscience Dept, U. Florida; *rhl68@humboldt.edu*

First signaling molecules identified in Octopus memory centers

Cephalopods have independently evolved complex centralized brains that demonstrate extreme innovations in the organization of virtually every organ and tissue. Their nervous systems utilize a distinct molecular toolkit that diverges from many other bilaterians, while still maintaining similar functions. The Cephalopod Vertical Lobe (VL) is one of the memory centers whose function and structure are analogous to the mammalian hippocampus. The objective of this study is to identify and map the expression of candidate signaling molecules responsible for neurotransmission in the VL-circuit of Cephalopods. Some candidates are novel and unique to Cephalopods or Molluscs, while others are conserved through the animal kingdom. First, we performed computational and manual annotation of RNA-seq data obtained from the Vertical and Superior Frontal Lobes of *Octopus vulgaris*. Next, candidate signal molecules were validated by cloning and localized using *in-situ* hybridization. Specifically, four neuropeptides were mapped to the *Octopus* brain - each revealing a unique expression pattern. While the function of these neuropeptides is yet unknown, our localization studies suggest that WhP may play a role at the first synapse of the simplified VL-circuitry and relay messages to the VL for processing. Two other neuropeptides, TkP and IRP, likely function at the second synapse of the VL-circuitry and process sensory inputs. In summary, the unique organization of the VL provides an illustrative example of convergent evolution and is an important model to understand the structural and molecular constraints on the development of mechanisms responsible for complex behaviors in cephalopods.

P2.114.5 LAVERGNE, S.L.*; MCGOWAN, P.O.; KREBS, C.J.; BOONSTRA, R.; Univ of Toronto Scarborough, Univ of British Columbia; *sophia.lavergne@mail.utoronto.ca*

Brain transcriptome response to predation risk during the 10-year snowshoe hare population cycle

The population dynamics of snowshoe hares *(Lepus americanus)* are fundamental to the ecosystem dynamics of Canada's 5,000,000 km2 boreal forest. Their 8-11 year population cycle is driven by predation, and hare densities can fluctuate up to 40-fold over the cycle. Predators (lynx, coyotes, great-horned owls) affect population numbers not only via direct mortality, but also through the indirect effects of chronic stress. Hares severely stressed by the threat of predation have been found to have greater plasma cortisol and glucose levels at capture and in response to hormonal challenge, heightened ability to mobilize cortisol and energy, and a poorer body condition. These effects may result in, or be mediated by differential gene expression. We tested transcriptional responses in the brain to elevated predation risk. An oligonucleotide microarray designed for a closely related species, the European rabbit, was used to characterize differences in hippocampal transcript abundance between wild-caught males during years of low versus high predator risk. A total of 106 gene loci were identified as having significant differences in transcript abundance between years. Results for candidate genes were validated with quantitative real-time polymerase chain reaction, and orthologous protein sequences were used for functional enrichment analysis of gene sets. Hares exposed to high levels of predation risk showed increased activity of genes involved in metabolic processes and hormone response, and decreased activity of genes involved in blood cell formation and immune response. These results are concordant with the physiological changes measured in previous studies. They indicate that there are pronounced transcriptional changes in the brain that occur in synchrony with changes in predation risk.

P2.30 LEASE, HM*; FULLER, A; MITCHELL, D; MEYER, LCR; HETEM, RS; Whitman College, Walla Walla, University of the Witwatersrand, South Africa, University of Pretoria, South Africa; *leasehm@whitman.edu*

The effect of captivity and game transport on core body temperature of wildebeest

Capture, transportation and temporary captivity of wild ungulates carries risk, including that of hyperthermia. Some wild ungulates die during capture, and capture-induced hyperthermia can be evident in both the presence and absence of chemical immobilizing agents. Much of the early work on physiological responses of ungulates under thermal stress was conducted on captive animals, and may not be applicable to free-ranging animals. No one has yet reported the body temperatures of the same wild-caught ungulates while ranging free, during capture, and while in captivity. Here we investigate the effects of captivity and game transport on core body temperature in blue (Connochaetes taurinus) and black (Connochaetes gnu) wildebeest during austral winter. We implanted miniature temperature-sensitive data loggers in wildebeest (n=19) to remotely and continuously assess core body temperature, and attached collars with miniglobe thermometers to assess wildebeest microclimate. We then exposed wildebeest to captive (boma-housed) and free-ranging conditions, while additionally opportunistically investigating the Tcore of wildebeest during transportation between these two conditions. We found that the amplitude of the daily rhythm of wildebeest core body temperature was higher when they were free-ranging than when they were captive, irrespective of species. We also found that wildebeest Tcore during transport reached temperatures much higher than maximum Tcore when free-ranging or boma-housed (up to 2.5°C higher for black wildebeest). We conclude that 1) homeothermy of captive ungulates thus does not imply homeothermy when ranging free, and 2) animals can experience precipitous rises in Tcore when transported, placing them at risk of morbidity and mortality.

P3.66 LEE, J.H*; YOON, T.H; KIM, A.R; KIM, K.R; KANG, H.E; LEE , S.R; KIM, H.W; Pukyong National University; *ellen3235@gmail.com*

Transcriptional analysis in muscular tissues using long dsRNA of Liv-MSTN/GDF11 from the whiteleg shrimp (Litopenaeus vannamei)

Myostatin (MSTN), also known as growth and differentiation factor 8 (GDF8), is a member of the transforming growth factor- (TGF-) superfamily. MSTN plays a crucial role in muscle growth, development, and differentiation. Recently, the primitive isoform of MSTN and GDF11 was identified in the shrimp, *Litopenaeus vannamei* (Liv-MSTN/GDF11). However, result of Liv-MSTN/GDF11 knockdown by dsRNA was different from the case with mammalian MSTN, by which muscle fibers were doubled. Instead, many of them were lethal and even survived shrimp showed significantly lower growth rate compared with those in control group. In present study, we compared transcriptomes between in the tail muscle and in the thoracic muscle after Liv-MSTN/GDF11 dsRNA injection using the Illumina Miseq platform. We screened the genes, whose transcriptional levels changes significantly (> 10 folds) in each tissue. 83 and 122 were identified as the differentially expressed genes between experimental and control groups; 57 and 88 of these genes were down-regulated, 26 and 34 genes were up-regulated in the thoracic and tail muscle. Among the differentially expressed genes after Liv-MSTN dsRNA injection, the transcriptional responses of the several isoforms of myosin heavy chains (MHCs) were different between the thoracic muscle and deep abdominal muscle. This result suggested that Liv-MSTN functions differently in different muscle types and further study should be made to know the biological implications of the different MHC isoforms in muscle growth and development in decapod crustaceans. These finding using the transcriptomic analysis help to understand the molecular mechanisms of muscle growth, development and differentiation.

P3.85 LEIGH, SC*; GERMAN, DP; University of California, Irvine; *scwright@uci.edu*

The Resource Acquisition Strategies of Seagrass-Eating Bonnethead Sharks

Sharks, which are uniformly carnivorous, have guts optimized for digesting a high-protein diet. Omnivores, on the other hand, also digest plant material, and thus, face the difficulty of digesting foods that are low in protein and lipid, and are sheathed in rigid cell walls. Interestingly, the bonnethead shark (*Sphyrna tiburo*) is known to consume copious amounts of seagrass as juveniles (62% of gut content mass in some populations), yet maintains a gut that morphologically reflects its carnivorous ancestry. Hence, in comparison to other sharks, juvenile bonnethead sharks may have adjusted their gut function to utilize plant material. The objective of this project is to investigate *S. tiburo* digestion to understand whether they can digest seagrass. The activities of various digestive enzymes, such as amylase, cellulase (including beta-glucosidase) and sucrase, were measured along with the concentrations of short chain fatty acids in the guts of juvenile bonnetheads. Digestibility of carnivorous, omnivorous, and seagrass diets was also measured in captive adult bonnetheads, and data analysis is in progress. This project could provide groundbreaking evidence that sharks, animals that were previously thought to be solely carnivorous, can benefit from the digestion of seagrass.

P1.132 LEMON, K.*; PODOLSKY, R.D.; Macalester College, College of Charleston; *klemon1@macalester.edu*

A latitudinal comparison of the effects of ocean acidification and temperature on the growth of sea urchin larvae

Anthropogenic CO_2-induced ocean acidification (OA) poses a threat to marine calcifying organisms. Early life-history stages may be especially vulnerable given their small size and relatively poor homeostatic capacities. In previous work we found significant effects on larval growth, but no significant genetic variation for resilience to near-future levels of OA, within a population of sea urchins (*Arbacia punctulata*). Here we tested for a difference in larval response to OA using latitudinally separated populations of *A. punctulata* from Woods Hole, MA and Charleston, SC. We fertilized eggs and reared larvae to the 4-arm stage (before food was needed) at two CO_2 levels (1x and 2.5x current) and at each of the two populations' collection temperatures (14 and 24°C), using a factorial design that treated fertilization and rearing conditions separately, producing a total of 16 treatments. Larval growth after 3 d (@ 24°C) and 6 d (@ 14°C) was quantified by recording 11 landmarks in three dimensions to measure 6 skeletal elements and several aspects of body size. Increased CO_2 during larval rearing had a significant and negative effect on skeletal measures in both populations but no significant effect on measures of body size. Larvae from the southern population were significantly larger in skeletal and body measurements. However, we found no significant interaction between population and CO_2 or between temperature and CO_2 in their effects on larval growth. Our findings suggest that A. punctulata does not show evidence of variation in resilience to acidification either within or between populations. A lack of genetic variation will make it more difficult for populations or species to rapidly evolve in response to future changes in ocean acidity.

P3.49 LEON, A.E.*; HAWLEY, D.M.; Virginia Tech, Blacksburg; *leona@vt.edu*

Varying exposure to a pathogen alters disease severity and resistance to secondary infection in a wild bird

In many host-pathogen systems, there is significant individual variation in the frequency and dose of pathogen exposure. Heterogeneity in exposure may result in differences in disease progression, the formation of immunological memory, and subsequent protection from future pathogen exposures. In the naturally-occurring house finch-*Mycoplasma gallisepticum* (MG) system, the pathogen is transmitted via bird feeders, and thus birds are likely exposed to frequent low doses of pathogen while foraging. We aimed to experimentally mimic heterogeneous exposure during foraging in order to determine how repeated low-dose exposures of house finches to MG influence host responses and resistance to a secondary high-dose challenge. MG-naive house finches were given priming inoculations that varied in number of exposures and ranged in dose from 10^1 to 10^5 pathogen color changing units. Resulting pathogen load over the course of infection was significantly affected by both dose and number of exposures, while disease severity was influenced by dose alone. All birds were then given a secondary high-dose (10^5) challenge to assess the level of protection generated by priming inoculations. All priming treatments showed significant protection to high dose challenge relative to birds that had not been previously exposed to MG. Strikingly, in some cases, repeat low-dose exposure to MG, a proxy for what birds likely experience in the wild while feeding, provided complete protection against a high dose challenge. Our results suggest that bird feeders, which serve as a source of infection in the wild, may also act as "immunizers", with important consequences for disease dynamics.

P2.5 LEVENGOOD, J.C.*; ROSTAL, D.C.; Georgia Southern Univ.; *jl03683@georgiasouthern.edu*

Egg and Hatchling Size from Two Populations of Gopherus polyphemus in Southeastern Georgia: Effects of Habitat Quality

The influence of habitat quality on female size, egg size and hatchling size has received limited attention in tortoises. This region of study is of utmost importance in the conservation of chelonians because of the vulnerability of subadults of these species to predation. This study examines the difference between the size of the eggs and hatchlings from two populations of gopher tortoise in southeastern Georgia. The study sites are George L. Smith state park and the Fort Stewart Army Reserve. Both sites contain sandhill habitats dominated by longleaf pine and wiregrass, which is the primary habitat of the gopher tortoise in Georgia. These sites have varying management plans in relation to prescribed burns, with the entirety of the Fort Stewart Army Reserve being burnt biennially and George L. Smith state park being burnt irregularly, with the last burn occurring in 2014. Female tortoises from each site were captured and measured, then taken to Georgia Southern where they underwent X-ray radiography to determine gravidity and clutch size. They were released at the point of their capture within 24 hours. Nests were located and staked with vinyl coated wire mesh grates during the laying season from late May to early July and eggs were retrieved from those nests on August 19th (Fort Stewart) and August 21st (George L. Smith) to be incubated until hatch. Ten nests were retrieved from Fort Stewart, while five nests were retrieved from George L. Smith. The eggs from each site are compared first to each other, then to a historical data set covering the past 20 years in order to determine if controlled burns have an effect on egg and hatchling size and weight.

P3.108 LI, C*; TIAN, R; PORTER, W; HAMMOND, Z; STRACHAN-OLSON, D; KOOKER, AW; OLIVAS, J; KESSENS, CC; JAYARAM, K; FEARING, RS; FULL, RJ; University of California, Berkeley, Army Research Laboratory; *chen.li@berkeley.edu*

Cockroach-inspired self-righting robots

Legged animals and robots running in complex natural or artificial terrain must be able to right themselves if they flip over. Recent legged robots, such as RoboCrab, have added extra appendages dedicated to kinematic self-righting. By contrast, insects display far more diverse self-righting strategies using existing body structures and appendages in novel ways, some of which may be well suited for existing robots. Here, we explore likely exaptations where wings and body bending appear to be co-opted for self-righting. We developed two novel self-righting robots as a first step towards taking advantage of structures already existing in some robots. The discoid cockroach inspired robot has two wings that can fold against each other about the fore-aft axis of the body. The Madagascar hissing cockroach inspired robot has two dorsal shells equivalent to body segments that can fold against each other about the lateral axis of the body. By raising the center of gravity and reducing ground contact, the folding motion renders both robots unstable when upside down and results in rapid self-righting. We use experiments and modeling to explore how righting performance depends on folding angle/speed and wing/body shell shape. Our next step is to integrate these novel folding mechanisms with recently developed rounded shells to enable legged robots to both traverse obstacles and self-right. We envision that our approach which takes advantage of existing body/appendage structures will help robots overcome diverse locomotor challenges in complex terrain without adding complex, specialized structures.

P3.200 LICHTI, NA; POST, AM*; ROSAS, MM; WILSON, RC; STRAND, CR; Cal Poly State Univ, San Luis Obsipo, Cal Poly State Univ, San Luis Obispo, Allan Hancock College, Santa Maria; *cstrand@calpoly.edu*

Effects of sex and season on neuroplasticity of cortical brain regions in Western fence lizards, Sceloporus occidentalis

In reptiles, the dorsal and medial cortices (DC and MC) are important brain regions involved in the formation and storage of spatially relevant memories and exhibit plasticity in response to changes in spatial navigation. As with many reptiles, male Western fence lizards (*Sceloporus occidentalis*) are territorial during the breeding season. In other species, territorial males have larger cortical volumes than non-territorial males, however it is unknown if there are differences in the volumes of cortical brain regions between males and females. In this experiment, male and female *S. occidentalis* were captured from the wild during the breeding season and during the post-breeding season and were held in captivity for approximately four weeks, during which time, spatial memory tests were performed. At the end of the experiment, lizards were sacrificed and brains were collected and processed for histology. Cresyl-violet stained sections were used to quantify brain region volumes. There were no differences between the sexes or seasons in spatial learning abilities; lizards failed to demonstrate learning in either season. If plasticity of the cortical regions depends on differences in spatial navigation ability, there may not be differences in the volumes of the cortical regions. However, if plasticity in these brain regions depends on differences in space use, not differences in the ability to learn, male lizards during the breeding season will have larger DC and/or MC volumes compared to females during either season and compared to males during the non-breeding seasons.

P1.158 LIEBL, EC; Denison University, Granville OH; *liebl@denison.edu*

Drosophila sensory neurons and the larval forager to wanderer transition

We are using dosage-sensitive genetics to better understand the biology that governs the Drosophila larval forager to wanderer (f-t-w) transition. The f-t-w transition occurs late in larval development, as larvae prepare to pupate. Previously we had uncovered a dosage-sensitive genetic interaction between the zinc-finger transcription factor Sequoia and the Rho-GEF Trio that disrupts the f-t-w transition. We now report that selective expression of Trio in the larval class IV da sensory neurons that tile the larval body wall completely rescues this disruption. On-going work aims to characterize the morphology and the functionality of the class IV da sensory neurons between these disrupted and rescued larvae.

P1.110 LIM, I*; KLEMPAY, BL; MALLULA, ML; OLSEN, AM; Williams College, Yale University, University of Kansas, University of Michigan, Ann Arbor; *il3@williams.edu*

The Effect of Oxalic Acid on Apis Mellifera Motor Responses

The decline of the honeybee population has been receiving media attention recently. Perhaps a contributing factor in colony collapse disorder (CCD), honeybees are also bombarded with many other stresses such as pesticides and miticides. In order to study the potential effect of miticides on honeybees, 160 forager honeybees (*Apis mellifera anatoliaca*) were tested for motor control in response to doses of oxalic acid. Using a LD_{50} of 548.95 µg/bee, the different doses tested were 1/5, 1/10, 1/50, 1/100, 1/500, 1/1000 of the LD_{50}. Subscores were blindly given before and after treatment for four different parts of the bee: proboscis, legs, wings, and abdomen. The aggregate scores were then analyzed. A null hypothesis of no significant changes in motor scores and an alternative hypothesis of any change in motor scores were tested. Even at high doses, oxalic acid did not have any effects on the motor control of bees, and thus it can be concluded that the commonly used miticide is not dangerous to forager bees, failing to reject the null hypothesis ($p = 0.572$). These results corroborate finding of the previous REU researchers, which show that pesticides vary in their toxicity to honey bees. Similar to acetamiprid in these prior studies, oxalic acid did not significantly affect motor control of honey bees. Oxalic acid is a miticide that we tested in a single factor experiment as acute doses. Since other general insecticides may accumulate in the hive and oxalic acid is applied for much longer periods than in our study, more research is needed on the effects of chronic and combined pesticide exposure on honeybee behavior.

P2.158 LIMERI, L. B.*; MOREHOUSE, N. I.; University of Pittsburgh; *lbl9@pitt.edu*

The evolutionary history of the 'alba' polymorphism in the butterfly sub-family Coliadinae (Lepidoptera: Pieridae)

Polymorphisms are common in the natural world and have played an important role in our understanding of how selection maintains multiple phenotypes within extant populations. Studying the evolutionary history of polymorphisms has revealed important features of this widespread form of phenotypic diversity, including its role in speciation, niche breadth, and range size. Here, we examined the evolutionary history of a ubiquitous color polymorphism in the sulfur butterflies (sub-family: Coliadinae) termed the 'alba' polymorphism. We investigated the origin and stability of the 'alba' polymorphism using ancestral state reconstruction analysis. Our results indicate that the ancestor of the Coliadinae was polymorphic and that this polymorphism has undergone repeated transitions to monomorphism. Repeated loss of polymorphism suggests that the 'alba' polymorphism may be relatively unstable over evolutionary time. These results provide a framework for future studies on the origin and maintenance of the 'alba' polymorphism and guide the direction of future hypotheses. We discuss these results in light of current understandings of how the 'alba' polymorphism is maintained in extant populations.

P3.198 LIN, C.*; CRONIN, T.W.; University of Maryland Baltimore County; *linc@umbc.edu*

Neural organization of the optic lobes in the two midband-row stomatopod Squilla empusa

Stomatopod crustacean have tripartite compound eyes, each with a dorsal and ventral hemisphere separated by two to six ommatidial rows called the midband. The structure and function of the retina have been studied extensively, but the organization of the optic lobe is less well documented. Using reduced silver staining, Golgi impregnation and fluorescent tracers, we show that in *Squilla empusa*, a species that has two midband rows, the optic lobe organization follows the malacostracan ground pattern. The lamina, medulla and lobula are composed of small columnar subunits that retinotopically correspond to inputs from each ommatidium of the compound eyes. Photoreceptor projections from the midband supply two enlarged lamina cartridges lying adjacent to those of the ventral hemisphere. A gap in the lamina exists at the location of the missing lamina cartridges of the four rows of color-processing channels. Projections from the remaining two midband rows can be traced through the entire optic lobe, as they stain more darkly with reduced silver. At the medial end of the optic lobe, outputs from the dorsal and ventral hemispheric laminas supply the medulla on its dorsal and ventral halves respectively. These neurons then project horizontally in the medulla, and each crosses with the midband lamina projections at the midline. Fluorescent tracer studies targeting this region show increased axonal arborizations at each intersection between these crossing projections, indicating potential for crosstalk between the midband and the dorsal and ventral hemispheres. Our results support the concept that two midband row species are derived from an ancestor that had six midband rows. Visual information from distinct eye regions appears to be combined in the medulla, permitting comparison of visual inputs to all three retinal regions.

P3.109 LIN, Y.F.*; KONOW, N.; DUMONT, E.R.; University of Massachusetts, Amherst, Brown University; *yifen@bio.umass.edu*

Back to sprawling: the kinematics of humerus in Eastern moles during walking and burrowing

The evolution of tetrapod locomotion is typically considered to progress from a sprawling gait with the limbs out to the side, as in salamanders, to an erect stance with the limbs underneath the body, as in birds and mammals. However, studies of crocodylians reveal that a derived, erect stance can revert to sprawling stance. Moles (Talpidae) are one of the most specialized fossorial mammals and assume a sprawling stance. Their short, broad humerus is oriented perpendicular to the sagittal plane of body, and its movement has been suggested to be the primary contributor to the production of force during digging. We investigated the kinematics of the humerus in Eastern moles (*Scalopus aquaticus*) during walking, lateral strokes, and scratching. Behavioral studies suggest that moles use these three movements extensively during tunnel building and patrolling. We implanted radiopaque markers into the humerii of Eastern moles and tracked the movements of the humerus using x-ray reconstruction of moving morphology (XROMM) during walking on a flat surface, doing lateral strokes in loose couscous, and scratching in compact couscous. We found that the humerus moved differently during these three movements. During walking the humerus rotated primarily in the transverse axis, presumably to increase stride length. In contrast, during lateral strokes and scratching, rotation mainly occurred along both the longitudinal and transverse axes. However, transverse axis rotation started at a larger angle during the lateral stroke than during scratching, indicating a more extended posture of forearm at the beginning of the burrowing cycle in the lateral stroke than in scratching. The physiological and mechanical mechanisms behind these kinematic differences will be the focus of future study.

P1.203 LITWA, H.P.*; VASSALLO, B.G.; PAITZ, R.T.; HAUSSMANN, M.F.; Bucknell Univ., Illinois St. Univ.; *hpl002@bucknell.edu*

A metabolic buffer in the in ovo environment of Japanese quail (Coturnix japonica) regulates exposure to maternal glucocorticoids

Maternal effects, the nongenetic changes in offspring due to the maternal environment, can have a large influence on offspring phenotype. Glucocorticoids (GCs), steroids involved in the stress response, can be passed from mother to offspring and influence development. Recent evidence suggests that embryos can regulate their exposure to maternal GCs. Given this active regulation of the early endocrine environment, we examined how site of injection (yolk vs. albumen) and dose affected embryonic exposure to corticosterone (CORT). We injected eggs of Japanese quail (*Coturnix japonica*) with a low or medium dose (within physiological range) or a high dose (pharmacological) of [3H]-CORT, and then collected eggs after 6 or 9d of development. Eggs were then separated into albumen, yolk, and embryonic tissue to identify the presence of free and conjugated steroids while CORT and its metabolites were identified through thin layer chromatography (TLC). We found that both site of injection and dose influenced embryonic exposure to CORT. Yolk-injected eggs had more free and conjugated steroids in the yolks compared to albumen-injected eggs at both days of development. The level of free steroids in the yolk was lower at lower doses and decreased during development, while the conjugated steroids in the yolk increased with dosage and during development. In addition, the level of free and conjugated steroids in the embryonic tissue were highest early in development and at higher doses. TLC analysis detected a number of CORT metabolites along with CORT in the embryo which suggests that while a buffer plays an extensive role in metabolizing steroids, this buffer can be overwhelmed at higher maternal steroid levels.

P1.131 LIZÁRRAGA, D.M.*; DANIHEL, A.; PERNET, B.; California State University, Long Beach; *daveml@ucdavis.edu*

Interference by large inedible particles reduces clearance rates of echinoderm larvae

Many marine invertebrate larvae must feed in the plankton in order to complete development. During this time, larval mortality is high due to factors such as predation and advection. Larvae that most rapidly obtain the energy needed to reach competence are most likely to survive to metamorphosis; thus larvae should maximize their feeding rates. Larval feeding rates are commonly measured in suspensions of edible particles, but natural plankton also contains particles so large that they can not be ingested (e.g., some dinoflagellates and diatoms). Hansen (1991, JEMBE 152:257-269) showed that feeding rates of copepodites and veligers are lower in the presence of large inedible particles at high concentrations (1,000-20,000•ml^{-1}). We hypothesized that the presence of such particles reduces feeding rates of echinoderm larvae. Larvae of two asteroids (*Astropecten armatus* and *Patiria miniata*) and two echinoids (*Dendraster excentricus* and *Lytechinus pictus*) were permitted to feed briefly on 6 µm beads alone, or in combination with large inedible beads (asteroids, 100 µm; echinoids, 75 µm) at concentrations of 25, 50, 100 or 500•ml^{-1}. We quantified ingestion rates of 6 µm beads and estimated clearance rates in each treatment. Clearance rates of all four species were ~50% lower in treatments including large inedible beads at 100 or 500•ml^{-1}, consistent with our hypothesis. In the presence of large inedible particles, larvae may alter their swimming behavior, or engage in particle rejection behavior; both activities might reduce the amount of time larvae would otherwise spend feeding. Our results suggest that the feeding performance of larvae in nature may depend not only on the amount of available food, but also on the presence and abundance of potentially interfering non-food particles.

P3.182 LOHMANN, A.C.*; EVANGELISTA, D.J.; WALDROP, L.D.; MAH, C.; HEDRICK, T.L.; Univ. of North Carolina, Chapel Hill, Smithsonian Institution; *alohmann@live.unc.edu*

Covering ground: A look at movement patterns and random walk behavior in Aquilonastra sea stars

The paths animals take while moving through their environments can determine the likelihood of encountering food and other resources, thus models of foraging behavior abound. To collect movement data appropriate for comparison with these models, we used time-lapse photography to track movements of a small, hardy and easy to obtain organism, *Aquilonastra* sea stars. We recorded the sea stars in a tank over many hours, with and without a food cue. With food present, they covered less distance, as predicted by theory because this strategy would allow them to remain near food. We compared the search performance of the observed sea star movements to Brownian motion and Lévy walks using simulation and found that a model incorporating intermediate correlated random walk behavior drawn from observed *Aquilonastra* tracks outperformed Lévy and Brownian models when the target was at middling distances from the starting position. In contrast, our intermediate model was outperformed by Brownian walkers at close distances, and by Lévy walkers at far distances. Thus, *Aquilonastra* may have a movement strategy that allows them to effectively locate resources outside their immediate detection range. Furthermore, while organisms are unlikely to truly follow an idealized random walk such as a Lévy walk in all details, our data suggest that comparing the effectiveness of a given organism's paths to those from theory can give insight into the organism's actual movement strategy. Additionally, automated optical tracking of invertebrates proved feasible and *Aquilonastra* was a revealed to be a tractable tabletop 2D movement study system.

P2.6 LOLAVAR, A*; WYNEKEN, J; Florida Atlantic University; *jwyneken@fau.edu*

The Effect of Rainfall on Green Turtle Incubation Temperatures and Hatchling Sex

Marine turtles have temperature dependent sex determination (TSD), by which lower nest temperatures produce more males. Nest temperature variation can be affected by environmental factors such as rainfall, shade, and sand type. We measured relationships among nest temperatures, rainfall, and hatchling sex ratios of green turtle (*Chelonia mydas*) at a nesting site in Boca Raton, Florida USA across the 2010-2013 nesting season. Rainfall events were synchronized with the temperature profiles of each nest sample. We analyzed nest temperature data to identify any signal that rainfall events altered nest temperatures. A subset of hatchlings was sexed laparoscopically to provide empirical measures of the sex ratio for the beach. Nest temperature profiles were synchronized with rainfall data from weather services to identify relationships with hatchling sex ratios. The majority of hatchlings in the samples were female suggesting that across the four seasons most nest temperatures were not sufficiently cool to produce males. However, in the early portion of the nesting season and in wet years, nest temperatures varied and significantly more males hatched. The study suggests that rainfall events can lower nest temperatures during incubation, but the embryonic sex response to rainfall may produce results not appreciated by temperature alone. Thus, predicting sex ratios under field conditions remains challenging.

P2.130 LOUGH-STEVENS, M.*; SCHULTZ, N.; DEAN, M.; University of Southern California; *loughste@usc.edu*

Variation in the baubellum across different genetic strains of mice (Mus musculus domesticus)

The evolution, diversification, and maintenance of external genitalia are important aspects of natural selection and sexual selection in evolutionary biology. The coevolution between male and female genitalia, whether in concert or in conflict, naturally leads to integrative questions that unite many disciplines of biology. The os penis or baculum in males, and the os clitoris or baubellum in females, are ossified structures located in the genitalia of mammals. While the baculum has been the subject of 100 years of research the baubellum by contrast has received little attention, and there are no testable hypotheses for its evolution or diversification. Here we apply a novel morphometric approach to study the baubellum in three dimensions, and to test whether phenotypic variation has a genetic basis. The results of our analysis will add a novel aspect to studies of the heritable basis of mammalian reproduction.

P2.199 LOUIS, L.D.*; BADGER, M.A.; DUDLEY, R.; Univ. of California, Berkeley; *llouis@berkeley.edu*

It's a breeze: aperture negotiation by hummingbirds flying with and against the wind

Hummingbirds face many environmental challenges during flight (e.g. wind, rain, and constrictions formed by vegetation), and movement through the natural world often presents these challenges simultaneously. Whereas we know in part how hummingbirds confront individual challenges, we do not understand how they handle multiple constraints at once. In these situations, birds could use a combination of the compensatory behaviors they use to overcome individual challenges. Alternatively, novel behaviors could emerge when birds are confronted with simultaneous constraints. Novel behaviors would suggest the importance of learning when adapting to complex situations. To assess responses to multiple locomotor challenges, we measured behaviors and kinematics in hummingbirds flying through a geometric constriction in either a headwind or a tailwind. Then, we compared our findings with what hummingbirds do when confronted with wind or constrictions individually to determine if birds use predictable or novel behaviors when faced with simultaneous constraints. Results demonstrate the capability of birds to adapt to complex environments, and suggest principles for designing flying devices that operate in these environments.

P3.130 LOWDER, KB*; TAYLOR, JRA; ALLEN, MC; DEHEYN, DD; Scripps Institution of Oceanography, UC San Diego; *kblowder@ucsd.edu*

Effect of decreased pH and increased temperature on the growth, coloration, and calcification of the grass shrimp Hippolyte californiensis

The coloration of many caridean shrimp allows them to blend into their environment but with a degree of success that can depend on both physiology and cuticle structure. While decreased ocean pH and increased temperature—consequences of increased atmospheric pCO_2—may affect both animal characteristics, their impact on color change has yet to be explored. Here, we exposed the grass shrimp *Hippolyte californiensis* to low pH and increased temperature to determine the effect on growth, calcification, and the ability to match environmental color cues of their eelgrass habitat. For seven weeks, solitary shrimp experienced ambient pH and temperature (7.98, 17°C), low pH and ambient temperature (7.53, 17°C), or low pH and increased temperature (7.48, 20°C). After five weeks, the ambient light color was changed from white to green. Carapace length and mass were measured for growth, cuticle mineral ratios were analyzed via inductively-coupled plasma mass spectrometry, and coloration was determined from digital imaging taken under controlled settings and analyzed as red, green, and blue channels in Photoshop. Shrimp showed no significant differences in growth or coloration. However, shrimp in low pH, high temperature conditions had significantly higher ratios of $^{26}Mg/^{48}Ca$ and $^{86}Sr/^{25}Mg$ than those in ambient conditions. These findings indicate that these shrimp have sufficient capabilities to compensate for pH changes in their environment in order to maintain growth, mineralization, and coloration, which are perhaps derived from living in eelgrass with diurnal pH changes. Yet, the combined effect of increased temperature and low pH seems to alter the calcification process and change the composition of the cuticle.

P1.186 LUCAS, A.R.*; RICHARDS, D.Y.; RAMIREZ, L.M.; LUTTERSCHMIDT, D.I.; Portland State Univ., OR; *ashley.maine@yahoo.com*

Relationship between neuropeptide Y, arginine vasotocin, and seasonal life-history transitions in red-sided garter snakes.

Many animals exhibit seasonal changes in life-history stages that are often accompanied by dramatic switches in behavior. For example, migration is frequently accompanied by transitions between reproduction and feeding. While the neuroendocrine mechanisms that regulate such behavioral transitions are poorly understood, arginine vasotocin (AVT) and neuropeptide Y (NPY) are excellent candidates: brain AVT modulates reproductive behavior while NPY regulates feeding. We asked if seasonal changes in AVT and NPY are concomitant with migration to and from the breeding grounds in red-sided garter snakes (*Thamnophis sirtalis*). We collected male and female snakes pre- and post-migration during the spring and fall. Brains were processed for immunohistochemistry and the total number of AVT- and NPY-immunoreactive (ir) cells was counted and corrected for variation in regional brain volume. As predicted, males had significantly more AVT-ir cells in the preoptic area and bed nucleus of the stria terminalis during the spring mating season. Males had significantly more NPY-ir cells during the fall in the cortex and posterior hypothalamus, likely reflecting increased feeding behavior during the summer foraging period. Surprisingly, females did not exhibit seasonal differences in NPY-ir cell number, but did have more AVT-ir cells in the preoptic area during the spring. Neither AVT- nor NPY-ir cell number varied significantly with migratory status, although we did observe significant changes related to behavioral status (reproductive vs. nonreproductive). Our results suggest that AVT and NPY play a role in regulating seasonal transitions in reproductive and foraging behaviors, and may be involved in mediating sex differences in the timing of life-history events.

P3.56 LUOMA, R.L.; BUTLER, M.W.; STAHLSCHMIDT, Z.R.*; Univ. of Georgia, College of Vet. Med., Lafayette College, University of the Pacific; *zstahlschmidt@pacific.edu*

Does eating enhance or impair immune function?

Following a meal, animals can exhibit dramatic shifts in physiology, including rapid growth of the gut and heart, as well as a massive (>40-fold) increase in metabolic rate associated with the energetic costs of processing a meal (i.e., specific dynamic action, SDA: defined as the accumulated energy expended from the ingestion, digestion, absorption, and assimilation of a meal). However, little is known about the effects of digestion on an important physiological and energetically costly trait: immune function. Thus, we tested two competing hypotheses. First, digesting animals up-regulate their immune systems due to increased microbial exposure associated with ingested food. Second, digesting animals down-regulate their immune systems to devote energy to the breakdown of food. We assayed innate immunity (the chief mechanism of host defence across animal taxa) in corn snakes (*Pantherophis guttatus*) during and after meal digestion. We specifically measured hemoagglutination (antibody-mediated agglutination of foreign red blood cells) and hemolysis (complement-mediated lysis of foreign red blood cells) at two time points (1 and 7 day[s] post-feeding during absorptive and non-absorptive states, respectively). Agglutination was higher during absorption in support of our first hypothesis. Because immune up-regulation likely contributes to SDA, the definition of SDA may need to be expanded to include this costly physiological process.

P1.30 MAH, J.L.*; LEYS, S.P.; University of Alberta; *jmah@ualberta.ca*

The interplay between neurodevelopmental genes and sensory regions in sponges

Recent phylogenomic studies have suggested that ctenophores are basal in Metazoa, leading to two hypotheses on the evolution of the nervous system: either sponges, a phylum of nerveless animals, lost a nervous system or ctenophores independently gained one. This is difficult to test, but understanding the function of neurodevelopmental genes in an aneural animal is informative. An intriguing suite of neurodevelopmental genes have been discovered in sponges. A tentative regulatory network consisting of an atonal-related bHLH, Notch and Delta orthologs was found to underlie the differentiation of a distinct cell type in the larvae of *Amphimedon queenslandica*. Orthologs of Six, Pax, Elav and Msi are expressed in another sponge, *Sycon ciliatum*. And multiple Sox genes are differentially expressed during development of the larvae and juvenile of *S. ciliatum*. Moreover, adult sponges can sense a disruption of flow in its canal system and respond with a choreographed inflation-contraction behavior to flush out obstructions. Though the underlying genetic basis of this behavior remains obscure, sensory abilities and initiation of the inflation-contraction behavior can be traced to primary cilia in the osculum, the excurrent canal of the sponge. This suggests that the osculum may act as a sensory and coordinating hub. Since transcriptomes of various life stages and body regions are available from *Sycon*, this hypothesis can be tested by searching for expression of these neural genes during development of the osculum and in the region proximal to the osculum. I will present the findings of these analyses, a first step towards using the sensitive osculum as the basis of functional experiments to explore the neural heritage of sponges.

P1.194 MAJOR, A.K.; FOKALA, D.A.; LEININGER, E.C.*; St. Mary's College of Maryland; *ecleininger@smcm.edu*

The effects of androgens on vocalizations of Xenopus species with temporally simplified male advertisement calls.

African clawed frogs depend on sex-specific vocalizations to mediate reproduction. The male advertisement (fertility) call varies across species in sound pulse rate and in the complexity of its temporal structure. We examined the role of sex hormones in the vocal masculinization of two species of *Xenopus*, *X. borealis* and *X. boumbaensis*, which both exhibit evolutionarily derived and temporally simplified male advertisement call patterns, but display different degrees of vocal sex differences. In X. borealis, advertisement call simplification has occurred alongside reduced sex differences in call rapidity. In contrast, vocal sex differences are extreme in *X. boumbaensis*, as females do not produce calls. We previously showed that a loss of sex differences in vocal effector physiology has occurred in *X. borealis*, but not *X. boumbaensis*, suggesting species-specific modifications to the hormonal regulation of sexually differentiated features. Exogenous androgen treatment (but not ovariectomy alone) caused development of advertisement-like vocalizations in as quickly as one week (*X. borealis*) or 6 weeks (*X. boumbaensis*); advertisement inter-call intervals decreased over 16 weeks of treatment, but still remained elongated relative to intact male inter-call intervals. Additionally, androgen treatment caused significant increases in laryngeal mass, relative to that of controls. Our results suggest that androgen sensitivity of the vocal circuit is conserved across the *Xenopus* genus, and that androgens are capable of masculinizing vocal circuits even in cases of extreme vocal sex differences.

P1.128 MAK, K.K.Y.*; CHAN, K.Y.K.; University of British Columbia, Hong Kong University of Science and Technology; *karenmakky@yahoo.com.hk*

Interactive effect of warming and hyposalinity stress on early life stages of the sea urchin Heliocidaris Crassispnia

In the face of global climate change, marine organisms are challenged by multiple and interactive environmental stressors. In the subtropics, warming and intensified precipitation, and hence, reduced salinity are particularly relevant. Using the sea urchin, *Heliocidaris crassispina*, we investigated the effect of warming and hyposalinity on fertilization success and early development because these early life history stages have significant impacts on population dynamics of this commercially harvested species. Gametes were held at two salinities (24 psu and 32 psu) and exposed to a temperature gradient. Fertilization appeared to be less sensitive than blastula formation to warming as indicated by a higher critical temperature (LT_{50}); this observation highlights a sensitivity difference for different developmental stages. When reared at one of the four combinations of temperatures (24°C and 28°C) and salinities (24 psu and 32 psu), larvae in the low salinity treatments had significantly lower survival rates but temperature alone had no effect on survivals. Temperature and salinity has a synergetic effect on larval growth. Larval cloning was documented under both warming and low salinity treatments. However, incomplete separation were observed only at 28°C suggesting the mechanism for cloning may be disrupted under high temperatures. We also observed significant difference between maternal lineages. Such intra-specific variations implies the present of genetic variations upon which natural selection can act, and hence, urchins may be able to adapt to future salinity and temperature stress.

P2.168 MANAFZADEH, A.R.*; HOLROYD, P.A.; RANKIN, B.D.; Univ. of California, Berkeley; *armita@berkeley.edu*

Using the geometric properties of jaws to constrain dietary reconstructions of phylogenetically ambiguous taxa

Reconstructing feeding behavior for extinct taxa typically relies on comparisons to living relatives. However, this is problematic when studying fossils with ambiguous phylogenetic affinities. In the early Paleogene, several faunivores with unclear evolutionary relationships exploited prey with different physical properties. Here we use a biomechanical approach and apply beam theory to determine the cross-sectional properties of dentaries, assessing the capacity of these taxa to process tougher versus more ductile foods. Micro-CT scans were prepared for 20 dentaries comprising four orders of early Paleogene taxa from North America. For each specimen, the dimensions of the dentary were measured at homologous slices along the tooth row to calculate section moduli (geometric properties of beams) using the BoneJ plugin to ImageJ. Some fossil carnivorans and creodonts were found to overlap in range for mean dorsoventral section moduli with small extant canids, suggesting that they are equally resistant to dorsoventral bending during prey capture and processing. In addition, different genera within the Pantolestidae are differentially resistant to bending stresses, supporting previous hypotheses of pantolestid feeding behavior based on comparative tooth morphology. The biomechanical properties of the dentary are independent of phylogeny and reflect bone remodelling in response to forces encountered during life. Thus, they can be used in conjunction with other lines of evidence to develop more explicitly testable hypotheses about behavior in extinct organisms and create more informed reconstructions of feeding behavior.

P2.162 MARKELLO, K.M.*; ROOPNARINE, P.D.; MOOI, R.J.; California Academy of Sciences; *kmarkello@calacademy.org*

Multiple manifestations of miniaturization in microechinoids

The Fibulariidae is a family of miniaturized microechinoids (Clypeasteroida: Laganina) seldom achieving a body length of 20 mm. Dwarf clypeasteroids from a variety of disparate groups have been placed in this family on the basis of the superficial criterion of size. Confusion is largely due to overall morphological simplification resulting from what appears to be paedomorphosis. Extreme, paedomorphosis-driven miniaturization causes loss of terminally added characters that might otherwise inform relationships. An example of how mysteries stemming from this loss can be resolved comes from a supposed *Echinocyamus*, *E. planissimus*. This curiously flattened form seems out of place among other *Echinocyamus* in several respects. Using digital imaging, X-rays, microCT, and morphometrics, we examined the external and internal morphology of *E. planissimus* and discovered several traits suggesting that it is not only not a member of *Echinocyamus*, but not even a fibulariid. When compared with members of the sister family Laganidae, *E. planissimus* had similarly branched internal buttresses, supporting its removal from Fibulariidae and assignment either to the laganid genus *Peronella*, or perhaps a new genus. The resolution of such seemingly "small issues" is important because of what this means for our overall view of evolutionary pattern. With more accurate determination of the affinities of *E. planissimus*, we add another detailed example of convergent evolution involving miniaturization among echinoids. We also add concomitant support for theories of why this life history strategy is crucial to understanding diversification of the clypeasteroid clade. This illustrates how reassessments of phylogenetic position can culminate in enhanced understanding of the processes of evolution in marine forms.

P3.70 MARCOUX, T.M.*; KORSMEYER, K.E.; Hawai'i Pacific University; *tmarcoux@my.hpu.edu*

Wave Induced Stress and Its Effects on Coral Reef Fish Swimming Performance and Energetics

Fishes living in high energy coral reefs are faced with the challenge of maintaining position against wave-induced water surges and must expend energy to remain stationary in bi-directional flow. This process of dealing with wave stress is an energetically expensive endeavor, and examining the energetic costs of inhabiting these environments is important in understanding a species habitat use and distributions, and responses to environmental change (e.g. wave intensity). Thus far, the swimming costs of station-holding in a bi-directional wave surge have not been measured, and may vary with swimming style and morphology of the fish. Using a novel wave-simulating apparatus, the Simulated Wave Motion Respirometer (SWMR), energetic costs were measured via intermittent-flow respirometry as fish swam through a regiment of increasing wave frequencies and amplitudes. Oxygen consumption rates were measured for coral reef associated species that utilize a wide variety of swimming modes. Comparisons were made for metabolic rates between species using body-and-caudal fin (BCF) swimming, and median-and-paired fin (MPF) swimming including labriform, balistiform, and ostraciiform swimming subtypes. Within swimming modes, metabolic rate comparisons were made between species that differed in fin morphology, examining the role of fin aspect ratio in unsteady swimming performance and coping with energy demands in increased wave-action. These measures may help elucidate the observed relationships between morphology, swimming ability, habitat use, and the diverse swimming modes of coral reef fishes.

P3.95 MARSHALL, H.*; BERNAL, D.; SKOMAL, G.; RICHARD, B.; BUSHNELL, P.; WHITNEY, N.; Mote Marine Laboratory, University of Massachusetts Dartmouth, Massachusetts Division of Marine Fisheries, National Marine Fisheries Service, NOAA, Indiana University South Bend; *hmarshall@mote.org*

Blood stress physiology parameters and mortality rates of sharks after commercial longline capture

The National Marine Fisheries Service recently released the Atlantic Highly Migratory Species Management-Based Research Needs and Priorities, with key research needs including establishing post-release mortality rates for commercially caught sharks. Such information is listed as *High Priority*, and very important in creating effective fisheries management plans for sharks targeted or caught as bycatch in commercial gear. Published at-vessel mortality rates indicate that capture-associated mortality is species-specific. Research assessing interspecific mortality rates is critical, but it is also imperative to understand the physiology underlying such mortality events. The physiological upset sharks experience while captured on fishing gear can result in irreversible cellular damage, resulting in immediate or delayed mortality. Longline research on various coastal sharks reveal some stress physiology parameters are correlated with magnitude of the capture stress (e.g., lactate), and that blood potassium levels are significant ($p<0.05$) predictors of both at-vessel and post-release mortality. Specifically, the role potassium plays in these mortality events needs to be better understood. The further elucidation of mortality indicators, and what is driving such mortality events, can be used on various scales in the future to predict mortality rates, and develop mitigation measures for fisheries management.

P1.96 MARSHALL, C.A.*; GHALAMBOR, C.K.; Colorado State University; *cam13@colostate.edu*

The effects of short- versus long-term salinity acclimation on resting metabolic rate in Trinidadian swamp guppies

Salinity tolerance is a defining factor in shaping geographic range limits of many species. Nonetheless, the influence of salinity tolerance on patterns of dispersal and local adaptation are relatively understudied for most species. In aquatic environments, euryhaline species are capable of acclimating to a wide range of salinities; however, most species typically exhibit a preference for a particular salinity. For example, previous work in euryhaline teleosts indicates that crossing along a salinity gradient typically results in increased oxygen uptake, incurring an energetic cost for the organism. On the island of Trinidad, swamp guppies, *Poecilia picta*, are typically found in adjacent fresh and brackish water habitats, but the degree to which these populations are locally adapted to different salinities is unknown. We investigate the physiological responses to variations in salinity at different temporal scales as a means to determine whether the physiological response to salinity variation in these populations is locally adaptive. To do so, we split wild-caught individuals from each population and laboratory acclimated them to freshwater (0ppt) and brackish water (30ppt) conditions over a 3-month period. By gradually acclimating wild *P. picta* to alternate salinities, we simulated slow movement along the salinity gradient. We also tested the effect of a rapid acclimation through a fast-changing salinity titration to simulate conditions these fish might encounter during dispersal or flooding events. If the populations are locally adapted, then we predict that elevated metabolic rates will be higher when fish are exposed to their "away" salinity conditions.

P3.4 MARTINEZ, E.; AGOSTA, S.J.*; Virginia Commonwealth Univ. , Virginia Commonwealth Univ.; *sagosta@vcu.edu*

Thermo-limit respirometry in rain forest and dry forest Atta soldiers: are tropical ectotherms really living close to their thermal limits?

Climate warming is predicted to have particularly strong effects on tropical organisms. Studies suggest that tropical organisms have evolved to be thermal specialists that routinely experience habitat temperatures close to their physiological limits. Most of this work is theoretical or based on mining physiological data from the literature and temperature data from weather stations. Therefore, many questions remain regarding the precise empirical relationships between the thermal tolerances of tropical organisms and the thermal environments they experience. In this study, we compared the thermal tolerance of individual *Atta cephalotes* soldier ants inhabiting very different thermal regimes in rain forest and nearby dry forest in Area de Conservacion Guanacaste (ACG), Costa Rica. Thermo-limit respirometry profiles indicated no significant difference in upper thermal tolerance (CT_{max}) between rain forest and dry forest ants. However, the frequency and magnitude of discontinuous gas exchange patterns were higher in ants collected from the rain forest. Infrared imaging of the nest surface coupled with hourly air and soil surface temperature recordings indicated that only dry forest ants could experience habitat temperatures close to and even beyond the estimated CT_{max}. These results raise the question of how tropical insects, like ants living in ACG dry forest, will respond to warming. However, in contrast, results for rain forest ants suggest a large safety margin for warming and question the generality of the idea that tropical organisms routinely operate close to their thermal limits.

P3.76 MARTIN, SA*; TAHIR, U; NISHIKAWA, KC; Northern Arizona University; *sam732@nau.edu*

The Effects of Activation On Force Depression

The sliding filament theory fails to explain several characteristics of muscle function, including enhancement of force with stretch and depression of force with shortening. The winding filament hypothesis (WFH) adds to the sliding filament theory by introducing a role for titin in muscle contraction. The WFH predicts that titin is activated upon calcium influx and the N2A region of titin binds to actin. The PEVK region of titin winds upon actin due to rotation of actin by the cross-bridges. In mice, a deletion in the N2A region of the titin gene (the mdm mutation) results in different active and passive muscle properties compared to wild-type mice. The goal of this study was to examine how force depression during shortening changes over many activation levels using muscles from wild-type and mdm mutant mice. Soleus muscles were extracted from wild type and mutant mice, and attached to a force lever, which measured muscle length and force. Isovelocity tests were performed in order to measure the force produced by the muscles at different shortening velocities and activation levels. Muscle shortening ranged between ±10% of optimal length. Three different levels of activation (partial, none and full) were achieved by modulating the frequency and voltage of stimulation. Wild type muscles showed an increase in force depression as activation level increased. The mdm muscles displayed the same level of force depression at all activation levels. These results suggest that the mechanism that links the amount of force depression with the level of activation in wild-type muscles is absent in muscles of mdm mutant mice. Because the mdm muscles have a deletion in the N2A region of titin (the proposed site for calcium-dependent binding of titin to actin), these results provide support for the WFH that titin plays a role in depression of force with shortening.

P3.45 MASON, P.A.; MASON, Peri; Univ. of Colorado, Boulder; *peri.mason@colorado.edu*

Does Host Plasticity Promote Shifts by Parasites?

It is increasingly recognized that ecological speciation plays a significant role in the diversification of parasites, a major component of biodiversity on Earth. Understanding mechanisms that promote or constrain host shifts by parasites is therefore critical to our understanding of diversification processes. In this poster, I explore the idea that phenotypic variation in hosts arising from environmental stimuli can promote shifts in parasites by bridging both spatiotemporal, and phenotypic gaps between ancestral and novel hosts. This hypothesis, which I call the plastic bridge hypothesis, is conceptually distinct from those invoking genetic variation in bridging these gaps. The plastic bridge perspective suggests that parasite diversity is due not only due to divergent selection provided by hosts, but also to the intraspecific variation that facilitates shifts between them. This view is timely, as biological invasions and range shifts associated with climate change foster novel host-parasite interactions.

P3.44 MATTERSON, KO*; THACKER, RW; University of Alabama at Birmingham, Stony Brook University; *kenanm@uab.edu*

Reduced irradiance and elevated nutrient concentration negatively impacts host growth and symbiont abundance in the tropical ascidian Trididemnum solidum

Intimate partnerships between invertebrates and symbiotic microbial communities are widespread across marine habitats. Such interactions are exemplified on tropical reefs, where sessile organisms survive in nutrient-poor environments due to their association with autotrophic symbionts. Caribbean reefs are under considerable pressure from anthropogenic stressors (e.g. eutrophication) that may disrupt these symbioses by reducing light availability and altering water quality. To test whether these factors impact host growth and microbial community dynamics, we conducted a six-week factorial experiment examining the effects of reduced irradiance and elevated nutrient concentration on growth, chlorophyll concentration and cyanobacterial density in the tropical ascidian, *Trididemnum solidum*. Holobiont growth demonstrated a stepwise reduction in biomass as light intensity decreased. Chlorophyll concentrations were not significantly different among light treatments, however, photosymbiont abundance decreased significantly under lowered irradiance. Although nutrients had minimal impacts under control irradiance, when coupled with reduced light, increased nutrients resulted in decreased cyanobacterial density and a two-fold reduction in holobiont biomass. Moreover, *T. solidum* colonies subjected to the lowest irradiance and highest nutrient concentrations exhibited significant pigmentation loss and tissue death, indicating that invertebrate-microbe symbioses may be unable to compensate for multiple stressors working in conjunction. Overall, these results emphasize the importance of microbial symbionts for the survival and proliferation of marine invertebrates and highlight the necessity of examining multiple factors in combination to understand how anthropogenic stressors can disrupt invertebrate-microbe symbioses.

P3.12 MATZKE, N.J.; The Australian National University; *nick.matzke@anu.edu.au*

Trait-dependent dispersal models for phylogenetic biogeography, in the R package BioGeoBEARS

Organism traits must be important in historical biogeography. In particular, rates of dispersal (both range-expansion dispersal, and jump dispersal leading to founder-event speciation) must depend to some degree on traits such as flight and its loss, and seed dispersal mechanisms and the dispersal abilities of animals that transport seeds. However, to date no probabilistic historical biogeographical models have been available that allow geographic range and traits to co-evolve on the phylogeny, with traits influencing dispersal ability. In purely continuous-time Markov models, adding a trait is just a matter of doubling the size of the rate matrix; however, biogeographical models also include a much more complex discrete-time model describing how geographic range can change during cladogenesis. Traits might also influence this process. I present an addition to the R package BioGeoBEARS that enables an evolving discrete trait to influence dispersal ability for both anagenetic and cladogenetic range change. This model can be freely combined with models adding jump dispersal (e.g., DEC+J), distance as a predictor of dispersal (+x models, with dispersal rate multiplied by distance^x), and other variants. I test the model against simulations and datasets where large evolutionary changes in dispersal ability are highly likely (e.g., Pacific rails, which have repeatedly lost flight).

P2.122 MATTES, CN*; JAMES, KM; MADRIGAL, MA; MARTINEZ ACOSTA, VG; Univ. of the Incarnate Word; *vgmartin@uiwtx.edu*

The effects of lithium chloride on morphallaxis and epimorphosis in Lumbriculus variegatus.

We present experiments which characterize beta-catenin's cellular role during epimorphosis and morphallaxis. Lithium chloride, a GSK-3 inhibitor, was used to prohibit the degradation of -catenin in two experimental worm populations. The effectiveness of both epimorphosis and morphallaxis were assessed by counting regenerated segments and administering behavioral tests. Worm fragments placed in 14.88mM of lithium chloride (LiCl), wound healed with 90% forming blastemal tissue devoid of segmentation and 0% exhibiting behavioral changes associated with morphallaxis. In the second experiment, worm fragments were treated with 14.88mM LiCl for one week before being placed in 0mM LiCl for a four-week recovery period. During the initial week, segmental regeneration and behavioral changes again were not recorded. However following the recovery period, anterior worm fragments regenerated 6.14+0.1 head segments and posterior worm fragments regenerated 7.5+0.1 head segments. Segmental regeneration was thus not significantly reduced as compared to control populations; even still recovery of behavior was reduced. Posterior worm fragments exhibited posterior behaviors 25% of the time and anterior behaviors 8.3% of the time (n=8). Taken together these data suggest that overexpression of beta-catenin in Lumbriculus results in reduction of functional recovery via morphallaxis but does not significantly effect epimorphosis.

P2.41 MAVROIDIS, SM*; MIGNOGNA, ME; CAMERON, SE; MATHIE, BN; Univ. Mount Union; *mavrois@mountunion.edu*

Effect of overwintering temperatures on the energetics and survival of Isabella Tiger Moth (Pyrrharctia isabella) caterpillars

Anthropogenic climate change models predict more frequent temperature extremes and warmer winters in temperate regions such as North America. Temperate ectotherms that enter a prolonged period of dormancy (diapause) may be more vulnerable because of the direct relationship between body temperature and metabolism. The Isabella Tiger Moth (*Pyrrharctia isabella*) is a species that is found throughout the United States and parts of southern Canada and survives subfreezing winter temperatures in the larval stage. We tested the hypothesis that caterpillars overwintering at warmer temperatures would have higher metabolic rates and thus lower energy reserves at the end of a 4-month diapause period. Caterpillars were divided into four temperature treatment groups (2°C, 5°C, 8°C, and 11°C; n=20 in each) in lab incubation chambers while three groups (n=20 in each) were maintained outside with different amounts of straw insulation. Metabolic rate measurements were taken monthly on the animals in the lab and triglyceride and glycerol measurements were taken on all surviving individuals after the 120-day diapause period. As expected, metabolic rates increased with increasing body temperatures while triglyceride concentrations decreased with increasing overwintering temperatures. Survival was higher (range 75-90%) for the outside and the 2°C and 5°C groups while there was a sharp decline at the 8°C and 11°C treatments, 55% and 45% respectively. Glycerol, which this species uses as a cryoprotectant, was highest in the animals that overwinter outside and experienced below freezing average temperatures, while concentrations decreased with increasing temperatures in animals maintained in the lab.

P2.135 MAXFIELD, JM*; COLE, K; University of Hawaii Manoa; *JMax@hawaii.edu*

Uncovering The Secret of Sex Change: Mapping the Sex Change Pathway in Gobiid Fishes

The ability to change sex (hermaphroditism) is a rare reproductive strategy found among teleost fishes. It has been documented in only 27 of 448 fish families. This study aims to understand the development, evolution and diversification of sex change in two species of marine fishes in the family Gobiidae, using a variety of molecular and histological techniques. We have created a developmental series for sex change in one species of goby, *Lythrypnus dalli*, in order to document the morphological changes that take place as a fish transitions from ova producing to sperm producing. We have also sequenced the whole transcriptome of one lobe of the gonad and brain (RNAseq) from fish as they transitioned from ova producing to sperm producing. From these data we have identified how expression levels of key genes related to sex change fluctuate over transitional time. By connecting the histological data with the genetic data, the genetic pathway(s) that lead to a change in reproductive function can be elucidated. These data will be further analyzed to construct coexpression networks, which will allow additional genes related to sex change and novel genes and splice variants to be identified. Finally, a comparison between *L. dalli* and a closely related species, the Hawaiian *Eviota epiphanes*, will be preformed to evaluate the evolution of this characteristic in multiple fish lineages. This will provide key insights into how novel features and diversity arise.

P1.130 MAY, M.A.*; RAWSON, P.D.; University of Maine; *melissa.may@maine.edu*

Carryover effects associated with hypoosmotic stress experienced during larval development of the blue mussel, Mytilus edulis

Blue mussels, *Mytilus edulis*, are important members of intertidal communities and their distributions depend on the ability to respond to environmental stress. Because larvae are typically more sensitive to environmental stress than post-metamorphic mussels, their tolerance to stress will directly affect recruitment of mussels and the resilience of intertidal community structure. Furthermore, stress experienced during larval development may alter the ability of juvenile or adult mussels to withstand stress through latent or carryover effects. To better understand the complex consequences of salinity stress on blue mussels, we monitored the effects of osmotic stress on the growth of pre- and post-metamorphic animals. Larvae at either the veliger or competent, pediveliger stage were exposed to low salinity (20 ppt) or control salinity (30 ppt) for 24 hours and then monitored for 3 weeks following metamorphosis. In a subset of mussels, the 24-hour stress was repeated at 1 week post-settlement to evaluate whether stress incurred during previous developmental stages influences the response later in life. We predict that stressed larvae, at both developmental stages, will show reductions in size pre- and post-metamorphosis compared to unstressed larvae. Furthermore, we expect that stress repeated throughout development will continue to stunt growth and reduce fitness in juvenile mussels.

P1.93 MAYNARD, A.M.*; BIBLE, J.; SANFORD, E.; EVANS, T.G.; California State University East Bay, University of California Davis; *amaynard@horizon.csueastbay.edu*

Enhancing the restoration of California's estuaries by exploring the genetic basis of salinity tolerance in Olympia oysters (Ostrea lurida)

The Olympia oyster, *Ostrea lurida*, is the only oyster native to the west coast of N. America and a foundation species in estuarine habitats. Once abundant, *O. lurida* is now considered functionally extinct. Human-assisted reintroduction of *O. lurida* is one potential strategy to restore *O. lurida* numbers in the wild. Therefore, the ability of oysters to tolerate climate change will be a major factor in the long-term success of this restoration strategy. Ideally, restoration would use genotypes capable of surviving future conditions, however, which *O. lurida* populations will be most tolerant of climate change is unknown. In San Francisco Bay, oysters that can withstand exposure to low salinity water are predicted to be suitable candidates for reintroduction because climate change is projected to increase the frequency of heavy rainfall and freshwater flooding events that can cause mass mortality in oyster beds. Salinity tolerance was examined in three *O. lurida* populations in and around San Francisco Bay to identify genotypes tolerant of low salinity. Oysters from Loch Lomond had significantly higher survival rates during freshwater challenge than Oyster Point or Tomales Bay populations. My research uses RNA-Seq to explore the physiological and evolutionary mechanisms of differential salinity tolerance among these populations. Shifts in gene expression following exposure to reduced salinity are being compared among the populations to determine physiological changes that underlie enhanced freshwater tolerance. Changes in allele frequency between oysters surviving freshwater challenge and those held at ambient conditions are being identified to understand the evolutionary basis of salinity tolerance.

P2.13 MAYOL, M*; IYENGAR, E.V.; Muhlenberg College; *mm248692@muhlenberg.edu*

Preferences and rates of feeding in the terrestrial slugs Ariolimax columbianus and Arion rufus

The invasive terrestrial slug *Arion rufus* was introduced to San Juan Island, WA, within the last century and represents a novel potential competitor to the native banana slug *Ariolimax columbianus* as no other local pulmonate attains such a size. Building on past findings, we investigated the feeding rates and preferences of these two species. Both species (regardless of size class) preferred mushrooms (*Agaricus bisporus*) to pathfinder (*Adenocaulon bicolor*), sword fern (*Polystichum munitum*), and lichen (*Usnea* sp.). However, when mushrooms were oven-dried and lichen was super-hydrated, both species of slugs switched their preference to the lichen, suggesting that moisture and texture are more important here in dictating food choice than are nutrients and taste. Mushrooms in both the local forested areas and grasslands are typically scarce, patchily distributed, with a small biomass compared to common local plants, and so may represent an important limited resource that might promote inter- and intra-specific competition. Additionally, we observed the effects of temperature (5°C, 10°C, and 20°C) on feeding rates (consuming spinach leaves and stinging nettles, in separate experiments) in both species of slugs. Surprisingly, despite the fact that slugs are ectothermic, we found no evidence of increased feeding rates with increasing temperature across this range. Again, moisture levels, which differed slightly across our chambers, may be more important than temperature. These considerations may be critical in predicting how these terrestrial slugs may respond to impending climate changes.

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Leveraging story telling, natural history, and spirituality to educate the public about anthropogenic climate change and ocean acidification

Scientists, especially biologists, are well positioned to play a time-critical role in educating the public about the ongoing impacts of global climate change and ocean acidification. Despite a recent diminishment of the perceived value of science in American societal affairs, the public generally respects the opinion and objectivity of scientists. So how do biologists communicate effectively with the public on the contentious issue of climate change? One approach is for biologists to author topical op-eds, popular magazine articles, and books to engage diverse, general audiences. In my first book, Lost Antarctica, I used stories of Antarctic adventure and natural history to frame a narrative of polar climate change and ocean acidification. Media generated from the book reached an estimated 5 million readers/listeners/viewers. In my second book, A Naturalist Goes Fishing, I used stories of fishing adventures to engage readers in a narrative of conservation, climate change, and ocean acidification. The prospective audience includes the thirty-five million Americans that fish. Another approach to climate change education is to establish links between a spiritually-based stewardship of the earth and anthropogenic climate change. I recently co-directed a successful three-day climate change workshop that was attended by individuals of different religious backgrounds, including a number of faith leaders in positions to influence those under their guidance. My collective experiences in global environmental outreach indicate that biologists are in a unique position to significantly further the public's appreciation of anthropogenic climate change, its serious implications, and hope for a better future. I wish to acknowledge the support of an Endowed Professorship in Polar and Marine Biology from the University of Alabama at Birmingham.

P3.29 MCCOY, A.*; MOOI, R.; Univ. of California, Santa Cruz, California Academy of Sciences, San Francisco; *alexmccoy0469@gmail.com*

Sand dollars and the sands of time: Patterns of echinoid evolution in the Cenozoic North Pacific

Biodiversity levels can be correlated with widespread, geologic shifts in environmental parameters similar to those occurring in the Anthropocene. Sand dollars (Clypeasteroida, Echinoidea) have a superb fossil record throughout the Cenozoic northern Pacific, in an arc from Japan, along the Aleutians, and south to California and Mexico. With a robust skeleton and high fossilization potential in ambient sediments, clypeasteroids record the influence of environmental change on faunal histories. A database incorporating 160+ northern Pacific sand dollars since their Eocene origin was developed through museum collections and published resources, integrating stratigraphic occurrences, biogeographic data, and morphology. Taking into account sampling bias, we correlated biodiversity fluctuations in clades over geologic time with factors including temperature, current regimes, oceanic pH, and geologic events such as the opening of the Bering Strait and the closure of the Central American seaway. Among several correlations, we noted radiations in certain clades as the Bering Strait opened near the end of Miocene. These taxa exhibit eccentric placement of various features instrumental to their life history. Eccentricity evolved independently in three clades, and is correlated with upright, suspension-feeding behavior. Suspension-feeding likely provided advantages for these taxa during cold periods characterized by strengthened upwelling. Global change today suggests that the tropics will become larger, just as they have in the past. Other changes in the distribution of many sand dollar groups suggest future alterations linked to ongoing, anthropogenic change.

P2.140 MCELHINNEY, AL; University of Mount Union; *mcelhial@mountunion.edu*

Gene expression patterns & evolutionary implications in echinoderm larvae

The Phylum Echinodermata is ancestrally indirect developing via a feeding larva lacking a skeleton, and evolved to include both direct and indirect developing species. Larvae are bilaterally symmetrical with a ciliary band dividing oral and aboral ectoderm territories. The classes Echinoidea and Ophiuroidea develop via feeding pluteus larvae with underlying calcified skeletons. These pluteus larvae likely arose independently; evolving the skeleton and overlying arm ectoderm from pre-existing adults. This evolution involved reorganization and co-option of numerous genes in the production of pluteus arms. The research pursued here aims to understand the evolution and development of pluteus arms by beginning to dissect regulatory controls involved in their development. The expression patterns of the arm-associated genes *carbonic anhydrase*, *msp130*, and *tetraspanin* were analyzed using whole mount *in situ* hybridization. The expression patterns for these genes were compared between direct and indirect developing species of sea urchins. Additionally, expression patterns were determined in indirect developing species by interfering with signaling pathways in early development that perturbed pluteus arms. Following developmental perturbation, changes in marker gene expression were assessed and the following questions were answered, how do expression patterns of marker genes change when normal development is disrupted? Do their region(s) of expression expand, contract, disappear, or remain unchanged? What does a change in their expression reveal about the evolution of developmental regulation? This study in conjunction with existing knowledge of ancient gene pathways shed light on the evolution of axial regulation and development in echinoderms.

P1.161 MCKEE, A*; MCHENRY, MJ; Univ. of California, Irvine; *biologymajor8@gmail.com*

A high-throughput method for identifying responses to visual stimuli

Predator evasion requires that prey identify a threatening stimulus. Fish rapidly achieve this feat, but it is unclear what features of a visual stimulus succeed in stimulating an escape response. To understand these visual cues, we developed a high-throughput experimental setup that characterizes the responses of a fish to a variety of looming stimuli. This was achieved by triggering a high-speed video camera to record the fish after the presentation of a stimulus that was projected upon the wall of an experimental chamber. Using customized software, the behavior of the fish was quickly determined with an automated kinematic analysis and this result determined the sequence of experiments that were performed. The ability of this setup to generate automated results from a series of experiments on an individual may be applied to characterize the behavioral responses to a variety of stimuli and may thereby provide an indispensable tool for behavioral research.

P1.200 MCMAHON, E.K.*; LITWA, H.P.; STEVENSON, J.R.; HAUSSMANN, M.F.; Bucknell Univ.; *ekm011@bucknell.edu*

Oxytocin mitigates some of the negative consequences of chronic social isolation in Prairie Voles (Microtus ochrogaster)

Chronic stressors, such as chronic isolation in social mammals, can elevate glucocorticoids, which may affect cellular aging mechanisms such as increasing levels of oxidative stress and shortening telomere lengths. Prairie voles (*Microtus ochrogaster*) are a useful model species to study chronic isolation due to their social and pair bonding behaviors. Recent work in prairie voles suggests that oxytocin and social support may mitigate some of the negative consequences of social isolation, possibly by reducing glucocorticoid levels. We investigated the influences of isolation, oxytocin or social support on stress physiology, behavior, and cellular aging. Voles were divided into six groups: isolated (I), paired (P), isolated (IV) and paired (PV) with daily vehicle injections, and isolated (IO) and paired (PO) with daily oxytocin injections. Blood samples were collected at the start of the study, then again after 3 and 6 weeks. Acute stress tests were conducted using the resident-intruder paradigm at 6 weeks to determine if treatment had any effect on stress responsiveness. Anhedonia, a behavioral index of depression, was measured using sucrose solution preference tests to determine depression-like symptoms throughout the study. We found that daily oxytocin injections in isolated individuals prevented anhedonia as compared to those who were isolated with and without daily vehicle injections. The effect of social isolation and oxytocin treatment on GC levels, oxidative stress, and telomere length will also be discussed. Overall our findings suggest that oxytocin appears to mitigate some of the negative consequences of social isolation.

P3.208 MCPHERSON, D.R.*; SHELKEY, E.N.; SUNY Geneseo; *mcpherso@geneseo.edu*

The Dactyl Opener Muscle of the American Lobster (Homarus americanus) Expresses a 5-HT7 Receptor

Serotonin (5-HT) is a potent enhancer of neuromuscular signaling in decapod crustaceans. This has been studied extensively in the dactyl opener muscle of lobsters and crayfish. In that system, serotonin positively modulates neurotransmission through a combination of presynaptic and postsynaptic pathways. Some of these pathways involve an increased concentration of cyclic adenosine monophosphate (cAMP), and that in turn suggests the presence of a serotonin receptor whose activation stimulates adenylyl cyclase. In vertebrates, three known types of 5-HT receptor have this quality, namely 5-HT4, 5-HT6, and 5-HT7. Because 5-HT7 receptors have been identified in some other invertebrates, we decided to inquire whether the American lobster (*Homarus americanus*) dactyl opener muscle expresses a 5-HT7 receptor. Degenerate primers were designed by comparison of known or putative 5-HT7 receptors from molluscs, insects, crustaceans and annelids. Total RNA was isolated from dactyl opener muscle using Tri Reagent® and then treated with DNase to remove contaminating genomic DNA. Reverse transcription using MMLV (Clontech) yielded cDNA, and standard PCR was used to test the primers. The PCR products of expected size were cloned and sequenced, yielding one sequence which, when compared to other vertebrate and invertebrate monoamine receptors, appears to be a 5-HT7 receptor.

P1.89 MCQUISTON, A*; CHEN, J; PIERMARINI, PM; GILLEN, CM; Kenyon College, OH, The Ohio State University; *gillenc@kenyon.edu*

Roles of Na-dependent cation chloride cotransporters in osmoregulation by larval Aedes aegypti mosquitoes.

We investigated the role of cation chloride cotransporters (CCCs) in osmoregulation by larvae of the yellow fever mosquito, *Aedes aegypti*. Three putative Na-coupled CCCs are expressed in larval tissues. Prior qPCR studies showed that the VectorBase genes AAEL006180 (tentatively named aeCCC1) and AAEL009888 (aeCCC2) are more highly expressed in larval Malpighian tubules compared to anal papillae. In contrast, AAEL009886 (aeCCC3) is more highly expressed in larval anal papillae compared to Malpighian tubules. To evaluate the physiological role of aeCCC1 and aeCCC2, we used RNAi to reduce expression of each transporter. We exposed first instar larvae to aeCCC1 or aeCCC2 dsRNAs. Negative controls were no dsRNA or a dsRNA without sequence homology to *A. aegypti* genes. Hemolymph cations of fourth instar larvae were measured by cation chromatography. Larvae exposed to aeCCC1 or aeCCC2 dsRNA had up to five-fold increases in mean hemolymph total ammonia (ammonia and ammonium) levels compared to negative controls. Hemolymph potassium was reduced by approximately 15% in response to aeCCC1 dsRNA, with no consistent change in hemolymph sodium. In contrast, hemolymph sodium was increased by approximately 20% in response to aeCCC2 dsRNA exposure, with no consistent change in hemolymph potassium. These findings suggest physiological roles for aeCCC1 and aeCCC2 in osmoregulation and ammonia balance of larval mosquitoes.

P2.57 MESSYASZ, A*; MONSEN-COLLAR, K; HALL, M; HAZARD, L; Montclair State Univ., New Jersey, NJ Div. of Fish and Wildlife; *hazardl@mail.montclair.edu*

Environmental correlates of Ranavirus disease distribution in New Jersey

Amphibian pathogens are contributing to the global decline and extinction of many species, and are thus a significant potential threat. Variation in environmental conditions may influence either pathogen presence or susceptibility of amphibians to pathogen infection. Very little is known about how environmental factors may influence *Ranavirus* (Iridoviridae), a virus affecting aquatic ectothermic vertebrates. It is hypothesized that water quality, landscape characteristics, habitat characteristics, and the community of amphibian species present can potentially affect either presence of the disease or amphibian susceptibility to disease. In studies conducted in 2013 and 2014 (Smith et al. unpub.), *Ranavirus* presence/absence and prevalence (% of individuals testing positive) varied among 17 vernal pool sites in northern New Jersey, and we used this existing variation to evaluate the effects of biotic and abiotic factors that we hypothesized might influence *Ranavirus* distribution. We measured water quality, landscape and pool characteristics, extent and type of human activity, and amphibian species present. We also tested for presence of *Ranavirus* and documented two apparent outbreaks of disease in 2015. Disease presence/absence and prevalence were not consistent within sites from year to year, making correlations with static environmental factors difficult to ascertain. If environmental predictors of *Ranavirus* infection can be determined, it may be possible to predict habitats more likely to be susceptible to *Ranavirus* outbreaks and potentially prioritize management activities to reduce the impact of *Ranavirus*.

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P3.189 MIDFORD, P E*; CLARK, A B; MARGULIS, S W; PARR, C S; None, Binghamton University, Canisius College, USDA-ARS; *peter.midford@gmail.com*

A Newly Integrated Ontology for Behavioral Biology: NBO meets ABO

This presentation reports on a series of workshops held to explore and implement the merger of two ontologies used to classify and annotate behavior. The NBO (NeuroBehavior Ontology) is a member of the OBO family of ontologies and contains over 800 terms for behavior processes and phenotypes. The ABO (Animal Behavior Ontology) was developed by a community of animal behavior researchers interested in metadata, developing a common vocabulary for ethograms and facilitating searches for digitally available behavioral datasets. In 2013 a 1-day session sponsored by the Phenotype Ontologies Research Coordination Network brought people involved in both ontologies together for the first time. Based on that session, a group of behavioral ecologists proposed to develop a way to integrate the two ontologies and were funded for two additional workshops through NSF and the Phenotype RCN. The first, in August 2014, brought together 17 animal behaviorists to review the NBO and ABO and propose changes to the NBO that would allow the ABO to be incorporated as a sub-ontology for behavioral ecologists and behaviorists working with non-model organisms. At a second workshop in October 2015, six participants of the 2014 workshop met with the developer of the NBO and several additional ontology development experts to delineate a process of integrating the ontologies in a way that would allow a subset for behavioral ecology to be defined in a theoretically coherent way, without rendering the NBO either incorrect or unverifiable (computationally intractable). This presentation will describe the changes made to the NBO and give examples of how the merged ontology will be used for behavioral studies of both model and non-model organisms. It will also demonstrate the value of this ontology for data-sharing, data-storage, and comparative research.

P1.36 MIKUCKI, EE; University of Vermont; *emikucki@uvm.edu*

Fitness consequences associated with variation in developmental temperature in Pieris rapae butterflies

For insects, most physiological processes are temperature-dependent. Laboratory studies have shown that rearing conspecifics at different temperatures can induce variation in morphology, fitness, and other life history traits. With short lifespans over four distinct metamorphic stages, butterflies provide an excellent model system for studying the effect of variation of developmental temperature on individual body size and fitness. Here I examined the phenotypic plasticity and fitness consequences of *Pieris rapae*, or cabbage butterflies, when individuals were incubated and reared under different temperature treatments, mimicking climate change patterns observed in the Northeastern United States. Larval size at hatching and pupal mass both decreased with increasing temperature, suggesting that individuals reared primarily in colder temperatures are larger at adulthood. However, contrary to what has been shown in previous studies, larger size did not correlate with higher reproductive success. Moreover, fitness, measured as the number of eggs laid per female, did not vary significantly among temperature treatments. These data suggest that *P. rapae*, a widespread and abundant temperate species, shows a strong plastic response to temperature variation, suggesting that this species may exhibit resilience in the face of future climate change scenarios.

P1.145 MILLER, H.V.*; SPEISER, D.I.; University of South Carolina; *hvmiller@email.sc.edu*

Pupillary responses in scallops

The amount of light entering an eye is functionally important: too much can damage tissue and not enough can affect the quality of images formed. To modulate the amount of light that enters their eyes, cephalopods and vertebrates have pupils that contract and dilate in response to changing light conditions. Scallops (Family Pectinidae) may gain similar benefits from a pupillary response, but one has yet to be documented for their unique mirror-based eyes. By varying light conditions and monitoring the eyes of live, intact bay (*Argopecten irradians*) and sea (*Placopecten magellanicus*) scallops, we were the first to document pupil responses in a bivalve mollusk. After we dark-adapted animals for two hours and then exposed them to bright, white light, we found that the pupils of bay scallops contracted by 63 ± 3 μm (mean ± SE), a decrease in diameter of 17 ± 1% (N = 12). Similarly, we found that the pupils of sea scallops contracted by 34 ± 3 μm, equal to a 13 ± 1% decrease in diameter (N = 16). In both species, a majority of the pupillary response occurred in the first minute of light exposure. Once we returned animals to the dark, their pupils tended to dilate to their original, dark-adapted width within an hour. The amount of light that enters an eye is proportional to the square of pupil diameter, suggesting that the pupil contractions we observed in bay and sea scallops were associated with decreases in sensitivity of 31% and 24%, respectively. In additional experiments, we observed pupil responses under intensities of white light that varied over a range of 10^3 and under both narrow-spectrum blue (470 nm) and green (525 nm) light. Although the pupil responses of scallops may do relatively little to compensate for changes in light intensity, they may be useful for striking an optimal balance between sensitivity and image quality under different light conditions.

P3.99 MINICOZZI, M*; FINDEN, A; GIBB, A; Nothern Arizona University; *mrm539@nau.edu*

Are there performance tradeoffs in the ability to perform the aquatic C-start and terrestrial tail-flip jump in killifishes?

The killifishes (Cyprinodontiformes) usually respond to a negative aquatic stimulus by performing an aquatic escape, or C-start, but some species will jump onto land when threatened. Once on land, fish often perform a tail-flip jump to return to the water. During the tail-flip jump, a fish raises its head from the substrate and bends towards the tail, forming a "C", then straightens its body while pushing off of the substrate with the caudal peduncle to launch into ballistic flight. This behavior shares key similarities with the aquatic escape response, including large-amplitude lateral bending, followed by axial straightening. However, a jump must be performed against the forces of gravity and over a longer time interval, relative to the aquatic C-start. Because the mechanical demands on the musculoskeletal system are different on water vs. land, we hypothesized that there would be functional tradeoffs between the C-start and tail-flip jump. We predicted fishes that perform better (longer) terrestrial jumps would perform worse (slower) aquatic C-starts. To test this prediction, we examined three species of killifish: *Gambusia affinis, Poecilia mexicana,* and *Jordanella floridae*. We filmed individuals (n=10) of all three species performing the C-start in water (recorded at 800 fps) and tail-flip jump on land (600 fps). In contrast with our original prediction, we found no functional tradeoff between C-start and tail-flip jumping performance. Fishes that performed faster C-starts also tended to perform longer tail-flip jumps. This suggests that the selection pressures that underlie the evolution of both of behaviors may generate a body shape that is capable of producing effective movements in both environments, despite the drastic physical differences between the aquatic and terrestrial realms.

P1.18 MITCHELL, H.L*; CAUGHRON, J; DAVIS, J; MCGEE, J; PHELPS-DURR, T; Radford University; *hmitchell9@radford.edu*

The creation of software to affectively organize the fungal taxonomy which will be used to classify any unidentified species that were collected in the Madre de Dios region of the Peruvian Amazon.

The Peruvian Amazon has not been extensively studied when compared to the Brazilian Amazon. With deforestation being an average of 52 thousand square miles every year, there is an urgent need to sample the species especially those not as widely studied such as fungus. These decomposers are important to the health of the ecosystem, and understanding their phylogeny helps toward understanding their role. The purpose of this study is to collect fungal DNA samples from the Peruvian Amazon and create a new piece of software using existing fungal taxonomy and genetic information to classify the DNA sequences. This method of classification would be faster than current processing times because there would be a centralization of both genetic information as well as characteristic information of the species. To solve this problem, a database of centralized information will allow researchers to easily identify the species of fungus they seek to gain information on. Software will be used to categorize groups of fungi using genetic material and physical appearance. The method of molecular phylogenetic and physical characteristic identifications through the use of a software program, which uses categorical distribution, will allow for quick and efficient identification of fungal species. Currently, samples of Peruvian Amazonian fungal species have been obtained and are being compared to known fungal species. We will use existing fungal information and defined algorithms as parameters, they will be matched to the closest species or genius. Finally their physical characteristics and sequences will be entered into the program in order to determine if the species is known or unknown.

P1.71 MIYANO, C.A.*; HESSEL, A.L.; NISHIKAWA, K.C.; Northern Arizona University , Northern Arizona University, Northern Arizona University Center for Bioengineering Innovation; *cam523@nau.edu*

Stretch shortening cycle protocols demonstrate the age associated difference in eccentric properties of EDL and soleus muscles.

During animal movement, cyclical changes in muscle length are common. However, age-associated muscle mechanics are not well understood. We used a stretch-shortening cycle (SSC) protocol that stimulated muscles over the first third of lengthening to determine eccentric contraction properties during length oscillations in mice that ranges in age from 30 - 400 days. Mouse extensor digitorum longus (EDL, fast twitch) and soleus (slow twitch) muscles were used in the experiments. We calculated the rate of force development (RFD) during eccentric contractions and total work. A passive SSC was also conducted to measure passive properties, because an age-associated increase in muscle stiffness was expected. The results indicate that the RFD and total negative work increased with increasing age. These results appear to indicate that active muscle stiffness increased with age. The contribution of passive muscle components remained consistent or increased only slightly with age. These results suggest that the increase in muscle stiffness with age is associated with components of active muscle. These could include age-associated changes in cross bridge cycling or an increase in stiffness of the titin filament. Titin has been shown to contribute to passive and active stiffness in eccentrically contracting muscles. Because titin stiffness is modified by a variety of pathways, we believe future work should focus on identifying age-associated changes in titin stiffness.

P3.161 MONHART, M*; HANNA, M; FOOTE, S; YEE, S; QUINDE, J; MAUCH, E; FATEYE, B; SCHREIBER, A; St Lawrence University; *aschreiber@stlawu.edu*

Thymus gland remodeling during natural and thyroid hormone/dexamethasone-induced Xenopus laevis metamorphosis

Anuran metamorphosis is modulated by the synergistic actions of thyroid (TH) and glucocorticoid hormones. Metamorphosis is accompanied by immune system remodeling as larval antibodies are replaced by a new adult repertoire. Although glucocorticoids have been shown to induce thymus lymphocyte cell death, the influence of TH on thymus remodeling remains unknown. Here we profile changes in thymus gland cell proliferation (immunoreactivity against phosphohistone H3; PH3) and apoptosis (immunoreactivity against active caspase-3) during natural metamorphosis, and also following treatment with TH (5 nM T3) and/or dexamethasone (Dex, 2 uM) for 48 hours. Natural metamorphosis was accompanied by a doubling of thymus size from late prometamorphosis (NF57) through the end of metamorphic climax (NF66). Peaks in caspase and PH3 immunoreactivity occurred at early (NF 60) and late climax (NF 62), respectively. Treatments of premetamorphic (NF 50) or prometamorphic (NF 56) tadpoles with either TH or Dex alone increased caspase immunoreactivity, with Dex+TH in combination producing the highest response. Compared with prometamorphic controls, Dex treatment alone or in combination with T3 doubled PH3 immunoreactivity, whereas T3 alone quadrupled the amount of signal. Taken together, our findings suggest that both glucocorticoids and TH each contribute to thymus cell proliferation and apoptosis during metamorphosis.

P1.90 MONROE, I; WENTWORTH, S.A.; THEDE, K; ARAVINDABOSE, V; GARVIN, J; PACKER, R.K.*; The George Washington University, GWU, Case Western Reserve University, CWRU; *rkp@gwu.edu*

Effects of temperature and salinity on the activity of Na/K-ATPase and H-ATPase from the gills of fathead minnows, (Pimephales promelas).

Na/K ATPase on the basolateral membrane of gill cells actively transports Na^+ from the cell interior to blood, creating the electrochemical gradient that drives secondary active transporters in the apical membrane for Na^+ influx. H-ATPase on apical membranes is hypothesized to facilitate Na^+ uptake. Factors such as temperature and salinity affect the activities of enzymes. It has been postulated that the activities of proteins such as Na/K ATPase and H-ATPase are reduced in cold acclimated poikiotherms to conserve energy. We hypothesized that both Na/K ATPase and H-ATPase activity would be lower in cold vs. warm acclimated fish, and that fish acclimated to higher salinities would have lower activities of both enzymes. Fish were acclimated to 20&degC, 12.5&degC, and 5&degC for 28 days, and Na/K ATPase and H-ATPase activity measured. Na/K-ATPase activity from fish at 5&degC was 2.79&plusmn0.07 while that from fish at 20&degC was 1.62&plusmn0.08 &micromoles/mg protein/hr ($p < 0.05$), 72% greater. In contrast, H-ATPase activity was 0.0&plusmn0.06 at 5&degC and 0.48&plusmn0.05 &micromoles/mg protein/hr at 20&degC ($p<0.01$). High salinity (130.53 mM vs 0.60 mM) resulted in decreased Na/K-ATPase activity (1.40&plusmn0.11 vs 1.95&plusmn0.17&micromoles/mg protein/hr; $p<0.05$). Surprisingly, H-ATPase activity increased in fish acclimated to higher salinity (0.00&plusmn0.05 vs. 0.58&plusmn0.10 &micromoles/mg protein/hr). We find that: 1) Na/K ATPase activity increases in cold acclimated fish to compensate for loss of activity caused by temperature; 2) H-ATPase is unlikely to contribute to Na absorption under some conditions 3) the concept of "channel arrest" may not apply to Na absorption in gill epithelium.

P3.75 MONROY, J.A.*; ENRIGHT, D.E.; NISHIKAWA, K.C.; Denison University, Northern Arizona University; *monroyj@denison.edu*

Activation and length dependence of muscle power output during in vitro cyclic movements of mdm mouse muscles

The timing and magnitude of muscle stimulation with respect to sinusoidal length changes can have significant effects on muscle power output. The winding filament hypothesis suggests that upon activation, titin binds to actin and winds on the thin filament, which leads to an increase in titin stiffness that varies with muscle activation and length. As a spring in active muscle, titin could store elastic energy, which may contribute to muscle force during dynamic length changes. Here, we used the *mdm* mouse, with a deletion in the N2A region of titin, to investigate titin's role during *in vitro* work loop experiments. Soleus muscles from wildtype and *mdm* mice were subjected to sinusoidal length changes while stimulated at various phases with and without the addition of a single stimulus (doublet). We hypothesized that force enhancement and doublet potentiation during cyclic movements are reduced in *mdm* mice. In both wildtype and *mdm* muscles, power increased with the addition of a doublet, but the magnitude depended on the length of the muscle at the onset of activation. Both genotypes showed the largest increase in power when stimulated at the shortest lengths and the smallest increase when stimulated at the longest lengths ($p < 0.0001$). The increase in power was nearly twice as large in wildtype compared to *mdm* muscles when they were at their shortest lengths ($p = 0.0006$) but did not differ at the longest lengths ($p = 0.19$). These results are consistent with the hypothesis that upon activation, titin stiffness increases as a result of N2A-actin binding and contributes to the force, work and power of muscles during cyclic movements. This work was funded by the Anderson Endowment at Denison, an APS UGSRF award to D.E.E. and NSF IOS-1456868.

P2.65 MONTALVO, A.M.*; RIVEST, G.L.; FURR, E.K.; JORGENSEN, D.D.; Roanoke College, VA; *ammontalvo@mail.roanoke.edu*

Clearance of Bacteria From The Hemolymph in American Lobsters: Characterization By Whole Organ Culture And Confocal Microscopy

American lobsters mount an immune response to bacterial infection by releasing hemocytes (which engulf bacterial cells) into their hemolymph. In the open circulatory system of lobsters, hemolymph issues from the arterial network and bathes tissue cells directly before being collected into the venous system, which terminates in the infrabranchial sinus located just upstream from the gill circulation. Previous research suggests that hemocytes that have engulfed bacteria embolize in different tissues. The gills have been suggested to be particularly important in lobsters' immune response to infection, but other tissues and organs appear to be involved as well. In our research, we acutely-challenged lobsters with *Vibrio campbellii* bioengineered to: 1) be resistant to the antibiotics kanamycin and chloramphenicol, and 2) express green fluorescent protein. We characterized the role of tissues and organs in the immune response by two means: 1) tissue/organ culture and 2) confocal microscopy. While we focused our attention on several different tissues/organs, we were particularly interested in characterizing hemocyte sequestration by the gills. Our results suggest that the gills are important in lobsters' immune response to acute bacterial infection, but that other tissues and organs play a significant role as well.

P2.153 MONSON, TA*; HLUSKO, LJ; University of California, Berkeley and Museum of Vertebrate Zoology, Berkeley, CA, University of California, Berkeley; *tesla.monson@berkeley.edu*

Late premolar eruption is derived in the ruminants and may represent an adaptation to changes in diet or life history

Dental eruption patterns are largely controlled by genetics and often exhibit a strong phylogenetic signal. In many mammals, the timing of dental eruption is an adaptive response to diet and life history strategy. We examined postcanine eruption patterns in 86 genera of ungulates spanning 11 families and five major clades of Artiodactyla and Perissodactyla. All specimens are held at the Museum of Vertebrate Zoology and the National Museum of Natural History. We visually examined specimens at multiple ontogenetic stages with earlier and/or more complete eruption of either the fourth premolar or the third molar being used to identify dental eruption patterns. Of the 51 ruminant genera for which we could definitively assess the postcanine dental eruption pattern, 46 genera share a dental replacement pattern where the fourth premolar erupts later than all molars. Five genera of Family Bovidae deviate from this pattern with three genera erupting their fourth premolars and third molars approximately simultaneously, and two genera, both in Subfamily Caprinae, erupting their third molars last. All of the closest terrestrial relatives of the ruminants erupt the third molar last suggesting that late premolar eruption in ruminants is directly related to phylogeny. Dental eruption patterns in early fossil Artiodactyla indicate that eruption of the third molar last may be the basal condition. Further examination of the fossil record will help inform the evolution and possibly adaptive advantage of this trait in the ruminants. *This project was supported by the Department of Integrative Biology and the Museum of Vertebrate Zoology, UC Berkeley.*

P2.166 MONTUELLE, SJ*; WILLIAMS, SH; Ohio University Heritage College of Osteopathic Medicine; *montuell@ohio.edu*

Variability in jaw movements of goats in response to different foods

Most mammals are characterized by a unique form of food processing (i.e., mastication) that is based on rhythmic 3-dimensional movements of the jaw allowing unilateral tooth occlusion. Low variability in jaw movements during mastication is thought to minimize energy expenditure to meet the higher energetic demands of mammalian metabolism. However, food properties vary immensely and sensorimotor integration within the oral cavity ensures that jaw movements are flexible (i.e., variable) enough to allow different food to be processed. Accordingly, in dietary generalists, the morphology of the feeding system typically supports a wide range of jaw movements responding changes in food properties. In contrast, organisms that are specialized for a narrow diet are typically characterized by morphological adaptations of the feeding system (e.g., restricted temporomandibular joints) that may limit the range of feeding movements that can occur. The objective of this study is to investigate the extent to which a model dietary specialist (Goat, *Capra hircus*) is able to alter jaw movements in response to different foods. Using biplanar fluoroscopy, 3D kinematics and temporal characteristics of the gape cycle are compared between two types of food: chow and dry leaves. Results indicate that jaw movements are significantly different in amplitude (e.g., mediolateral rotation of the lower jaw at the condyle) and timing (e.g., power stroke duration) when processing different foods. This suggests that (i) the specialized feeding morphology of goats allows flexible jaw movements, and (ii) sensorimotor integration in the oral cavity plays an important role in the neuromotor control of feeding movements, even in dietary specialists.

P1.85 MOSKOWITZ, NA*; VASQUEZ, AM; WARKENTIN, KM; Boston University, Universidad de Antioquia, Medellin; *nmosk11@bu.edu*

Embryo decisions and developmental changes in metabolism across the plastic hatching period of red-eyed treefrogs

Agalychnis callidryas embryos develop in gelatinous egg masses on plants above ponds, into which tadpoles fall upon hatching. If young clutches are flooded or fall into ponds, development slows and embryos often die. However, from halfway through normal embryonic development flooded embryos can hatch to escape. To quantify ontogenetic changes in the response to flooding, we submerged egg clutches of 5 ages in normoxic water for 1 h. Only 13% of embryos hatched at the onset of competence, at 3.8 d, and hatching increased to 97% at 6.5 d, near the peak of spontaneous hatching. Hatching speed and synchrony also increased developmentally. Higher response proportion and speed might reflect higher oxygen demand, such that flooding imposes a greater metabolic cost on more developed embryos. To assess developmental changes in metabolism, unconstrained by gas exchange across the egg capsule, we used closed system respirometry to measure oxygen consumption of individual newly hatched *A. callidryas* tadpoles at 4 ages across the plastic hatching period. We estimated P_{crit}, the level below which oxygen limits metabolism, in two ways, fitting a broken-stick regression to metabolic rates across oxygen levels and noting the oxygen level at which tadpoles suddenly increased activity and surfacing attempts. Then we calculated unconstrained metabolic rates above P_{crit}. Both P_{crit} and unconstrained metabolic rate increased developmentally but showed substantial overlap across and variation within ages. Thus metabolic needs may contribute relatively little to the striking ontogenetic change in flooding-induced hatching. In supra-lethal hypoxia, embryos near the onset of hatching competence may tolerate a period of metabolic suppression in order to hatch at a more developed stage.

P1.67 MUKHERJEE, R.*; TRIMMER, B.A.; Tufts University; *ritwika.mukherjee@tufts.edu*

Adaptive Control of Caterpillar Proleg Grip

The transfer of forces during adaptive locomotion in animals depends on body morphology, the properties of the tissues (e.g., stiff skeletons, muscular hydrostats or hydraulic systems) and neural activation of muscles. When external forces change (e.g., the direction of gravity with shifts in animal orientation), movement adaptation could be *passive* through mechanical self-compensation or *active* by sensory feedback control of muscle tension. Because of their deformable bodies, soft animals are expected to be particularly affected by external forces. To explore the mechanism of compensation we recorded EMGs from the Principal Planta Retractor Muscle (PPRM) of the caterpillar *Manduca sexta* while the animals crawled upright and upside down. PPRM is the primary muscle responsible for controlling grip release and its activity is critical for locomotion. Because PPRM is controlled by a single neuron, EMGs can be resolved into electrical spikes representing the neuron spike activity. During upright crawling the firing frequency increases approximately 0.6 seconds before grip release but during upside down crawling this activity begins significantly earlier possibly pre-tensioning the muscle. To quantify this change the activity of PPRM was divided into two phases Pre-tension and Pre-release (> 0.6 s and < 0.6 s before proleg release respectively). The average number of spikes was significantly greater (Mann Whitney U-test; $P = 0.009$, $n=47$) in the pre-tension phase in the upside down orientation although the total number of spikes before release did not differ (Mann Whitney U-test; $P = 0.254$, $n=94$, $n=104$). This suggests that under different loading conditions *M. sexta* alters the timing of its motor commands relative to the stance/swing cycle of the prolegs. We have undertaken a direct test of this interpretation by monitoring the kinematics and PPRM EMGs with different loads applied to the body.

P1.3 MULLER, UK*; LENT, DD; RAWAT, M; California State University Fresno; *umuller@csufresno.edu*

How faculty implement Vision in Change in Biology courses - challenges and opportunities

Vision and Change is an initiative by AAAS to transform undergraduate Biology education. It identifies five core concepts and six core competencies for Biology. On our campus, we have begun to implement *Vision and Change*. At the curriculum level, we are refocusing our two one-semester introductory biology courses around the core concepts of ‘energy' and ‘information', replacing the traditional ‘atom to cell' and ‘organism to ecosystem' with a look at biology across all scales through the lens of ‘energy' and ‘information'. We also have mapped all five core concepts onto our current core curriculum. To implement the teaching of core competencies, we have begun to include authentic research, including the teaching of research techniques and skills. At the faculty development level, we are building faculty communities to move beyond individual faculty redesigning individual courses and instead collaborate to redesign curricula. This NSF-funded initiative coordinates across five STEM departments, involves 30 faculty, and directly affects ten introductory and general-education STEM courses. Faculty (1) are seeking out opportunities to observe each other's classes to learn about new practices, (2) are developing cohesive cross-disciplinary course content that cut across multiple courses, (3) are uniting to build critical mass to initiate infrastructure improvements, such as SCALE-UP ready classrooms. We found that faculty overall embrace *Vision and Change* (core concepts and competencies), but struggle to find effective ways of implementing them effectively through evidence-based, active-learning practices. To address this issue, we are using the PULSE rubrics to identify focal areas for faculty development.

P2.187 MUNDELL, P*; OEHRIG, C; KANE, S; Haverford College; *pmundell@haverford.edu*

Diurnal raptor take-off and maneuvering kinematics: a comparative study

Using high-speed 3D video and a synchronized custom data acquisition station, we measured the kinematics and force profiles of several species of diurnal raptors during takeoff and subsequent in-flight maneuvering. This study was performed during bird-banding by the Cape May Raptor Banding Project, allowing us to study birds under natural conditions in the field. This study design also enables measurements on many individuals for multiple raptor species including Cooper's Hawks, Sharp-shinned Hawks and Red-tailed Hawks. We describe in detail our custom integrated field 3D video recording station that uses Streampix software to capture synchronized video from three 90 frame/s cameras in tandem with synchronized audio, force, and wind velocity data from additional sensors. Custom Matlab image processing code was used to track features on the birds in flight, and then DLTdv5 was used to compute 3D flightpaths. These reconstructions were used to determine velocity and acceleration profiles during takeoff. A parallel effort in collaboration with a falconer allowed us to also collect force profiles during take-off. We present results for the acceleration and maneuvering capabilities of these birds during realistic field conditions.

P1.22 MUNRO, C*; SIEBERT, S; HOWISON, M; ZAPATA, F; DUNN, CW; Brown University, Providence RI; *catriona_munro@brown.edu*

Exploring the evolution of functional specialization in siphonophores using RNAseq

Siphonophores are pelagic colonial hydrozoans that are composed of genetically identical zooids that are considered to be homologous to solitary individuals. The zooids are produced asexually, and remain physiologically integrated and attached to one another. Within the colony, each zooid is functionally specialized to a particular task, for example: feeding, swimming, defence, and reproduction. In mature colonies, new zooids bud from two distinct growth zones with the youngest zooids closest to the growth zone and the oldest furthest away. We use a comparative approach to look at the mRNA expression in different zooid types at different developmental stages both within a single siphonophore species, and also between different species, to assess sets of genes that are involved in specifying zooid identity, and to determine whether there is molecular evidence for homeotic transformations in zooid identity. Here we describe preliminary results suggesting key differences between different zooid types, and discuss methods to analyze gene expression within a phylogenetic context, overcoming issues of non-independence of the data due to phylogenetic relatedness.

P2.203 MUNSON-CATT, AC; JACKSON, BE*; Longwood Univ.; *jacksonbe3@longwood.edu*

Biomechanics of competitive flight behaviors in wild American Goldfinches Carduelis Tristis

Wild birds exhibit countless flight behaviors previously unstudied in biomechanical laboratories because the behaviors are limited to field or natural settings. For example, conspecific aggressive interactions are common in competition for food, mates, and habitat in many species. During such behaviors, birds may exhibit flight performance parameters near physiological limits previously unexplored in lab settings. Wild American Goldfinches (*Carduelis Tristis*) were recorded arriving and departing within 1 m of a bird feeder using high speed videography techniques to triangulate flight paths and calculate flight kinematics. Over nine days of recording, with an estimated seven individual birds, we recorded 30 arrivals, and 50 departures, which were subcategorized based on whether the target bird was forced by a conspecific to take off or left voluntarily. Most flight paths involved velocities between 0 and 2 ms^{-1}, indicating potentially costly low-speed flight. Approaching birds frequently scrubbed kinetic energy by gaining potential energy as they swooped from beneath the feeder. Voluntarily departing birds reversed the approach strategy, and dove from the feeder to trade kinetic for potential energy. Birds forced from the feeder by a competitor usually accelerated horizontally under power, and gained greater horizontal velocities (4.5 ms^{-1}) in a shorter time (0.25 s) than freely departing birds. However, many observed interactions involved maneuvering at near-hovering velocities, suggesting that high flight speed and acceleration are not the only parameters involved in competition in flight. Supported by LU-PRISM.

P2.45 MURPHY, GK; CARLISLE, JF*; ROARK , AM; Furman University; *judith.carlisle@furman.edu*

Gonadal morphology of symbiotic and aposymbiotic Aiptasia pallida anemones

In this project, we investigated how the presence or absence of algal symbionts affects gonadal morphology of cnidarians. Specifically, we studied *Aiptasia pallida*, a subtropical species of anemone that can be found from North Carolina to the Florida Keys, on the eastern coast of Baja California, and around the Hawaiian Islands. This species typically maintains its caloric requirements through food intake combined with the photosynthetic products produced by mutualistic dinoflagellate algae of the genus *Symbiodinium*, although hosts can survive without their symbionts. Our previous research suggested that aposymbiotic anemones, which were reared in the dark and thus lacked algal symbionts, failed to develop gonads. However, we were not able to confirm whether the inability to develop gonads was due to the lack of symbiotic algae or to the lack of light. The purpose of this study was to determine the extent to which gonad development is dependent on the presence of symbiotic dinoflagellate algae. Gonadal development and spawning were induced in both aposymbiotic and symbiotic anemones by two consecutive 28-day cycles, each consisting of a 12h:12h light:dark photoperiod for 23 consecutive days and a 16h:8h light:dark photoperiod with simulated moonlight during scotophase for five consecutive days. Each week during the study, nine or ten anemones were anesthetized, fixed in seawater-buffered formalin, embedded in paraffin wax, and sectioned at 7 µm. Serial sections were then alternately stained using either a modified Masson trichrome stain or a standard hematoxylin and eosin stain. Morphological differences in size and number of oocytes or sperm follicles in the gonads and their implications in light of climate change will be discussed.

P2.156 MURPHY, P.J.*; LESSIOS, N.; RUTOWSKI, R.L.; Arizona State University; *pjmurph7@asu.edu*

Regional Genetic Variation of Two Ephemeral Pool Crustacean Species: Implications for Visual System Plasticity or Local Adaptation

Triops longicaudatus and *Streptocephalus mackini* are two crustaceans which cohabitate ephemeral freshwater pools throughout the arid Southwestern USA. They both lay desiccation-resistant eggs that disperse passively to new hydrologically isolated environments. The extent of genetic differentiation among the regions is of perennial interest in animals that live in such isolated habitats. This study estimated the amount of gene flow these two species undergo within and between regions. Populations in six natural ephemeral pools located in two different regions of the Sonoran Desert were sampled. Three of the pools are located in central Arizona near the Phoenix metropolitan area, whereas the remaining three are located roughly 250 kilometers away in southeastern Arizona near the city of Willcox. The extent of gene flow was assessed through the use of neutral markers to estimate genetic variability within and among pools. The outcome of this work has implications for the potential for local adaptations in these species. One implication that the outcome will inform our understanding of the extent to which opsin expression in the eyes of these crustaceans is developmentally plastic versus regionally adapted. In other animals with multiple spectral classes of opsins, opsin expression patterns may covary with the properties of the light environment in which they develop. Light environments in the ephemeral pools studied exhibit a high degree of regional variation. Potential links between the observed patterns of genetic differentiation among pools and the properties of their opsins will be discussed.

P2.132 NAJAFI, A.E.*; SIKES, J.M.; Univ. of San Francisco; *anajafi@dons.usfca.edu*

Germ line fate specification in a basal bilaterian

The germ line serves as an essential tool for sexual reproduction by giving rise to gametes that create successive generations. To understand how germ line specification has evolved, we have characterized genes with conserved germ line function in acoel flatworms, which likely occupy an important phylogenetic position basal to other bilaterians. The hermaphroditic acoel *Convolutriloba macropyga* possesses neoblasts that give rise to both male and female germ cells directly within parenchymal tissues. We have characterized the spatiotemporal dynamics by which germ cell differentiation occurs; germ cells first appear at an anteromedial body location and then migrate posteriorly to somatic accessory organs. While homologs of *nanos, piwi, pumilio*, and *argonaute* are co-localized in both neoblasts and germ cells, *vasa* homologs are exclusively present in germ line cells. Most markers are expressed in both the male and female germ line, yet *argonaute* homologs are specific to female germ cells only. By using RNAi-mediated gene knockdown, we are functionally characterizing these genes to elucidate putative roles in specifying germ cell lineage fate and sex-specific germ cell determination.

P2.112 NAYLOR, M.F. *; GRINDSTAFF, J.L.; Oklahoma State University; *madeleine.naylor@okstate.edu*

Environmentally Relevant Levels of 17&alpha-Ethinylestradiol Influence Male Zebra Finch Courtship Behaviors, Pair Bond Formation and Reproductive Success

Estrogen has organizational and activational effects in birds. Females require estrogen for development of reproductive anatomy and courtship and reproductive behaviors of both sexes are associated with estrogen levels. Therefore, exogenous estrogen exposure may significantly change physiology and behavior. 17&alpha-Ethinylestradiol (EE2), a synthetic estrogen in oral contraceptives, is ubiquitous in wastewater effluents. EE2 exposure is known to alter avian embryonic development, but activational effects on adults are not well studied. We tested the potential for EE2 to disrupt reproductive success through effects on male courtship behavior of zebra finches (Taeniopygia guttata). We used three EE2 doses, 0 ng (control); 4 ng, which is a concentration found in streams near wastewater effluent sites; and 100 ng, which serves as a positive control. Males were dosed orally every other day for three weeks prior to courtship trials continuing until nestlings hatched or for up to six weeks after pairing, if no eggs were laid. We recorded male and female courtship behaviors to test whether the time required to initiate pair bond behaviors was affected by EE2 treatment. Measures of nesting success included number of eggs laid, number of young hatched, nestling growth, and nestling survival to fledging. In courtship trials, EE2 treated males were less likely to mount females than controls but took less time to initiate pair bond formation via clumping behavior than controls. Preliminary data suggest that EE2 exposure of males may also influence nesting success of the pair. These results demonstrate significant evidence that environmentally relevant EE2 exposure in adulthood influences avian behavior and reproductive success.

P1.184 NAKAYAMA, R.*; NAKANO, T.; YUSA, Y.; Kyoto Univ., Japan, Nara Women's Univ., Japan ; *nakayama.ryo.27c@st.kyoto-u.ac.jp*

Phylogeny and Life history of snail attaching limpets the "Lottia kogamogai" species complex

The *"Lottia kogamogai"* species complex is a group of lottiid limpets. It consists of four species, all of which inhabit the intertidal rocky shore in Japan. In this complex, shell sculpture that is regarded as important diagnostic character is sometimes eroded. Therefore, it is difficult to identify the species in the field. In particular, ribs on the shell of juveniles are often undeveloped, making identification of the juveniles even more difficult. To reveal the identity of each species, we first conducted molecular phylogenetic analysis. Moreover, in this complex, small individuals are often found attached to snails. To clarify their life history, including the period in which juveniles living on the snails, we observed seasonal changes of limpets on snails from September 2013 to September 2014. To correct identify juveniles on snails, we also performed DNA barcoding. Molecular phylogenetic analysis revealed that the *"Lottia kogamogai"* species complex consisted of two different lineages, and two cryptic species were recognized in addition to the four known species. Observations of seasonal changes and DNA barcoding revealed that juveniles of two species exhibited such attaching behavior. Moreover, there are two peaks of recruitment of the juveniles on snails, in early spring and early summer. The period in which the limpets lived on snails was up to one year after settlement. From the results of those studies revealed two species which attaching to snails belongs to the same linage. This lineage consists of species that are distributed in coastal areas around North Pacific, and attaching behavior was also reported in some North American Lottiidae limpets. Therefore, in Lottiidae, it is suggested that such behavior might have evolved only in this lineage.

P2.114 NEEDHAM, KB*; KUCERA, AC; HEIDINGER, BJ; GREIVES, TJ; North Dakota State Univ.; *katie.needham@ndsu.edu*

Transient sperm decline from a simulated pathogen exposure in house sparrows

Mounting an immunological response is energetically demanding and necessarily redirects allocation of resources towards immune system activation and away from other processes, such as reproduction. Repeated exposure to pathogens may impose long-term costs. Here we induced an immunological energetic challenge by giving three lipopolysaccharide (LPS) injections to probe for potential trade-offs between immunity and sperm viability following repeated immune challenges. LPS induces a reversible inflammatory acute phase response that can result in impaired testicular steroidogenesis and compromised sperm membrane integrity by disruption of spermatogenesis. Our study species, a wild-caught captive population of house sparrows (*Passer domesticus*), is a highly social species that engages in extra-pair copulations with intra- and inter sexual selection pressures for high-quality sperm. In birds, the number of sperm ejaculated and sperm fertilizing ability are influential for sperm competition in the wild. We measured sperm concentration and straight-line velocity at 4 time points for each of the 3 LPS injections: pre-injection and 24 hours, 48 hours, and 14 days post-injection. The 24- and 48-hour sperm samples would represent possible effects of fever on sperm stored in the testes, while the 14-day sperm sample indicates an influence on end stage spermatogenesis. The results will inform whether repeated immune challenges can readily induce a trade-off in resource allocation, and at what time point sperm quality is affected in house sparrows.

P2.47 NEEL , L.K.*; MCBRAYER, L.D.; Georgia Southern University, Statesboro; *lauren_k_neel@georgiasouthern.edu*

The effects of thermal opportunity and habitat on thermoregulatory effectiveness

An organism's ability to thermoregulate affects many physiological traits in ectotherms. Therefore, thermal factors are paramount when considering behavior, activity time, body temperatures, energy budget, and performance capabilities. Thermoregulatory effectiveness refers to the improvement in accuracy of thermoregulation with respect to a non-thermoregulating model organism. We examined populations of the Florida Scrub Lizard *Sceloporus woodi* that live in two contrasting habitat types. Operative temperatures were measured using PVC 'lizard' models placed throughout two habitat types in Ocala National Forest. Here, this species' habitat is maintained by either clear-cut logging in scrub stands, or prescribed burning in longleaf pine stands. Thermal quality of a habitat can be estimated via an index of how closely the available operative temperatures in a given habitat align with an animal's preferred range of temperatures determined in a thermal gradient. Thus far, we have found that available operative temperatures are not different between longleaf and scrub habitats. However field active body temperatures are higher in animals occupying longleaf sites, indicating possible differences in thermoregulatory behaviors. Data on thermal quality of habitat and thermoregulatory effectiveness will also be examined to uncover how thermal opportunity influences thermoregulatory effectiveness and behavior.

P3.83 NEPTUNE, T.C.*; RAHE, C.E.; BOUCHARD, S.S.; Otterbein University; *troy.neptune@otterbein.edu*

Predation risk in the face of limited resources: nutritional plasticity in red-eyed treefrogs

Predation risk can strongly influence the growth and development of organisms. In anurans, predators can depress larval growth rates and induce changes in morphology. For some species, increases in tail size can improve larval escape rates but come at the cost of decreased gut length and digestive efficiency. In red-eyed treefrogs, *Agalychnis callidryas*, highly competitive, low resource environments induce longer guts and shorter tails. In this study, we evaluated the net effect of combining a larval predator and a low resource environment. At the Smithsonian Tropical Research Institute in Gamboa, Panama, we reared *A. callidryas* larvae in 400 L mescocosms with and without a caged *Belostomatid* predator. Predators were fed two *A. callidryas* hatchings every other day to generate kairomones in the larval environment. Larvae were maintained at 25 individuals per mesocosm, a density known to produce a competitive environment and induce longer guts. Larval growth was highly variable among tanks and did not vary significantly with predator treatment. Food availability may have limited larval growth to such an extent that further predator effects were not possible. Predators did induce small but significant increases in larval tail length. However, there were no associated changes in gut length. These morphological results suggest that when faced with simultaneous stressors of food limitation and predation, larvae adopt a morphology that allows for modest increases in tail size without sacrificing digestive efficiency. Additional studies are needed with higher food resources and varying rates of predation pressure to better understand these tradeoffs.

P3.117 NESBIT, K*; ROER, R; University of North Carolina Wilmington; *ktn1192@uncw.edu*

Silicification of the medial tooth in the blue crab, Callinectes sapidus

The blue crab literature currently lacks a description of the ultrastructure, composition, and molt cycle dynamics of the medial tooth, a siliceous structure located within the gastric mill on the distal portion of the urocardiac ossicle. Examples of mineralization of siliceous structures in the Crustacea have been a largely understudied phenomenon, with exception to opal teeth of copepods (Michels et al. 2012, Miller et al. 1990) and the amphipods (Mekhanikova et al. 2012). Development of mineralized structures, and more specifically feeding structures, through the molt cycle is critical for acquisition of nutrients to aid in growth and development of the organism. Here we examine the dynamics of silicification of the medial tooth in the gastric mill of the blue crab, *Callinectes sapidus*. Scanning electron microscopy was utilized to examine surface structural features of the medial tooth, in tandem with energy dispersive x-ray analysis for compositional information. These data revealed degradation of the old tooth during the premolt stages, along with elaboration of the new siliceous layer through late premolt into post molt. Furthermore, conical projections are apparent on the outer surface of the exocuticle, and appear to contribute to deposition. A variety of histological preparations across various stages of the molt cycle were examined in order to compare the cellular changes and characteristic features of tissue surrounding the medial tooth to those features and changes that occur during calcification of the cuticle. These novel data provide the first description of the medial tooth of the blue crab, as well as a foundation for uncovering structural and cellular similarities and differences in two essential mineralization processes: calcification and silicification. The study was supported by grant 2014-1751 from North Carolina Sea Grant.

P2.177 NEUBAUER, DL*; BRODEUR, LK; GERRY, SP; Fairfield University; *david.neubauer@student.fairfield.edu*

'N Sync: The Evolution of Jaw Muscle Activation in the Batoids

Batoids (skates and rays) have specialized jaws that may function independently due to their cartilaginous skeleton, euhyostylic jaw suspension, and the presence of a highly flexible symphysis at the center of the upper and lower jaws. Bilateral implantation of the jaw muscles has lead to a greater understanding of the activity occurring on the left and right sides of the jaw during feeding events. Sharks and skates have demonstrated unilateral activation when feeding on complex prey items. We investigated pairwise activation of the jaw muscles in four species of batoids (*Dasyatis sabina, Gymnura micrura, Potamotrygon motoro, Urobatis halleri*) from four families in order to examine the evolution of synchronous and asynchronous feeding behaviors. We hypothesized that these rays would use synchronous activation when feeding on small prey and unilateral activation to process larger prey items. Electrodes were implanted bilaterally into four muscles that control the jaws and hyoid. All species were fed squid pieces standardized to one-half mouth width and one mouth width. Two asynchrony indices were used to quantify the duration of muscle activation and the lag, or degree by which muscles are activated out of phase. All rays showed synchronous activation when feeding on both sizes of squid: there was no difference in duration or lag indices ($P > 0.05$). However, *Gymnura* were sometimes observed using unilateral activation. Based on the data collected, we hypothesize that asynchronous activation is an ancestral trait of the batoids that has been lost in the derived species. Future studies should incorporate additional derived species to test this hypothesis.

P2.63 NEUMAN-LEE, L.A.*; FRENCH, S.S.; Utah State Univ.; *lorin215@gmail.com*

Ecoimmunology tools in gartersnakes

The field of ecoimmunology is interdisciplinary and complex, and the toolbox of ecoimmunological methods is appropriately multifaceted to reflect this fact. However, assays can be expensive and sample volumes can be small, so choices must be made to determine what tests should be run to best meet the needs of the researcher while acknowledging the limitations of the model. In this study, we evaluated the immune function of Common Gartersnakes (*Thamnophis sirtalis*) with a wide variety of commonly used ecoimmunological metrics, including microbiocidal ability, lymphocyte counts, oxidative stress, hemoagglutination, lysis, and assessments of internal and external parasites using histological techniques. Some measures, like micobiocidal ability, showed high amounts of individual variation, while other measures, like oxidative stress, remained fairly constant in this species. Although we found strengths and weaknesses in many commonly-used metrics, we also found that interpreting multiple measures of immunity together was much more informative than looking at any single measure individually.

P2.26 NEWBERRY, G.N.*; SWANSON, D.L.; University of South Dakota; *gretchen.newberry@coyotes.usd.edu*

Nest microclimate and hatching success of Common Nighthawks (Chordeiles minor) at rooftop nest sites in an agriculturally dominated landscape

Reduction of grassland nesting habitat for Common Nighthawks (*Chordeiles minor*) has resulted in nesting on urban rooftops in the Northern Prairie region. I documented nest microclimates and hatching success at rooftop sites in southeastern South Dakota in 2014-2015 to document the potential thermal stress on incubating adults. Bird body temperature reaches lethal levels at approximately 46°C. As an index of thermal microclimates, I measured operative temperatures (a measure of heat exchange between an animal and its environment) and their influence on hatching success using copper sphere operative temperature thermometers. I used Student's t-tests to compare mean minimum temperature, mean maximum nest temperature and mean percent of temperature readings greater than 46°C between nests where eggs hatched and those abandoned for these preliminary data (12 successful and 7 failed nests). Nest mean minimum temperature (9.4±1.1°C, 10.2±1.1°C), mean maximum temperature (50.0±0.8°C, 48.9±0. 7°C), and mean percent of temperature readings greater than 46°C (2.00±0.005%, 1.49±0.004%) did not differ significantly for successful and failed nests, respectively. Thus, thermal microclimate for incubating adults does not appear to be a major cause of nest abandonment in southeastern South Dakota. However, this result might change with increasing temperatures due to climate change, so thermal microclimates should be incorporated into future projections of population responses to land use and climate change for this declining species. Future studies should also examine the relationships of thermal biology and microclimates of eggs and nestlings and their impact on nesting success to determine if these factors might contribute to nest failures.

P3.180 NEYER, A.A.*; BACHMAN, G.C.; University of Nebraska-Lincoln; *neyeraa@gmail.com*

Hatchling ornate box turtles (Terrapene ornata ornata) prefer safety over thermoregulation.

Juvenile organisms may be faced with conflicting decisions regarding behaviors that promote their growth, development, and survival. In ectothermic animals, juveniles may be expected to seek habitats that allow them to maintain preferred body temperatures which could reflect temperatures optimal for foraging, growth, or digestion. However, these areas may not provide cover from predators. Juvenile turtles could face high mortality due to their small body sizes and undeveloped shells that only provide a small amount of protection. Little is known about juvenile turtle behavior and physiology, therefore the outcome of a potential trade-off between thermoregulating and avoiding predation risk is unknown. In this study, we determined the preferred body temperature of hatchling turtles placed in a thermal gradient. We then tested juveniles in an experiment that offered individuals a choice between thermoregulating or remaining in protective cover. Our data suggest that hatchling turtles prefer staying in areas providing shelter over open areas that allow them to thermoregulate near their preferred temperature. Turtles are long-lived animals, and so for young individuals promoting survival may be more critical than regulating body temperatures. These results begin to address the decisions that a long-lived organism may make as a juvenile when faced with trade-offs between maximizing growth and maximizing survival.

P3.87 NGUYEN-PHUC, B.Q.*; STEWART, S.; DEMETROPOULOS, C.; GERMAN, D.P.; Univ. of California, Irvine, Southwest Aquatic and Terrestrial Consulting, Thousand Oaks; *baoquann@uci.edu*

Understanding the Digestive Physiology of the Herbivorous Sucker Catostomus santaanae

Very little is known about the energy acquisition strategies of Santa Ana suckers (*Catostomus santaanae*). This is due to their current listing as a threatened species resulting in limited access and study. *C. santaanae* is endemic to freshwater systems in southern California and is suffering due to habitat decline. Therefore, it is imperative to understand the nutritional needs of these fish in order to make informed decisions with respect to habitat conservation, with particular attention to the food resources of *C. santaanae*: the epithilic algal complex (EAC). A sample of fifteen individuals from the Santa Clara River are currently being subjected to a feeding trial comprised of an artificial algal diet simulating an EAC. We will be measuring growth, assimilation efficiency, and gut structure and function (including digestive enzyme activities) to better understand nutrient assimilation from EAC resources in this species. We anticipate that *C. santaanae* will exhibit similar morphological and physiological characteristics to that of convergently evolved herbivorous minnows, genus *Campostoma*, considering these genera occupy similar niches in their respective habitats.

P1.87 NICHOLS, Z/G*; BUSCH, S; MCELHANY, P; University of Alabama , Northwest Fisheries Science Center ; *zgnichols@crimson.ua.edu*

Metabolic response of dungeness crab larvae to varying pH and dissolved oxygen

Ocean acidification (OA) and deoxygenation, both resulting from rising atmospheric CO2 levels, are lowering the pH and oxygen levels of global oceans. Assessing the impacts of OA and deoxygenation on harvested species is crucial for guiding resource management strategies to maintain healthy and sustainable populations. The Dungeness crab, *Cancer magister*, is an important species ecologically and economically for the US West Coast. Crabs transition through four life stages: zoea, megalopa, juvenile, and adult. Each stage differs distinctly in morphology and behavior, and thus differs in the pH and dissolved oxygen (DO) conditions they are exposed to. The first two stages exhibit diel vertical migration while the final two stages are benthic. We focused on the megalopa stage and their metabolic response to different pH and DO treatments. We exposed wild-caught megalopae to a low/high pH x low/high DO cross. We used closed-system respirometry at 12˚ C to assess the metabolic response (standard metabolic rate, SMR) to each of the four treatments. We predict that megalopae exposed to the low pH/high DO treatment will have higher metabolic rates than those exposed to the high pH/high DO treatment. We likewise predict that high pH and low DO will depress metabolism relative to exposure to high pH and high DO due to the megalopae conserving oxygen in a limiting environment. If results support our hypothesis, they would suggest that OA and hypoxia affects Dungeness crabs in sublethal ways.

P1.37 NIESE, RL*; TOBALSKE, BW; University of Montana; *robniese@gmail.com*

Specialized primary feathers in Rock Pigeons (Columba livia) produce tonal sounds during take-off

The sounds produced by the wings of Rock Pigeons have intrigued naturalists for centuries. Many have suggested that the tonal elements of these sounds may be signals or sonations of alarm, but spurious tonal sounds are produced passively by the flight feathers of almost all birds when they aeroelastically flutter. Before we can conclude that tonal wing sounds are sonations, we must identify some characteristic of the feathers of Rock Pigeons that is specifically adapted for sound production rather than flight. We must also provide evidence to suggest that this morphology is necessary for *in vivo* sound production and is sufficient to replicate *in vivo* sounds alone. Our investigations revealed unique structural characteristics of a small portion of the inner vane on the outermost primary feather (P10) of Rock Pigeon wings that facilitates aeroelastic flutter above certain velocities. These same velocities were insufficient to activate flutter in other feathers. We were able to successfully silence the tonal wing sounds of live birds through manipulating this region of P10 to increase its stiffness, thus preventing flutter. Laboratory experiments on isolated feathers indicated that tones produced by flutter in this region of P10 nearly match those produced *in vivo*, and that the activation of flutter in P10 results in a significant decrease in the feather's aerodynamic force-producing ability (C_R). This evidence suggests that the tonal sounds produced by P10 feathers are not purely incidental, opening the door to investigations of their communicative significance. Funding provided by NSF CMMI-1234737.

P3.125 NINAD, N.*; DAVIS, J.L.; FIELD, B.S.; MCCLOUD, E.S.; University of Southern Indiana; *emccloud@usi.edu*

Contributions of wing condition and wing veins to flexural stiffness in three species of Lycaenid butterflies

Wing flexural stiffness plays an important role in our understanding of insect flight and other behaviors. Wing condition during testing is especially important to the generalizability of the findings. Structural damage will play a significant role in altering the flexural stiffness; the degree of alteration can be expected to vary for damage to wing veins or interveinal regions. In addition, variation in the "freshness" of the wings and their veins can also be expected also play a role because moisture in the wing is lost over time as dissected wings and veins become dry and more brittle. Testing wings and their veins immediately after dissection may be a good way to measure flexural stiffness that approximates living specimens but it is not clear whether drying affects wings or wing veins differently in different wing regions. Further, the contribution of wing veins to wing flexural stiffness may vary. We tested wings and dissected veins from 3 species Lycaenid butterflies. The flexural stiffness increases over time; dry wings can be almost 50% stiffer than fresh wings at certain locations along the length of the wings and a similar pattern with drying occurs in wing veins. In addition, the contribution of the fresh veins to the flexural stiffness of the whole wing is not same as the contribution of dry veins to the flexural stiffness of the dry wings.

P2.70 NITSCHMANN, BS*; MARTIN III, AL; Saginaw Valley State University; *almarti2@svsu.edu*

Environmental Effects on Crayfish Shelter Preference

Shelters are necessary in order for many animals to survive. It is well known that animals often use shelters for reasons such as protection, breeding, and territoriality. In natural settings it has been shown that crayfish use shelters for protection from predators and conspecifics. However, it is not well understood what types of shelter preference crayfish exhibit under these different environmental pressures. In this study crayfish were subjected to predators or conspecifics and observed on whether or not these factors affect the shelter preference they exhibit. A 152cm circular experimental tank, filled with 61 cm of water, was used as the arena for this project. Submerged in the center of the tank was a Plexiglas test chamber (35.6 x 35.6 x 20.3 cm). An experimental crayfish was placed in the test chamber that consisted of four different shelter types, each of which had a different number of openings. Focal crayfish placed in test chamber were tested in three different behavioral scenarios: 1) no external stimulus (control), 2) a competitor crayfish as the external stimulus, and 3) a small mouth bass acting as a predator. Each scenario consisted of 15 trials that were recorded for 24 hours and then analyzed by observing what shelter the crayfish chose and the duration in which it stayed there. The goal of this experiment is to illustrate that different environmental factors may cause a crayfish to exhibit a different preference based on shelter type.

P1.144 NOTAR, JC*; GORDON, MS; Univ. of California, Los Angeles; *jnotar@ucla.edu*

A Comparative Study of Sea Urchin Visual Ecology

Sea urchin behavioral reactions to light are more complex than previously thought. These animals have a diffuse photoreceptive system with at least two types of opsins expressed throughout their epidermis. Essentially, each urchin functions as a large compound eye. Their dermal light sense facilitates behavioral tasks that even include coarse spatial vision. This is novel, as diffuse dermal photoreception is generally assumed to mediate non-visual tasks. It has been suggested that urchins inhabiting rocky reefs use spatial vision to locate dark crevices to hide from predators. It is commonly thought that animals have photoreceptive and visual abilities that correlate to the complexity of their light-guided behaviors. The goal of this investigation was to determine the thresholds of urchin photoreception and spatial vision in the context of environmental relevance. Laboratory behavioral trials were conducted to establish the lower limits of intensity required for spatial tasks, action spectra, and image resolution of several Southern California urchin species that vary in depth range and habitat. Results indicate that each species has visual abilities relatively suited to its environment. Intensity thresholds correlate to naturally occurring irradiance levels for different species: for example, deeper dwelling species can perform spatial tasks under dimmer light than intertidal ones. Additionally, reef dwelling species reliably move towards a dark target, while sandy flat dwelling species do not. Describing the function of the urchin as a compound eye allows us to understand how these animals perceive their environments and make choices based on visual cues.

P3.138 OATMAN, S.R.*; PITTS, N.L.; DAS, S.; DONALD, D.L.; Colorado State University, Fort Collins; *sroatman@rams.colostate.edu*

Analysis of key molt-inhibiting hormone (MIH) signaling pathway components in the molting gland (Y-organ) of Gecarcinus lateralis

Growth in decapod crustaceans occurs by the shedding of the exoskeleton in a process known as molting. The molt cycle is comprised of three stages; intermolt, premolt and postmolt. The premolt stage is further broken down into three phases, early, mid and late, which are defined by changes in molting hormone titers in the hemolymph. Molting hormones, or ecdysteroids, are synthesized and released from the molting gland, the Y-organ (YO). Ecdysteroid synthesis is regulated by a neuropeptide, molt inhibiting hormone (MIH), which binds a receptor on the surface of the YO and represses ecdysteroidgenesis. MIH is synthesized in the X-organ (XO) and secreted from the sinus gland (SG) of the eyestalk ganglia (ESG). Removal of the ESG via eyestalk ablation (ESA) eliminates the primary source of MIH, stimulating ecdysteroid synthesis by the YO. The proposed MIH signaling pathway involves a cAMP/Ca2+-dependent triggering phase, followed by NO synthase (NOS)/cGMP-dependent summation phase. Analysis of a YO baseline transcriptome identified the components of the MIH pathway: adenylyl cyclase (AC), calmodulin (CaM), calcineurin (CaN), NOS, NOS inhibitory protein (NOSIP), NO-sensitive guanylyl cyclase (GC-I), protein kinase G (PKG), and the catalytic -subunit of protein kinase A (PKA). ESA increased *Gl-NOS* and *Gl-GC-I* mRNA levels in the YO, but the effects of ESA on the other signaling components was not determined. These data suggest that the YO responses to acute MIH withdrawal by increasing its sensitivity to MIH. Quantitative PCR is being used to determine the effects of ESA on the expression of *Gl-AC*, *Gl-CaM*, *Gl-CaN*, *Gl-NOS*, *Gl-NOSIP*, *Gl-GC-I*, *Gl-PKA*, and *Gl-PKG* in the YO. Supported by NSF (IOS-1257732).

P3.20 OBERSKI, JT*; JAY, KR; COBLENS, MJ; JOHNSON, JE; SHARMA, PP; BOYER, SL; Macalester College, Univ. of Wisconsin, Madison; *joberski@macalester.edu*

Systematics and Biogeography of Mite Harvestmen from Australia's Wet Tropics

Mite harvestmen of the genus *Austropurcellia* (Opiliones: Cyphophthalmi: Pettalidae) have come to attention in recent years as a study system for understanding the biogeography of the Australian Wet Tropics biodiversity hotspot. The limited dispersal, excellent persistence, and ancient age of this lineage make it a particularly useful group for historical biogeographic study. Although phylogenetic relationships within this genus have been explored in recent years, previous studies did not achieve full taxonomic or biogeographic sampling across the genus. In addition, *Austropurcellia* divergence dates within the genus have not been calculated. Using recently collected specimens from species and subregions not represented in previous analyses, we sequenced one variable mitochondrial locus (cytochrome c oxidase subunit I, or COI) and two more conserved nuclear loci (18S and 28S rRNA). Phylogenetic trees were inferred using Bayesian methods in MrBayes. Maximum likelihood analyses were performed in RAxML and nodal support was estimated using bootstrap resampling. Relaxed molecular clock methods implemented in BEAST were used to determine dates of species divergence. We tested the hypothesis that rainforest contraction and fragmentation during the Pleistocene glacial cycles drove speciation within the genus, and also explored the taxonomic implications of the relationships we uncovered. Here we evaluate evidence for the hypothesis that rainforest contraction and fragmentation during Pleistocene glacial cycles is a driver of speciation within this paleoendemic arthropod genus. We also detail the taxonomic implications of the relationships recovered by our molecular tree topology.

P3.65 OCHAB, J.L.*; KOENIG, A.J.; KINSEY, S.T.; Universirty of North Carolina Wilmington; *jlo3999@uncw.edu*

The effects of metformin of skeletal muscle differentiation and fusion

J.L. Ochab, A.J. Koenig, S.T. Kinsey The University of North Carolina Wilmington jlo3999@uncw.edu The effects of metformin on skeletal muscle differentiation and fusion AMP activated protein kinase (AMPK) functions as a cellular energy sensor and it is a target for the treatment of obesity and type II diabetes. Activation of AMPK has well-known benefits such as increased fuel oxidation and enhanced insulin sensitivity, however, it also may lead to compromised satellite cell function. This may be particularly detrimental to muscle development in juveniles, when satellite cell density and activity is high. In this study, the type II diabetic drug metformin was used to pharmacologically activate AMPK in C2C12 mouse skeletal muscle myoblasts and in juvenile mice. Myocytes and early myotubes treated with 1mM metformin had a decreased expression of the myogenic marker, myogenin, but there was no difference in the expression of the adhesion molecule NCAM. Laser scanning confocal microscopy demonstrated that metformin-treated cells in mid-late differentiation also had decreased cell-cell membrane fusion. These results were consistent with a reduced gastrocnemius mass in juvenile mice treated with metformin. Further gastrocnemius muscle from mice treated with metformin had a reduced expression of the satellite cell marker, Pax7, as well as the myogenic markers, myogenin, MyoD, and NCAM. Together, the *in vitro* and *in vivo* results support the hypothesis that AMPK activation with metformin inhibits muscle development by interfering with satellite cell differentiation and fusion.

P3.55 ODETUNDE, A.O.*; CASTO, J.M.; Illinois State University; *aodetun@ilstu.edu*

Does blood loss explain ectoparasite-induced changes in nestling development?

We investigated how blood loss and other outcomes of hematophagous mite infestations contribute to previously reported developmental trade-offs in European starling nestlings. We first microwaved nests to reduce ectoparasites in all treatment groups one day after egg laying ceased, and assigned the nests to one of three treatments: control, blood loss and mite infestation. To simulate infestation, immediately following microwaving, we inoculated mite infestation nests with 40 Northern fowl mites. To assess treatment effectiveness on mite levels, blood spots on the eggs from nests in all treatments were assessed 10 days later. Nestling growth and survival were assessed on brood days (BD) 5, 10 and 15. On BD 5 and 10, we collected 10% of the blood from nestlings in the blood loss treatment and much smaller blood samples from nestlings in the other two treatments. Nestlings in all treatments were bled similarly on BD 15. From these samples we assessed blood glucose and hemoglobin concentrations, as well as hematocrit. Preliminary analyses indicate that wing length, tarsus length, body mass and blood glucose increased significantly with age, but there were no significant treatment effects. We found an interaction between treatment and age, where nestlings in the mite infestation treatment had lower levels of hematocrit and hemoglobin than other nestlings especially on BD 15. These results suggest that the effects of mite infestation extend beyond those of mere blood loss, perhaps involving a trade-off involving increased energetic demands associated with immune activation. Results will be discussed further in light of ongoing analysis of bacterial killing capacity of plasma across development, assessment of mite loads in nests after fledging, and possible seasonal influences.

P3.194 OGLESBY, TL*; MURRAY, JA; CAIN, SD; Savannah State University , Cal State East Bay, Eastern Oregon University; *james.murray@csueastbay.edu*

How water flow interacts with the olfactory tentacle of the nudibranch Tritonia tetraquetra

We were interested in learning how olfactory cues that guide navigation in the gastropod nudibranch *Tritonia tetraquetra*, formerly known as *Tritonia diomedea* are received by the rhinophores in turbulent flow. We measured boundary layer thickness at various speeds, and characterized water flow turbulence caused by their rhinophore. This was done using Particle Image Velocimetry (PIV), which measured velocity fields by determining particle displacement during laser sheet illumination. Using a fixed (dead) rhinophore on a clay model slug, in 1 cm/s laminar flow, there was an approximately 2-3 mm thick boundary layer upstream and lateral to the rhinophore clavus, as well as turbulence for several mm downstream. We also characterized cilia-generated flow on the clavus of three species of nudibranch (*Tritonia diomedea*, *Tritonia festiva*, *Armina californica*). Dye flow patterns show cilia-driven currents from near the distal region of the rhinophore to the proximal region of the rhinophore. In *Tritonia*, the current originated at the distal tip and flowed proximal into the folds of the clavus, then spread outward towards the circumference of the base of the clavus. In *Armina*, the flow was unidirectionally proximal along the infolds of the clavus. The cilia on the rhinophore may help the animal respond faster to odor changes by removing the boundary layer (i.e. sniffing). Scanning electron micrographs showed that the tuft at the distal end of the rhinophore (a.k.a. clavus) had large patches of dense cilia on its vertical inner folds, but lacked dense cilia on the parts of clavus that are more exposed around the circumference.

P2.133 OKUMURA, M; JOHNSON, G; SPICA, E; SHAPIRO, J A; DAVIS, G K*; Bryn Mawr College; *gdavis@brynmawr.edu*

Induction of reproductive fate in the Pea Aphid

The pea aphid, *Acyrthosiphon pisum*, exhibits several environmentally cued, discrete, alternate phenotypes (polyphenisms) during its life cycle. In the reproductive polyphenism, differences in day length determine whether mothers will produce daughters that reproduce either sexually by laying fertilized eggs (oviparous sexual reproduction), or asexually by allowing oocytes to complete embryogenesis within the mother without fertilization (viviparous parthenogenesis). Among other aspects of the polyphenism, we are interested in the process that specifies sexual versus asexual fate during embryonic development. Two lines of evidence implicate juvenile hormone (JH) in this process: titers of JH correlate with day length (Ishikawa et al. 2012) and topical application of JH can alter reproductive fate (Corbit and Hardie 1985). Together these observations suggest that high titers of JH are responsible for specifying asexual fate. We have confirmed the sufficiency of JH to specify asexual fate and have explored this JH hypothesis further by 1) testing whether JH is also required for the specification of asexual fate during embryonic development and 2) attempting to discriminate among competing models for the role JH plays in the process. As a complementary approach we have used RNAseq to identify genes that are differentially expressed in sexually versus asexually fated embryos, both during the periods of specification and subsequent differentiation. Finally, with an eye toward understanding how this response to photoperiod might evolve, we have begun to characterize a population reported to have lost the ability to produce sexuals in response to shortened day length. Corbit TS and Hardie J. 1985. *Entomologia Experimentalis et Applicata* 38: 131-135. Ishikawa et al. 2012. *Insect Mol Biol* 21: 49-60.

P1.123 OLSEN, AM*; MALLULA, ML; TOSUNOGLU, A; ÇAKMAK, I; HRANITZ, J; BARTHELL, J; GONZALEZ, V; University of Michigan, Ann Arbor, University of Kansas, Uludağ University, Uludağ University, Bloomsburg University, University of Central Oklahoma; *amolsen@umich.edu*

Bee visitation patterns of Centaurea solstitialis L. (Asteraceae) in an urban environment in northwestern Turkey

The Eurasian yellow star-thistle (*Centaurea solstitialis* L., Asteraceae) is a highly invasive weed that has become established in western United States. In natural and agricultural environments of its invasive range, *C. solstitialis* produces high amounts of nectar per floret and is predominantly visited by honeybees. The opposite case appears to occur in its native range. In semi-natural areas of Lesvos, Greece, *C. solstitialis* produces low volumes of nectar and are visited by a diverse group of bees, but rarely or never visited by honeybees. Herein we document the visitation pattern of bees on *C. solstitialis* in an urban environment of its native range. We also explore the relationship of bee body size and nectar availability. Studies were conducted during July 2015 in patches of *C. solstitialis* established in abandoned lots at the Uludağ University campus in Bursa, Turkey. A total of 41 species, including honeybees, belonging to five families and 19 genera were recorded. Not a single bee species dominated the visits, although small species of the families Megachilidae and Halictidae bees were common. Average nectar standing crop volume per floret was low (0.003 to 0.117 µl) and average bee head was not significantly correlated with nectar availability in the studied patches. Analyses of pollen loads as well as direct observations of bee foraging behavior suggest that a large number of bees visit *C. solstitialis* for nectar only. These results are similar to previous observations on native populations of *C. solstitialis* in natural or semi-natural landscapes. They also support the observed differences in the pollinator interactions of *C. solstitialis* across continents.

P2.131 ORBACH, DN*; MARSHALL, CD; WüRSIG, B; MESNICK, SL; Texas A&M University at Galveston, Southwest Fisheries Science Center, NOAA; *orbachd@tamug.edu*

Potential evolution and function of vaginal folds in cetaceans

Whales, dolphins, and porpoises possess unusual folds of vaginal wall tissue, which vary strikingly in shape, number, development, and position across taxa. The evolutionary functions of vaginal folds are unclear and non-mutually exclusive hypotheses have been proposed. Natural selection (i.e. adaptations to mating in marine environments and/or parturition) or sexual selection (i.e. sperm retention or movement) pressures could drive the presence and variation of vaginal fold morphology. Vaginal folds could also reflect common ancestry as folds are present in some related terrestrial artiodactyls. We predicted that if vaginal folds function in natural selection, such as restricting seawater during copulation, species with longer vaginas would also have more folding. The reproductive tracts of 13 cetacean species were assessed during necropsies of fresh or frozen-thawed females (n = 48 specimens). Measurements of vaginal lengths and the sums of vaginal fold depths were collected per specimen. The mean values were calculated for each species and regressed on body lengths. Using a phylogenetically controlled regression (PGLS), we show that the cumulative depths of vaginal folds increased significantly with vaginal lengths ($P = 0.045$). Our data support the natural selection functional hypothesis of vaginal folds, but the strength of the relationship was driven by only one species. There was no significant relationship when the pygmy sperm whale (*Kogia breviceps*) was removed. An increase in species diversity and data on the genital morphology of both sexes will help elucidate the evolutionary forces driving the unusual vaginal folds of cetaceans.

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Pouched and placental predators, past and present: the evolution of carnivore guilds

The effects exerted by predatory mammals have long been recognized for their role in shaping community structure, but what factors drive the evolution of carnivore guilds? Most analyses addressing this question have focused on Northern Hemisphere carnivorans, but Australian marsupial predators (dasyuromorphs, hypsiprymnodontids, and extinct thylacoleonids) represent a guild with a separate evolutionary history that may prove valuable in teasing apart phylogentic and ecological effects. Previous comparisons of Australian and Laurasian predators have focused on craniodental data from large-bodied, extant taxa. These analyses support the hypothesis that the two guilds are convergent, possibly indicating the importance of environmental factors in driving carnivore evolution. This analysis was expanded to include small-bodied taxa and postcranial functional indices. These data were used to reconstruct the morphospace occupied by Australian and North American predator guilds, both Recent and Pleistocene, in order to test the hypothesis that the two are convergent and shaped primarily by abiotic factors. While some overlap exists among modern taxa, large areas of morphospace were occupied by one guild and not the other. Small mesocarnivores comprise a large portion of the Australian guild, while large hypocarnivores are absent; the opposite is true for North America, possibly indicating that either phylogenetic effects or biotic interactions play an important role in driving predator evolution. The fossil data allow a more direct test of the influence of changing climate on predator guild structure. These data suggest a large degree of change between the Pleistocene and Recent, the implications of which will become clearer with increased sampling and by incorporating paleoenvironmental data.

P2.178 ORSBON, CP*; NAKAMURA, Y; KIJAK, NA; PALMER, SE; ROSS, CF; University of Chicago, Niigata University; *orsbon@uchicago.edu*

Variation in large feeding biomechanics datasets visualized using different dimensionality reduction methods

Dimensionality reduction has been used to study locomotor and reaching biomechanics; however, such methods have had limited application to primate feeding, particularly to the hyolingual apparatus which features high functional variation. We applied both conventional and newer dimensionality reduction methods to a large feeding dataset to evaluate their ability to discriminate between two stages of feeding: chewing and swallowing. The dataset included the digitized anatomical and implanted markers of two adult rhesus macaques filmed in lateral view using videofluoroscopy while feeding on a variety of food items. The aggregated Cartesian coordinates of the markers constituted a quantified "posture" for each frame, and postures were analyzed using principal components analysis (PCA) and t-stochastic neighbor embedding (t-SNE). Preliminary results demonstrate that the first three principal components account for the majority of variation in posture (88%). Once embedded in low-dimensional space, pairwise distances among swallowing postures were smaller than a random sample from all cycles, and these distances were smaller in t-SNE than PCA. The results suggest that 1) intra-individual variation in feeding posture is low-dimensional and 2) dimensionality reduction techniques may be a useful tool for exploring large datasets of feeding biomechanics. Future directions will include using similar approaches to analyze datasets of three-dimensional motion capture data and electromyography of jaw, hyoid, and tongue musculature during feeding. Low-dimensional approaches may deepen our understanding of the major sources of variation in hyolingual behavior and how they contribute to feeding performance.

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Influence of habitat on predation intensity of the Florida scrub lizard

Both predation and habitat type have been shown to influence divergences in behavior and morphology. Habitat fragmentation can divide source populations into inferior habitats with increased predation, forming sink populations. Understanding the relationship between habitat fragmentation and predation intensity is a vital step in designing successful conservation outlines. The Ocala National forest (ONF) is a highly fragmented landscape among cut stands of sand pine scrub (SPS) and stands of long leaf pine (LLP) throughout the forest. Small terrestrial endemics such as the Florida scrub lizard (*Sceloporus woodi*) are at particular peril of habitat fragmentation due to their limited vagility. LLP and SPS habitats differ remarkably in vegetation, openness of habitat, and substratum. Predation can be difficult to measure in the field, confining most studies to the laboratory. Alternatives to laboratory studies include premeditated placement of camera traps, clay models, and tethered animals. We quantified relative predation intensity on the Florida scrub lizard between LLP and SPS by using both clay models and camera traps from June to August 2015. This study elucidates the relationship between habitat complexity and relative predation intensity. Models placed in SPS received more attacks than those placed in LLP. In accordance with the lack of abundance of scrub lizards in SPS, this data may infer a source-sink response to habitat fragmentation. The data also serves to identify the presence and relative abundances of potential scrub lizard predators by habitat type within the ONF.

P2.55 OVERMAN, BD*; GOESSLING, JM; MENDONCA, MT; Auburn University; *goessling@auburn.edu*

Seasonal lag of constitutive innate immune function in gopher tortoises (Gopherus polyphemus)

Disease has been attributed to significant declines in populations of ectothermic vertebrates, including the gopher tortoise (*Gopherus polyphemus*), which is a keystone species native to the southeastern United States. Across ectothermic vertebrates, climatic instability has been suggested to drive patterns of disease susceptibility, as individuals are often most susceptible during periods of thermal instability. The objective of this study was to experimentally test the seasonal lag hypothesis in *G. polyphemus*, which predicts rapid temperature changes cause a miss-alignment of realized and optimal immune function. We measured one parameter of innate, constitutive immune function, bactericidal ability (BA), in *G. polyphemus* during seasonal acclimation states of winter dormancy and summer activity. Additionally, we measured BA in winter-acclimated animals (N = 22) exposed for 48 hours to the summer-acclimated temperature (32.5°C) and summer-acclimated animals (N = 17) exposed for 48 hours to the winter-acclimated temperature (12.5°C). We found support for the seasonal lag hypothesis, and that this effect is context dependent on acclimation state. Specifically, we found no effect of the rapid temperature increase on winter-acclimated individuals exposed to 32.5°C (P = 0.325), but we did find a significant reduction in BA in summer-acclimated animals exposed to a rapid temperature decrease (P = 0.040). Results from this study generally support a process by which thermal variability may increase disease susceptibility in ectothermic vertebrates. Specifically, this study highlights the constraints that rapid temperature decreases may impose on individuals acclimated to warm temperatures.

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The impact of substrate on the terrestrial locomotion of juvenile Oligocottus maculosus (tidepool sculpin).

Tidepool sculpins, *Oligocottus maculosus* , are found in the rocky intertidal, and juveniles are often present in the high intertidal at low tide where they are prone to experiencing emersion, both voluntary and involuntary. The substrate of the rocky intertidal zone is complex and heterogenous, a challenging environment for any organism, but particularly for a small fish. How does substrate affect the terrestrial locomotion of juvenile tidepool sculpin? We filmed a dorsal view of the terrestrial locomotion of O. maculosus on three different substrates: wet paper towel, small rocks (2-4mm), and large rocks (4mm-8mm). Sequences of two sequential strides were digitized for each habitat, where a stride consisted of a full head-tail oscillation from one side, to the other, and then back again. Tidepool sculpins move over land by utilizing movement of their trunk and tail in conjunction with their pectoral fins. Preliminary data show O. maculosus had the greatest movement of COM per stride when moving across the uniform surface and tail movements were also the least variable. As particle size and heterogeneity increased, the overall pattern of movement persisted, but fish didn't travel as far, movement appeared more labored, and locomotor bouts became shorter in duration. The increase in particle size may decrease the effectiveness of locomotion because it hinders the movements of the pectoral fins and adds a vertical component as the largest particles start to become obstacles. Relatively few studies consider substrate effects, yet understanding how substrates affect terrestrial locomotion in this model system can help us understand functional limits to movement, which offers potential insights to the challenges of the first amphibious vertebrates.

P1.179 PAGANO, A.M.*; RODE, K.D.; CUTTING, A.; OWEN, M.A.; JENSEN, S.; WARE, J.V.; ROBBINS, C.T.; DURNER, G.M.; WILLIAMS, T.M.; USGS, Alaska Science Center, Oregon Zoo, Inst. for Cons. Res., San Diego Zoo Global, Alaska Zoo, Washington State Univ., Univ. of California, Santa Cruz; *apagano@usgs.gov*

Using tri-axial accelerometers to remotely identify ursid behavior

Tri-axial accelerometers have been used to remotely identify the behaviors of a wide range of cursorial mammals. Assigning behavior to the accelerometer data often involves the use of captive animals or surrogate species. While it is assumed that accelerometer signatures of captives or surrogates are similar to those of their instrumented wild counterparts, this has rarely been tested. Here we developed accelerometer-behavior signature libraries for two species of ursid that use a plantigrade style of locomotion to remotely distinguish walking, swimming, eating, and resting. Data from captive and wild animals were compared by video-taping captive polar bears (*Ursus maritimus*; n=3) and brown bears (*U. arctos*; n=2) while they wore accelerometer-equipped collars in their enclosures and by collecting video from accelerometer-equipped camera collars deployed on wild polar bears on the spring sea ice of the Beaufort Sea (n=5). A subset of data from all bears was used in random forest models to predict behaviors. With the remaining subset we discriminated walking and resting with >95% accuracy and eating and swimming with >50% accuracy. We assess the causes of this discriminatory variation and evaluate the ability of captive data from polar bears or brown bears to predict wild polar bear behavior. By validating the use of accelerometer signatures in free-ranging ursids, this study also provides a framework for understanding how habitat conditions such as declines in Arctic sea ice may influence activity patterns and energy demands in the polar bear.

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Built to break: developmental assembly of a sea slug's autotomy plane

Autotomy refers to the voluntary detachment of a body part at a pre-determined breakage plane. The sacrifice is typically predator-initiated and the behaviour facilitates escape. The breakage plane (autotomy plane) is not inherently fragile, but rather its structural integrity is weakened by neural activation of effectors that abruptly reduce tensile strength. Dorsal appendages (‘cerata') of the nudibranch, *Melibe leonina*, readily detach when pinched by forceps or by a predatory crab's cheliped. The ceratal autotomy plane includes a nerve ring that innervates cells with granule-filled cytoplasmic processes extending to all connective tissue structures crossing the autotomy plane. Degranulation of these cells may disrupt collagenous connective tissues, including epithelial basal laminae, during autotomy behaviour. In addition, the nerve ring and associated granule-filled cells of the autotomy plane are flanked by a pair of sphincter muscles. When a ceras is pinched, a long-lasting train of synchronized action potentials is initiated within neurons of a ganglion at the base of the ceras, the sphincter muscles contract strongly, granule-filled cells degranulate, and tissues of the autotomy plane separate. The ability to autotomize a ceras emerges at a specific stage of juvenile development - stage III. We therefore hypothesized that the distinctive, granule-filled cells of the autotomy plane would differentiate at stage III. By immunolabeling nerves and phalloidin-labeling muscles, together with transmission electron microscopy, we found that granule-filled cells were present at the prospective autotomy plane well before stage III, but the sphincter muscles differentiated at the onset of stage III. We conclude that the sphincter muscles are an essential morphological component of autotomy behaviour.

P1.79 PARK, N.R.*; ANDERSON, C.V.; ROBERTS, T.J.; Brown Univ., RI; *noel_park@brown.edu*

Muscle twitch time limits gait dynamics in Anolis lizards

Maximum sprint speed should be determined by the contractile properties of muscles, but the exact nature of this link is unclear. It has been suggested that the rate at which a muscle can turn on and off, as measured by the time of a single muscle twitch, may set a limit to top speed by setting a minimum duration of stance or swing phase in a stride cycle. In *Sceloporus* lizards, the duration of a twitch in isolated limb muscles is approximately equal to the duration of stance phase during running at low but not high body temperatures, suggesting that the rate the muscles can turn on and off may limit sprint performance at certain temperatures. We studied muscle properties and sprint kinematics in two species of *Anolis* lizards, *A. cristatellus* and *A. sagrei*, to determine if muscle twitch times were closely matched to stance and swing times during running. Both species were maintained at field body temperatures (29.1°C and 32.0°C) and run over a trackway at five different inclines. Twitches were elicited in isolated limb muscles, and twitch time was measured as the onset of force to the time of 50% relaxation. Stance and swing times were variable at all speeds, but consistently reached minimum values that corresponded to the twitch time measured in isolated muscles. Furthermore, differences in muscle twitch time between the two species correlated with differences in kinematics. The average muscle twitch time for *A.sagrei* was approximately 71% that of *A. cristatellus*, similar to the difference (78%) in minimum stance time. These data suggest that *A.sagrei* are able to cycle their limbs faster than *A. cristatellus* due to their lower muscle twitch time. It is well established that morphological variation correlates to variation in sprint speed among *Anolis* lizards. These results suggest that muscle properties are also important determinants of locomotor performance. This research was supported by NSF grant IOS 1354620.

P1.111 PARK, K.E.*; CAKMAK, I; HRANITZ, J; BARTHELL, J; GONZALEZ, V.H.; Pomona College, Uludağ University, Bloomsburg University, University of Central Oklahoma, University of Kansas; *kep02013@mymail.pomona.edu*

Avoidance by bees and flies to field-realistic concentrations of four types of pesticides

Pesticides are routinely employed in modern agriculture, harming beneficial pollinators in addition to their intended targets. Bees and flies are among the main pollinators of plants worldwide, and through their foraging activities, they are especially at risk to chronic pesticide exposure. Using color pan traps (blue, white, and yellow) we assessed whether bees and flies are attracted to or repelled by field-realistic concentrations of four commonly used pesticides (6ml/L of Thiacloprid; 0.4ml/L imidacloprid; 0.75ml/L deltamethrin; 0.3g/L acetamiprid). Studies were conducted during two consecutive summers (2014 and 2015) in 27 unmanaged urban habitats at Uludağ University (Bursa, Turkey). A total of 5,756 arthropods were collected in both years. Diptera and Hymenoptera were the most common insect orders. In both years, nearly 50 native bees were collected, which accounted for less than 30% of the captured specimens; flies accounted for 22 and 43% in 2014 and 2015. Preliminary analyses show no significant differences in the number of bees collected between the control and the treatment for each pesticide and no effect between the pesticide and color of pan-trap used. This is not the case for flies, a group which showed a variety of responses (avoidance or attraction) to each pesticide. Thus, bees at the community level might be more vulnerable to the effects of pesticide exposure than flies.

P1.154 PARTRIDGE, CG; MACMANES, MD; KNAPP, R*; NEFF, BD; Univ. Western Ontario, Univ. New Hampshire, Univ. Oklahoma; *rknapp@ou.edu*

Brain Transcriptional Profiles of Male Alternative Reproductive Tactics in Bluegill Sunfish

Understanding the genetic mechanisms influencing variation in behavior can provide insight into how different behavioral phenotypes within populations evolve and are maintained. A type of behavioral variation that has received much attention from a behavioral ecology perspective are the distinct phenotypes that comprise male alternative reproductive tactics (ARTs), which are found in a wide array of taxa. One of the classic systems for studying male ARTs are bluegill sunfish, *Lepomis macrochirus*. In this species, there are two distinct life histories: parental and cuckolder, encompassing three reproductive tactics, parental, satellite, and sneaker. The parental tactic is fixed, whereas individuals who enter the cuckolder life history transition from the sneaker to the satellite tactic as they grow. We used RNAseq to characterize the brain transcriptome of each male tactic during spawning to identify gene categories associated with each tactic and identify potential candidate genes influencing their different spawning behaviors. We found that sneakers had higher levels of gene differentiation compared to the other tactics, suggesting that life history is not the main factor driving differential gene expression. Sneakers had high expression in ionotropic glutamate receptor genes, specifically AMPA receptors, which may be important for increased working spatial memory while attempting to cuckold nests on bluegill colonies. We also found significant expression differences in several candidate genes involved in ARTs that were previously identified in other species and suggest a previously undescribed role for cytosolic 5'-nucleotidase II (nt5c2) in influencing parental male behavior during spawning.

P2.115 PATEL, S.*; ZACHRY, J.; KIMBALL, B.A.; PARKER, M.R.; Washington and Lee Univ., U.S. Dept. of Agriculture, Monell Chemical Senses Center, James Madison Univ.; *mrockwellparker@gmail.com*

Estrogen implantation alters putative pheromone composition in male brown tree snakes

Sex pheromones are potent signals mediating mate choice, and the manipulation of pheromone production in natural populations serves as a powerful management strategy for pest and invasive species. At least one invasive reptile species, the brown tree snake (*Boiga irregularis*), is known to use skin-based cues for locating and choosing between potential mates, especially in its invasive range on Guam. The components of brown tree snake skin lipids that have pheromonal properties have been described previously, but it is not known if the their lipid profiles are strongly sexually dimorphic or respond to steroidal manipulation. Previous work in another snake species demonstrated that both estrogen implantation and testosterone removal (castration) could induce female pheromone expression in male red-sided garter snakes. It was thus the goal of this study to use estrogen implantation to manipulate putative pheromone expression in male brown tree snakes and determine the effect of implantation on male attractiveness. We implanted male brown tree snakes (n=7) with silastic implants (1 cm) containing estradiol and found that implanted males had significantly altered expression of long-chain methyl ketones, specifically the longer, monunsaturated ketones. This was supported by both general abundance analyses of specific compounds and using MRPP and multidimensional scaling plots. Next, we plan to test the pheromone extracts in bioassays to assess attractiveness of the isolates. If male brown tree snakes can be induced to express female-typical skin lipids that are attractive to other males, it may be possible to generate an attractant that could be used in trapping efforts currently in place on Guam.

P3.36 PECHENIK, J*; PIRES, A; BURNS, R; BOGAN, S; MEI, M; Tufts University, Medford MA, Dickson College, Carlisle PA; *jan.pechenik@tufts.edu*

Influence of reduced pH on growth and development of the marine gastropod Crepidula fornicata

The world's oceans are becoming more acidic. The consequences are difficult to predict, as effects can be far more subtle than simply causing mortality. We examined the effects of pH (7.5, 7.7, and 8.0) on aspects of growth and development of the widely distributed marine gastropod *Crepidula fornicata*. Larval survival was above 95% at all tested pH's. However, larvae grew significantly faster and became competent to metamorphose significantly sooner when reared at pH 7.7. After metamorphosis, juveniles grew significantly faster at pH 8 than at 7.5, regardless of larval rearing pH. Juveniles also showed consequences of larval experience: among the juveniles maintained at pH 8.0, individuals that had been reared as larvae at pH 7.5 grew more slowly than individuals that had been reared as larvae at pH 8.0. Finally, although most larvae grew very slowly at pH 7.5, ~10% of the larvae grew at normal rates. We are currently investigating differences in gene expression that could account for this performance difference among individuals under acidified conditions.

P1.52 PENNING, D.A.; SAWVEL, B.; MOON, B.R.*; Univ. of Louisiana at Lafayette; *bradmoon@louisiana.edu*

The Scaling of Strike Performance in Texas Ratsnakes (Pantherophis obsoletus)

Body size is profoundly important to organisms. Smaller individuals typically face greater predation pressures than larger individuals because they are vulnerable to more predators. In many organisms, juveniles may have higher performance that partly offsets their size disadvantage. However, despite the availability of scaling theory that provides testable hypotheses, the ontogeny of performance is not yet very well studied. We used high-speed video recordings to study the scaling relationships among morphology, muscle cross-sectional area (CSA), and defensive strike performance in nine Texas ratsnakes (*Pantherophis obsoletus*). We tested the hypotheses that maximum strike velocity is independent of body mass and that strike acceleration decreases with increasing body mass. Larger snakes struck from greater distances (range for all snakes = 3.5-30.1 cm), but all snakes covered the strike distance in similar times (0.04-0.2 s). Hence, maximum strike velocity (1.3-3.4 ms-1) and acceleration (46.1-299.2 ms-2) were positively related to body mass, refuting both hypotheses. Relative head mass decreased in larger snakes whereas relative muscle CSA (at multiple positions along the body) scaled with positive allometry or isometry. The greater relative muscle CSA of larger ratsnakes allows them to produce relatively higher forces, and those forces act on a relatively smaller head mass when it is thrusted forward. This differential scaling of cranial and axial morphology allows larger snakes to strike with higher velocities and accelerations than smaller individuals.

P1.84 PELLETIER, G.*; FREDERICH, M.; Univ. of New England, Biddeford; *mfrederich@une.edu*

Molt Cycle-Dependent Stress Tolerance in the Juvenile Green Crab, Carcinus maenas

The European green crab, *Carcinus maenas*, is variable in ventral sternite coloration, green after molting and often dark red after prolonged intermolt. Previous studies reported that red morphs are less stress tolerant than green morphs. We tested this previously by exposing crabs of both colors to 2h anoxia and assessed their subsequent motor activity as righting time after flipping them on their back. Green morphs maintained constantly fast while red morphs slowed down from 1 to 6 sec with corresponding differences in lactate accumulation, AMPK activity and HSP70 protein expression. To test how this differential stress tolerance changes throughout the molt cycle from green to red, we used freshly molted juvenile green crabs and assessed weekly their coloration, and tolerance to severe hypoxia. For accelerating the molt cycle and the associated color change we performed eyestalk ablation (ESA) on half of the animals, as ESA has been shown to accelerate molting in crabs. Unexpectedly, the duration of the molt cycle in controls and the ESA group was equal (54-64 days). Additionally, animals did not progress through all of the colors before molting. ESA animals increased in red/green ratio 2 fold, while controls' color did not change. Despite the lack of color change, some of these animals molted. However, stress tolerance to hypoxia in the ESA animals decreased gradually from 2.1±2.3 to 6.2±3.1 sec, while remaining constant at 1.5±0.9 for controls. This change was only correlated to time in the molt cycle, but not to ventral sternite coloration. Our data show gradual change in stress tolerance through a full molt cycle and indicate that ventral sternite coloration is most likely not mechanistically linked to the respective stress tolerance. Funded by a Maine Space Grant Consortium award to G.P.

P3.123 PEREZ , CP*; CLARK , AJ; UYENO, TA; College of Charleston , Valdosta State University; *perezcp@g.cofc.edu*

The Comparative Biomechanics of the Slimy and Fatty Pacific Hagfish Skin Versus the Taut and Scaly Penpoint Gunnel Integument

Pacific hagfish *Epatatretus stoutii* are jawless invertebrate fishes known for employing spectacular whole body knotting movements for feeding and escape. This extreme body deformation depends on the flexibility that may be made possible by a relatively loose skin. This slack skin morphology results from the absence of myoseptal tendons that provides the tautness in other fish skins. The skin's looseness and slimy surface texture may also prevent the teeth of predators from directly applying force to the body core, thus making the hagfish skin a puncture resistant "soft armor" reminiscent of a matador's red cape. Skin samples oriented in longitudinal and circumferential axes were analyzed from *E. stoutii* and *Apodichthys flavidus* using quasi-static uniaxial tensile tests to failure, with additional samples collected for histological reconstructions. Our results show that hagfish skin is a relatively thick, anisotropic, multilayered composite material comprising a superficial thin and slimy epidermis, a middle dermis layer densely packed with fibrous tissues, and a deep hypodermis layer comprised of adipose tissue, which collectively is stiffer when pulled in the longitudinal than circumferential directions. The skins of both species studied are comparable in strength and stiffness, but gunnel skins are twice as resistant to circumferential strains than longitudinal strains. While these results show gunnel skin having characteristics of pressurized cylinder walls, many taut fish skins do not function this way, though their skins show greater resistance to circumferential strains than longitudinal strain. The anisotropy we observe in *E. stoutii* skin might be characteristic of loose fitting integument.

P2.194 PETERSON, A/N*; AKANYETI, O; LIAO, J/C; University of California, Irvine, University of Florida, Gainesville; *otar@whitney.ufl.edu*

Steady swimming kinematics of juvenile Florida pompano

How fishes move during locomotion determines their thrust production and overall swimming performance. Here we describe steady swimming kinematics in the Florida pompano (*Trachinotus carolinus*), a member of the Carangidae family, in order to better understand one of the four major modes of fish swimming, carangiform locomotion. Juveniles (total length, *L*, 4.9±0.9 cm; n=7) were collected from the beaches of St. Augustine, and swam in a flow tank. Using a high speed, high resolution camera we measured swimming kinematics at 5, 9, and 13.5 $L\ s^{-1}$. We divided the fish into four sections; head, anterior body, posterior body, and caudal fin. We found that head, anterior body, and caudal fin motions can each be accurately modeled as a rigid line (maximum mean absolute error 7.09±2.43 %, 5.1±1.6 % and 12.8±3.97 %, respectively). We also found that the traveling wave equation, which has been traditionally used to describe swimming kinematics of fish in uniform flows, can also describe the bending of the posterior body (maximum mean absolute error was less than 7.4±3.6%). The traveling wave was initiated near the center of mass, which was 0.45 L from the snout of the fish, and did not change with swimming speed. Tail beat frequency increased with swimming speed ($y=0.83x+3.63$, $R^2=0.83$, $p<0.01$), whereas tail beat amplitude slightly decreased with swimming speed ($y=-0.01x+0.89$, $R^2=0.21$, $p<0.01$). Body wavelength remained constant (1.06±0.01 *L*). Our results suggest that our kinematic model can accurately describe swimming kinematics of carangiform locomotion regardless of swimming speed and provides a quantitative metric for biomimetic and field applications.

P3.8 PETERSON, CR*; ECHTERNACHT, AC; FITZPATRICK, BJ; University of Tennessee, Knoxville; *Christopher.R.Peterson@utk.edu*

Intraspecific variation and divergence in Anolis conspersus

Intraspecific divergence spurred by differing ecological conditions can provide insights into early stages of speciation. Anoles are a model clade for studying habitat-based divergence and speciation. *Anolis conspersus* (the Grand Cayman blue-throated anole) is endemic to a Caribbean small island and has body coloration patterns that are spatially arranged despite a lack of wider environmental gradients. I examined ecological, morphological, and genetic variation among and within A. conspersus populations to evaluate potential divergence along a small scale. I evaluated morphological and habitat-use characteristics of anoles at 19 sites across the native range, recorded body coloration, took tissue samples for sequencing, and analyzed the data with multivariate hierarchical Bayesian modeling. Our findings have the potential to provide insight into early stages of speciation on small islands and inform conservation management of a poorly studied island endemic.

P3.22 PETERSON, K.L.*; PARENT, C.E.; University of Idaho; *pete2511@vandals.uidaho.edu*

Investigating Community Assembly in a Volcanic National Monument

In island biogeography, geographical attributes such as area, isolation, and age are known determinants of community diversity. Craters of the Moon National Monument and Preserve (CRMO) located in southern Idaho contains multiple replicates of "island" habitats; that is patches of habitat separated from each other by less-hospitable terrain. The insular habitats in CRMO vary in area, isolation, and age and thus, make CRMO an ideal location for investigating questions of island biogeography in a continental context. Areas of recent geologic activity, such as CRMO, are excellent locations to investigate community assembly because ages of lava flows are known and age is an imperative attribute when testing hypotheses of island biogeography. The aim of this study is to understand how natural communities assemble on novel habitats and disassemble through time depending on geographical attributes. Our study focuses on the collection of spiders (Salticidae and Thomisidae) and plants to better understand the communities currently present on lava flows at CRMO. We quantified target lineage diversity across 20 transects established on four lava flows ranging in age (2,400-12,000 years old). We use these data to test for the role of age on the observed diversity and abundance of the target lineages to inform the community assembly process at CRMO.

P3.60 PETSHOW, S J*; UHRIG, E J; MASON, R T; Oregon State University; *samuelpetshow@gmail.com*

Sickness behavior and thermoregulation in the red-sided garter snake, Thamnophis sirtalis parietalis

Immune system activation in animals is energetically costly and may reduce reproductive investment. In ectothermic vertebrates, immune activation presents an interesting trade-off in energy investment between thermoregulation and reproduction. During an infection, some ectotherms employ thermoregulatory behaviors which increase body temperature and aid the immune system. Other sickness behaviors include decreased activity levels and anorexia. While effective, these strategies may come at the expense of other behaviors (e.g., anti-predation behaviors and reproduction). Reproduction of the red-sided garter snake, *Thamnophis sirtalis parietalis*, has been particularly well-studied, and this species has been noted to prioritize reproductive behaviors over thermoregulation. However, few studies have investigated sickness behaviors and immune-mediated thermoregulation in red-sided garter snakes. In this study, we investigated thermoregulatory behaviors and activity levels of garter snakes in response to an immune challenge. Specifically, we injected male and female snakes with lipopolysaccharide (LPS) or saline. Snakes were placed into a thermal gradient and their thermal preference and activity levels were scored. Overall, LPS treatment resulted in a decrease in activity levels, but the effect was only significant for male snakes. Our results provide evidence of behavioral costs of immune activation in garter snakes, which may contribute to conflict between reproduction and the immune system.

P1.147 PICCIANI, N.*; KERLIN, J. R.; JINDRICH, K.; GOLD, D. A.; OAKLEY, T. H.; Univ. of California, Santa Barbara, Univ. of Queensland, Brisbane, Mass. Inst. of Technology, Cambridge; *n_picciani@hotmail.com*

Light modulated cnidocyte firing predates the evolution of eyes in Cnidaria (Metazoa)

Understanding the evolution of complex structures like eyes has long fascinated biologists. Although many assume that eyes derive from simpler precursors, this hypothesis has rarely been demonstrated with explicit phylogenetic methods. We examine the hypothesis that light sensing components of eyes in Cnidaria had an earlier history, and were used in simpler functions. Light sensing structures are common among medusozoans, in which they vary from pigment spots to pigment cup ocelli and complex eyes. Molecular, behavioral and pharmacological evidence indicate that light modulates cnidocyte discharge in the hydrozoan *Hydra vulgaris* Pallas, 1976. By surveying literature and incorporating new experimental data, we test two predictions of the hypothesis that light sensing functions of eyes had an earlier role in modulating cnidocytes. First, we predict that light modulated cnidocyte firing can be reconstructed as an ancestral state. Second, we predict that eyes assembled later in the history of Cnidaria. We show that three lineages of non-medusozoans (Actiniaria, Octocorallia, and Corallimorpharia) exhibit significant difference between the numbers of nematocysts discharged under two blue light (470 nm) intensities (dim, 0.1W/cm^2; bright, 2.8W/cm^2). Based on a working phylogenetic hypothesis, we also show that eyes and ocelli were absent from the cnidarian ancestor. Our results suggest that cnidocyte discharge regulation by light predates the emergence of light sensing organs, and both potentially use a homologous opsin-based phototransduction pathway. As such, this represents an empirical case in which an opsin-based behavior might have predated this pathway's function in light sensing organs as complex eyes.

P1.137 PLUIMER, B.R.*; MUSCEDERE, M.L.; Hendrix College; *brock.pluimer@gmail.com*

Behavioral resilience with a tiny brain: can workers of the ant Pheidole dentata compensate for reductions in sensory ability?

Ants live in a sensory world dominated by smell, which they experience via their antennae. Damage to the antennae would be expected to diminish a worker's ability to perform behaviors regulated via olfactory cues - including brood care, detecting pheromone trails, or nestmate recognition. However, *Pheidole dentata* workers appear largely resilient to unilateral antennal ablation, both behaviorally and neuroanatomically. Workers injured early in adult life have few deficits beyond a reduced ability to follow pheromone trails. This behavioral resilience is correlated with an increase in expression of the synaptic protein synapsin in the higher-order olfactory brain regions ipsilateral to ablation, which suggests there may be anatomical compensation within the brain olfactory pathways in the days following early-life injury that could underlie the behavioral resilience of injured workers. If this hypothesis is true, worker performance would be expected to improve over time after injury as compensatory physiological changes accrue. Using assays to quantify the pheromone trail-following ability of age-matched, 15-day-old ants, we assessed the behavioral consequences of unilateral antennal ablations that occurred either early (immediately after eclosion) or later in adult life (14 days after eclosion). Each individual's speed and accuracy during trail following was measured and compared to intact individuals of the same age. Injured workers remain capable of following pheromone trails, and our results suggest that workers injured early in adult life may do so with more accuracy than workers injured later in life. These results demonstrate that *P. dentata* workers are highly resilient to injuries that reduce sensory ability.

P3.89 PLAKKE, M.S.*; GOETZ, B.J.; MESLIN, C.; CLARK, N.L.; MOREHOUSE, N.I.; University of Pittsburgh; *mep115@pitt.edu*

Stomachs in your butterfly: Exploring the identity and specificity of proteases in the reproductive tract of female butterflies

Reproductive traits are some of the most rapidly evolving traits in the natural world. However, research to date has focused heavily on male reproductive traits such as male genitalia, leaving female reproductive traits understudied. As a result, we know little about female reproductive adaptations or how they may have co-evolved with male reproductive traits. Butterflies provide an excellent system to study reproductive interactions and physiology from the female perspective. Female butterflies have a specialized reproductive organ called the bursa copulatrix that appears to be co-evolving with specific male traits. The bursa accepts and actively digests the complex male ejaculate, called the spermatophore. Our research focused on the proteases present in the bursa of the Cabbage White butterfly, *Pieris rapae*. Using a general colorimetric assay, we discovered high levels of overall protein digestion within the bursa. Using transcriptomic and proteomic approaches, we identified nine putative proteases from two main functional classes that may play a role in bursal digestion of the spermatophore. Using a zymogram approach, we conducted an *in vitro* protein digestion assay to measure the activity of specific bursal proteases. Finally, we investigated functionality of each protease by disrupting specific modes of protease action using targeted protease inhibitors and quantifying subsequent loss of activity. Our findings offer new insights into female bursal adaptations, and provide groundwork for future studies of co-evolution between the bursa and spermatophore.

P3.43 PLUNKETT, RA*; POMPONI, SA; Florida Atlantic University, Harbor Branch Oceanographic Institute; *rplunkett2014@fau.edu*

Ultrastructure of Larval Trematodes (Digenea) Discovered in Marine Sponges (Spongia spp.)

Larvae (cercariae) of digenean trematodes were discovered in sponges of the genus *Spongia* from a nearshore habitat in the Florida Keys. Digenean trematodes (Phylum: Platyhelminthes; Class: Trematoda; Subclass: Digenea) are obligate endoparasitic flatworms with complex multi-host life cycles. The intermediate larval stages of digeneans are typically found in marine invertebrates, and the adult worms always parasitize a vertebrate definitive host. Typically, transmission to the definitive host involves a link in the food chain - i.e., the definitive host's diet regularly includes the second intermediate host organism. Trematodes have not yet been documented in association with sponges from previous literature. This is an exploratory study of the larval trematode stage present in the sponge microenvironment. The goals of this poster presentation are: (1) provide preliminary data on the phylogenetic classification of these trematodes, obtained through 28S rDNA sequencing (2) document morphological and ultrastructural characteristics of the cercarial stage, obtained through light and electron microscopy.

P3.97 POLET, D.T.*; HASANEINI, S.J.; BERTRAM, J.E.A.; University of Calgary; *dtpolet@ucalgary.ca*

Quadrupedal walking revisited: energy minimization strategy of walking dogs

Pendular energy exchange has been highlighted as a crucial feature of efficient quadrupedal walking, but this perspective does not help to identify mechanisms responsible for energetic loss. We use the empirical ground reaction forces presented by Griffin et al. (2004) for walking dogs (*Canis familiaris*) to find the combination of phase offset and fore- and hindlimb duty factors that minimizes collisional losses. We find that the dynamics-based optimal symmetrical walk is a walking-trot or walking-pace, a pattern not normally used by dogs. However, these gaits are likely unavailable due to anatomical limitations and stability issues. When the model is constrained to options that are anatomically reasonable, the optimum is determined to be very near the actual walking gait chosen by dogs. These results indicate that collisional dynamics are influential in determining the optimum movement strategy for walking dogs. Some pendulum-like oscillations can be detected, but are much more likely a consequence of dogs employing an efficient movement strategy based on other factors, than a determinant of the effective strategy itself.

P3.46 POOLE, AZ*; WEIS, VM; Western Oregon University, Oregon State University; *poolea@wou.edu*

The role of complement in challenge of the anemone Aiptasia with Serratia marcescens

The complement system is an innate immune pathway that in vertebrates, involves a series of proteolytic cleavage events that initiate phagocytosis and destruction of foreign cells. Recent studies demonstrate a conserved role for this pathway in invertebrate immunity, but little work has focused on the role of complement molecules in cnidarians. Complement proteins, including C3, Factor B, and MASP have recently been characterized in the anemone *Aiptasia* making it a good model to study the role of complement in immunity and to investigate the interactions between immunity and symbiosis. In this study, the expression of two Factor B (Bf) and one MASP gene in response to challenge with the coral pathogen *Serratia marcescens* was measured using quantitative PCR (qPCR). The data indicate challenge with *S. marcescens* resulted in changes in expression that are dependent on both density of bacteria and symbiotic state. Specifically, Ap_Bf-1 and Ap_MASP were most responsive in symbiotic animals to a low concentration of bacteria, but in contrast, Ap_Bf-2b expression shows a more complex response, and its role in the response against pathogens is unclear. Overall, this study provides information on the role of the complement system in the immune response of a basal metazoan.

P3.133 PORTER, ME; Florida Atlantic University; *me.porter@fau.edu*

Squalus acanthias vertebral columns act as a continuously variable transmission

In this study, we introduce a methodology, Large-Amplitude Oscillatory Bending (LAOB), which increases the accuracy of measuring mechanical properties taking into account non-linear viscoelasticity (NLV). The NLV approach extends linear viscoelasticity theory by allowing measurement of the changes in both viscosity and elasticity within a single loading cycle. Where linear measurements might provide information comparing different tail-beats during swimming, NLV output describes the properties during the tail-beat such as those found at minimum and maximum strains. We apply NLV to the characterization of the mechanical behavior of vertebral columns, the primary skeletal element of the vertebrate body axis. Here we characterize the NLV properties of *Squalus acanthias*, the spiny dogfish shark, vertebral columns using LAOB. Vertebral column segments consisted of ten centra and nine intervertebral joints were tested on a MTS Tytron 250 using bending frequencies and body curvatures seen during volitional swimming. The resulting moment and curvature data were analyzed using the MITlaos analytic tool, purpose-built for NLV studies. We found that as inputs increase in magnitude, so, too, does the level of non-linearity in both elastic and viscous moduli. In a swimming shark this means that during faster swimming the vertebral column will behave as a stiffer more elastic spring.

P3.150 PRESNELL, J.S.*; BUBEL, M.; PATRY, W.; BROWNE, W.E.; Univ. of Miami, FL, Monterey Bay Aquarium, CA; *j.presnell@umiami.edu*

Continuous culture, post hatch metamorphosis and staging of the lobate ctenophore, Mnemiopsis leidyi

Ctenophores have increasingly become a critical taxon for investigating the molecular underpinnings of metazoan evolution and development. Most ctenophore species are self-fertile hermaphrodites and possess transparent embryos with rapid embryogenesis making them an attractive model system for developmental biology. Ctenophores have also proved useful for exploring the early evolution of animal multicellularity. For example, it has been shown that ctenophores possess nerve cells, ectoderm and endodermal germ layers, and well defined muscle cells. Considering recent molecular evidence supporting ctenophores as one of the earliest branching extant metazoan lineages, the combination of these features are striking. Yet to be answered are questions regarding the evolution of this collection of traits typically associated with later diverging lineages composed of ‘complex' metazoans. Were these features independently acquired in the ctenophore lineage, or were they present very early in the metazoan stem lineage and subsequently lost in other basally branching metazoan lineages? Investigation of these questions demands a thorough understanding of the unique life-history and ecology of ctenophores. We have developed robust resources for maintaining *Mnemiopsis* in culture generation over generation for mechanistic, morphological and functional genetic studies. Here, we present a continuous culturing system for the lobate ctenophore *Mnemiopsis* and describe stages of post hatching metamorphosis. Continuous culture opens up significant opportunities for labs without direct access to wild populations to work on these animals year round and facilitates the creation of stable transgenic lines and design of genetic-based experiments that span multiple generations.

P1.162 PRICE, C.L.*; GUMM, J.M.; Stephen F. Austin State University; *pricecl1@jacks.sfasu.edu*

The genetics of the visual system of two species of pupfishes (genus Cyprinodon)

Color vision in freshwater fishes is important for individuals to efficiently detect information from the external environment. Adaptations of visual systems to different photic environments drive visually-mediated behaviors, which include foraging, predator avoidance, and mate choice. The spectral sensitivity of photoreceptor cells in the retina is determined by the visual pigment in the photoreceptor, which is made up of a chromophore and an opsin protein. In this ongoing study, standard molecular methods were used to evaluate genetic variation in opsin gene sequences and expression profiles for two species of pupfish, *Cyprinodon variegatus* and *Cyprinodon rubrofluviatilis*. Preliminary evidence from PCR and gene sequencing suggests that both species express RH1, SWS1, SWS2A, SWS2B, RH2, and LWS opsin genes. When sequences were compared to known tuning sites within the seven transmembrane regions of the opsin protein, there was no variation between the species of pupfishes in the amino acid sequences of the LWS, SWS2B, and RH1 opsin genes. Pupfish opsins did differ from closely related killifish at known tuning sites. This suggests that pupfish visual systems may be tuned to their environments. Understanding the genetics behind the visual system is important to evaluate visual communication within species of freshwater fish.

P1.72 PRUETT, J.E.*; MAYERL, C.J.; RIVERA, A.R.V; BLOB, R.W.; Clemson University, Creighton University; *jepruet@clemson.edu*

Motor patterns of the hind limb muscles of pleurodire turtles: correlations between changes in muscle attachments and activity

Among the two extant lineages of turtles, pleurodires show derived specializations of the pelvic skeleton that are correlated with novel originations of several hind limb muscles. Despite such novelties, pleurodires exhibit locomotor kinematics during both swimming and walking that are broadly similar to those of many generalized cryptodires. Because the function of individual muscles can depend strongly on their locations of origin, it is possible that the functional roles of some muscles may differ between pleurodires and cryptodires, even during the performance of the same behavior. To test this possibility, we measured hind limb muscle activity (EMGs) and kinematics of the aquatic generalist pleurodire *Emydura subglobosa* while walking and swimming, and compared these data with previous results from a generalized aquatic cryptodire, *Trachemys scripta*. We found that some hip muscles with differing attachments showed different activity patterns between taxa. For example, puboischiofemoralis internus (PIFI) protracts the hip during swing in walking cryptodires, but also shows a novel low-amplitude burst during stance in *E. subglobosa*. Because the origin of PIFI has shifted ventrally to the shell in pleurodires, this additional burst could aid limb adduction or stabilization. However, activity patterns also differ between the taxa for some muscles in which attachments are similar: for example, the knee extensor femorotibialis shows a later burst in *E. subglobosa* than in *T. scripta*, corresponding with delayed knee extension. Our results suggest that, in turtles, novel neuromotor patterns can be correlated with differences in muscular arrangement, but also between muscles that retain similar attachments.

P2.195 PUTNEY, J*; AKANYETI, O; LIAO, J/C; Washington and Lee University, Lexington, University of Florida, Gainesville; *otar@whitney.ufl.edu*

Kinematic analysis of burst and coast swimming in rainbow trout

Most fishes adopt different styles of locomotion depending on their swimming speed. To achieve their highest speeds they must transition from steady swimming to burst-and-coast swimming, where the body alternately accelerates and passively coasts. Despite the fact that burst-and-coast swimming is crucial for behaviors such as prey capture and predator evasion, the lack of a detailed kinematic characterization prevents a deeper understanding of the underlying mechanisms involved. We used high speed, high resolution video to record burst-and-coast kinematics of rainbow trout (*Oncorhynchus mykiss*, n=7 fish, body length L = 22.4±2.0 cm) swimming at different flow speeds. More than 100 burst and coast events were analyzed to calculate tail beat frequency, tail beat amplitude, duration of burst and coast phases as well as the initial and final velocities during burst phase. Remarkably, we found that bursting and coasting trout could reach swimming speeds up to 10 L s^{-1}, which is twice their maximum speed during steady swimming. During bursting, tail beat frequency increased linearly with the average swimming speed ($y=1.84x+1.81$, $R^2=0.84$, $p<0.01$), while tail beat amplitude remained constant (0.17±0.1 L). In addition, we found that the duration of burst-and-coast events shortened as average swimming speed increased, and the range of initial and final velocities of the burst phase was highly constrained (10% below and above the average swimming speed, respectively). Our results suggest that during burst and coast swimming frequency modulation is the primary mechanism to increase swimming speed.

P2.202 QUINN, D.B.*; LENTINK, D.; Stanford University; *dbq@stanford.edu*

Inferring forces from kinematics in animal locomotion

The aerodynamic forces and torques that birds create to fly can be inferred from body kinematics if the mass distribution of the bird is known. This method of "inverse dynamics" has been used in several *in vivo* studies to estimate the aerodynamic loading from the tracked positions of body, wing, and head elements. Without a way to cross-reference forces, however, it has been difficult to estimate the accuracy and precision of these force/torque results. We present the first rigorous analysis of uncertainty in inverse dynamical models of flying birds by comparing estimated forces/torques on a pacific parrotlet, *Forpus coelestis*, with forces calculated via alternate methods. In addition, we examine the precision of the technique via a comprehensive study of error propagation. Scaling the methods with wingspan gives constraints on the spatial and temporal resolutions required for studying the dynamics of other birds such as lovebirds, pigeons, and hummingbirds.

P1.134 QUITTER, E*; WECHSLER, S; SPRAYBERRY, JDH; Muhlenberg College; *jsprayberry@muhlenberg.edu*

What smells funny: exploring the fidelity of olfactory associations in foraging bumblebees

Like honeybees, bumblebees use resource quality information from previous floral encounters to help inform future foraging decisions - with a demonstrated ability to select for resources whose sensory characteristics are associated with a food reward. While bumblebees learn and select for flower color, floral odors also appear to play a meaningful role in foraging behavior. Our prior work showed that olfactory pollution has a negative effect on bumblebee foraging behavior in a laboratory study that utilized two representative agrochemical odors. This small stimulus set indicated that olfactory pollution can impact behavior, but did not allow us to determine if the structural relationship of the contaminating odor signal relative to the original associative scent drove the observed behavioral changes. This begets the question, does the level of structural similarity between the associative (A) and contaminating (B) odors impact the likelihood of disrupting olfactory association? While there is minimal data on this topic in restrained bees, it remains largely unexplored in freely foraging bumblebees. Our current work trains bumblebees to associate a natural floral odor blend with a nectar reward in a single foraging chamber. After the association period, that chamber is then periodically replaced with two chambers, allowing bees to choose between one scented with A, the other scented with A+B. We use a range of polluting odors across trials to provide a varying degree of chemical structural similarity to odor-blend A. Automated tracking of foragers allows us to analyze preferences of individuals. Preliminary data indicate that individual bumblebees can preferentially forage. Interestingly, early analysis suggests that spatial memory may override olfactory association in some bees.

P3.9 RADOMSKI, T.P.*; KUCHTA, S.R.; BROWN, A.; HANTAK, M.; HIGHTON, R.; Ohio University, University of Maryland; *tr735813@ohio.edu*

Phylogeographic differentiation in the Eastern Red-backed Salamander, Plethodon cinereus

The Eastern Red-backed Salamander (Plethodon cinereus) has the largest geographic distribution of any woodland salamander, extending from the Great Lakes region through the Appalachian Mountains and onto the eastern coastal plain. Due to its large geographic range and high abundance, it is a model taxon for studies of ecology, evolution, and behavior. However, the phylogeographic history of this species remains unresolved. Here we report on a phylogeographic analysis of P. cinereus using two mitochondrial genes (Cyt-b and ND2) and three nuclear genes (RAG-1, GAPD, and MLC2A). Our sampling includes 290 individuals from 146 populations throughout the range of this species. We inferred a time-calibrated phylogeny using Bayesian methods, and we recovered multiple clades. The southern half of the range harbors deep phylogenetic diversity. However, clades in the north have larger geographic ranges. Both of these results are consistent with previous work hypothesizing rapid, post-Pleistocene range expansion. The implications of these results for climatic niche evolution will be discussed.

P3.191 RABOIN, M.J.*; ELIAS, D.O.; Univ. of California, Berkeley; *maggie.raboin@berkeley.edu*

The natural history and behavior of the mound-building mason spider Castianeira teewinot (Corinnidae)

Mason spiders are a member of the sac spider family, Corinnidae. Unlike other Corinnids, mason spiders cover their egg sacs with pebble mounds. I discovered mason spiders in the Snake River Canyon of Wyoming where in July and August, female mason spiders lay eggs on the exposed surfaces of rocks. They then cover each egg sac with mounds of pebbles, sealing each pebble in place with silk. Using observational and experimental field data from the summers of 2014 and 2015, I have described the natural history and behavior of this newly discovered species and its unusual behavior. I have determined that while some female mason spiders build mounds of varying sizes, other females do not. My findings also suggest that mason spider mounds protect egg sacs from predation by a parasitoid wasp (*Gelis*).

P3.82 RAHE, CE*; NEPTUNE, TC; BOUCHARD, SS; Otterbein University; *caitlyn.rahe@otterbein.edu*

Metabolic plasticity in red-eyed treefrog larvae

A variety of organisms exhibit metabolic plasticity in response to environmental conditions during development, but few studies have considered its importance in amphibians. In the red-eyed treefrog, *Agalychnis callidryas*, larvae reared in competitive environments with low food resources have smaller livers and longer guts than those reared in resource-rich environments. Although these larvae have large gut capacities, they continue to feed at low levels even when ad libitum food becomes available. The purpose of this study was to determine if differences in organ size and intake patterns are associated with differences in metabolism induced by the larval environment. We also examined the effect of larval predation risk on metabolism because other studies indicate this could be an important determinant of larval metabolism. We reared larvae in two sets of outdoor mesocosms at the Smithsonian Tropical Research Institute in Gamboa, Panama. In the first set of mesocosms, larvae were maintained at low and high densities (5 or 45 larvae per mesocosm, respectively) with a standard amount of food and different per capita resources. In the second set of mesocosms, larvae were reared at an intermediate density (25 larvae per mesocosm) with and without a caged Belostomatid predator. Predators were fed two *A. callidryas* hatchlings every other day for kairomone production in the mesocosm. Once larvae reached a standard size of aprox 3cm in length, we measured standard metabolic rate (SMR) with closed-system respirometry. As predicted, larvae raised in low resource environments had lower metabolic rates than those reared with high resources, explaining previously reported intake patterns. Metabolic rate did not vary with predation, but additional studies in which more kairomones are generated may be warranted.

P3.106 RANKIN, JW*; PAXTON, HP; HUTCHINSON, JR; DALEY, M; The Royal Veterinary College, UK; *jrankin@rvc.ac.uk*
Ontogenetic changes in broiler chicken walking capability
Broiler chicken production continues to increase rapidly worldwide. However, genetic success for desired production traits has come at a trade-off with increased concerns over musculoskeletal health. One perceived concern is that the chickens' walking capacity decreases as they age - likely caused by a rapid growth rate and large increase in breast muscle mass. However, quantitative methods for assessing chicken walking capability remain limited. Recent experimental and theoretical studies of similar sized birds (e.g., pheasants, guinea fowl) have found "leg loading angle ( )" to be a critical locomotor parameter. This angle, defined as the difference between the leg angle and the body velocity vector at footstrike, has a strong correlation with leg loading and leg work, factors relevant to both economy and leg injury risk. The aim of this study was to quantify broiler chicken walking ability by investigating changes in over ontogeny. We hypothesized that, consistent with a perceived reduction in broiler walking ability, the mean and standard deviation of would increase as chickens age. Ten (10) birds from three age groups (2, 4 and 6 weeks) were encouraged to walk across a platform while collecting marker data using 8 Qualisys cameras. At least 10 trials were collected per bird, generating a dataset with ~1,000 steps per group. Step data were binned by walking speed and mean and standard deviations (SD) calculated for at each speed and age group. In all age groups average values were similar to those previously found for pheasants (45-55 degrees versus 50 degrees, respectively). However, SD of for level running was consistently higher for 4 and 6 week old chickens compared to pheasants (5 versus ~10 degrees, respectively). The inability of broiler chickens to tightly regulate leg loading angle may indicate reduced walking stability and economy.

P1.104 REAUME, A.M*; KALTENBERG, A.; RANDALL, R.; Central Michigan University, Savannah State University; *amreaume@gmail.com*
Tidal Influences on Estuarine Prey Communities
Estuarine habitats are dynamic environments in which the rapidly changing fresh and saltwater compositions lead to changes in faunal composition. This study investigates the changes in plankton and fish abundance at the confluence of the Skidaway and Wilmington rivers in Savannah, Georgia over the tidal cycle. Fish trawls and plankton tows were conducted at three stations during both flood and ebb tide on three different days in June and July 2015. The hypothesis that plankton would respond to tidal changes differently than fish was supported by the data collected. Plankton abundance differed between flood and ebb tides, while fish abundance did not. This study supports the idea that plankton behave similarly to passive particles moving with the tides, while fish, who are stronger swimmers, can remain in the area despite the tidal velocities. These data will be useful for future studies aimed at predicting predator behavior.

P2.62 REEDER, SM*; FIELD , KA; Bucknell University; *smr020@bucknell.edu*
The White-Nose Syndrome Transcriptome: Exploring the Fungal Virulence Genes of Pseudogymnoascus destructans
White-nose syndrome (WNS) in North American bats is caused by an invasive cutaneous infection by the psychrophilic fungus *Pseudogymnoascus destructans* (Pd). We compared transcriptome-wide changes in gene expression using RNA-Seq on wing skin tissue from hibernating little brown myotis (Myotis lucifugus) with WNS to bats without Pd exposure. The pattern of gene expression changes observed demonstrates that WNS is accompanied by an innate anti-fungal host response similar to that caused by cutaneous *Candida albicans* infections. Using a dual RNA-Seq approach, which allowed us to gain insight into the gene expression of both the host and the pathogen simultaneously, we observed differences in Pd gene expression that suggest host-pathogen interactions that might determine WNS progression. We identified several classes of potential virulence factors that are expressed in Pd during WNS, including secreted proteases that may mediate tissue invasion, as well as zinc transporters, nitrogen metabolizers, fungal allergens, and factors involved in the oxidative stress response. We will be comparing expression levels in Pd grown on and actively infecting the wing of a bat with Pd grown in culture. We expect that some of the putative virulence factors seen in the dual RNA-Seq approach will be more highly expressed in Pd grown on bat wings. These putative virulence factors may provide novel targets for treatment or prevention of WNS.

P3.92 REEVE, C.M.*; ONTHANK, K.L.; Walla Walla University; *christopher.reeve@wallawalla.edu*
Can Octopuses Breathe Air?
Several species of octopus have been known to spend extended periods of time outside of water, often quite actively. Virtually no investigation has been made, however, in what sort of physiological processes allow octopus to maintain these excursions. I examined the ability of the ruby octopus (*Octopus rubescens*) to consume oxygen while out of water. To test this, I enclosed octopus in a respirometer in air for fifteen minutes and measured their oxygen consumption. Additionally I hypothesize that the ability to consume oxygen outside of water would allow the octopus to rely less on anaerobic metabolism when in air than when in a completely anoxic environment. To test this I compared oxygen debt and accumulation of anaerobic metabolites in arm muscle after a period of fifteen minutes in air or anoxic water. I will be presenting evidence for the possibility of in-air oxygen consumption by octopus.

P2.111 REILLY, C; DEPOY, E*; MORRA, A; CAPRIOTTI, D; MONHART, M; MORANTE, K; FATEYE, B/A; SCHREIBER, A/M; Biology Department, St Lawrence University; *bfateye@stlawu.edu*

Effects of estrogen and atrazine on the histology and function of the thymus gland of Xenopus laevis

Introduction of estrogens and estrogen-like pollutants into the natural habitats of aquatic species has been shown to adversely influence the physiology and ecology of these species. For example, we have shown that exposure of tadpoles to estradiol (10uM) induces apoptosis and involution of the thymus gland of Xenopus laevis. Since the thymus plays an important in the development of larval and adult immune cells in vertebrates, we compared the susceptibility to injections of live yeast (Saccharomyces cerevisiae) among X. laevis at different stages of natural metamorphosis or in tadpoles exposed for 1-5 weeks to estradiol, atrazine or dexamethasone. Premetamorphic tadpoles [Nieuwkoop-Faber (NF) stage 50] and post climax froglets were more susceptible to yeast injections compared with other stages of metamorphosis. Using immunohistochemistry, we detail the spatiotemporal changes in thymus structure and composition after exposure to the chemicals.

P3.69 RENDLEMAN, AJ*; DELEON, AE; RODRIGUEZ, JA; CHANG, ES; OHANIAN, A; FIGUEROA, P; PACE, DA; California State University, Long Beach; *anniejeanrendleman@gmail.com*

Energetic Efficiency of Growth in a Derived Echinopluteus Form: Centrostephanus coronatus

Planktotrophic marine larvae require exogenous nutrients in order to grow and develop. Typical sea urchin larval forms, or echinoplutei, exhibit eight arms. These ciliated arms allow for both feeding and swimming. The derived form of *Centrostephanus coronatus* (crowned urchin) larvae, however, only possess two long arms. This research seeks to understand the physiological consequences of such anatomical differences in larval forms through a detailed analysis of metabolic growth efficiency. We hypothesized that the dramatic difference in morphology of *C. coronatus* would result in significantly different growth efficiency relative to typical echinoplutei forms. Larvae were cultured under relatively high food concentrations (20,000 *Rhodomonas* sp. cells mL^{-1}). Rates of larval feeding, growth, and metabolism were measured throughout development. Larvae ingested 81,263 algal cells ind^{-1} by day 37, resulting in the acquisition of 186 mJ of energy. Analysis of metabolism determined that larvae used a total of 34 mJ by day 37. Protein growth resulted in the deposition of 1,458 ng protein. This resulted in a gross energetic efficiency of 68%. Protein growth efficiency was determined to be 37% (protein ingested standardized to protein grown). These values will now be compared against the growth efficiency of more typical echinoplutei forms. This research will be important for addressing the role of morphological variation in determining the physiological and biochemical efficiency of larval growth and development and its role in larval dispersal.

P1.153 RENN, S.C.P.; SCHMIDT, C.*; YOHANNES, M.; Reed College; *chrissyschmidt3@gmail.com*

Neuropeptide Activity in Sex Role Conventional and Sex Role Reversed Julidochromis

Julidochromis transcriptus, demonstrates conventional sex-biased parental and aggressive behaviors (i.e. males are more aggressive than females), whereas their close relative, *Julidochromis marlieri*, exhibits reversed sex-biased behaviors (i.e. females are more aggressive than males). Arginine vasotocin (AVT; the non-mammalian homolog to arginine vasopressin) and isotocin (IT; the non-mammalian homolog to oxytocin), are associated with reproductive plasticity, aggression, and other social behaviors. It is unknown whether the proportion of active AVT and IT cells is associated with aggression or dominance within sex-biased mating pairs in these species. I hypothesized that there would be more active AVT expressing cells in aggressive relative to non-aggressive individual's brains because AVT is associated with aggressive behaviors in some teleost species. To test this hypothesis, I recorded behavioral observations of mated pairs for both cichlid species, sectioned their brains, and performed immunohistochemistry (by triple labeling with AVT, IT, and Phosphorylated Serine 6 (PS6) antibodies) to quantify the number of active and non-active AVT and IT expressing cells. PS6 was used to indicate translational activity and was found to be more effective at measuring current cell activity than an immediate early gene. There were significantly more PS6 positive (+) IT neurons in the aggressive individuals (i.e.*J. transcriptus* males and *J. marlieri* females) relative to non-aggressive individuals (i.e. *J. transcriptus* females and *J. marlieri* males) ($p=0.0211$). The same pattern is true for both PS6 negative IT neurons ($p=0.00946$) and AVT neurons ($p=0.0133$), but no significant difference was found for the number of PS6+ AVT neurons. These results suggest that IT neuron activity may influence aggressive behaviors in *J. transcriptus* and *J. marlieri.*

P2.124 RENNOLDS, C.W.*; BELY, A.E.; Univ. of Maryland, College Park; *rennolds@umd.edu*

Anterior and posterior injury during thermal stress alter physiological performance in the regenerating annelid Pristina leidyi

Many animals possess the remarkable ability to regenerate body parts lost to injury. In the Naididae, a family of aquatic annelids, some species can regenerate lost anterior and posterior ends, while others can only effectively regenerate posteriorly. Little is known in this group about the physiological responses to injury, how these differ following anterior and posterior injury, and how the beginning stages of anterior or posterior regeneration alter organismal physiology in stressful environmental conditions, such as extreme temperature. In this study, we subjected individuals of the naidid *Pristina leidyi* to posterior- or anterior-end amputation and placed them within a range of environmentally-relevant ambient temperatures. We determined acute thermal tolerance ranges and LT50s for each injury state by assessing short-term survival. We then measured O_2 consumption of surviving individuals via membrane inlet mass spectrometry (MIMS); experiments assaying lipid content and heat shock protein expression are ongoing. Current data indicate that the ability to tolerate low temperature, but not high temperature, differs between injury states. Rate of O_2 consumption per unit mass appears reduced following injury across the range of temperatures and is lower overall following anterior amputation versus posterior. The temperature at which O_2 consumption is maximal also differs between injury states. Our results provide insight into how injury and regeneration alter physiological state, including while coping with additional physiologically-demanding stressors. Furthermore, they suggest that injury and early regeneration at the anterior end have a more substantial impact than at the posterior end.

P2.42 RESNER, EJ*; WESTMAN, AA; LEMA, SC; HARDY, KM; Cal Poly, San Luis Obispo; *eresner@calpoly.edu*

Effects of temperature and thyroid hormone on metabolism in two populations of a desert pupfish

Extreme environmental temperatures pose significant metabolic challenges for ectothermic organisms such as teleost fishes. Recently, we documented that a population of *Cyprinodon nevadensis amargosae* pupfish inhabiting a thermal spring referred to as Tecopa Bore in the Death Valley region of California experienced an approximately 15°C increase in mean temperature between 2008 and 2013. Here, we evaluated the aerobic and anaerobic metabolic capacity of *C. n. amargosae* from Tecopa Bore (TB) and the neighboring Amargosa River (AR), a variable temperature desert stream, when acclimated to high (34°C) and low (24°C) temperatures. In light of evidence that fish from these differing temperature habitats vary in thyroid hormone physiology in the wild, we also examined how temperature influences the potential regulation of metabolism by thyroid hormones. We hypothesized that the effects of exogenous triiodothyronine (T3) on metabolism would vary with thermal experience. To this end, we measured citrate synthase (CS) and lactate dehydrogenase (LDH) activity as indicators of aerobic and anaerobic metabolic capacity, respectively, in skeletal muscle and liver tissues of adult *C. n. amargosae* from both the TB and AR populations. In muscle, there was a strong temperature effect on CS activity whereby fish from both populations held in the higher temperature exhibited lower CS activity. In the liver, CS activity was not altered by temperature or T3 treatment, but LDH was elevated in the AR population compared to TB fish and increased in both populations in response to T3. Detailed analyses are ongoing, but our early results point to population-level variation and T3 regulation of glycolytic enzyme activity, and temperature sensitivity in oxidative enzyme activity.

P3.140 REYNOLDS, JA*; DENLINGER , DL; Ohio State University; *reynolds.473@osu.edu*

MicroRNA regulation of an insect diapause

Diapause is an alternative developmental pathway that provides insects, and other animals, a means to "escape" seasons of harsh environmental conditions. Diapause is characterized by altered gene expression profiles which mediate developmental arrest, metabolic depression, increased stress-resistance, and other physiological and biochemical changes associated with this dormant state. MicroRNAs are a class of small (18-23 nucleotide), non-coding RNAs that are predicted to post-transcriptionally regulate diapause-relevant changes in gene expression during pupal diapause in the flesh fly, *Sarcophaga bullata*. We identified 38 differentially expressed mature miRNAs and miRNA precursors in diapausing pupae compared to their non-diapause counterparts using Illumina sequencing and qRT-PCR. The abundance of several evolutionarily conserved miRNAs, including miR-305-3p, miR-125-5p, bantam-5p, and miR-13b-3p was reduced by at least 2-fold in diapause pupae compared to non-diapause pupae. Sixteen miRNAs were up to 5-fold more abundant in diapause pupae than in non-diapause pupae, including 12 evolutionarily conserved miRNAs (e.g., miR-289-5p, miR-307-3p, miR-190, miR-306-5p, miR-1-3p, and others) and 4 miRNAs that have not previously been identified and may be unique to this species. Together these data provide the first known miRNA sequences for a non-Drosophila fly and provide information about a previously unexplored mechanism for the regulation of diapause.

P2.151 REUTER, DM*; SULSER, RB; TOMIYA, S; Univ. of Oregon, Univ. of Chicago, Field Museum of Natural History, Chicago; *dreuter@uoregon.edu*

Morphological evolution of carnivoran milk teeth

Deciduous tooth morphology in mammals has received little attention despite the potential for insight into the ecology and phylogeny of these animals. We investigated the evolution of milk-tooth morphology in carnivorans with two goals: (1) document and quantify ecomorphological variation in deciduous dentition; and (2) assess the morphological integration of deciduous and permanent teeth at macroevolutionary scales. We collected ecomorphological data on milk and adult teeth of 44 extant species from eight families and conducted principal component analysis to identify major variations in the shapes and relative sizes of lower carnassial teeth (dp4/m1) and pre-carnassial premolars (dp3/p4), which are tied to dietary differences in adults. We then conducted phylogenetic regression analyses and fit models of trait evolution to the parallel data sets. Results show complex patterns of morphological variation and integration that depend on the phylogenetic scale. Across the families examined, the basic functional attributes of milk teeth and their adult counterparts are significantly correlated. For example, in canids both milk and adult teeth are conservative compared to other families. Mismatches are observed in some dentally specialized groups: felids and hyaenids have proportionally larger grinding areas in their milk teeth, and ursids have greatly reduced milk teeth. At finer phylogenetic scales (e.g., within families), the correlation between milk- and adult-tooth shapes is generally poor. The limited morphological integration of deciduous and permanent teeth is largely attributed to faster rates of evolution in adult teeth. The limited variation in the shapes of deciduous carnassial teeth may reflect developmental constraint or a homogeneous process of selection in juvenile ecology.

P2.88 RICHARDS, MH*; VICKRUCK, JL; BOTEZATU, A; PICKERING, G; Brock University; *richardsmiriam1@gmail.com*

Do bees smell? Hydrocarbon profiles and microsatellites reveal social recognition in carpenter bees

The Eastern Carpenter Bee, *Xylocopa virginica*, usually lives in small colonies of 2-6 females. Nestmates form reproductive queues in which the dominant female monopolizes both foraging and reproduction. A few females postpone reproduction, remaining in the natal nest as subordinate guards, thus assisting the dominant bee. In return, subordinate females are fed by dominants. Reproductive queues change over time, as females die, their positions are usurped, or when they move to new nests. Experimental evidence indicates that female carpenter bees are good at discriminating nestmates from non-nestmates, being more aggressive to non-nestmates and more peaceful with nestmates. Since social recognition in insects is thought to be based on the cuticular hydrocarbon profiles of individuals and colonies, we used GC-MS to assay the hydrocarbon profiles of 68 females that were also genotyped at 9 microsatellite loci. Analyses based on principal components and discriminant functions indicated that individual odours provide sufficient information to discriminate nestmates from non-nestmates, and that nestmates tended to have similar profiles. Microsatellite analyses indicated that most nestmates were unrelated. Taken together, these results imply that chemical profiles reflect residence, not kinship. This in turn means that nestmate recognition and discrimination against non-nestmates must be based on familiarity, rather than on kin relationships. Since nestmates cooperate as well as compete with each other, this is evidence that nestmate recognition based on individual odours facilitates cooperation among non-kin that breed cooperatively. Eastern Carpenter Bees may be the first example of a social bee society based on reciprocity.

P2.67 RIEGER, N.S.; STANTON, E.H.*; MARLER, C.A.; University of Wisconsin-Madison; *nrieger@wisc.edu*

Division of labor in territorial defense by the monogamous California mouse

In monogamous species territorial cooperation is hypothesized to play a major role in the success of pair-bonded animals in maintaining and defending a single territory. The sexually monogamous California mouse (*Peromyscus californicus*) is an ideal species for studying territorial cooperation as they form lifelong pair-bonds and both exhibit high levels of territorial behavior. While territorial behavior has been studied in the laboratory and field, division of labor within mated pairs has not. We used a territorial intrusion paradigm where either a male or female intruder in a cage box was placed into a chamber housing pair-bonded residents that were in one of three conditions; non-parental, with pups of a young age (<1 week), or older pups (>2 weeks). Pups of different ages were used due to differences in pup locomotery abilities. Division of labor was measured by noting whether one or both resident animals approached the cage box or stayed at the nest, whether one of the pair enforced retreat of the other to the nest, the total duration of time spent at the cage box or next to the nest, and ultrasonic vocalizations produced in response to the intruder. Preliminary data reveal that in 85% of trials only one mate approached the cage box while the other remained in the nest. In 25% division of labor was enforced by one mate pushing the other back to the nest before approaching the cage box. Across pairs, males and females were equally likely to approach the cage box, however within pairs the same individual approached the cage box regardless of intruder sex. This research shows that there is a defined division of labor within bonded California mice; however this division may be pair specific, not sex specific, suggesting that individual differences drive division of labor and not broader sexual differences.

P3.28 RILEY, J A*; PARKINS, K; MCCANN, C; CLARK, J A; Winston Salem State Univ., Fordham Univ., Wildlife Conservation Society of Bronx Zoo; *jriley111@rams.wssu.edu*

Can You Hear Me Now? Using Ultrasonic Vocalizations to Explore the Natural History of New York City Bats

Populations of U.S. bats are declining because of an increased number of threats, including white nose syndrome and collisions with wind turbines. As urban sprawl and wildlife habitats meet the occurrence of bats within urban areas is growing. These bats use urban environments to roost, forage, and breed. However, little is known about the natural history of bats in urban landscapes, particularly New York City (NYC), one of the largest metropolitan areas in North America. A previous acoustic survey of bats in the Bronx borough of NYC identified five species of bats. My study expands on this survey and examines the activity level and species composition of bats inhabiting four of the five NYC boroughs. Wild bats were surveyed at the Bronx Zoo, Central Park Zoo, Prospect Park Zoo, and Queens Zoo. Active and passive recorders were used to collect ultrasonic acoustic bat vocalizations. Passive recordings were collected year round from civil twilight to civil twilight using stationary recorders located on rooftops at each study site. Active surveys were conducted along walking transects twice at each zoo for one hour starting at sunset between June and July 2015. We identified six species of bats during the summer season. Bat activity was higher at the Queens Zoo site, likely because of the marsh lands near the zoo grounds. At two of the four sites, bat activity was correlated with temperature. In this study the big brown bat was the most active bat at all four sites vs. the red haired bat in previous records. Further research and a strong understanding of NYC bat populations will aid in a more complete understanding of urbanization and its effect on wildlife. This information will ultimately help protect bats, their urban habitats and their important ecosystem role.

P1.176 RITTSCHOF, D.*; HENCH, J.; DARNELL, M.Z.; CHEN, J.; Duke University Marine Laboratory, Nicholas School, Biology Department Nicholls State University; *ritt@duke.edu*

Blue Crab Movements in a Wind Driven System: Summer and Fall Movements of Adults

We studied movements of Blue crabs (*Callinectes sapidus*) in a wind driven system during Summer (August) 2012 and Fall (October) 2014. Free ranging crabs were tracked using radio frequency identification tags and antenna arrays deployed along a Canal connecting Lake Mattamuskeet to Pamlico Sound. Co-located and simultaneous meteorological and physical oceanographic instruments provided environmental data as context for crab movements. The environment in the summer was dominated by atmospheric pressures changing gradually between 1010 and 1024 hPa, south/south westerly winds generally < 4 m/s, air temperatures that fluctuated diurnally between 21 and 31 C and water temperatures changing gradually between 26 and 30 C. Crabs showed foraging movements up and down the canal. The fall was dramatically different. Atmospheric pressures ranged between 1002 and 1024 hPa with relatively rapid pressure changes in 2 to 3 days with passing fronts. North winds often greater than 5 m/s alternated with periods of winds similar to the summer pattern. Air temperatures fluctuated diurnally about 10 C and between 25 C and 6 C. Water temperatures lagged behind air temperatures and ranged from 26 C to 9 C. Water temperatures gradually decreased until they responded to a cold front that dropped the air temperature 19 C and the water temperature dropped briefly below 13.3 C, the lower activity limit of blue crabs. When the water warmed back up crabs initiated unidirectional migration toward the sound. Temperature shock appears to be the proximate cue that initiates the fall migration down estuary.

P3.32 RITZENTHALER, C. A.*; LITTON, C. M.; GIARDINA, C. P.; PELINI, S. L.; Bowling Green State University, University of Hawaii, Manoa, Institute of Pacific Islands Forestry, USDA Forest Service; *carir@bgsu.edu*

Soil moisture and millipede abundance are more important drivers of macroinvertebrate diversity than temperature in Hawaiian forest

Tropical forests undergo more carbon (C) cycling than other terrestrial systems; therefore, there is a critical need to understand how these forests respond to and drive changes in climate. In Hawaii, forest floor macroinvertebrates (isopods, millipedes, etc.) have a disproportionately large (30%) impact on decomposition, or mineralization of C. Although we know these impacts are climate dependent in other systems, the relationships between temperature, macroinvertebrate abundance and community composition, and above- and belowground C cycling in Hawaiian and other tropical forests have not been examined. In this study, we compared macroinvertebrate abundance and community composition across an elevational gradient where vegetation is similar but mean annual temperature and soil moisture varies. We found that variation in soil moisture, but not temperature, drives differences in forest floor macroinvertebrate community composition. Interestingly, millipede abundance, which was two orders of magnitude greater in the driest sites, was inversely related to macroinvertebrate diversity. If precipitation, and subsequently soil moisture, is further reduced under climate change, increases in millipede abundance may become widespread, thereby reducing macroinvertebrate species diversity across large areas. These changes in forest floor communities likely will yield alterations to C cycling in these tropical forests.

P3.13 RIVERA, L.*; SCHIZAS, N.V.; Univ. of Puerto Rico, Mayagüez; *liajayrivera1@gmail.com*

Comparative transciptome of Caribbean Octocoral Briareum asbestinum

The octocoral *Briareum asbestinum* is found in the Caribbean, Bermudas and Bahamas shallow reefs and consists of two morphological forms: erect and encrusted, sometimes found next to each other. They provide habitat for a great variety of invertebrates and are among the most visually dominating soft corals of the Caribbean reefs. Previous studies have examined their genetic differences through comparison of the nuclear ribosomal ITS-1, a problematic locus due to concerted evolution. The research focus on the comparison of transcriptomes of both erect and encrusted forms of *Briareum asbestinum*. We will use the Illumina sequencer to generate a transcriptome for each ecotype. Pairwise deferences of gene expression and sequence analysis of new molecular markers derived from the transcriptomes will be used to compare the two octocoral forms.

P1.63 RIVERA, G*; DEPPEN, C; OPPENHEIMER, J; Creighton University, Swarthmore College; *gabrielrivera@creighton.edu*

Patterns of fluctuating asymmetry in the limbs of turtles: are more functionally important limbs more symmetrical?

High levels of fluctuating asymmetry, random deviations from perfect symmetry in otherwise symmetric structures, have been shown to negatively impact animal locomotion. Because fluctuating asymmetry is both heritable and affects performance, it is possible for natural selection for enhanced locomotor performance to generate low levels of asymmetry in limbs that perform locomotor roles. Furthermore, it has been hypothesized that asymmetry will vary with the functional importance of structures, suggesting that in animals with two sets of paired limbs, the more functionally important limb set should be more symmetric. Turtles provide an excellent system in which to test this hypothesis because they are obligate limb-based locomotors. The aim of our research was to examine the patterns of fluctuating asymmetry present in the limb bones of emydid turtles (subfamily Deirochelyinae). This group employs a hind-limb dominant swimming style, and is therefore an excellent group in which to test the biomechanical hypothesis of symmetry. We hypothesized that forelimbs would display greater fluctuating asymmetry than hindlimbs, given their lower level of functional importance. We measured the left and right hind- and forelimb bone lengths in six species (one per genus in Deirochelyinae), and used their measurements to calculate asymmetry in each set of bones for each species. A consistent pattern was detected for fluctuating asymmetry (FA). FA was always higher in forelimbs, though not all species showed significant differences. Furthermore, hindlimb FA was less variable then forelimb FA across species. These results begin to generate a clearer picture of the evolutionary pressures exerted by the need for biomechanical efficiency in locomotion.

P2.113 RIVERS, J*; AMATO , C; MCCOY , K; East Carolina University ; *riversj12@students.ecu.edu*

The Effects of Sulforaphane on Vinclozolin Exposed Mice

Male reproductive abnormalities including altered testis function are becoming more common, and have been associated with fetal exposure to anti-androgenic endocrine disrupting chemicals (EDCs). These EDCs can disrupt the binding of hormones to their receptor, and alter testis morphology and function. Although limiting exposure to anti-androgens during pregnancy is the most efficient way to reduce fetal exposure to these chemicals, we are often exposed via unknown routes and are unable to adequately control our intake. Phase II detoxifying enzymes conjugate specific substances onto toxins to render them less harmful. Sulforaphane, is an inducer for GST (a phase II-inducing enzyme) and is expected to decrease the toxicity of EDCs reducing their effects on the developing fetus. We tested the hypothesis that sulforaphane can decrease the toxicity of the model anti-androgen vinclozolin on testis morphology and function. To test this hypothesis, we treated pregnant mice from embryonic day (E) 13.5- 16.5 with corn oil vehical alone, or vinclozolin (125 mg/kg) and supplemented vinclozolin exposed dams with 0, 15, 30, and 60 mg/kg of sulforaphane. Testes were dissected at E18.5 and processed for histology. Leydig, sertoli, and germ cell counts, and androgen concentration will be presented. The preliminary data suggests that Leydig cells increase with increasing sulforaphane supplementation supporting the hypothesis that testis cell function is rescued by increased Phase II detoxifying enzymes. Further data and their implications will be discussed.

P2.4 ROBERGE, TM*; MARION, KR; WIBBELS, TR; Univ. of Alabama at Birmingham; *troberge@uab.edu*

Assesing Diamondback Terrapin (Malaclemys terrapin) Nesting Beach Quality in Alabama Using a Surrogate Species

The Diamondback terrapin is considered a species of highest conservation concern in the state of Alabama in addition to other locations within its range. Nesting beach utilization in Alabama is not uniform, with one beach in particular, located at Cedar Point Marsh, hosting the highest abundance of nesting. The ability to assess nesting beach quality in an ecologically relevant way is important for the identification of optimal nesting habitats that are crucial to the recovery of the diamondback terrapin in Alabama. Hatchling phenotype (e.g. size, mass, locomotor performance) in reptiles are affected by both genetic and environmental factors which could ultimately impact the fitness of the individual. Due to the conservation status of the diamondback terrapin, we used a surrogate species (*Trachemys scripta elegans*), with similar life-history attributes to assess hatchling phenotypes produced on known diamondback terrapin nesting beaches. Thirty two artificial nests were distributed across 7 beaches that varied in substrate type and vegetative cover. Each nest contained 10 eggs and a datalogger recording hourly temperature. Eggs were recovered just before hatching and were subsequently measured and sexed; the gonads were photographed for digital analysis of gonadal morphometrics. These data provide the means of assessing nesting beach quality by comparing hatchling phenotypes associated with hatchling fitness within and among beaches. In addition to ecological and evolutionary implications, the information gleaned from this study provides insight for enhancing the recovery strategy for the diamondback terrapin in Alabama.

P2.148 ROBERT ROLLINS, E*; NANCY STAUB, L; Gonzaga University; *rrollins@zagmail.gonzaga.edu*

The presence of dorsal and ventral courtship glands in both male and female Desmognathus brimleyorum (Amphibia: Plethodontidae)

Plethodontid salamander courtship is an elaborate yet conserved set of behaviors that employ many different signals, including tactile and chemical. Certain glands within the salamander's dermis produce pheromones that aid in courtship behavior; these are known as courtship glands. These glands are sexually dimorphic, stain positively with the periodic-acid Schiff reagent, and are active during courtship. Glands of this sort have been described in several areas of the salamander dermis. Previously, courtship glands have been identified in male *Desmognathus brimleyorum* on the dorsal tail base. Using histology, we describe courtship glands on the dorsal and ventral surface of the tail base in both male and female *D. brimleyorum*. These glands are sexually dimorphic in size; male courtship glands are larger than female glands. Granular and mucous glands are not sexually dimorphic. Previously, caudal courtship glands have been described only on the dorsal tail base of *D. brimleyorum* males. Our results describing their presence in females and on the ventral tail surface raises questions about their functional significance.

P2.172 ROBERTS, A.S.*; GIDMARK, N.J.; FARINA , S.C.; University of Washington, Friday Harbor Laboratories, Harvard University ; *rober231@purdue.edu*

Feeding Mechanics and Functional Morphology in the Jaws of Sculpins

Species with overlapping geographic ranges, similar morphology, and comparable ecological roles often vie for the same resources and therefore face competitive exclusion. This competition can be reduced if species vary in skeletal and muscular anatomy, changing biomechanical performance. We examined biomechanical variation of feeding structures in a group of nineteen sculpins (Cottoidea) that co-occur in the marine habitat around the San Juan Islands. We quantified evolutionary correlations of skeletal morphology and muscle morphology by conducting phylogenetic independent contrasts using a phylogeny constructed from published molecular data. We hypothesized that skeletal leverage (mechanical advantage) and muscle architecture (gearing) could either display a positive evolutionary correlation (changing over evolutionary time to perform inversely of each other), or the features could display a negative correlation (changing over evolutionary time to perform in the same way). We found a positive correlation between evolutionary shifts of out-lever length and adductor muscle length, but no correlation between evolutionary shifts of in-lever length and adductor muscle length or adductor muscle length and lever ratio. Our results demonstrate that skeletal leverage and muscle architecture evolve independently in individual species of sculpins. These results also suggest that these two functional units (skeletal morphology and muscle morphology) both contribute to biomechanical diversity in closely related, geographically co-occurring sculpin species, indicating their importance as metrics of ecomorphological diversity.

P2.32 ROBINSON, CD*; GIFFORD, ME; University of Central Arkansas; *crobinson19@cub.uca.edu*

Embryonic Sceloporus consobrinus do not acclimate to thermal stress under fluctuating conditions

In response to global climate change, organisms can move, adapt, acclimate, or die. Ectotherms are at particular risk to the effects of climate change because they behaviorally thermoregulate instead of creating heat through metabolic processes, and many cannot migrate to suitable conditions due to environmental or physiological barriers. The fence lizard *Sceloporus consobrinus* is a well-studied organism whose embryos have been shown to acclimate to temperature differences during development, but these studies have been conducted using constant temperature states. It is unclear whether embryos will respond similarly to fluctuating temperatures that naturally occur daily and seasonally. To assess the effect of fluctuating temperature on *S. consobrinus* embryos, we split clutches from 30 females and incubated eggs under two fluctuating conditions. The first fluctuated between 24 and 34˚C (average 27˚C). The second treatment fluctuated between 24 and 38˚C (average 30˚C). After 30 ± 4.6% of the incubation period in each treatment we measured embryonic heart rate at 33˚C (which is near the optimum for performance for juvenile and adult lizards). We chose our thermal treatments to simulate the average current conditions experienced by embryos and a condition with high temperature fluctuations, to simulate what animals might experience in the future. Contrary to the previous study conducted using constant incubation conditions, we found no difference in heart rates between the two treatments, suggesting that *S. consobrinus* embryos do not acclimate to their environments during development. As suggested previously by many authors, inferences about physiological variation can be sensitive to experimental conditions. Researchers should strive to simulate natural environmental variation when assessing physiological responses to the environment.

P3.164 ROEGNER, ME*; CHEN, HY; WATSON, RD; University of Alabama at Birmingham, University of North Carolina Wilmington; *mzappe@uab.edu*

Cloning of a cDNA encoding a sarco/endoplasmic reticulum Ca^{2+} ATPase from Y-organs of the blue crab (Callinectes sapidus)

Stage-specific increases in intracellular free Ca^{2+} have been shown to stimulate ecdysteroid production in the molting glands (Y-organs) of crustaceans. Intracellular Ca^{2+} levels are regulated by proteins intrinsic to the plasma membrane and membranes of organelles. These include Ca^{2+} pumps, e.g., plasma membrane calcium ATPases (PMCAs) and sarco/endoplasmic reticulum calcium ATPases (SERCAs). In order to better understand the role of intracellular calcium signaling in the regulation of ecdysteroidogenesis, we used a PCR based cloning strategy (RT-PCR followed by 3'- and 5'-RACE) to clone a partial cDNA encoding a portion of a putative SERCA protein from the Y-organs of the blue crab (*Callinectes sapidus*). The cDNA includes an optimal translational initiation sequence, a start codon, and a 1749-bp open reading frame that encodes a 583 amino acid portion of a SERCA protein with 80% identity to comparable crustacean SERCA sequences. Experiments in progress are designed to clone the remainder of the SERCA cDNA and to assess SERCA transcript levels in the Y-organs and control tissues throughout the molting cycle using quantitative real-time PCR. We anticipate that the results will provide insight into the role of Ca^{2+} signaling and intracellular Ca^{2+} regulatory proteins in endocrine regulation of crustacean molting. (First and second authors contributed equally to this work).

P2.160 ROELL, Y.R.*; VOYLES, J.; PARENT, C.E.; University of Idaho, Moscow, University of Nevada, Reno; *yannik.roell@gmail.com*

The relationship of metabolic rate to shell morphology and environmental differences in endemic land snails of Galapagos

Adaptive radiation studies mainly focus on morphological characters and often overlook the physiological consequences to these adaptations. The link between morphological and physiological changes with environmental variation would allow for the understanding of why an adaptation would arise and why a lineage has diversified. The endemic land snails of the genus *Naesiotus* form the most species rich adaptive radiation of the Galapagos islands with over 80 species described. These snails inhabit most islands from low elevations that are hot and arid to higher elevations that are cool and humid. Along this climatic gradient, *Naesiotus* species present a diverse spectrum of shell size, shape, and color. We predict that snails in hot and arid climates have lower basal metabolic rates and smaller shell apertures which would minimize water loss. We quantified the metabolic rate (calculated from oxygen consumption and carbon dioxide production) and water loss of 13 species distributed along two Galapagos elevational transects using a Sable Systems International FoxBox. We measured spatial and temporal variation in temperature and humidity along the transects and tested whether species metabolic rate changes due to morphology or environment or both. This research work will help establish how snail physiology differs along elevational gradients and whether snail shell morphology represents an adaptation to these differences.

P2.60 ROGERS , EJ*; LILLEY, TM; FIELD, KA; Bucknell University, Bucknell University ; *ejr025@bucknell.edu*

Oxidative stress in white-nose syndrome infected bats during hibernation

White-nose syndrome, an invasive cutaneous fungal infection afflicting North American bats, has been shown to cause an increase in the frequency of euthermic arousals from torpor during hibernation. During such rewarming periods, oxygen consumption and metabolic rate increase dramatically, which may result in a surge of reactive oxygen species. To determine whether white-nose syndrome has an affect on cellular oxidative stress in hibernating little brown bats (Myotis lucifigus), we compared levels of the antioxidant enzymes catalase and superoxide dismutase, percent oxidized glutathione, and markers of oxidative damage such as lipid peroxide end products and protein carbonyls in the liver tissue of infected and uninfected bats at three time points during the winter. Additionally, we used skin temperature data collected throughout hibernation to examine whether stress indicators correlate with time since last arousal at the point of euthanasia. We expect that little brown bats with white-nose syndrome will show greater levels of oxidative stress than the control bats over the course of hibernation, due to increased frequency of arousal and the presence of an infection, which may redirect resources away from antioxidant defense. This will provide greater insight into how white-nose syndrome affects the physiology of this species.

P1.79.5 ROMAN, D*; LATIMER, M; BIGA, P; Univ. of Alabama, Birmingham ; *droman@uab.edu*

Physical injury induced myogenic repair in Danio rerio

Zebrafish; *Danio rerio*, skeletal muscle exhibits characteristics of determinate-like growth, similar to that of many mammals, where muscle growth is limited in sexually mature adults. Zebrafish have been shown to exhibit significant age-related senescence, however it is unknown if muscle repair mechanisms are limited in adults. Evidence shows that as myogenic precursor cells (MPCs) progress through the myogenic program during development Pax3, Pax7, and other myogenic regulatory factors (MRFs), MyoD, Myf5, and myogenin are expressed at distinctive times. During the muscle regeneration process, following physical or chemical injury or exercise, quiescent MPCs are activated to proliferate and differentiate to form new muscle fibers or repair damaged fibers. This process is regulated by MRFs, but it is unknown if the Pax genes are activated during repair in adult zebrafish indicating self-renewal of the MPC population. Therefore, the goal of this study was to characterize the expression of Pax7a, Pax7b, Myf5, MyoD1, and myogenin, after physical injury to test the hypothesis that over one-week post injury MRF expression will increase in conjunction with the recruitment of MPCs to the wound site while Pax7 expression will remain stable or decrease. Injuries were inflicted to the left anterior muscle in between the pectoral and dorsal fins using a four-pronged tool. Muscle samples were collected over one-week post injury, snap frozen in liquid nitrogen, and RNA was extracted using RNA-zol for qPCR analysis. Wound healing included an activation of the myogenic process with in the one-week period

P3.74 ROMERO, I/J*; PETAK, J/L; TAHIR, U; TESTER, J; NISHIKAWA, K/C; Northern Arizona University; *ir75@nau.edu*

A Neuromuscular Approach to Powered Prosthetic Controllers

A Neuromuscular Approach to Powered Prosthetic Controllers By: Isaac Romero, Jeremy Petak, Uzma Tahir, John Tester, and Kiisa Nishikawa The BiOM is a powered foot-ankle prosthesis that allows users a more human like walking experience. The commercially available BiOM controller uses a state based control algorithm to command the required torque at the ankle. However, this approach requires optimization to specific walking conditions, such as level walking or stair ambulation. In order to mimic robust human walking on a variety of terrains, we used a bio-inspired model based on muscle physiology to compute ankle torque. Hill-type muscle models, based on the sliding filament theory, are unable to account for intrinsic muscle properties. A new theory of muscle contraction, called the winding filament hypothesis (WFH), predicts muscle force during dynamic conditions and was incorporated into the BiOM controller. The winding filament model consists of a titin spring and a series tendon spring, a contractile element, a damper, and a pulley. The human lower limb is modeled as a hinge at the ankle joint, with anterior and posterior muscle groups that dorsiflex and plantarflex, respectively. The BiOM's internal sensor measures ankle angle, which is then converted to virtual muscle length to determine anterior and posterior muscle force based on the force-length and force-velocity relationship of muscles, and the WFH. By using parameters such as damping and spring constants that are subject specific, and muscle activation patterns that resemble biological muscles, we were able to command net ankle torque matching intact subjects. Control algorithms for powered prostheses will allow robust control, adapting to changing environments and terrains, increasing freedom for users.

P1.183 ROSAS, MM*; LICHTI, NA; POST, AM; WILSON, RC; STRAND, CR; Allan Hancock College, Santa Maria, Cal Poly State Univ, San Luis Obispo; *cstrand@calpoly.edu*

Quantifying spatial memory in male and female Western fence lizards, ‚Sceloporus occidentalis

In order for animals to survive in the wild, they must be able to properly navigate within a home range or territory. The ability of animals to perform this type of spatial task and the underlying neural mechanisms have been investigated almost entirely in mammals. Recent evidence suggests that lizards can use visual cues to spatially navigate, however it is unclear if all lizards have this ability or if there are sex differences in the ability of lizards to navigate. We developed a Barnes Maze to test whether Western fence lizards (*Sceloporus occidentalis*) were capable of spatial learning using visual cues and to determine if there were sex differences in this ability. We performed two sets of trials, one with minimal internal visual cues and the second with very prominent internal visual cues. Cues were not directly associated with an escape hole, thus the lizards had to learn the position of their escape hole in relation to the visual cues present. Lizards failed to learn either maze based on the total distance moved, the number of incorrect holes investigated, and the angle of first approach. However, in some individuals, there seemed to be trends for them to learn. Clearly, lizards in the wild demonstrate an ability to remember their territory, however quantifying this ability in the laboratory is challenging. Identifying the appropriate motivators and sensory cues for each species may be necessary to better understand this behavior and the neural mechanisms regulating spatial navigation and memory.

P3.147 ROSS, DL*; PERRY, KJ; HENRY, JQ; SHUBIN, NH; Univ. of Chicago, Univ. of Illinois, Urbana-Champaign; *DarcyLRoss@uchicago.edu*

The role of dpp in shell coiling of a slipper shell snail

The gastropod shell is well-studied due to its preservation in the fossil record and interesting logarithmic coiling shape. In contrast to the typical coiled shell, a limpet-like shell morphology (no coil, apex of the shell central or slightly anterior, large aperture) has convergently evolved many times across the vast phylogeny of gastropods. With new genetic resources and developmental tools, we are able to investigate whether limpet-like lineages use similar or divergent developmental pathways to achieve their morphology. Several studies have implicated the morphogen dpp (BMP2/4 homologue) in shell coiling. *dpp* correlates with the direction of coiling in a heterobranch and is symmetrically expressed around the shell-secreting tissue in two patellogastropod limpets (Shimizu *et al.* 2013). Shimizu and colleagues hypothesize that changes in dpp activity result in differential cell proliferation that may underlie the numerous evolutionary transitions from coiled to limpet-like shells seen across Gastropoda. We are the first to investigate and functionally test this hypothesis in a caenogastropod (a speciose lineage) by using the developmental model *Crepidula fornicata*, the common slipper shell. *Crepidula* has a flattened limpet-like shell morphology, yet it does have a coil of less than one whorl. We hypothesize that because the shell has a right-handed coil, *dpp* expression will be higher on the right side of shell-secreting tissues. We characterize *dpp* expression in *Crepidula* using *in situ* hybridization from shell gland development through metamorphosis, and report effects of knocking down dpp signaling through the inhibitor dorsomorphin. We report a preliminary assessment of the role of cell proliferation in shell shape. Shell morphology was analyzed using a micro-CT scanner and geometric morphometrics.

P3.86 ROTT, K.H.*; CAVIEDES-VIDAL, E.; KARASOV, W.H.; Univ. of Wisconsin, Madison, Universidad Nacional San Luis & CONICET; *katherine.rott@gmail.com*

Intestinal enzyme activity in nestling house sparrows (Passer domesticus) not depressed by high dietary lipid content

Previous research has indicated that high dietary lipid content inhibits intestinal carbohydrase activity. This effect has been observed in adult rodents and house sparrows, as well as in 12-day old nestling house sparrows that spent nine days on diets containing high lipid content. We are now studying enzyme digestion with even younger nestlings fed diets with contrasting compositions for shorter periods of time, and we tested for this apparent inhibition by dietary lipids. Three-day-old nestlings were captured and fed a diet with 5% carbohydrate/8% lipid followed by three days on the same diet or three days on a higher lipid version of the diet (5% carbohydrate/25% lipid). We found that high dietary lipid content had no significant effect on carbohydrase activity after three days, contrary to what we expected. Although the reason for this different pattern is unknown, it could be related to the younger age, shorter feeding time span, or different diet compositions that were used. We concluded that the impact of dietary lipid on intestinal enzyme activity is complex and that studies of dietary modulation of intestinal enzymes should be conducted with careful attention to this possible effect. The mechanistic basis for dietary lipid's sometimes significant effect on intestinal enzymes remains to be determined. Supported by NSF IOS-1354893 to WHK.

P3.57 ROWAN RAMPTON, RWR*; TONY D WILLIAMS, TDW; ROXANA TORRES, RT; Simon Fraser University ; *rrampton@sfu.ca*

Does the trade-off between immune function and reproduction in females influence the maternal effects trade-off in offspring?

Although trade-offs are a key component of life-history theory we still know relatively little about the specific physiological mechanisms underlying any trade-off. Much attention has focussed on the trade-off between reproduction and immune function and although it is widely assumed that the limiting resource for this trade-off is energy there is only weak and contradictory evidence that variation in immune function is driven by energy or resource costs of reproduction *per se* (or vice versa). Moreover, any trade-off between immune function and reproduction will not only be driven by the female (parent) but also by her offspring, when both reproductive (e.g. yolk hormones) and immune (e.g. maternal antibodies, MAb) resources are transferred to eggs. Here we studied the effects of mounting a secondary immune response (against injections of LPS spaced 10 days apart) on reproductive investment of female zebra finches (*Taeniopygia guttata*). We obtained data on laying interval, egg mass and clutch size of LPS-treated and control females (pre- and post-LPS injection) and blood sampled females to measure Ab titers. We then manipulated eggs with high- and low-MAb by egg injection to elevate yolk T. We were therefore able to investigate a) the effect of mounting an immune response on the female's own reproductive investment, and b) the consequences of the female's reproductive decisions for offspring fitness in terms of egg mass, maternally-transferred Ab (which we predicted would enhance offspring immune function), and maternally-derived T (which we predicted would enhance offspring growth). We expected that the trade-off between effects of MAb and yolk T in offspring would interact with the trade-off between immune function and reproduction in females.

P2.71 RUBIN, A.M.*; DIAMOND, K.M.; SCHOENFUSS, H.L.; BLOB, R.W.; Clemson Univ., St. Cloud State Univ.; *amrubin@g.clemson.edu*

Field observation of intraspecific and predatory attack behaviors of the Hawaiian sleeper fish, Eleotris sandwicensis

All native fishes living in Hawaiian streams are amphidromous, meaning that larvae hatched in streams are swept to the ocean and must migrate back upstream to reach adult habitats. The Hawaiian sleeper, *Eleotris sandwicensis*, is the primary predator on these migrating juveniles. Sleepers are ambush predators that lie on the stream bottom until bursting into motion to attack passing prey. Recent studies of the escape behavior of a common prey fish for sleepers, juveniles of the goby *Sicyopterus stimpsoni*, indicated that prey fish may be more vulnerable to attacks from the front as they migrate upstream, because pressure waves from an attacking fish might be masked by surrounding water flow. However, predatory performance of sleepers has only been measured in a lab setting without the influence of stream flow. To determine how sleepers attack prey in the wild, we recorded 42 hours of video from an array of four GoPro cameras mounted underwater in areas of Hakalau Stream (Big Island of Hawai'i) where sleepers and migrating gobies are abundant. In addition to observing predatory strikes on juvenile gobies, we also recorded sleepers striking at other sleepers. None of these resulted in the capture of a sleeper by another, but did result in smaller sleepers being driven away by larger ones. Analyses of motion patterns found no correlation between angle of attack and peak escape angle for attacks by *E. sandwicensis* on either gobies or other sleepers. These results are consistent with the conclusion that, if an attack can be detected, responses by juvenile gobies and sleepers may be a fixed action pattern that is not modulated in response to variation in stimuli.

P1.114 RUBY, A.L.*; FALLON, B.; WELCH, A.M.; College of Charleston, South Carolina Governor's School of Science and Mathematics; *rubyal@g.cofc.edu*

Effect of increased salinity on different life stages of squirrel tree frog (Hyla squirella)

Salinization of freshwater habitats is an increasing environmental concern. Rising sea level, storm surge, deicing salts, and other forms of habitat modification can contribute to increased salinity in freshwater ecosystems. Elevated salinity can increase the demands of osmoregulation in freshwater organisms, and amphibians are particularly at risk due to their aquatic development and permeable skin. The typical anuran life cycle requires freshwater for fertilization as well as embryonic and tadpole development. Determining the salinity tolerance of these three life stages is important for identifying stages that are at greatest risk due to habitat salinization. However, most studies have focused on a single life stage, and salinity effects on fertilization have seldom been tested. We investigated the effects of a range of salinities on fertilization, embryos and tadpoles of the squirrel tree frog, a species found in the coastal plain of the southeastern US. Although increased salinity had negative effects on each life stage, the embryo stage was the most sensitive, with complete mortality at a salinity that allowed some fertilization and some tadpole survival. Unexpectedly, however, tadpole survival was significantly reduced in the lowest (control) salinity level, suggesting that squirrel tree frogs may require additional solutes during larval development. Overall our results suggest that populations of squirrel tree frogs may be adversely affected by modest increases in salinity; consequently, habitat salinization could present a threat to their reproductive success and survival.

P1.49 RUELAS, E. C*; BARRAZA, A. D; FORSGREN, K. L; California State University Fullerton; *evelynruelas@csu.fullerton.edu*

Histological Description of the Reproductive Morphology of a Viviparous Fish, the Black Perch (Embiotoca jacksoni).

Black perch are a common southern California reef fish. During breeding season, male black perch transfer a spermatophore (capsule containing spermatozoa) to the female via an intromittent organ during copulation. Females store the spermatozoa within the ovarian cavity until December when the eggs become fertilized and give live birth in May. The objective of our study was to describe the gonadal development of female and male black perch and describe the pathway of spermatophore transfer. Black perch were collected along the southern California coast. Gonadal tissues were dissected, preserved in Bouin's fixative, and embedded in paraffin wax. Tissues were sectioned using a rotary microtome (5 µm thick) and analyzed. All female black perch had one developed ovary. Preliminary observations of the ovarian tissue from females < 150mm SL, had all stages of follicle development (primary, secondary, tertiary); no fertilized ova or embryos were present. In the fall, secondary follicles and fertilized ova were present in the ovarian tissue collected from females > 150mm SL. In spring, the ovarian cavity of females > 150mm SL contained 2-8 embryos 37.8 ± 4.1mm SL. In the fall, primary and secondary spermatocytes and spermatids were present within the testicular tissue of fish < 150mm SL. The intromittent organs on the anal fin consisted of a white patch with no external protrusion. In the fall, testicular tissue from males > 150mm SL contained all stages of spermatogenesis including spermatozoa and the development of spermatophores. The intromittent organs were enlarged and protruded from the anal fin. Males collected in spring are currently being analyzed and the pathway of spermatophore transfer is being determined. Histological analyses of gonadal development will aid in the understanding of reproduction in black perch.

P3.63 RUFFIN, T/C*; GORDON, E/N; NGUYEN, C/QM; KOOPMAN, H/N; KINSEY, S/T; University of North Carolina Wilmington; *tcr9304@uncw.edu*

Membrane lipid content as an indicator of whole animal metabolic rate

Skeletal muscle fibers tend to grow as large as possible, often to the brink of oxygen diffusion limitation. This appears to be a strategy to minimize the cost of maintaining the membrane potential across the sarcolemma in resting muscle, since large fibers have a lower surface area to volume than small fibers. However, the sarcolemma is but one of many membrane systems in organisms, all of which require energy to maintain transmembrane gradients. We hypothesized that whole animal resting metabolic rate would be positively correlated to membrane lipid content, but unrelated to non-membrane lipid content. We tested this hypothesis in species of tropical freshwater fishes by measuring the oxygen consumption rate at rest using closed-chamber respirometry, and lipid content using thin layer chromatography in the whole animal. The oxygen consumption rate scaled negatively with body mass across all species, as expected. Six classes of lipids were identified: triacylglycerols (TAGs), free fatty acids (FFAs), sterolesters, cholesterol, and two classes of phospholipids. The 3 classes of non-membrane lipids (TAGs, FFAs and sterolesters) were not significantly correlated with oxygen consumption rate. In contrast, the 3 classes of membrane lipids (cholesterol and the two phospholipid classes) were significantly positively correlated with the rate of oxygen consumption. These results indicate that the extent of metabolic compartmentation may be a major contributor to variation in resting metabolic rate.

P1.163 RUSCH, C*; ROTH, E; VINAUGER, C; RIFFELL, JA; University of Washington, Seattle; *ruschc2@uw.edu*

Neural processing during high-order cognitive tasks in the honeybee Apis mellifera

There is an increasing interest in understanding the neural bases of cognition. Insects, with their miniature nervous systems and their complex behavior, offer a unique opportunity to investigate the interplay between neuronal structures and behavior. Among them, the honeybee *Apis mellifera* has an incredibly rich behavior and relatively simplified neuroanatomy making it a model for neuroethological studies, including those in high-order learning. For example, after training, free-flying honeybees can categorize, count and extract abstract rules applicable to unknown objects (e.g. "larger than", "on top of", "different from"). However, a current gap in visual learning has been the inability to link functional studies on the neural substrates and information processing areas in the brain directly with behavior. Here, we use a locomotion compensator and a visual display to present stimuli to a tethered bee, thus enabling sensorimotor control and neurobiological experimentation in a fixed preparation. Online trajectory information from the locomotion compensator can be send to the visual display and allow the stimuli to move accordingly to the honeybee movement (e.g., close loop). My preliminary results demonstrate that honeybees on the locomotion compensator discriminate visual stimuli with performances that can be compared to free flying honeybees. By coupling this system with multichannel recordings from the optic lobe and mushroom bodies, our aim is to compare neural signatures of different brain structures during and after simple or high-order learning.

P1.206 SABIR, NT*; ROARK, AM; Furman University; *tasneem.sabir@furman.edu*

Sequencing of the COUP-TF nuclear receptor gene in Aiptasia pallida anemones

Nuclear receptors are transcription factors and include retinoic acid receptor, retinoid X receptor, estrogen and androgen receptors, and the chicken ovalbumin upstream promoter- transcription factor (COUP-TF). This study focuses on the COUP-TF orphan receptor. COUP-TF is involved in development, homeostasis, and reproduction in both vertebrates and invertebrates. The purpose of our study was to clone and sequence the *COUP-TF* gene from pale sea anemones (*Aiptasia pallida*), which are increasingly used as model organisms for the study of cnidarian development. Total RNA was extracted from *A. pallida* anemones and reverse transcribed to produce cDNA. Degenerate primers designed by comparison of the *COUP-TF* gene sequences from four cnidarian species were used to amplify cDNA by PCR, and PCR products were separated by gel electrophoresis. Bands of the desired length were excised, and amplified cDNA was purified from these bands and then ligated into pGEM-T plasmids. Bacteria were transformed with these recombinant plasmids and cultured overnight. Plasmid DNA was then extracted and sequenced. We successfully cloned and sequenced 929 nucleotides of the *A. pallida COUP-TF* gene. The DNA-binding and ligand-binding domains of this gene fragment are 77.7 % and 78% homologous to the *Acropora millepora* coral *COUP-TF* gene. To our knowledge, *COUP-TF* is the first nuclear receptor gene to be sequenced from *A. pallida*.

P2.77 SABOL, A*; HELLMANN, J; HAMILTON, I; The Ohio State University; *sabol.39@osu.edu*

The role of ultraviolet vision in individual interactions in a social cichlid

Despite the inability of humans to see ultraviolet light, ultraviolet vision is common among many taxa including fish, birds, reptiles, insects, and some mammals. In species that can see in the UV spectrum, individuals often have UV markings on their face or body. These markings can serve a variety of purposes, including signaling for mate choice, dominance, and individual recognition. However, the majority of the research in the area of UV signaling has been done on birds and there is limited knowledge about the role of UV markings in fish. We found that *Neolamprologus pulcher*, a species of cooperatively breeding fish, has UV markings around the face. We investigated the role that these UV markings play in individual interactions by comparing interactions between fish when they can see their opponent's UV markings and when those markings are obscured by UV-blocking film. If the fish react differently when presented with a familiar individual with and without being able to see UV markings, then UV markings may be involved in individual recognition. Alternatively, if the fish react differently to individuals of the opposite sex with and without being able to see UV markings, the UV markings may play a role in mate choice. Lastly, if the fish react differently to individuals of the same sex with and without being able to see UV markings, then these markings may be involved in establishing dominance. As *N. pulcher* are considered a model system for studying cooperation, learning more about what role UV signals play in their social interactions would add extra insight to future studies and a deeper understanding of their social dynamics as a species and measuring individual levels of UV markings could become a useful indicator of related social variables.

P2.43 SALAS, HK*; DELMANOWSKI, RM; TSUKIMURA, B; , ; California State University, Fresno; *BrianT@CSUFresno.edu*

Annual vitellogenin levels in hemolymph of Petrolisthes cinctipes using ELISA and insights into P. manimaculus

Petrolisthes cinctipes and *P. manimaculis* are two closely related species of anomurans that live in the upper intertidal zone along the Central California coast. Morphometric measurements were collected to gain insight on the reproductive cycles of these species. Ovary weights of *P. cinctipes* increased from July (0.2 ± 0.1µg) to September (18.0 ± 6.0µg), and remained similar through January (19.0 ± 7.0µg). Vitellin (Vn), an egg yolk protein, is metabolized from a larger hemolymph protein, vitellogenin (Vg). Using SDS-PAGE, it was determined that the Vn of the conspecifics, *P. cinctipes* and *P. manimaculis*, consist of three major subunits that have a MW of 93±2 kDa, 82±2 kDa, and 65.7±1.4 kDa. Two minor bands were also detected at 111±2.3 kDa and 40±1.3 kDa. Using HPLC, the native molecular mass of *P. cinctipes* vitellin was found to be 301±14 kDa with a small doublet. The native molecular mass for *P. manimaculis* vitellin is 324±11 kDa with a more pronounced doublet of 160±13 kDa. A Western blot was used to test the reactivity of the *Petrolisthes* vitellin with various antibodies. It revealed that two of the major *Petrolisthes* vitellin subunits, 93±2 kDa and 65.7±1.4 kDa, successfully bound with *Homarus* anti-vitellin antibodies. An ELISA was developed that can measure Vn and Vg in the hemolymph of both *Petrolisthes* species, with an effective range from 9-3000 ng. This ELISA was used to determine that the average vitellogenin concentration each month for *P. cinctipes*, which ranged from 30.6 µg/mL in May 2015 to 385.9 µg/mL in October 2014. We will present an annual profile of this reproductive event.

P1.27 SANFORD, RS*; KOHN, AB; MOROZ, LL; The Whitney Lab for Marine Biosci; St. Augustine, FL 32080, The Whitney Lab for Marine Biosci; St. Augustine, FL 32080; Dept of Neurosci and Brain Institute, Univ of Florida, Gainesville, FL 32610, USA; *rsanford@ufl.edu*

Genomic Basis of Regeneration in the Ctenophore, Mnemiopsis leidyi.

The amazing ability of regeneration in ctenophores has captured the interest of biologists for centuries. The morphological features of ctenophore regeneration have been documented, but the molecular and cellular components behind this phenomenon have remained a mystery. With this study we have performed RNA-seq analyses of the regeneration dynamics using next generation sequencing technologies. The data show evidence for the involvement of several dozen of evolutionarily conserved and ctenophore-specific signal transduction pathways in the regeneration in *Mnemiopsis* including novel secretory peptide candidates, their receptors, components of downstream Ca^{2+}-dependent and MAP-kinase cascades as well as energetic and cell adhesion components. In addition, we identified a unique subset of transcription factors involved in the regeneration including homeobox, forkhead, transcriptional enhancers and inhibitors. Our data suggest that many of these transcription factors are upstream regulators of the pathways involved in regeneration. In summary, the identification of hundreds of ctenophore-specific genes and molecules associated with regeneration illuminate novel evolutionary mechanisms and strategies underlying morphogenesis and origins of evolutionary innovations in Metazoa. Supported by NSF, NIH, NASA

P2.98 SASSON, D.A.*; RYAN, J.F.; University of Florida; *dsasson@ufl.edu*

The sex lives of ctenophores: the reproductive behavior and ecology of the ctenophores Mnemiopsis leidyi and Beroe ovata

Ctenophores are prodigious predators that can capture prey at high levels and are capable of altering the composition of coastal marine communities. Repeated invasions of European waters by both *Beroe ovata* and *Mnemiopsis leidyi* have led to substantial alterations in the plankton fauna diversity in these environments. *Mnemiopsis* and *Beroe*, like most other ctenophores, are simultaneous hermaphrodites capable of self-fertilization. Previous studies have suggested that *Beroe*, unlike *Mnemiopsis*, may have barriers to self-fertilization. In this study, we describe the reproductive behaviors of *Mnemiopsis* and *Beroe* by categorizing their spawning cues and egg production. We measure the costs and benefits of self-fertilization vs. out-crossing in *Mnemiopsis* and investigate potential blocks to self-fertilization in *Beroe*. Finally, we show evidence suggesting that *Mnemiopsis* has the ability to store and use conspecific sperm for future spawning events; we explore the implications of this finding using a combination of behavioral and molecular approaches. Understanding the reproductive mechanisms and capacity of these ctenophores is key to understanding their ecology and may be useful in limiting future invasions.

P3.158 SARWAR, PF*; SUZUKI, Y; Wellesley College; *psarwar@wellesley.edu*

Transcriptional regulation of ecdysteroid biosynthesis is conserved between hemimetabolous and holometabolous insects.

Recent studies have shown that in holometabolous insects, Ventral veins lacking (Vvl), a POU domain transcription factor, regulates ecdysteroid biosynthesis to influence molting. To determine the degree of conservation in the transcriptional control of the endocrine system, we silenced the expression of *vvl* in the hemimetabolous insect, *Oncopeltus fasciatus*. When *vvl* was silenced, the nymphs failed to molt and eventually died. *vvl* knockdown led to reduced expression of the ecdysone response gene, *HR3*. Injection of 20E into *vvl* knockdown nymphs rescued the *HR3* expression but not the molting phenotype. *vvl* knockdown also led to subsequent reduction in the levels of the ecdysone biosynthesis genes in the anterior portion of the body. Therefore, the transcriptional regulation of ecdysteroid biosynthesis is conserved between hemimetaoblous and holometabolous insects.

P2.37 SAWYER, S. J. ; RAMEZAN, E. E. *; Glenville State College; *sara.sawyer@glenville.edu*

The effect of increased temperature on the expression of extracellular matrix genes in the sea anemone, Aiptasia pallida

The mutualistic symbiosis between many Cnidarians and dinoflagellate algae is increasingly threatened by different environmental stressors that can induce breakdown of the symbiosis, or bleaching. We are using rt-qPCR to determine how increased water temperature affects gene expression of two extracellular matrix genes (matrix metalloproteinase (MMP) and collagen), two stress-sensitive genes (HSP90 and ubiquitin) and two control genes (NADH-dehydrogenase 5 (NDH5) and glyceraldehyde-3-phosphate dehydrogenase 1(GPD1) in the tropical sea anemone, *Aiptasia pallida*. We temperature-shocked anemones for 0, 6, and 12 hours, isolated RNA, converted it to cDNA, and then used qPCR to measure gene expression. MMP and ubiquitin expression relative to NDH5 showed elevation at 6 and 12 hours, however when expressed relative to GPD1, MMP and ubiquitin were elevated at 6 hours, but not at 12 hours, and collagen expression was elevated at 12 hours. These results suggest that temperature is inducing changes in gene expression for MMP and collagen, but it is also affecting the control genes in a manner that was unexpected. Thus, temperature is inducing changes in expression of the control genes NDH5 and GPD1. We are investigating the relative expression of the two control genes and are also investigating whether a third control gene, actin, will resolve these discrepancies. Results from this study will help elucidate the underlying cellular mechanisms of temperature-induced Cnidarian bleaching and yield insight into which cellular pathways are affected by increased water temperature.

P1.106 SCHACHAT, SR; Smithsonian Institution; *schachatsr@si.edu*

The evolutionary morphology of wing pattern in basal moths: implications for the origin of butterfly symmetry systems

Within the order Lepidoptera (moths and butterflies), the wing patterns of nymphalid butterflies and many other derived lineages are comprised of parallel multicolored bands called "symmetry systems." These symmetry systems are of great importance to evolutionary and developmental biologists. However, the origin of symmetry systems is not yet understood: basal moths have simpler wing patterns comprised of bands and/or spots. Existing hypotheses on the origin of symmetry systems from bands or spots are based on little or no empirical data, and homologies between the bands and spots of basal moths are also not known beyond the level of family or superfamily. I examined the relationship between wing pattern and wing venation in Micropterigidae, the most basal extant family of Lepidoptera, and found a consistent relationship between wing pattern and wing venation at the costal margin of the forewing. In the genus *Sabatinca*, wing patterns are multicolored. Recognizable pattern elements in this genus (multicolored bands), known to be homologous to simple bands in other taxa, resemble butterfly symmetry systems. When plotted onto butterfly wing venation, typical *Sabatinca* color patterns very closely resemble the "nymphalid groundplan" that represents wing pattern in butterflies and other derived Lepidoptera. It therefore appears that symmetry systems may have originated from the vein-dependent bands on the wings of basal moths.

P2.80 SCHER, C.L.*; WADLEIGH, R.L.; ABOLINS-ABOLS, M.; KETTERSON, E.D.; University of Virginia, Earlham College, Indiana University, Indiana University; *cls9fa@virginia.edu*

The effect of competition on male courting songs in Dark-eyed Juncos (Junco hyemalis)

Male reproductive success commonly depends on the ability to attract a mate. While a wide variety of courtship techniques are used by males of different species, a common trade-off exists: Males that court more are more likely to attract a mate, but also more likely to attract a competing male. Males are known to disrupt one another's courting attempts, which often results in loss of a potential mate, a risk that may be more severe in conditions of high competition. To examine this tradeoff, we used simulated territorial intrusions (STIs) to manipulate perceived competition level of 42 male Dark-eyed Juncos (*Junco hyemalis*). We exposed some males to frequent playback of conspecific male song for a day and treated others as controls. On the next day we simulated an opportunity for extrapair mating by presenting a live lure female on each male's territory. We recorded male vocalizations to determine whether the perceived competition level altered male courtship as indicated by number and complexity of songs. Courtship did not differ significantly between the high competition and control groups. However, the data suggest an interaction between body size and male song as a function of competition level. Under low competition (controls) males courted similarly, but under high competition, smaller males tended to sing more frequently and to sing more complex songs than larger males. This indicates that only some males react to changes in competition level, and furthermore that this response may be dependent on body size.

P3.81 SCHMIDT, J.E.*; SIRMAN, A.E.; CLARK, M.E.; REED, W.L.; HEIDINGER, B.J.; North Dakota State University; *jacob.e.schmidt@ndsu.edu*

Telomere Length Correlations of Somatic Tissues in Juvenile Franklin's Gulls

Telomeres are repetitive, non-coding segments of DNA that form protective caps at the ends of linear eukaryotic chromosomes that enhance genome stability. Telomeres shorten during cell replication and in response to oxidative stress and both telomere length and loss rate have been shown to be predictive of longevity. Evolutionary ecologists are keenly interested in the role that telomere dynamics (length and loss rate) play in mediating individual differences in life-history strategies. Typically, telomeres are measured in blood cells because this tissue can be easily and non-destructively sampled. A few human studies have examined whether blood cell telomere length is correlated with the telomere lengths of other tissues and there is generally good correspondence. In birds, one study in adults also found telomere lengths in blood and other tissues were positively correlated. However, no avian studies have investigated intra-individual telomere correlations in juvenile birds. This could be potentially important if variable developmental rates of different tissues in the body result in tissue specific telomere dynamics. We examined these questions by collecting several somatic tissues in Franklin's gull (*Leucophaeus pipixcan*) embryos prior to hatching in 2014 and from 40 day old, captive raised, Franklin's gull chicks in 2015. Relative telomere length was assessed with quantitative PCR, and we will determine if there are significant differences between the intra-individual telomere length correlations of the embryonic and the 40 day old gulls.

P2.18 SCHOMBURG, NJ*; HUBENY, JB; TAPLEY, DW; Salem State University; *n_schomburg@salemstate.edu*

Isotopic Analysis of Aurelia aurita off Winter Island Massachusetts

Stable isotopes have proven useful in demonstrating trophic relationships within food webs, including marine planktonic systems. The isotopic profiles of jellyfish in general are not well studied in the waters of Massachusetts. We determined the $\delta^{13}C$, $\delta^{15}N$ and some $\delta^{34}S$ values of *Aurelia aurita* collected from Salem Harbor, Massachusetts. Individuals were sectioned into the bell, oral arms, and tentacles to determine if fractionation of isotopes varies within the body. Subsamples had lipids extracted and were run in parallel with non-extracted samples from the same individuals and tissues. Stable isotope values for lipid-extracted samples did not differ from unextracted, so further analyses were performed on unextracted samples. $\delta^{13}C$ values for oral arms and bell were -20.8‰ and -21.2‰, respectively. $\delta^{15}N$ values were 9.9‰ and 11.6‰ for the same tissues. Values for all except bell $\delta^{15}N$ differ significantly from those found for Aurelia sp. in the Gulf of Mexico (D'Ambra *et al.,* 2014; $\delta^{13}C$: -18.8 and -18.3‰; $\delta^{15}N$: 12.0 and 11.5‰). These differences may reflect a more inshore site of collection for our samples, latitudinal or seasonal differences, or differences in trophic position. $\delta^{34}S$ values are very enriched (20.7-28.9‰) suggesting a low trophic position for *A. aurita* in Massachusetts.

P3.61 SCHREIER, KC*; GRINDSTAFF, JL; Oklahoma State University; *kaati.schreier@okstate.edu*

Does corticosterone exposure mediate disease avoidance strategies in zebra finches?

Disease exposure is a universal threat to all organisms, and self-defense can occur in a variety of ways. Individuals can proactively prevent disease through avoidance behaviors. However, if they become infected, individuals can activate the immune response to control the infection. It is hypothesized that a trade-off occurs between avoidance behaviors and immune response activation because of costs associated with each strategy. Individuals may balance behavioral and immunological strategies to provide optimal protection against disease, but the physiological mechanism underlying this proposed trade-off is unknown. We conducted hormone-dosing experiments with the glucocorticoid corticosterone (CORT) to address this gap. CORT is produced as a result of activation of the hypothalamic-pituitary-adrenal (HPA) axis and induces a variety of physical and behavioral changes. Acute exposure to stressors that cause a short-term increase in CORT may boost the immune response of an individual and cause them to associate more with sick conspecifics. With a captive population of zebra finches (*Taeniopygia guttata*), we orally dosed focal birds with exogenous CORT immediately prior to hour-long association trials. We then inoculated birds with lipopolysaccharide (LPS) and collected blood samples to measure baseline and post-LPS acute phase protein (haptoglobin) levels. We predict that CORT-treated birds will spend more time with sick individuals and have higher average haptoglobin levels than birds from the control group. Studying the role of stress hormones in strategy utilization will bring insight into the persistence of variation in susceptibility to diseases.

P2.118 SCHULT, N.*; PITTENGER, K. ; DAVELOS, S.; MCHUGH, D. ; Colgate Univ., Hamilton, NY; *dmchugh@colgate.edu*

Phylogeographic analysis of an Asian invasive earthworm, Amynthas agrestis, in North America.

Amynthas agrestis Goto & Hatai 1899, an earthworm native to Japan and South Korea, was first documented in the United States in 1953 and has since been reported in over 20 states with noticeable negative impacts in hardwood forests. Known colloquially as Crazy Worms, Alabama Jumpers, or Snake Worms, individuals of *A. agrestis* reach up to 18 cm in length and exhibit a surprisingly lively behavior when disturbed from their epigeic habitat. We are undertaking a phylogeographic analysis of *A. agrestis* using sequences from the mitochondrial genes cytochrome-c oxidase subunit I (COI) and 16S rRNA. Our goal is to understand whether *A. agrestis* is becoming established in new areas through multiple, ongoing introductions or by dispersal along a leading front from an original southern introduction. Our analyses of populations of *A. agrestis* from sites in northern states show the presence of shared haplotypes across sites and similar levels of genetic variation within and among populations, suggesting multiple colonization events; there is no isolation-by-distance pattern for populations of this parthenogenetic worm. Frequent human-mediated jump dispersal of the worm, probably by transport within horticultural materials or as bait, may explain our results. We will discuss these results and our analyses of expanded sampling across the range of *A. agrestis*. Ultimately, we hope to understand whether ongoing transport occurs directly from the native habitats of *A. agrestis*, or from sites within North America, so that the spread of this invasive species might be minimized or controlled.

P2.129 SCHULTZ, NG*; LOUGH-STEVENS, M; ABREU, E; ORR, T; DEAN, MD; University of Southern California, West Adams Preparatory High School , University of Massachusetts Amherst; *ngschult@usc.edu*

How Many Times Did the Mammalian Baculum Evolve?

The rapid evolution of male genitalia is a nearly ubiquitous pattern across sexually reproducing organisms, likely driven by the evolutionary pressures of male-male competition, male-female interactions, and perhaps pleiotropic effects of selection. The penis of many mammalian species contains a bone called a baculum that similarly displays astonishing rates of phenotypic divergence over time. The evolution of baculum size and shape does not consistently correlate with any aspects of mating system, hindering our understanding of the evolutionary processes affecting it. One potential explanation is that the baculum is not actually a homologous structure. Since approximately half of mammalian species have a baculum, it could have been independently derived, which would violate the assumption of homology inherent in comparative studies. Here, we specifically test this hypothesis by modeling the presence/absence of bacula of over 800 mammalian species across a well-established phylogeny. Our results reveal high support for 6 independent gains and 6 independent losses of the baculum across mammals. Indicating that the baculum should not be considered a homologous structure, which may help to explain why there is a lack of ecological correlates for bacular morphology.

P3.141 SCHWAB, D.B.*; CASASA, S.; MOCZEK, A.P.; Indiana University; *schwabd@indiana.edu*

Investigating the ecological and evolutionary consequences of niche construction during dung beetle development

A growing body of work demonstrates that many organisms adaptively modify their developmental environment through their metabolism, activities, and choices through a process known as niche construction (NC), which has the potential to bias selective environments and alter the rate and direction of evolution. Here we assess the influence of NC on larval development in two species of *Onthophagus* dung beetles that differ in the duration of larval development, and hence the opportunity for larval NC to impact developmental outcomes. Larval *Onthophagus* develop in subterranean brood balls made of dung and constructed by their mothers. In both nature and the laboratory, *Onthophagus* larvae engage heavily in several putative niche constructing behaviors within this dung ball, including mechanical manipulation of the surrounding dung and the construction of specialized feeding and pupation chambers. However, the functional attributes and fitness consequences of these putative niche constructing behaviors are unclear. Here, we utilize a novel method for eliminating larval NC from the brood ball environment, and assess the effect of this elimination on developmental rate, adult body size, and relative investment into morphological structures. We predict that preventing larvae from modifying their environment will result in decreased performance across all developmental measures, and that this effect will be most pronounced in the species that spends the longest time inside the brood ball. Consistent with our predictions, results to date suggest that eliminating niche constructing behaviors reduces adult body size, and that this effect is stronger in species with extended larval stages, supporting a role for NC in developmental outcomes. Here we present our latest results and discuss them within the context of developmental plasticity and adaptation.

P1.10 SCHWARTZ, L.C.*; GONZALEZ, V.L.; GOETZ, F.E.; MASLAKOVA, S.A.; WIRSHING, H.H.; NORENBURG, J.L.; Muhlenberg Coll, Allentown, PA, Smithsonian Natl Mus Nat His, Washington, DC, Smithsonian NMNH, Washington, DC, Oregon Inst Mar Biol, Coos Bay, OR, Smithsonian NMNH, Washington, DC; *norenburgj@si.edu*

Carcinonemertidae: Ribbon Worms in search of their family history

Phylogeny within Nemertea has been well characterized by two multigene studies (Thollesson & Norenburg 2003, Andrade et al 2014a), whose broad consensus results were recently supported by a transcriptomics study (Andrade et al 2014b). A surprising result in both earlier studies was the placement of Carcinonemertidae as the sister-group to the suborder Distromatonemertea. Consensus understanding of carcinonemertid biology and their much-simplified anatomy - reflected in long-standing taxonomy - suggests they are highly derived within that suborder. We obtained transcriptome data for *Carcinonemertes epialti* and will have combined and reanalyzed it with the previous nemertean transcriptome data, to test the placement of Carcinonemertidae inferred by the previous multigene studies. Current possible hypotheses for phylogenetic placement of Carcinonemertidae with respect to Distromatonemertea are: 1) it is sister to the suborder as a) a basal lineage within it, or b) a member of the sister clade including Cratenemertidae; 2) it is a derived member of the suborder but a) its position reflects a rapid molecular clock, or b) it is an ancient surviving lineage among more basal lineages that have gone extinct. The highly reduced anatomy of carcinonemertids offers only one standard morphological feature with potential to inform these hypotheses; it is the synapomorphy for Distromatonemertea: rhynchocoel wall circular and longitudinal musculature having the state "bilayered" rather than "interwoven." To date, histological studies for any species of Carcinonemertidae have been inconclusive but new confocal microscopy images presented here weakly support the state "bilayered."

P3.193 SCIBELLI, AE*; TRIMMER, BA; Tufts University; *anthony.scibelli@tufts.edu*

Novel Approach to Characterizing Mechanosensory Feedback in Soft-Bodied Animals Using Manduca sexta

The ability of organisms to locomote efficiently depends on detecting key features within the environment. For soft-bodied animals moving in terrestrial habitats, most mechanical interactions deform the body more than for animals with stiff skeletons. It is not known how this affects the collection of sensory information or how such information is used to adapt ongoing behavior. To begin answering these questions we have used reduced preparations of the caterpillar, *Manduca sexta* to record the overall spike activity produced by cuticle sensory cells in response to a spectrum of stimuli. Traditional electrophysiological recording techniques requires cutting the body wall with extensive damage to the multi-dendritic neurons. We have developed a new preparation that inverts the animal without making longitudinal cuts or severing muscle attachments. This dissection technique maintains tension circumferentially on the body wall as well as keeping the trachea largely intact. Extracellular nerve recordings in this preparation can be maintained for ~2 hours and a wide variety of coordinated nerve activity is produced spontaneously. We are currently using this preparation to explore the effects of mechanosensory stimulation on the patterns of sensory and motor activity involved in different behaviors including crawling and defensive strike behavior. Preliminary recordings demonstrate the efficacy of this technique to record both tonic and phasic activity encoded by cuticle sensory cells.

P3.90 SECOR, S.M.*; ANDREW, A.L.; CASTOE, T.A.; University of Alabama, University of Texas at Arlington; *ssecor@ua.edu*

Single-cell RNAseq differentiates gene expression among cell types of the small intestine

RNAseq provides the ability to fully analyze comprehensively changes in gene expression. Our RNAseq studies on the small intestine of the Burmese python revealed approximately 1800 genes that are differentially expressed with the onset of digestion. For the python intestine, genes were equally downregulated or upregulated in expression with feeding, with expression patterns reversed upon the completion of digestion. With the aim of matching gene expression patterns to phenotypic changes of the intestine, specifically the structural and functional changes of enterocytes, we must however consider that the intestinal mucosa is composed of different cell types (e.g., enterocytes, smooth muscle, endocrine, immune, etc.), and that our tissue expression data reflects the combined expression pattern of each cell type. In order to generate cell-specific transcriptional data, we employed single-cell RNAseq on intestinal tissue from a 4-day postfed boa constrictor (*Boa constrictor*). Using the Fluidigm C1 platform, we constructed cDNA libraries from 54 live cells. Illumina RNAseq libraries created from these cDNA were pooled and sequenced. Analysis of single-cell gene expression enabled us to differentiate among, and to identify, distinct cell types of the boa's intestine. We therefore are able to identify divergent gene expression patterns across cell types, to link differential expression signatures to distinct cellular phenotypic responses, and to develop cell-specific signaling pathways.

P1.175 SEDDON, RJ*; HEWS, DK; Indiana State University; *rseddon@sycamores.indstate.edu*

Correlates of melaninization in multiple high and low-elevation populations of the lizard, Sceloporus occidentalis: aggression, testosterone, and stress reactivity

We study pleiotropic effects of mechanisms underlying pigment production. Melanin, and molecules regulating melanin, can directly and indirectly affect other traits such as aggression and stress physiology. Our earlier study revealed population differences in breeding-season male Sceloporus occidentalis from two elevations. Here we examine four additional populations (two high, two low). As expected, the two new higher-elevation populations were significantly darker than the lower-elevation populations. Principle-components analysis on behavioral responses to staged territorial intrusions revealed that males in the two darker (higher-elevation) populations were more aggressive than males in the two lighter populations, as we found in our earlier two-population comparison. Analyzing baseline plasma testosterone (TESTO) we found no differences associated with elevation and no differences among these four populations. Analyses of plasma corticosterone (CORT) revealed population differences in stress reactivity (CORT after 60-min of captivity) between high and low elevation populations. Hence these high- and low-elevation differences in aggression and stress-reactivity but the lack of an association of behavior with TESTO appear to be robust results. Assays of plasma -MSH are underway to determine if population differences in the melanization or aggression are associated with differences in plasma levels of this peptide.

P2.167 SELZNICK, L.A.*; JOHNSON, M.A.; Trinity University, Trinity University ; *lselznic@trinity.edu*

Evolution of lizard jaw morphology in association with diet and social behavior

Many animals utilize their jaw muscles to capture and consume prey, while some also use their jaws to bite competitors during combat. Jaw morphology may thus have evolved in association with diet, social behavior, or a combination of these factors. In this study, we use a diverse group of six lizard species to test the hypothesis that species with greater dietary niche breadth, those that consume other vertebrates, and those that use their jaws in combat, have larger relative head dimensions and jaw muscles. Three of our focal species are insectivores that are opportunistically saurophagous (i.e., consume other lizards): green anole lizards (*Anolis carolinensis*), Texas spiny lizards (*Sceloporus olivaceus*), and northern curly tails (*Leiocephalus carinatus*). The other three species in this study are exclusively insectivorous: Mediterranean house geckos (*Hemidactylus turcicus*), little brown skinks (*Scincella lateralis*), and spotted whiptails (*Aspidoscelis gularis*). Of this group, only green anoles regularly use jaws in male combat. For each of these six species, we collected dried jaw muscle mass of 3-6 males, and for 10 males per species, we measured SVL (snout-vent-length), body mass, head length, head width, and head depth. We estimated dietary niche breadth by the total number of taxonomic orders of prey consumed by each genus, as reported in the herpetological literature. Results show that saurophagous species had relatively greater jaw muscle mass and larger heads than non-saurophagous species, with green anoles (the species that uses biting in combat) exhibiting the largest jaw muscle mass of the group. In addition, dietary breadth was positively associated with relative jaw muscle mass. Together, these results suggest that jaw morphology has evolved as a function of both diet and social behavior in lizards.

P1.21 SEOK, R*; CHOU, J; FERRIS, A; SUZUKI, Y; Wellesley College; *rseok@wellesley.edu*

Investigating blastema-specific factors in limb regeneration in the flour beetle, Tribolium castaneum

Regeneration is characterized as a renewal process that restores lost body parts, organs and tissues in the appropriate dimensions and size. In organisms that can regenerate limbs, a key step in regeneration is the de-differentiation of cells to form a blastema. In this study, we sought to identify blastema specific factors in the flour beetle, Tribolium castaneum. An RNA-seq analysis identified a POU domain transcription factor as a potential blastema factor. Findings show that upon gene silencing, regenerating limbs were notably smaller, most likely due to decreased duration of blastema maintenance. A GFP enhancer trap line indicated that the expression of this gene is upregulated during the blastema maintenance phase. Thus, the POU domain transcription factor appears to regulate the duration of the blastema stage to ultimately regulate limb size.

P2.180 SHAH, S*; PATEL, H; KOLMANN, MA; LOVEJOY, NR; University of Toronto Scarborough; *swara.shah@mail.utoronto.ca*

Scaling of feeding biomechanics in two lineages of durophagous stingrays: alternative methods of high-performance feeding

Feeding performance in durophagous stingrays is typically associated with large jaw adductor muscles, a robust jaw skeleton, and rigid, interlocking teeth. All four genera within Myliobatidae have diets composed entirely of decapod crustaceans, bivalves, and gastropods. High bite forces allow juveniles to compete with adults and access these robust prey early in their ontogeny. Bullnose rays (*Myliobatis freminvillii*) and cownose rays (*Rhinoptera bonasus*) represent two evolutionary lineages of durophagous stingrays. Here we consider the anatomical basis of bite force generation in *Myliobatis*, and compare it to previously collected data for *Rhinoptera*. An ontogenetic series of 12 bullnose rays were dissected and the arrangement and size of their jaw muscles were used to estimate maximum bite force using a biomechanical model. Both species of ray have jaw adductor muscles that increase rapidly in size during ontogeny, driving positive allometry of bite force generation. We find that the primary jaw adductor muscle tendon functions as a biological pulley in both rays. This tendon redirects lateral muscle forces in a direction perpendicular to the occlusal plane. This tendon is less robust in bullnose rays compared to cownose rays. Cownose rays have a drastically wider gape, coercing the tendon to form a more acute angle over which muscle forces are redirected. We also detected differences in interactions between the tendon and jaw cartilage that likely effect the mechanical strength of the jaw.

P2.128 SHAKIR, R*; MOORE, BC; Sewanee: The University of the South; *shakirg0@sewanee.edu*

Gonadopodium morphology in Gambusia affinis collected from a municipal sewage treatment plant lagoon

Male *Gambusia* possess a modified, elongated anal fin, a gonopodium, which facilitates sperm transfer to females resulting in internal fertilization. Developmental exposure to hormonally active environmental factors has the ability to inhibit gonopodium development resulting in decreased male anal fin elongation. Elevated levels of hormonally active chemicals, such as pharmaceutical estrogens, may be found in wastewater treatment sewage plant waters. Here we study two populations of *Gambusia*: one from the local municipality drinking water source (Lake O'Donnell, Sewanee, TN) and another from the associated municipal sewage treatment plant. We investigated if male fish from the polluted treatment lagoons displayed altered or impaired gonopodium morphology, putatively with with shorter rays in their gonopodium, as compared to those of fish from the reference lake. We discuss our results in relation to the elevated levels of municipal pollution down-pipe from a large university and it's potential ability to de-masculinize wildlife.

P3.183 SHAW, C*; MELROY, L; BAIR, J; COHEN, S; University of New Hampshire, San Francisco State University; *calebshaw14@gmail.com*

Performance variation in Leptasterias spp. among populations and habitats

A clade of cryptic species of six rayed sea stars (Leptasterias spp). with limited dispersal potential are found in differing rocky intertidal habitats including protected pools and wave-exposed rocks. Field and laboratory performance tests were carried out with stars from pools and exposed rocks in Central California to test for behavioral differences associated with habitat type. It is hypothesized that individuals living on wave-exposed rock are less mobile because the selective focus is to hold tight to the rock to avoid being washed away. Conversely, sea stars from pool habitats are expected to show more flexible behavior as wave impacts are attenuated by pools. In this study, a careful methodology for field and laboratory comparison of behavior was developed and used to collect performance data on activity levels. Righting response, a standardized performance measure, was used for comparisons of rock and pool stars, and subsequently, stars were genetically barcoded to determine the phylogenetic clade composition of the habitat and behavior types. Pool stars were significantly faster in righting response in comparison to rock stars in field tests. Laboratory tests showed a similar pattern, and there may also be an effect of sea star size on righting response that was not detected in field comparisons. Barcoding revealed that there may be differences in clade composition between habitat types with the pool clade showing broader habitat distributions in comparison to the rock clade, compatible with greater activity measured in the righting response in the pool stars. These subtle variations in behavior or activity levels related to overlapping, yet differing habitat distributions, may help to explain the occurrence of multiple clades of cryptic Leptasterias spp. along the northeast Pacific coast.

P2.190 SHIGLIK, A*; BERG, O; MULLER, UK; CSU Fresno; *umuller@csufresno.edu*

The asynchronous flapping oscillator in house flies: mapping the parameter space by detuning wing mass

Beetles, flies, and bees flap their wings by an asynchronous mechanism: Wing strokes are not individually triggered by nerve impulses; rather, delayed stretch-activation allows the flight muscle to oscillate spontaneously when coupled to a resonant load. This type of 'distributed' control mechanism has advantages, such as neurological economy and robustness against perturbation, but the implications have not been fully explored. Previous studies found that asynchronous flappers are constrained to a narrow frequency range. We have constructed mathematical and mechanical models of delayed feedback oscillators that display additional complex dynamics that have not been observed in insects. We use high-speed video recordings of house flies to investigate how wing mass affects wing movements. To increase wing mass, we spray-paint the entire wing with a thin layer of spray-on make-up. We attach the fly to a wire and record the wing movements of the tethered fly at 6900 frames per second. We determine wing beat frequency and amplitude from the recordings. By mapping the dynamical parameter space displayed by a real insect we can determine whether the delayed feedback oscillator mechanism is sufficient, or whether additional control mechanisms are employed. We found that flies with increased wing mass are still able to fly and flap their wings. However, adding weight to the wings decreases the frequency of the flapping as well as increasing the amplitude of wing movement during each flap. This observation is consistent with our prediction that the wings behave like a harmonic oscillator and carries implications for the evolution of flight and robotics; a different result would have indicated that the dynamics are more complex or the control mechanism is neurologically rather than mechanically mediated.

P1.70 SHUMAN, J.*; SHIELS, L.P.; NICASTRO, L.K.; COUGHLIN, D.J.; Widener Univ.; *jshuman@mail.widener.edu*

Thermal acclimation and red muscle function in rainbow smelt (Osmerus mordax)

Rainbow smelt (*Osmerus mordax*), a eurythermal fish, swim in environments from -1.8˚C to 20˚C. These different temperature regimes pose distinct challenges to feeding and locomotion by smelt. The acclimation to cold by the red muscle of the smelt can be studied with the goal of understanding how these fish can swim in such different thermal environments. Swimming performance in warm vs. cold acclimated smelt was tested and a video analysis of the swimming was examined to determine average tailbeat frequency. The cold acclimated smelt had a faster maximum steady swimming speed and swam with a higher tailbeat frequency than the warm acclimated smelt. Muscle mechanics experiments demonstrated faster contractile properties in the cold acclimated fish. Histology, dot blot analysis, and RNA-SEQ indicate that there is a change in the myosin heavy chain composition and other muscle proteins of muscle with cold acclimation. In addition, increased expression of antifreeze proteins in cold acclimated smelt confirm that thermal acclimation has occurred.

P1.117 SHUMAN-GOODIER, M.E.*; SINGLETON, G.R.; PROPPER, C.R.; Northern Arizona University, International Rice Research Institute; *ms2883@nau.edu*

Pesticides Intensify Competition Between Invasive and Native Rice Paddy Amphibians

Butachlor, an anti-androgenic endocrine disruptor, is the most common herbicide used in rice agriculture throughout the Philippines and Southeast Asia. The recommended application rate of 4.8 mg/l is toxic to amphibians inhabiting rice ecosystems. However, several species are able to persist and even flourish in these modified habitats. To determine if two dominant amphibians in the Philippines exhibit developmental responses to butachlor exposure that influence interspecific competition, the following hypotheses were tested: 1) Differences in the developmental response of invasive *Rhinella marina* and native *Fejervarya vittigera* tadpoles to a low dose of butachlor render *R. marina* less susceptible 2) Due to compromised development, butachlor intensifies interspecific competition incurring an advantage to the less susceptible *R. marina*. A laboratory experiment was conducted at the International Rice Research Institute (IRRI), and *F. vittigera* and *R. marina* tadpoles were exposed both independently and in combination (competition) to an environmentally relevant concentration of butachlor (0.2 mg/L). Three initial results emerged. 1) When tadpoles were not in competition, butachlor exposure did not affect survivorship or activity. 2) In competition, butachlor treated water significantly lowered survival of *R. marina* tadpoles. No difference was observed in percent survival for *F. vittigera* across treatments. 3) *F. vittigera* were significantly less active than *R. marina* in competition. Preliminary outcomes indicated an interaction between susceptibility to butachlor and interspecific competition in two dominant rice paddy amphibians. However, the direction of this interaction was contrary to our hypotheses, suggesting that invasive *R. marina* is more sensitive to butachlor in a competitive environment than endemic *F. vittigera*.

P2.3 SIFUENTES, I*; TEZAK, B; WYNEKEN, J; MILTON, SL; Florida Atlantic University; *jwyneken@fau.edu*

Effect of incubation conditions on DNA methylation in turtles with environmental dependent sex determination

Temperature-dependent sex determination (TSD) is a mechanism by which temperature determines the sex of the embryo. Experimental studies with turtles presenting TSD suggest moisture conditions during egg incubation may influence sex determination, showing that wetter substrates produce males, whereas drier substrates produce females. This relationship is consistent with findings from field studies where sex ratios obtained from Loggerhead turtle (*Caretta caretta*) nesting beaches show a poor relationship with temperature recorded *in situ*. However, when the effect of moisture (particularly rainfall) is added to nest temperatures, sex ratio trends become more predictable. Still, the mechanisms by which environmental factors (temperature or moisture) affect sex determination remain unknown. It has been suggested that embryonic sex differences are initially determined by different patterns of nuclear DNA methylation. Evidence supporting this hypothesis was found in the American alligator (*Alligator mississippiensis*), where males showed elevated aromatase promoter methylation compared to females, while the opposite occurred in the *Sox9* promoter, displaying an inverse relationship between methylation and expression levels. These results led us to hypothesize that moisture can influence sex ratios in turtles via an epigenetic mechanism regulating the expression of sex determination/differentiation genes. Here we tested the effects of moisture on sex determination by exploring DNA methylation in the gonadal aromatase and *Sox9* promoter of the freshwater turtle *Trachemys scripta*. Such a mechanism would affect gene expression, and hence sex ratios, in species with environmental sex determination.

P3.31 SILVA, D.H.*; ÇAKMAK, I; HRANITZ, J.M.; BARTHELL, J.F.; GONZALEZ, V.H.; St. Mary's University, Uludağ University, Bloomsburg University, University of Central Oklahoma, University of Kansas; *dsilva15@mail.stmarytx.edu*

Pollinator composition in three types of unmanaged urban habitats

As an emerging field, urban ecology holds promise for advancing knowledge of bee foraging dynamics and advocating bee conservation efforts. A wide array of green spaces in urban areas constitute important reservoirs of both food and nesting sources for a diverse bee fauna. Such areas include undisturbed lots, recreational parks, botanical and zoological gardens, and open areas in university campuses, among others. The goals of this study were i) to assess the diversity and abundance of bees among three types of unmanaged urban habitats (woody areas, abandoned lots, and open areas) at the Uludağ University campus in Bursa, Turkey, ii) determine if changes in the diversity and abundance of bees are related to the diversity and abundance of plant species, and iii) assess changes in bee body size and guild composition (ground-nesting vs cavity-nesting) among habitats. We collected roughly one hundred species belonging to 28 genera of six families. Preliminary results suggest a negative correlation between bee species richness and increasing land cover as well as an increase in the abundance of cavity-nesting species.

P1.78 SIMMONS, S*; SATTERLIE, R; University of North Carolina Wilmington; *sls5653@uncw.edu*

Mesoglea and Muscle in Cubozoan Jellyfish Carybdea marsupialis and Tripedalia cystophora

The jellyfish body plan has remained relatively unchanged over time, and it has been quite successful evolutionarily. The origin of muscle from mesoderm is a central part of the investigation into the evolution of higher order (triploblastic) animals. Triploblasts have three embryonic germ layers: the endoderm, mesoderm, and ectoderm, which develop into organs, muscle, and skin. Diploblasts, lack mesoderm, the layer thought to give rise to the skeleto-muscular system. However, phyla such as Cnidaria and Ctenophora, typically classified as diploblasts, both possess striated musculature. Within Phylum Cnidaria, Class Cubozoa includes powerful, carnivorous, swimming box jellyfish that are capable of extending and contracting their tentacles for predation and defense mechanisms. We investigated the tentacle musculature of the cubomedusae *Carybdea marsupialis* and *Tripedalia cystophora* using transmission electron microscopy in conjunction with light microscopy to further understand the composition of the musculature in these primitive animals. Cross-sections of tentacular tissue exposed endodermal layers separated from ectodermal layers by a collagenous mesogleal layer. Muscle cells border the mesoglea, but remain separate from it, suggesting these muscle cells do not arise from mesoglea.

P3.72 SIMS, O.C.*; DEAROLF, J.L.; AVERY, J.P.; Hendrix College, Conway, AR, Univ. of North Florida, Jacksonville, FL; *simsoc@hendrix.edu*

Assessment of fiber-type profile and myosin heavy chain expression in the neonatal guinea pig rectus thoracis

To combat neonatal respiratory problems, glucocorticoids are frequently given to pregnant mothers at risk of premature delivery. Previous studies have examined the effect of multi-course exposure to these steroids on the fiber diameters, fiber-type profiles, oxidative capacity, and myosin heavy chain isoform expression in the rectus thoracis (RT), an inspiratory muscle, of fetal guinea pigs (*Cavia porcellus*). However, little is known about how the morphology of these muscles compares to that of the RT of a full term neonate (one-day old). This comparison will allow us to determine if the administration of prenatal steroids accelerates fetal muscle development. Antibody staining was used to identify and quantify the percentages of type IIX and IIA fast-twitch fibers. The diameter of these fibers was then measured using ImageJ. To determine oxidative capacity of the neonatal RT, citrate synthase activity was measured with enzyme kinetic assays. Finally, we assessed the neonatal RT myosin heavy chain profile with 7% acrylamide, 30% glycerol gels. Bands representing fetal, neonatal /IIA/IIX, and slow myosin were identified, and the proportions of each myosin present relative to the total myosin expressed were measured using ImageJ. The neonatal RT features will be compared to those of fetal muscles exposed to prenatal steroids using ANOVAs. If the characteristics of the muscles are not found to be significantly different, these results would support the hypothesis that multi-course prenatal steroids accelerate fetal breathing muscle development. Therefore, it would be suggested that steroid-treated preterm infants would be just as equipped to handle times of respiratory distress as full term infants.

P1.25 SINCLAIR, A.M.*; CROWTHER, L.N.; SIKES, J.M.; Univ. of San Francisco; *amsinclair@dons.usfca.edu*

Post-embryonic axis modification in the acoel Convolutriloba macropyga

The establishment of the anterior-posterior (A-P) axis is a defining characteristic of all bilaterians. While the molecular mechanisms specifying A-P axis polarity during embryogenesis are well characterized, the mechanisms utilized by asexual organisms to post-embryonically modify existing body axis polarity are not well understood. Radical alterations in axis polarity occur during reverse polarity budding in the acoel flatworm *Convolutriloba macropyga* when buds develop with A-P axis polarity completely reversed relative to the parent. We have identified a polarity transition zone characterized by a loss of muscle fiber organization at the base of each budding site. Unlike other regions, tissues excised from within this region fail to regenerate suggesting a transient loss of axis polarity. Chemical genetic screens have identified Hedgehog and Wnt signaling proteins as candidates for functioning in this disruption and reversal of the A-P axis during asexual reproduction in *C. macropyga*. By characterizing the spatiotemporal expression and function of specific Hedgehog and Wnt signaling components, we show that alterations in Hedgehog signals likely mediate a loss of axial polarity in the polarity transition zone and subsequent upregulation of Wnt signals allow for patterning of novel, reversed axes at the bud site.

P1.64 SINOTTE, V. M.*; FISHER, B. L.; University of Scranton, Scranton, California Academy of Science, San Francisco; *vmsinotte@gmail.com*

A male-based comparative morphological study of the mouthparts and genitalia of the genera of the subfamily Formicinae (Hymenoptera: Formicidae) in the Malagasy region

The morphology and reproductive physiology of male ants remain largely unstudied yet offer valuable insight into the phylogeny, diversity, and biology of the family Formicidae. We surveyed the morphological diversity of male ants in the subfamily Formicinae found within the Malagasy region. Generic characteristics of the eight extant genera of Madagascar (*Brachymyrmex, Camponotus, Lepisiota, Nylanderia, Paratrechina, Paraparatrechina, Plagiolepis*, and *Tapinolepis*) and the genus *Anoplolepis* of Seychelles were compared using multiple stage dissection and Leica imaging systems. Based on the morphology of the mouthparts and genitalia a dichotomous key was established to distinguish between genera. Characteristics such as the mandible shape, masticatory margin, vosella shape, and features of the aedeagus provide diagnoses for each genus. Further, we offer a general comparison between the tribes Plagiolepidini and Camponotini. We also identify characteristics such as multiple mandibular teeth and a suture between the basimere and paramere previously thought to be unique to the family Dolichoderinae. This study contributes to an ongoing male-based comparative study of major ant lineages of the Malagasy region. An improved understanding of male morphology and identification will facilitate new studies in ant reproductive biology and evolution. In turn, such additional characters, in conjunction with ongoing molecular studies, will contribute important features to delimit species and establish phylogenetic relationships.

P1.155 SINKIEWICZ, DM*; WILCZYNSKI, W; Georgia State University; *dsinkiewicz1@student.gsu.edu*

Regional expression of "vocal learning" genes in brains of Hyla cinerea

Acoustic communication, including vocalization, occurs in many animal species. Vocal animals produce either unlearned/innate sounds or a combination of both unlearned and learned sounds. Research into the molecular basis of vocalization has focused primarily on the production of learned sounds and has identified a suite of genes including *foxp2, foxp1, and cntnap2* as regulators of this behavior. Little is currently known about how this suite of genes is expressed in highly vocal species that only produce unlearned vocalizations. *Hyla cinerea* (green treefrog) is an organism that produces unlearned vocalizations. Additionally, only males produce vocalizations in this species. We determined if this network of genes (*foxp2, foxp1, and cntnap2*) is expressed in both a regionally specific and/or sex-specific manner. Male and female brains were trisected and RNA was extracted using TRIzol (Invitrogen). Transcription levels of *foxp2, foxp1, and cntnap2* were then measured in each brain region of each sex using quantitative PCR. Analysis revealed a regional difference in both *fox* genes with *foxp2* exhibiting highest expression in the midbrain when compared to either the forebrain or the hindbrain ($p<0.00001$). *foxp1* expression is significantly lower in the hindbrain than in either the midbrain ($p=0.0002$) or the forebrain ($p=0.035$). *cntnap2* did not exhibit a regional difference in expression. None of these genes exhibit a difference in expression based on sex. These data suggest that this suite of genes is not specifically tied to sex differences in vocal production, or that potential sex differences exist in specific brain nuclei that are lost in gross regional characterization.

P3.155 SIRMAN, A.E.*; SCHMIDT, J.E.; CLARK, M.E.; REED, W.L.; HEIDINGER, B.J.; North Dakota State University; *aubrey.sirman@ndsu.edu*

Role of insulin-like growth factor-1 in growth and seasonality in Franklin's gulls

Individuals often do not grow at their maximal rates and are capable of undergoing rapid, compensatory growth following developmental setbacks. One reason that this might occur is that rapid growth induces costs that reduce longevity. However, mechanisms underlying this link are poorly understood. One mechanism that might be important in this regard is insulin-like growth factor 1 (IGF-1). The IGF-1 signaling pathway is evolutionarily conserved and is positively related to growth and negatively related to lifespan across taxa. In this study, we experimentally manipulated growth rates in Franklin's gull(*Leucophaeus pipixcan*) and examined the effects on circulating IGF-1 concentrations. In this system, chicks that hatch later in the season grow at a faster rate than early-hatched chicks. We collected first laid eggs from 20 early-nesting and 20 late-nesting females and incubated the eggs in the lab. After hatching, chicks were reared in captivity and randomly assigned to either a control treatment in which food was available *ad libitum* or experimental treatment in which food was restricted to 60% of *ad libitum* between days 7-17 post-hatch. Prior to and after this period of restriction food was available *ad libitum*. This experimental treatment altered growth rates. Both early season and late season birds had reduced growth during the period of restriction ($P<.001$) and accelerated, compensatory growth following restriction ($P<.001$). We also examined the influence of the treatment on IGF-1 levels and the results will be discussed within the context of life-history evolution.

P1.48 SKANDALIS, DA*; GROOM, D; SEGRE, P; WELCH, JR., KC; WITT, CC; MCGUIRE, JA; DUDLEY, R; ALTSHULER, DA; Univ. of British Columbia, Vancouver, Univ. of Toronto Scarborough, Toronto, Univ. of New Mexico, Albuquerque, Univ. of California, Berkeley, Berkeley; *da.skandalis@gmail.com*

Hummingbird lift generation depends primarily on velocity within species but on wing area between species

The principles of aerodynamic lift generation imply that body weight support can be derived from any number of strategies depending on different combinations of species ecology, kinematics, and wing morphology. We show that across hummingbird species, scaling of lift generation is driven solely by hyperallometric growth of wing area, while tip velocity, air density, and lift coefficient are all size invariant. How this phenotype has arisen depends on whether it is an extension of phenotypes observed within species (i.e., developmental conservation), or is instead the result of selection. In contrast with the interspecific phenotype, but in accordance with the central role of wing velocity modulation observed in laboratory studies, hummingbirds exhibit intraspecific wing area hypoallometry and compensate with a strong dependence on wing velocity modulation. Hypoallometry of wing area within species likely minimizes muscle power requirements by reducing the wing moment of inertia, but potentially at the cost of reduced reserve burst power. Hyperallometric wing growth instead minimizes power requirements and maximizes reserve wing velocity, but at a large cost in torque. Though this evolutionary strategy has evidently been effective within the body size range of hummingbirds, the great muscle power requirements may have ultimately limited maximum hummingbird body mass.

P1.82 SKOLIK, RA*; WEBSTER, D; MENZE, MA; Eastern Illinois University; *raskolik@eiu.edu*

LEA proteins provide protection to cells and enzymes during water stress

LEA proteins are a group of hydrophilic polypeptides and have been linked to the survival of plants and animals during prolonged periods of water stress such as freezing and drying. LEA proteins occurring in the brine shrimp (*Artemia franciscana*) can be classified into 3 different groups (group 1, 3 and 6). The exact function of these proteins is still poorly defined. The aim of our study was to assess the impact of LEA proteins from *A. franciscana* on both enzyme activity and cellular function under water stress. The group 6 LEA protein AfrSMP, protected activity of the enzyme lactate dehydrogenase (LDH) in bacterial extracts during multiple freeze-thaw cycles, and about 12% higher activity was observed in extracts that contained AfrSMP compared to extracts lacking the protein. *Drosophila melanogaster* (Kc167) cells that concurrently express two different LEA proteins (AfrLEA3m and AfrSMP; tagged with fluorescence marker proteins), were challenged with NaCl concentrations ranging from 0.1 to 1 M and oxygen consumption was measured. Acute reduction in respiration with increasing salt concentration were similar in control and LEA expressing cells, and extracts of these cells did not exhibit LDH activity above non-transfected control cells when dehydrated. Our result may suggest that the large fluorescent tags hinder the function of LEA proteins. Cells expressing AfrLEA3m-GFP and AfrSMP-mCherry concurrently, showed about 12% higher proliferation rates than control cells when challenged with increasing sucrose concentrations over 48 h. While LEA function may be inhibited by GFP and mCherry, the fluorescent-tagged LEA proteins might still provide some cellular protection during prolonged water stress. Constructs to express untagged LEA proteins are currently being developed. Supported by NSF *IOS-1457061/IOS-1456809*.

P1.54 SLATER, G*; BOWSHER, J; YOCUM, G; SLATER, garett; North Dakota State University Fargo, ND, USDA-ARS Fargo,ND; *garett.p.slater@ndsu.edu*

Nuances in diet quality and quantity influence phenotypic dimorphism during honey bee (Apis mellifera) caste determination

Nutrition intake during the larval stage of holometabolous insects influences and fuels growth throughout metamorphosis. In social insects, differences in larval nutrition can regulate a profound reproductive division of labor. Provisioning by nurse bees differs between worker-destined and queen-destined larvae, and drives caste determination. Many studies have evaluated the dietary factors determining caste, but few consider how diet quantity might influence caste determination. We evaluated the influence of both dietary quantity and quality on caste determination by using the geometric framework. This powerful method gauges the interactions among nutritional components and allows us to evaluate if either specific dietary components, or multiple dietary interactions, determine caste in honey bees. Using in vitro rearing, we manipulated diet by varying both the macronutrient and quantity components. By following bees to eclosion, we were able to evaluate phenotypic differences between castes such as head, basistarsus and mandible dimensions along with eclosion weight and barbed stinger. Using untreated hive bees as a control, principal component analysis (PCA) was used to classify the experimental bees as queens, workers or intercastes. The results of this study will provide insights into the role of specific nutritional components in caste determination.

P1.189 SMALL, TW*; SCHOECH, SJ; Univ. Memphis; *twsmall@memphis.edu*

The stress-response phenotype has sex-specific impacts on lifespan and reproductive success in Florida scrub-jays

The rapid stress-induced elevation of plasma glucocorticoids (CORT) is well documented in a variety of animals. In many species, including Florida Scrub-Jays (*Aphelocoma coerulescens*), the magnitude and time course of increased CORT during a stressor varies greatly among individuals. In Florida scrub-jays, these among individual differences are repeatable throughout the adult lifespan (up to nine years), which indicates they are persistent aspects of the individuals' phenotypes. These hormonal differences are also correlated with a number of behavioral differences, such as the degree of neophobia, suggesting they are a part of a broader physiological-behavioral phenotype. Why this phenotypic diversity persists in the population is not known, but by monitoring jays throughout their entire lives (up to 14 years), clear sex-specific differences in lifespan have been documented. More stress responsive females (faster CORT release and higher levels of CORT during a stressor) live significantly longer than females that are less stress-responsive. However, the opposite relationship is true for males, with less stress-responsive males living significantly longer. Interestingly, life-long reproductive success (offspring surviving to adulthood) does not closely follow lifespan, and parental effort appears to differ between the phenotypes. This suggests that individuals of the same sex, but with different stress-responsive phenotypes, employ different reproductive strategies. Further, it suggests that males and females with similar phenotypes are either employing different reproductive strategies or that they incur different costs and benefits from employing similar reproductive strategies.

P3.143 SMITH, M.E.*; SCHIFFMACHER, A.; SPENGLER, J.; RICE, R.; GILBERT, S.F.; TANEYHILL, L.A.; CEBRA-THOMAS, J.A.; Millersville University, University of Maryland, Stowers Institute, University of Helsinki, Swarthmore College; *mesmith.mail@comcast.net*

Regulation of neural crest cell emigration in turtle embryos

Cells expressing neural crest markers emerge from the trunk neural tube in the turtle *Trachemys scripta* in two migratory phases over a greatly extended period. The NCCs that emerge late (in stage G16-17 turtle embryos), well beyond the stage of neural crest emigration in chick or mouse embryos, appear to migrate ventrally to form an ectomesenchymal dermis that gives rise to the bones of the plastron. Transfection with a GFP-expressing plasmid has shown that the early phase of migration is still occurring in stage G10, but not stage G12 turtle embryos. The specification of premigratory NCCs, and the epithelial-mesenchymal transition that produces migratory NCCs, is controlled by a gene regulatory network. We are currently comparing the expression of markers of premigratory and early migratory NCCs in G10 and later turtle embryos to examine whether the premigratory NCC domain persists during the period between the early and late migratory phases. Preliminary results have demonstrated the expression of Cad6B protein in the dorsal neural tube of G12 turtle embryos, suggesting the maintenance of the premigratory NCC population between the two phases of NCC migration. We are using antibody staining and in situ hybridization to confirm and extend these findings to additional genes expressed in premigratory NCCs, including the transcription factors *Snail2*, *Sox9*, *FoxD3*. If the expression of premigratory NCC markers persists after the first wave of NCC migration, it will suggest that the premigratory NCC region is maintained longer than in other model amniotes, and that the lack of NCC migration in stage G11-15 turtle embryos may be due to the absence of a supportive environment.

P1.35 SMITH, S.M.*; ARANOFF, G.; WILSON, G.P.; University of Washington; *ssmith7@uw.edu*

Quantitative dental ecomorphology reveals a wide range of mammalian dietary ecologies in the first 1 million years following the Cretaceous-Paleogene mass extinction

Two and three-dimensional quantitative dental surface data can be used to understand dietary ecology of extinct mammals using information from only one or a few teeth. We used these methods to investigate dietary ecology of therian mammals following the Cretaceous-Paleogene (K-Pg) mass extinction, to elucidate the tempo and mode of dietary change during the earliest Pg, a pivotal period in the evolution of modern mammalian diversity. Previous work has investigated change in mammalian dietary ecology at the K-Pg boundary, but has not extended later than the very earliest Pg (within 80,000 years of the extinction), and consequently has not captured changes in dental ecomorphology during the period of main faunal recovery. This recovery period lasted approximately one million years in western North America, during which the fossil record documents a change from species-poor "disaster" faunas to richer, more ecologically even "recovery" faunas. To fill this gap in our knowledge of the origins of mammalian dietary diversity, we studied 3D scans of tooth rows of earliest Pg mammals from the western interior of North America. We measured relief index (RFI), a homology-free ratio comparing 2D and 3D area of mammalian teeth, on µCT scans of 11 species of earliest Pg therian mammals and compared them to RFI values of extant species with known dietary ecologies. We also compared mean RFI values and ranges through time. Our results suggest a variety of dietary ecologies present in the earliest Pg, with higher RFI values, indicative of insectivory, in the Puercan 1 (Pu1) North American Land Mammal Age (NALMA), and an expansion into lower RFI values, indicative of the emergence of omnivory and frugivory, by the Torrejonian 1 (To1) NALMA.

P2.165 SMITH, H.J.; GOULET, C.L.; MAIE, T.*; Lynchburg College, St. Cloud State University; *maie.t@lynchburg.edu*

Scaling of feeding biomechanics in esocid species (Esocidae): Functional demands and ontogenetic constraints

When animals grow, the functional demands that they experience often change as a consequence of their increasing body size. In this study, we examined the feeding morphology and biomechanics of esocid species that represent three different mean size classes (Red fin pickerel, *Esox americanus*; Chain pickerel, *Esox niger*; Northern pike, *Esox lucius*) and how their bite forces change as they grow. In order to evaluate bite performance through ontogeny, we dissected and measured dimensions of the feeding apparatus and the jaw closing adductor mandibulae muscle complex across a wide range of body sizes. The collected morphological data was used as input variables for the anatomical model (i.e., MandibLever program) to simulate jaw function in these fish species. The peak bite forces estimated for the largest individual of each esocid species were: 2.29 N (frontal) and 5.04 N (deep bite) for *Esox americanus* (Total Body Length = 21.4 cm); 1.93 N (frontal) and 4.45 N (deep) for *Esox niger* (TBL = 24.4 cm); 26.7 N (frontal) and 60.5 N (deep) for *Esox lucius* (TBL = 59.1 cm). Our study provides insights into not only the musculoskeletal basis of the jaw function in esocid species, but also the feeding capacity of these species in relation to the functional demands they face during ontogeny as one of the piscivorous predatory fish in lake and river systems in North America.

P2.52 SMITH, GD; BERRYMAN, A*; ZANI, PA; FRENCH, SS; Utah State University, University of Wisconsin, Stevens Point; *alex.berryman@hotmail.com*

Latitudinal differences in response to an immune challenge in side-blotched lizards (Uta stansburiana)

Life history strategies are known to shift with latitude in some species. While body size, reproductive investment, and behavior have been studied for years, another crucial life history component is the immune system, which can influence an animal's survival. We housed side-blotched lizards from northern and southern portions of their range under controlled laboratory settings. Animals from each region were split into treatment groups of restricted diet or *ad libitum* feeding, and all animals received a cutaneous biopsy as an immune challenge. Lizards were bled at the end of the study for immunological and hormone assays. We found that southern animals had faster wound healing and stronger microbiocidal ability, but did not eat as much or gain weight like the northern animals. Differences in climate might be influencing the pace of life in these populations and causing differences in their immune response.

P2.150 SMITH VIDAURRE, G*; VEALE, A; RUSSELLO, M; WRIGHT, T; New Mexico State University, University of British Columbia-Okanagan; *gsmithvi@nmsu.edu*

Detecting genomic signatures of selection in an invasive parakeet (Myiopsitta monachus)

Human movement and trade have greatly accelerated the rate of biological invasions across the globe. Naturalized monk parakeet (*Myiopsitta monachus*) populations have established in multiple urban areas in the Northern hemisphere as a consequence of the pet trade. These populations present an ideal natural experiment for investigating the complex relationship between natural selection, genetic drift and adaptation following invasion. Previous research shows low neutral genetic diversity among naturalized populations compared to native South American populations. These patterns of low genetic diversity in the naturalized range suggest that either naturalized populations are adapting to selective regimes imposed by new environments, or populations are experiencing genetic drift, including population bottlenecks and founder effects. I am distinguishing between these hypotheses using a genome-wide approach, RAD-sequencing, to identify genes under selection among naturalized and native populations. My results show differentiation between native and naturalized populations, and overall, similar patterns of differentiation to a previous population genetics study. As diseases are among the foremost selection pressures experienced by colonizing populations, I am also working on a candidate gene approach targeted to immune-related major histocompatibility complex (MHC) and toll-like receptor (TLR) genes. This study of genetic adaptation on a genomic scale in a vertebrate invader will broaden our understanding of genetic change associated with biological invasions, and will set the stage for studies of phenotypic adaptation.

P2.192 SOTO, A*; MCHENRY, M.J.; Univ. of California, Irvine; *alberts2@uci.edu*

The pursuit strategy of predatory zebrafish

The outcome of a predatory encounter is determined by the strategy of both predator and prey. Biomechanical studies of these interactions in fishes have largely focused on the evasive maneuvers of prey, whereas the pursuit strategy of predators remains unresolved. We investigated the prey-targeting strategy of juvenile zebrafish (*Danio rerio*) by kinematic analysis of high-speed recordings of the pursuit of simulated prey, a dot that was projected on the wall of an aquarium. Consistent with pursuit-evasion models, we found that zebrafish predators employ a pursuit strategy in which their instantaneous velocity is aligned toward the prey. According to our modeling, this strategy does not minimize the time to capture, but offers accuracy for targeting of slow-moving prey. These findings give insight into the study of predator strategies and emphasizes the utility of integrating mathematical modeling with experimental approaches.

P1.77 SPAINHOWER, K.B.*; MEYERS, R.A.; Weber State University, Ogden; *kylespainhower@mail.weber.edu*

Fiber Type Distribution and Tail Muscle Function in Birds

The avian tail is used to facilitate locomotion and perform specific behaviors. For example, woodpeckers use their depressed tail as a prop to increase stability while climbing and drilling on trees. We used immunohistochemistry to quantify fast and slow fiber types in eight tail muscles from five Northern Flickers (*Colaptes auratus*), three Rock Pigeons (*Columba livia*), three Yellow-headed Blackbirds (*X. xanthocephalus*), two Red-winged Blackbirds (*Agelaius phoeniceus*), four Black-billed Magpies (*Pica hudsonia*), and one Western Scrub-Jay (*Aphelocoma californica*) to ascertain a relationship between fiber composition and behavior. Muscle fiber types differ in contraction speed: fast fibers are best suited for dynamic (i.e., locomotor) action while slow fibers are associated with postural functions. M. levator caudae (tail elevation) contained fast and slow muscle fibers in all species. M. depressor caudae (tail depression) was entirely fast in adult blackbirds, jays, and magpies; in flickers it contained a population of slow fibers. We believe that the slow fiber populations found in Mm. depressor caudae and levator caudae are correlated with distinct behaviors in these species. Birds generally maintain an elevated tail position against gravity implying a postural function for the slow fibers in levator caudae in all species. Woodpeckers rely on their tail for support during climbing and maintain it in a depressed position. Slow fibers in this muscle would facilitate isometric contractions of sustained tail depression associated with this behavior in flickers. Study of additional species of woodpeckers to validate the structure/function relationship is warranted.

P2.136 STABILE, F. A.*; MUSSER, J. M.; WAGNER, G. P.; Yale University, European Molecular Biology Laboratory; *frank.stabile@yale.edu*

Identification of four genes involved in the development of feathers but not scales in birds

Despite advances in our understanding of feather development and avian evolutionary history, little is known about the relationship between feathers and bird scales. To better grasp the relationship between these structures, we examined the genetics of developing feathers and scales in Leghorn chicken embryos. Using transcriptomics, we identified four genes that seemed specific to feathers—*Gata3*, *Ghrh*, *Akap12*, and *Tcf7l2*. These genes are thought to be involved in the development of the feather sheath, polarization, barb formation, and follicle growth, respectively. Whole-mount *in situ* hybridizations confirmed the activity of these genes in the feather buds of developing chicken embryos, but not the scales. To further demonstrate the feather specificity of these genes, we also performed whole-mount *in situ* hybridizations on the legs of Silkie chickens. Silkies are a unique chicken breed with many unusual features, including feathers in areas on the tarsometatarsus and phalanges where scutate scales are normally present. The expression patterns of these four genes on Silkie legs matched patterns observed on the Leghorn chickens. These experiments take advantage of natural morphological variation in chickens to show that the four genes identified by transcriptomics are truly specific to the feather, a morphological structure, rather than a particular location on the body. Thus, these four genes are specific to the development of feathers, but not avian scales.

P3.135 STANHOPE, ME*; PASCUAL, MG; LAMEYER, TJ; CHI, M; SHEA, DN; MARDER, E; SCHULZ, DJ; DICKINSON, PS; CHRISTIE, AE; Bowdoin College, University of Hawaii, Manoa, Brandeis University, University of Missouri, Columbia; *mstanhop@bowdoin.edu*

Expanding the lobster, Homarus americanus, neuropeptidome using in silico transcriptome mining

Peptides are the largest and most diverse class of molecules used by nervous systems for chemical communication; neuropeptides play critical roles in modulating essentially all aspects of physiology and behavior. While many methods have been used to identify neuropeptides, *in silico* transcriptome mining has recently become one of the most powerful strategies for peptidome elucidation. The lobster, *Homarus americanus*, is a crustacean of commercial and biomedical importance; considerable effort has already gone into identifying its native neuropeptides. Here, a lobster neural transcriptome was mined for transcripts encoding putative neuropeptide precursors. Using known proteins as query sequences, 30+ pre/preprohormone-encoding transcripts were identified, with nearly 200 distinct neuropeptides predicted by subjecting the deduced proteins to a well-vetted bioinformatics workflow. Included in the predicted peptidome were isoforms of adipokinetic hormone-corazonin-like peptide, allatostatin A, allatostatin C, bursicon, CCHamide, corazonin, crustacean cardioactive peptide, crustacean hyperglycemic hormone, diuretic hormone 31, diuretic hormone 44, eclosion hormone, FLRFamide, GSEFLamide, insulin-like peptide, intocin, leucokinin, myosuppressin, neuroparsin, neuropeptide F, orcokinin, pigment dispersing hormone, proctolin, pyrokinin, SIFamide, sulfakinin and tachykinin-related peptide. While some of the predicted peptides are known *H. americanus* isoforms, most are novel identifications, more than doubling the extant neuropeptidome for the lobster.

P1.5 STAUB, NL*; POXLEITNER, M; BRALEY, A; SMITH, H; PRIBBENOW, C; JAWORSKI, L; LOPATTO, D; ANDERS, K; Gonzaga University, Univ. of Wisconsin, Madison, Grinnell College; *staub@gonzaga.edu*

Scaling Up: Adapting a Phage-hunting Course to Increase Earlier Participation of Students in Research

Authentic research experiences are valuable components of effective undergraduate science education. Furthermore, research experiences during the first two years of college are especially critical to increase persistence in STEM fields. To offer a research experience for all students (350+) in Gonzaga University's introductory biology course, we modified the traditional two-semester Phage Hunters course (SEA-PHAGES) by streamlining the first semester experience and integrating research from the second semester lab into upper division courses. Both quantitative and qualitative assessments indicate that the learning gains of our one-semester phage discovery course are significant and are comparable to other course-based research experiences.

P3.181 STEELE, AN*; STRASBURG, ML; MARTIN III, AL; Saginaw Valley State University; *almarti2@svsu.edu*

Can Crayfish Distinguish Between Variable Oxygen Concentrations?

Species inhabit a variety of aquatic habitats that can fluctuate between hypoxic and normoxic conditions throughout a season. Many aquatic species exhibit changes in behavior when exposed to hypoxic conditions. Crayfish have been shown to experience adverse physiological effects due to hypoxic waters, but little is known about the crayfish's ability to exhibit a behavioral preference in the presence of variable oxygen concentrations. The purpose of this study was to analyze the responses of the invasive crayfish, *Orconectes rusticus*, when exposed to varying levels of oxygen. Each animal was placed in a y-maze with each arm containing water of different oxygen concentrations, ranging from 2 to 8 mg O_2 l^{-1}. A current of 10 cm/sec was run through each arm of the y-maze. A series of three experimental scenarios were tested and included 8 v. 2 mg O_2 l^{-1}, 8 v. 4 mg O_2 l^{-1}, and 8 v. 6 mg O_2 l^{-1}. A total of 25 trails were completed for each experimental setup. After each set of trials, data was analyzed based on initial arm choice, time spent in each arm, and time spent at the upmost upstream position. Preliminary data has been quantified and is being analyzed to assess if crayfish exhibit a preference for environments with higher O_2 concentrations.

P3.127 STEIN, C.S.*; SCHRAM, J.B.; MCCLINTOCK, J.B.; Univ. of Alabama at Birmingham; *cwstein@uab.edu*

Gastropod dentistry: An analysis of teeth in two Antarctic species

Antarctica is a model environment for the study of the effects of anthropogenic climate warming and ocean acidification. Only a small number of studies have investigated the prospective effects of warming and acidification on shells of Antarctic gastropods, and to date there have been no studies on the radula, a key component of feeding anatomy. The purpose of the present study was to determine the prospective impacts of increased seawater temperature and decreased pH on radula tooth condition (evidence of dissolution, erosion, or breakage) of two common benthic Antarctic gastropods, the limpet *Nacella concinna* and the topshell snail *Margarella antarctica*. We exposed individuals of both species over a 6-week period to combinations of pH and temperature based on current ambient conditions (pH 8.0, 1. 5ºC) and those predicted for 2100 (pH 7.8, 3.5ºC). Following exposure, the radulae were dissected and mounted for observation using light microscopy and SEM. The docoglossate radular teeth of the limpet *N. concinna* showed no significant differences in tooth condition among the pH/temperature treatments. An evaluation of rhipidoglossan radulae of *M. antarctica* from the different treatments is currently underway. Our results to date indicate that the radula of the most common Antarctic limpet, *N. concinna*, is resistant to near-future pH and elevated temperature.

P2.97 STEINKE, K.B.; COLLIN, R.*; Western Washington University, Smithsonian Tropical Research Institute; *steinkk@students.wwu.edu*

How environmental variation affects the reproductive cycle and brood size of a tropical Chthamalus species

Stable environmental conditions in the tropics promote breeding year round in intertidal invertebrates but reproduction is still influenced by abiotic factors. Reproduction often responds to where animals are in the intertidal and larval release is more time-restricted as you move higher up. Biotic factors play a key role and crowding can reduce reproductive effort. We studied a tropical *Chthamalus* species to see if reproduction varies with tidal height, temperature or crowding. We gathered barnacles from two tidal heights in the Bay of Panama and measured percent brooding, maternal dry weight and brood dry weight. We used animals from three proximity levels to their neighbors. To see if temperature has an effect on reproduction we altered the surface color of various barnacle patches. There was no clear semi-lunar or monthly reproductive cycle. Barnacles in the mid-intertidal were more likely to be brooding than those higher up. Barnacles in the high intertidal had a drop in percent brooding during the week of the new moon in July but not in August. There was an interaction effect of tidal height and crowding on the relationship between brood weight and maternal size. Partially crowded barnacles in the mid-intertidal had a steeper increase in brood size with maternal body weight than massed or solitary animals. Barnacles under reduced temperatures had a greater increase in brood size with maternal body weight than controls or those under increased temperatures. The results suggest that settlement site and temperature have an effect on *Chthamalus* reproduction. We collected our data in the wet season and it will be notable to see if they show the same pattern during the dry season and if events like the current El Niño affect their reproduction.

P3.205 STERCULA, J.M.*; ROBERTS, J.L.; JOHNSON, M.A.; Trinity University; *jstercul@trinity.edu*

Temperature influences lipid composition and membrane fluidity in lizard brains

Lipids, the defining feature of biological membranes, allow cells to remain viable across varying temperatures through changes in membrane fluidity, the extent of disorder in the lipid bilayer. At high temperatures, lipid tails are long and saturated, stabilizing the membrane in a liquid-solid phase. As temperature decreases, double bonds in acyl chains produce kinks in lipid tails, stabilizing the membrane in a solid-liquid phase. Membrane fluidity further affects the functions of proteins in the bilayer, altering critical cellular functions. However, little research has addressed how temperature differences within and across species affects lipid composition and membrane fluidity in the brain. Here, we test whether lizards that experience similar temperatures maintain similar membrane fluidity by adjusting the ratio of specific membrane lipids. First, we performed a field study comparing brain lipid composition in seven Puerto Rican *Anolis* species in habitats of varying temperature. Next, we conducted a laboratory experiment in which *Anolis carolinensis* lizards were housed in a hot (34°C) or cool (26°C) room to directly determine how temperature influences brain lipid content. In both studies, we use qualitative mass spectroscopy analysis of cell membrane extracts from whole brains to describe lipid composition as a function of temperature. Lastly, we cultured astrocytes from *A. carolinensis* brains at 28°C and 35°C to measure differences in cell growth and lipid synthesis, and to directly quantify plasma membrane fluidity by fluorescent polarization. Results show that cells at 28°C grow more rapidly, and the abundance of lipid droplets in the cells varies with temperature. Together, these results will improve our understanding of how organisms respond to a rapidly changing environment.

P2.142 STERN, JH*; SMITH, WL; University of Kansas; *jenny.stern1@gmail.com*

Recurrent Evolution of Venomous Spines in Cartilaginous Fishes

Venom is present in a diverse array of life, and its associated delivery mechanisms have been described in arachnids, cephalopods, cnidarians, crustaceans, insects, reptiles, mammals, and fishes (cartilaginous and bony). While most animals use their venom offensively, bony and cartilaginous fishes tend to utilize venom defensively. We have looked in detail at structural and anatomical variations in spines and accompanying venom glands across a variety of selachimorph families (e.g., Centrophoridae, Squalidae, Etmopteridae, Dalatiidae, Heterodontidae, and Somniosidae). There is significant morphological variation present both between and within families. We document variation in the size and shape of dorsal spines and their associated venom glands. The morphology, connectivity, and evolution of elasmobranch spines is relatively understudied in the literature. By using anatomical and molecular data, we developed a hypothesis of the recurrent evolution and impact of dorsal spines, and likely venom, in cartilaginous fishes.

P3.16 STERN, D.B.*; CRANDALL, K.A.; The George Washington Univ., Compuational Biology Insitute; *dbstern@gwmail.gwu.edu*

Comparative Vision Gene Expression in Cave Adapted Crayfish

The repeated evolution of convergent morphologies in cave adapted organisms, across widely divergent taxonomic groups, has long fascinated biologists. Evolving to live in the absence of light, many cave organisms are blind with reduced or absent eyes, yet genes involved in light-interaction and eye development are often still intact in the genome. This suggests that evolutionary and developmental changes in gene regulation may be responsible for the observed phenotypes. Freshwater crayfish present an excellent system to study this phenomenon in a phylogenetic framework. The phylogeny of the group is relatively well understood and a number of independent lineages have invaded caves at different points in time and in different geographic locations. This provides evolutionarily independent replicates of the process, increasing the power of comparative analyses. Additionally, many genes in involved in phototransduction, circadian rhythms and eye development have been identified in related organisms, facilitating transcriptome annotation and PCR primer design. We used RNA-seq to compare eye transcriptomes of cave and surface crayfish. We then identified differentially expressed genes, taking into account phylogeny and intra-specific variation. Candidate genes involved in vision loss will be used in a greater phylogenetic context to reveal how evolutionary changes in gene expression result in convergent phenotypes in cave organisms and further unravel the genetic mechanisms of vision in decapod crustaceans.

P3.201 SUCHYTA, KJ*; GOROFF, MS; QU, X; DICKINSON, ES; HARMON, K; JOHNSON, AS; ELLERS, O; DICKINSON, PS; Bowdoin College, Brunswick, ME; *ksuchyta@bowdoin.edu*

Mechanisms of Stretch Feedback and Interactions with Neuromodulators in the Cardiac Ganglion of the American Lobster

Organisms' production of rhythmic behaviors is controlled by central pattern generators (CPGs), whose output can be modulated by neurotransmitters, such as the peptide, SGRNFLRamide (SGRN), as well as by sensory feedback. The cardiac ganglion (CG) of *Homarus americanus* is a CPG that consists of 4 premotor and 5 motor neurons, which are electrically and chemically coupled and thus produce synchronous driver potentials (DPs) that generate bursts of action potentials to drive cardiac contractions. We examined the role of stretch in altering the CPG by isolating the CG along with muscles surrounding and underlying the premotor cells. We recorded intracellularly from a motor neuron, while stretching the muscle fibers. Tonic stretch decreased DP cycle periods and increased burst durations as a function of force. The effects were larger in motor neurons with longer intrinsic burst durations. When perfused with 10^{-9}M SGRN, the effects on the CG due to stretch were enhanced, while 10^{-8}M SGRN decreased the effects of stretch. Mathematical modeling is one way to tease apart the components of a complex system to test hypotheses. One model that has been used to examine the CG is the Morris-Lecar model, which uses two model ionic currents and can reproduce a variety of oscillatory behavior. Starting with two Morris-Lecar oscillators (representing premotor and motor neurons), coupled by electrical and excitatory synapses, we added an additional current to model stretch feedback and ran the model with multiple reversal potentials. Many simulations mirrored some of our experimental results, including state-dependent relationships, but none reproduced all of the effects we have seen experimentally.

P3.149 SUR, A.*; MEYER, N.P.; Clark University; *asur@clarku.edu*

Spatio-temporal expression pattern of neurogenic homologs reveals a possible role in early neurogenesis in Capitella teleta

How centralized nervous systems (CNSs) evolved remains an unresolved question. Previous studies in vertebrates and arthropods have revealed that similar neurogenic homologs regulate their CNS development. Such genes regulate important cellular processes like cell proliferation and differentiation. Here, we have isolated and studied the spatio-temporal expression patterns of neurogenic homologs in the annelid *Capitella teleta*, which belongs to a separate bilaterian clade (Spiralia) as compared to arthropods (Ecdysozoa) and vertebrates (Deuterosomia). This will help identify which aspects of bilaterian neurogenesis may have been ancestral or were derived within Spiralia. During *C. teleta* brain neurogenesis, neural precursor cells (NPCs) in the surface ectoderm proliferate and generate daughter cells that begin to exit the cell cycle, ingress inward, and generate neural subtypes. Using whole mount in-situ hybridization, *Ct-soxB1* was detected in surface cells in the neuroectoderm whereas *Ct-soxB* was detected in overlapping domains of *Ct-soxB1* expression, which indicates a possible interaction between the two classes of soxB factors similar to vertebrates. *Ct-msi* is expressed in a similar pattern as *Ct-notch* and *Ct-delta*, which might indicate involvement with the Notch pathway. *Ct-pros* expression suggests a possible role in specification of neural fate in early development of *C. teleta*. *Ct-ngn* is expressed in superficial cells, similar to *Ct-ash1* and *Ct-soxB1*, whereas, *Ct-neuroD* is expressed in more internalized cells. Functional studies will help understand the role of these homologs during *C. teleta* neurogenesis.

P1.148 SWAFFORD, A.J.*; OAKLEY, T.H.; Univ. of California, Santa Cruz; *Andrew@Swafford.com*

Gain and Loss of Sensory Modalities Alter Guidance of Allomyces Zoospores

Understanding the evolution of complex traits has piqued the interest of the scientific community for decades. However, it is difficult to identify clades simple enough to allow for easy manipulation, yet with enough diversity to display multiple sensory modalities across a manageable taxonomic distance. An early diverging lineage of fungi, genus *Allomyces*, reproduces via motile zoospores. These zoospores must rely on external cues in order to move towards, and settle at, a favorable location. Previous literature has demonstrated that *Allomyces* zoospores are known to respond to either light or chemical stimuli. I investigated the evolutionary history and zoospore-specific sensory suites in three species: *A. reticulatus* (*AR*), *A. arbuscula* (*AA*), and *A. macrogynus* (*AM*). Behavioral experiments revealed that zoospore movements of *AR* are guided solely by phototaxis; *AM* are guided only by chemotaxis; *AA* rely on both photo- and chemotaxis. Further analysis showed differences in the ability/preference of *AA* and *AM* zoospores in response to amino acid gradients. Phototactic behavior in *AA* is preferentially sensitive to Blue(480nm) and Green(530nm) over Red(600nm) light; a similar action spectrum to *AR* zoospores. My comparisons of new *AR* transcriptomic data and existing *AM* genomic data found an Opsin/Guanylyl-cyclase fusion gene(OpGC) present in both species. PCR showed no evidence of OpGC expression in *AM* zoospores. This, along with species-specific differences in the side-body complex, may have led to loss of photoreception in *AM*. Informed by a phylogenetic analysis of Blastocladiomycota, I conclude that there have been several critical shifts in zoospore sensory suites throughout the phylum.

P2.72 SYKES, D*; SURIYAMPOLA, P; MARTINS, E; Indiana University, Bloomington; *sykesd@indiana.edu*

Previous experience in complex habitats increases aggression and group cohesion

Early rearing environment can have a lasting impact on sensory systems and social behavior. Here, we asked whether previous experience has a similar impact on adult behavior of zebrafish *(Danio rerio)*. We housed groups of six adult fish in either an empty aquarium or in an enriched physical context with plastic vegetation and clay pots. After 30 days, we assayed each group in two novel arenas (an empty aquarium and an enriched physical context) and used an optomotor assay to test visual response. Fish with previous experience in the enriched physical context shoaled more closely together and chased each other more frequently than fish that were housed in an empty arena. Fish with previous experience in the enriched physical context also responded more vigorously to the optomotor assay than did fish that had been housed in an empty arena. These effects depended, in part, on the assay context and sex. The previous experience effect on shoaling was more pronounced when assayed in the enriched physical context, whereas the previous experience effect on aggression was more pronounced in the empty testing arena. Taken together these results suggest that previous experience affects both visual response and social behavior in adult zebrafish.

P3.40 SZUTER, EM*; SABREE, ZL; BENOIT, JB; University of Cincinnati, Cincinnati, OH, The Ohio State University, Columbus, OH; *szuterem@mail.uc.edu*

Midgut microbiota and overwintering: are bacterial symbionts necessary for the northern house mosquito, Culex pipiens, to prepare for diapause?

The northern house mosquito, *Culex pipiens*, is a pest species that is capable of serving as a vector for diseases such as West Nile Virus and St. Louis encephalitis. Diapause is essential for this species to successfully survive adverse winter conditions and is marked by increased lipid storage and reduced activity levels. Although much is known about the physiological and molecular underpinnings of mosquito diapause, how microbial symbionts influence this complicated process has been largely ignored. This could represent a substantial gap in diapause knowledge, as microbial symbionts have been repeatedly shown to influence various physiological processes in mosquitoes. Illumina sequencing of 16s rRNAs revealed that community profiles do not differ significantly between diapausing and nondiapausing individuals. This suggests that there is no specific midgut microbial community associated with *C. pipiens* diapause. Although a specific community profile is not necessary to undergo diapause, preliminary studies suggest that the presence of microbiota can alter lipid accumulation during diapause preparation. Specifically, diapausing females lacking gut bacteria accumulate proportionally less lipid reserves than their nondiapausing aposymbiotic counterparts. Future, studies will examine the mechanism in which the microbiota affects lipid accumulation and whether the reduced lipid stores affects survivorship or fecundity post diapause.

P2.33 TABOR, SW*; MOODY, SC; WORLD, CJ; BERNER, NJ; MINEO, PM; Berea College, Sewanee: The University of the South, Sewanee: The University of the South; *Patrick_Mineo@berea.edu*

Does membrane composition affect whole-animal performance and thermal tolerance in the eastern newt (Notophthalmus viridescens)?

To maintain membrane function at low temperature, many ectotherms that live in temperate climates incorporate more polyunsaturated fatty acids (PUFAs) into their membranes in winter. The eastern newt (*Notophthalmus viridescens*) uses thermal acclimation to remain active throughout the year. Winter-acclimated newts swim faster at low temperature and have higher activities of metabolic enzymes in skeletal muscle compared to summer-acclimated newts. The muscle membranes of winter-acclimated newts also have higher PUFA contents compared to summer-acclimated newts, and northern populations have muscle membranes with higher PUFA contents than southern populations. However, it is not clear how seasonal membrane remodeling and differences in membrane composition between populations affects whole-animal performance. To determine if the remodeling of membranes affects thermal tolerance and the thermal dependence of swimming performance, we manipulated membrane composition independently of acclimation temperature. Newts were separated into four diet regimes: high saturated fatty acid (SFA), high monounsaturated fatty acid (MUFA), high omega-3 PUFA, and high omega-6 PUFA for 12 weeks. All newts were housed at 20˚C (12L:12D). Next, we measured the swimming speed of newts at a range of temperatures between 6-33.5˚C. We also measured the lower critical temperatures (CT min) and upper critical temperatures (CT max) of newts.

P3.121 TAFT, NK; HENCK, HE*; University of Wisconsin - Parkside; *henck001@rangers.uwp.edu*

Variation in stiffness among fins of the yellow perch Perca flavescens by different preservation techniques.

Fish use their fins for propulsion and maneuvering in a three-dimensional environment. In addition, many fishes use their fins for more specialized behavior like crawling or holding onto the substrate. The bony, segmented fin rays (lepidotrichia) support and control the relative shape and position of the fins, and are therefore critically important for fin function. The yellow perch, *Perca flavescens*, is a species that uses its fins for a variety of behaviors. For example, the pelvic fins can be used to interact with the bottom as well as for maneuvering in the open water. Here, we examine the variation in stiffness of the fin rays both within and among the paired and median fins of the yellow perch. It is not always possible to get fresh specimens, here we investigate how preservation techniques, (fresh vs. freezing and preserving with formalin followed by storage in alcohol), affects fin ray stiffness. We performed three point bending tests using an Instron model 5942 testing apparatus to compare stiffness in a sample of fin rays from all soft fins (pelvic, pectoral, soft dorsal, anal and caudal) of the yellow perch. For all specimens, we found that the pelvic rays were significantly stiffer than the other fins and the pectoral fins the least stiff. We also found no significant difference between fresh and frozen specimens in fin ray stiffness. We predicted that the fixed fin rays from the preservation in formalin and storage in 95% ethanol would be stiffer than the fin rays of fresh and frozen specimens. We found that preservation in formalin resulted in decreased stiffness of smaller rays, < 25 mm long. Overall, the trends in the relative stiffness among the fins was consistent in all specimens, regardless of preservation method.

P1.73 TAHIR, U*; NISHIKAWA, KC; Northern Arizona University; *ut5@nau.edu*

Effect of activation on force velocity properties of muscles during cyclical length changes.

The sliding filament theory was proposed over 50 years ago and remains largely unchanged despite the fact that it fails to predict a number of important muscle properties. These properties enable muscles to change their force output in response to changes in load, length and velocity instantaneously without input from the nervous system. The force velocity relationship (FVR) describes how muscle force decreases with increasing shortening velocity, up to maximum shortening velocity, Vmax, and how muscle force increases with increasing stretch velocity. The FVR is typically attributed to the attachment and detachment kinetics of the cross bridges, but is often only studied in supra-maximally activated muscles in after-loaded isotonic contractions. This relationship can also be obtained from experiments in which muscles experience cyclical length changes demonstrating history dependent properties. The goal of the present study was to use work loop experiments to investigate how the FVR of muscles varies with activation. Soleus muscles from mice were isolated and attached to a force lever that measured muscle force and length during imposed length changes. Muscles were stretched and shortened cyclically over a range of lengths from ±2% to ±10% of optimum muscle length and activation levels of 100% to 0% of maximum activation. Force velocity curves were constructed from the data at all activation levels. Though seldom studied, passive muscles also display a force-velocity relationship. The curves were scaled to maximum activation to compare their shapes at different activation levels. Preliminary data suggest that force velocity curves from active muscles scale linearly with activation. The shape of the force-velocity curve differs between passive and active muscles, suggesting that a mechanism other than the cross bridges may contribute to the FVR in passive muscles.

P3.206 TATA, CM*; HENRIQUEZ, SA; MARTINEZ-ACOSTA, VG; Alamo Heights High School, The Atonement Academy, Univ. of the Incarnate Word; *vgmartin@uiwtx.edu*

Observations of regenerative and behavioral properties of Eisenia fetida.

Eisenia fetida (common name: red worm) is a member species of the phylum Annelida, which generally encompasses segmented worms. Eisenia is a terrestrial species that functions as a decomposer and is noted for its ability to survive after fragmentation, whether artificial or natural (Xiao, Ge, & Edwards 2011). The purpose of this experiment was to determine the regenerative properties of Eisenia fetida and whether or not this species might also be used as a model for regeneration. It was hypothesized that the anterior fragments would be more successful in regeneration and survival than the posterior fragments. The results of this study indicate that Eisenia do not regenerate as fast or as well as Lumbriculus, although they do exhibit relatively consistent behaviors and physical changes during wound healing and regeneration. These changes, that appear mainly in the posterior fragments, include adapting head behaviors and fissioning. The anterior fragments showed unexpected behavior as well by going into a state of hibernation and then dying soon after. Overall it was found that Eisenia worms are not a good model for regenerative investigations as compared to Lumbriculus variegatus.

P2.191 TATOM-NAECKER, T*; WESTNEAT, M.W.; Univ. of Chicago, Illinois; *ttatomnaecker@uchicago.edu*

Sand-diving kinematics in the slippery wrasse, Halichoeres bivittatus (Labridae)

Sand-diving, a behavior documented in the three fish families Creedidae, Trichonotidae, and Labridae, consists of a headfirst plunge into the substrate followed by undulatory axial body movements to completely bury the fish. Previous behavioral work has shown that sand-diving is a predator avoidance and energy conservation behavior. The kinematics of this behavior remain unstudied, however. We employed high-speed video to analyze sand-diving by the slippery wrasse, *Halichoeres bivittatus* (Labridae). Seven captive *H. bivittatus* were induced to bury in small aquaria containing crushed coral gravel substrate. Sand-diving events ranged in duration from 1.05 to 3.06 seconds. Coordinate points digitized along the body midline of the fish for each frame of the diving event were used to calculate kinematic variables. Kinematic and visual analyses show that sand-diving of *H. bivittatus* is composed of two distinct phases of undulatory axial body movements. The first phase is characterized by body undulations with high frequencies and wave speeds and low amplitudes. Individuals remain orientated approximately perpendicular to the substrate as they bury. The second phase begins when individuals are between halfway and two-thirds buried. Undulations visibly slow and individuals orient more parallel to the substrate. Body undulations have lower frequencies and wavespeeds and higher amplitudes than during the first phase. The two phases of sand-diving in *H. bivittatus* have implications for slurry exploitation, as the initial high frequency undulation may serve to liquefy the substrate, creating a slurry through which the animal can more efficiently bury itself during the second phase. This project was funded by NSF grant IOS-142549.

P3.96 TENNETT, K.A.*; COSTA, D.P.; FISH, F.E.; West Chester University, Univ. of California, Santa Cruz; *kt753341@wcupa.edu*

Kinematics of terrestrial locomotion of northern elephant seals

The aquatic specializations of phocid seals has restricted their ability to locomote on land by primarily using spinal flexion. This terrestrial gait has limited the performance (i.e., speed, endurance) of phocids. The northern elephant seal, *Mirounga angustirostris*, is the second largest phocid seal with males and females reaching 2,000 kg and 600 kg, respectively. While elephant seals are proficient swimmers, diving deeper and longer than any other pinniped, their extreme size can be especially restrictive to terrestrial movement when using spinal flexion. The kinematics of terrestrial locomotion in northern elephant seals was analyzed from video recordings of animals observed on the beach of Año Nuevo State Reserve, CA. Terrestrial motions were quantified using ProAnalyst software. The seals exhibited dorsoventral spinal flexions, where the chest, pelvic region, and fore flippers served as the main points of contact with the ground. The spine was flexed by a wave that traveled anteriorly along the body. The spinal wave and fore flippers were used to lift the chest off the ground, and subsequently the fore flippers were retracted to pull the body forward. Simultaneously, the pelvic region served as a friction point from which the body extended forward. Frequency of locomotor spinal flexions (1.6±0.3 Hz) was found to be at its highest when velocity was between 0.3-0.5 BL/s. Contact with the ground differed between the fore flippers and pelvic region as the duty cycle ranged from 0.59-0.97 and 0.08-0.48, respectively. Despite their massive size, these animals can reach speeds up to 4.8 m/s (0.7 BL/s).

P3.23 TERNES, WM*; LATTANZIO, MS; Christopher Newport University; *william.ternes.15@cnu.edu*

Geographic variation in morphology and ecology of a widespread lizard

Geographic variation typically coincides with differences in local selection pressures, leading to broad patterns of phenotypic variation in widespread species. In several species, variation in morphological and ecological traits in particular is often associated with differences in elevation or latitude, or both. Here, we use data collected on 15 populations of the ornate tree lizard (*Urosaurus ornatus*) in southern Arizona that differ in elevation and latitude to evaluate patterns of geographic variation in key morphological (body size, head shape) and ecological (diet) traits linked with fitness. Overall, we show that body size declined with increasing elevation, and these patterns differed by sex. Conversely, we did not detect any latitudinal variation in body size. Jointly, these findings support a greater role of elevation in driving body size evolution in *U. ornatus*, in terms of both overall adult size and magnitude of sexual size dimorphism. With respect to head shape, lizard jaw length declined with both increasing latitude and elevation, suggesting that other ecological factors might be involved in driving variation in this trait. To that end, previous work in our lab with *U. ornatus* has demonstrated that head shape can inform variation in diet in this species, which may explain our observed patterns of jaw length in this study. Currently, tissue samples from these lizards are being processed for their carbon and nitrogen stable isotope content. We plan to use these results to test whether these observed geographic patterns in morphology are concomitant with differences in diet. Ultimately, via inclusion of these isotopic data with our current findings, we will provide important insight into the factors driving phenotypic variation in this widespread species.

P2.44 TEZAK, B.M*; SIFUENTES, I; MILLER, D.L; WYNEKEN, J; Florida Atlantic Univ., Boca Raton, Univ. of Tennessee, Knoxville; *btezak@fau.edu*

Can sex-specific proteins be used as a reliable method to identify the sex of sea turtle hatchlings?

Marine turtles exhibit temperature dependent sex determination (TSD). During critical periods of embryonic development, the nest's thermal environment directs whether an embryo will develop as a male or as a female. Warmer sand temperatures tend to produce female-biased sex ratios. The rapid increase of global temperatures highlights the need for a clear assessment of the resulting effects on the sex ratios of these animals. Estimating hatchling sex ratios at rookeries remains imprecise due to the lack of sexual dimorphism in young marine turtles. We currently rely mainly upon laparoscopy and biopsy to verify hatchling sex; however, these are invasive methods. Histology of dead-in-nest hatchling gonads can also be used to verify hatchling sex, but this method may not provide accurate estimates of live turtle sex ratios. Additionally, in some species, morphological sex can be ambiguous, even at the histological level. The purpose of this study was to develop a technique to identify sex in loggerhead sea turtle *Caretta caretta* hatchlings via analysis of blood samples. This approach uses Western blots to detect the expression of several proteins known to play an important role in sex determination, such as AMH in the blood and gonadal tissue of the hatchlings. The presence of the protein was then compared to the results from laparoscopic procedures in order to validate this new approach. Developing a technique to identify the sex of turtle hatchlings through blood samples will greatly enhance our ability to reliably determine sex ratios across nesting beaches, which is a crucial step in assessing the impacts of climate change on turtle demographics.

P3.41 THACKER, R.W.*; MATTERSON, K.O.; EASSON, C.G.; Stony Brook Univ., Univ. Alabama, Birmingham, Nova Southeastern Univ.; *robert.thacker@stonybrook.edu*

Genetic variability of sponge-cyanobacteria associations across the Caribbean

Marine sponges frequently host symbiotic, unicellular cyanobacteria classified as *Synechococcus spongiarum*. Previous investigations used Sanger sequencing of the cyanobacterial16S-23S ribosomal RNA internal transcribed spacer (ITS) region to document 13 distinct clades of *S. spongiarum*. These clades are hypothesized to vary in host specificity from generalists to specialists, but the expense and labor involved in Sanger sequencing has limited replication across multiple geographic areas. We developed a high-throughput method to obtain ITS sequences using the Ion Torrent next-generation sequencing platform, multiplexing 61 specimens that represented 14 species from 6 locations, as well as positive (cloned sequences inserted into plasmid vectors) and negative controls. Quality filtering and analysis using the mothur pipeline identified 16,951 *S. spongiarum* sequences, which were subsequently clustered into the 13 known clades. Individual sponge specimens hosted an average of 2.6 *S. spongiarum* clades (ranging from 1 to 5 clades), while individual *S. spongiarum* clades occurred in 1 (Clade G) to 13 (Clade B) host sponge species. The relative abundance of clades hosted by some species varied significantly among locations; for example, *Aplysina cauliformis* hosted 99% Clade A in Martinique but only 33% Clade A in Panama. Similarly, *Ircinia felix* hosted 100% Clade J in Panama, but only 55% Clade J in the Bahamas and Martinique. These data suggest that selective pressures exerted by hosts and/or environmental conditions vary across the Caribbean. Future work will use this method to determine whether experimental manipulations of environmental conditions can change the relative abundance of *S. spongiarum* clades within individual hosts.

P3.197 THOMAS, R.I.; NASH, A.M.; WATSON, W.H.; NEWCOMB, J.M.*; New England College, University of New Hampshire; *jnewcomb@nec.edu*

Localization of the circadian protein, CLOCK, in Melibe leonina

Most organisms express circadian (24-hour) rhythms of behavior, such as the locomotor patterns exhibited by the nudibranch mollusc *Melibe leonina*. CLOCK is an important protein underlying circadian rhythms, and its amino acid sequence in *Melibe* has been determined, facilitating the development of a custom antibody to CLOCK. In this study, brains were removed from animals at 9am and 9pm and immunohistochemistry was done to localize neurons containing CLOCK. Labeling was consistently seen in eight individually identifiable neurons in three locations of the brain: 1) the buccal ganglia, 2) below each eye, and 3) to the left and right of the midline of the cerebropleural ganglia. The number of labeled neurons, and the intensity of fluorescence, was similar between night and day samples, indicating a potential lack of fluctuation in the abundance of CLOCK throughout the day. This evidence suggests that the circadian clock in *Melibe* is relegated to only a small number of individually identifiable neurons, facilitating future studies of circadian rhythms in this animal.

P1.185 THOMPSON, M.L.*; WILLIAMS, C.T.; BUCK, C.L.; California State University, Long Beach, Northern Arizona University; *thompson.mirandalynn@gmail.com*

Sex-Specific Differences in Reproductive Requirements Affect Aboveground Activity and Energy Expenditure of Arctic Ground Squirrels

Animals living in polar regions, such as arctic ground squirrels (*Urocitellus parryii*), are exposed to extreme seasonal changes. As the northernmost hibernating small mammal, arctic ground squirrels are only active three to five months of the year when environmental conditions are favorable. During their short active season, arctic ground squirrels must rapidly transition through life history stages as they reproduce and subsequently prepare for the next hibernation cycle. Prior studies indicate that male and female ground squirrels differ in when and how they allocate energy towards reproduction. Therefore, we predicted that these sex-specific differences in reproductive requirements would affect time budgets and daily energy expenditure. We equipped free-living male and female ground squirrels in northern Alaska with light loggers affixed to collars, which provide information on time spent above vs. below ground and accelerometers, which allow us to measure overall dynamic body action (ODBA), an index of energy expenditure. We found that, compared to males, females spent less time aboveground during early lactation but were more active per unit of time aboveground and had higher daily measures of ODBA. Thus, in addition to costs associated with lactation, females also have higher activity-specific energy expenditure during this interval. Overall, our results support the hypothesis that differences between the sexes in reproductive requirements influence time and energy budgets of arctic ground squirrels.

P2.36 THOMPSON, M.A.*; TRACY, C.R.; California State University, Fullerton; *mthompson1188@csu.fullerton.edu*
Thermoregulatory consequences of water deprivation in Desert Iguanas (Dipsosaurus dorsal is)
Current climate change models predict increases in operative temperatures and changes to the timing and quality of precipitation events within desert habitats. Increased operative temperatures and prolonged periods of water deprivation may pose a threat to herbivorous lizards by restricting water quantities in habitats and food sources thus, requiring lizards to modify behavior in order to conserve water. Various species of snakes and insectivorous lizards are known to reduce preferred temperature (Tpref) when deprived of water, and change thermoregulatory shuttling behaviors by expanding the range of temperatures voluntarily tolerated (i.e. expanding Tpref range). However this interaction is known to be species-specific and has not been studied in herbivorous lizards. We predicted that thermoregulatory behaviors and Tpref would be modified more as the time lizards are deprived of water lengthens. Desert iguanas (*Dipsosaurus dorsalis*) and chuckwallas (*Sauromalus ater(=obesus)*) were deprived of water for 1-4 weeks. During this time, shuttling behaviors and Tpref were assessed using a shuttle box and thermal gradient. Blood osmolality was measured at the onset of thermal measurements to determine hydration status. Preliminary results for *D. dorsalis* suggest that shuttling behaviors and Tpref changed as the duration of water deprivation increased. However, Tpref of *D. dorsalis* after only three days was not significantly different from fully hydrated lizards. Sample size for *S. ater* is as yet, too small for any patterns to be clear. Overall, these results suggest that *D. dorsalis* has a high tolerance to prolonged periods of water deprivation and therefore may be buffered against changes in climate better than other lizard species.

P3.18.5 THOMPSON , C.L; THOMPSON, carl; University of Hawaii-Manoa ; *carlthom@hawaii.edu*
Distribution of Anthropogenic Mercury in a Forested Wetland
Global climate change will have an impact on the distribution and movement of global Hg during a period in which the global mercury and methylmercury budget is increasing. The main impact of mercury in the environment is that in its organic form, methylmercury. It becomes methylated while within wetlands. The two main sources for anthropogenic mercury are atmospheric deposition and legacy soil mercury. It causes neurological damage to organisms in terrestrial and marine/aquatic ecosystems. Studying the dynamics and distribution of mercury within wetlands can inform environmental planners on best practices to mitigate this ecological health issues.

P1.91 TIETZE, S.M.*; LEWIS, J.M.; Georgia Southern University; *st03311@georgiasouthern.edu*
Effects of rapid pH and salinity change on the physiology of an estuarine fish species, Fundulus heteroclitus.
Fundulus heteroclitus (Atlantic killifish or Mummichog) is an example of an organism that has evolved coping strategies which allow them to withstand and thrive in a highly variable environment. However, these fish also exhibit strong acclimation to home range conditions which may limit their ability to handle non-native stressors such as altered salinity and pH. There is a vast amount of laboratory based research examining tolerance limits of *F. heteroclitus*, but little to no field work in natural settings to examine the effects of multiple stressors. Our goal is to determine if low salinity and low pH combined is more stressful to *F. heteroclitus* than only low salinity. To address this area of interest, *F. heteroclitus* were captured from a site with neutral pH (7) and mid-range salinity (15-20 ppt) and transplanted into cages at one site with low pH (4.5) and low salinity (0-5 ppt) and another site with neutral pH (7) and low salinity (0-5 ppt). Once a week, a subsample of the fish (6 individuals) were euthanized and the gills and liver were taken. Changes in the mRNA expression levels of HSP 70 and Na+/K+-ATPase will be compared between treatments using qRT-PCR analysis. Results will show whether or not *F. heteroclitus* challenged with both low salinity and low pH will experience a higher level of stress compared to fish challenged with only low salinity.

P3.171 TINGLE, A.M.*; COOPER, D.D.; HAYES, D.M.; REDMOND, S.B.; Radford University; *sredmond3@radford.edu*
The Effects of Handling on Immunological Stress in Adolescent Rats
Stress levels in laboratory rats have been shown to respond to handling treatments that mimic typical adolescent socialization interactions. Adolescent rats were subjected to physical manipulations to assess their potential impact on stress systems; treatments included tickling, playing, restraint, and minimal handling. Treatments were administered every other day for a three week period, followed by a 2 week period without treatment. Body weights, blood smears, serum samples, and ultrasonic vocalizations were collected throughout all 5 weeks. Delayed-type hypersensitivity (DTH) is a cell-mediated response to an antigen that is introduced into the body. The duration and degree of inflammation can be impacted by stressors which inhibit the immune response. We sensitized rats to 2,4-Dinitrochlorobenzene (DNCB) on the abdomen and later assessed the DTH response on the ear lobes. After DNCB application ear swelling was measured with a caliper at 24, 48, and 72 hours. A DTH test started on day 10 of handling showed significant inflammation in all treatment groups at 48 hours post-application of DNCB, but not at 24 or 72 hours ($p<0.0001$) indicating similar level and timing of DTH reaction. This effect was not detected during a second DTH test at day 24, however the duration of the inflammatory response was longer in rats which had been tickled or played with ($p=0.031$). While there was no significant effect of treatment on body weight during the 3 week handling period, rats subjected to restraint were heavier than rats from the playful handling and minimally handled groups at 10 days post-treatment ($p=0.006$). Taken together, these results suggest that handling by researchers can significantly impact these measures of stress, and we will continue to analyze vocalizations, antibody levels, and circulating blood cell populations.

P1.76 TRUEBLOOD, LA; CYR, S; DARAKANANDA, K; HITCHCOCK, A; QUIST, J; ELLERBY, DJ*; La Sierra University, Wellesley College, Wellesley College; *dellerby@wellesley.edu*

Linking phenotype and swimming performance in bluegill sunfish

Locomotor performance is dictated by a complex array of interacting phenotypic features. In swimming fish these include the physiological properties of muscular power sources and the form of propulsors and drag inducing structures. Where distinct modes of locomotion are employed by the same organism, the overlap between the phenotypic features associated with each mode dictates whether performance in these modes is linked. Bluegill sunfish (*Lepomis macrochirus*) have two swimming modes: pectoral fin power labriform at low speeds; body-caudal fin (BCF) at high speeds. Our goal was to develop an integrated understanding of how phenotype dictates swimming performance in bluegill sunfish. If labriform and BCF swimming are associated with separate groups of phenotypic features, then performance in each mode should be decoupled from the other and associated with distinct aspects of phenotype. Maximal swimming speeds were established during flume swimming. The contractile properties and the activity of metabolic enzymes (citrate synthase and lactate dehydrogenase) in the pectoral and myotomal muscles were measured along with detailed morphological and anatomical data. Labriform and BCF swimming performance were not decoupled, maximum speeds in both modes were correlated. Each mode was however associated with largely separate sets of phenotypic features. Muscle masses, power outputs and metabolic enzyme activities were generally more important determinants of performance than external morphology. Identifying the phenotypic features that most strongly predict performance is an important step in establishing predictive links between phenotypic and performance variation.

P1.62 TSAI, H.P.*; MIDDLETON, K.M.; HOLLIDAY, C.M.; Brown University, University of Missouri; *henry_tsai@brown.edu*

The hip joint functional module and its significance in the evolution of avian locomotor posture

Birds walk using a habitually flexed hip posture and a locomotor cycle proximally driven by knee flexion and femoral axial rotation. This unique locomotor repertoire originated in a diverse assemblage of theropod dinosaurs. Theropods are characterized by wide disparities in body size, locomotor posture, and hip joint morphology. However, the origin of the modern avian hip joint is poorly understood. This study reconstructs the soft tissue anatomy of theropod hip joints using osteological correlates, infers trends in character transitions, and tests the integration between femoral and acetabular anatomy. Femora and pelves of 96 theropods and outgroup taxa were digitized using 3D imaging techniques. Key transitions were estimated using maximum likelihood ancestral state reconstruction. The femora of basal theropods possessed expanded fibrocartilage sleeves on the metaphysis, which surrounded the hyaline cartilage cores. The acetabulae of basal theropods permitted mostly parasagittal femoral movements, due to bony constraints imposed by the rostrolaterally ossified joint capsule. In contrast, avian-like articular cartilage, which consists of a composite fibro-hyaline structure, originated within Maniraptora. Reduction of joint capsule in Avetheropoda allowed the femur to undergo axial rotation and coupled protraction-abduction. Multiple maniraptoran lineages independently expanded the bony antitrochanter, suggesting bird-like hip postures evolved independently in Therizinosauria, Oviraptorosauria, Deinonychosauria, and Avialae. In particular, the femoral and the acetabular cartilages evolved as distinct modules in the avian stem-lineage, likely associated with the correlated evolution with joint loading, growth strategies, and body size.

P2.116 UIBEL, N.C.*; ADAMS, N.L.; CARROLL, J.A.; LEMA, S.C.; California Polytechnic State University San Luis Obispo; *nuibel@calpoly.edu*

Effects of Bisphenol-A and Styrene on Fertilization and Development of Strongylocentrotus purpuratus

Plastic waste and debris have greatly increased in the marine environment during the past 50 years. Not only do these plastics entangle and get ingested by marine mammals, turtles, and sea birds, but they also leach chemicals, such as bisphenol-A (BPA) and styrene into the aquatic environment, sometimes at high concentrations. While some of these chemicals are known to be toxic, few studies have examined their effects on broadcast spawning organisms, specifically at environmentally relevant concentrations. California purple sea urchins, *Strongylocentrotus purpuratus*, were utilized to examine effects of BPA and styrene on gametes and developing embryos. Previous research has demonstrated that BPA and styrene decrease successful fertilization and delay development of sea urchins, though no previous studies have examined effects on *S. purpuratus* development. We exposed eggs, sperm, or both to environmentally relevant concentrations of BPA or styrene (100µg/L - 1000µg/L) to test the hypothesis that exposure would lead to developmental abnormalities, including increased time to first cleavage and later developmental hallmarks. While fertilization was not affected by exposure, time to first cleavage was on average faster in exposed vs. unexposed gametes (eggs: 16.92 ± 5.62 minutes; sperm: 9.13 ± 2.24 minutes; both: 18.06 ± 6.27 minutes). However, later development was greatly affected by both chemicals, as normality decreased by as much as 90% in some treatments. Examining how these chemicals affect development will add to our understanding of how plastic pollution is affecting ecosystems.

P3.42 UL-HASAN, S*; FLAHERTY, S; WILSON, J; SINDI, S; BEMAN, MJ; DAWSON, MN; UL-HASAN, Sabah; Univ. of California, Merced; *sul-hasan@ucmerced.edu*

Host-symbiont interactions on community and molecular levels, before and after ENSO events

Palau, an archipelago of islands in Micronesia, is home to a handful of the world's only marine lakes known to host hundreds of thousands to millions of *Mastigias papua* medusae. Though these populations fluctuate year to year, how the lakes have the capacity to sustain these potentially massive populations is unclear. The only perturbation known to cause drastic die off is a sudden increase in temperature, brought on by events such as El Niño. An El Niño Southern Oscillation (ENSO) perturbation with a predicted Niño 3.4 Sea Surface Temperature (SST) index, possibly surpassing the 1997 El Niño, is anticipated to arrive for the coming year. The influence abiotic factors—like temperature fluctuations from ENSO events—have on population dynamics with respect to biotic relationships is poorly understood. This study is the first to ask how the *Mastigias papua* population of Jellyfish Lake (Ongeim'l Tketau), and its microbial community, recovers after an abiotic-sourced perturbation. By utilizing comparative molecular techniques, this research aims to address the posed question by first (1) describing what microbes are present in the environment versus the *Mastigias papua* host before an ENSO event via 16S and ITS sequencing and (2) determining what genes may be associated with immune response via *Mastigias papua* genome assembly and annotation. Preliminary results will provide a foundation for developing hypotheses on what the genetic and microbial drivers are for recovery within a marine host-symbiont relationship after an abiotic-sourced perturbation, and if there is an association between these drivers and immune response in the host.

P2.61 UNZUETA MARTINEZ, A.*; FEINMAN, S.G.; TLUSTY, M.; BOWEN, J. L. ; University of Hawaii at Manoa, University of Massachusetts Boston , New England Aquarium , University of Massachusetts Boston; *andreaun@hawaii.edu*

Exploring the microbial community of shell disease in Homarus americanus

The American lobster, *Homarus americanus* is one of the most important commercial fisheries in New England. A recent increase of shell disease in *H. americanus* populations has generated a great deal of concern regarding its causes and spread. Shell disease is thought to be caused by a polymicrobial infection, however an etiological agent has not yet been identified. This project investigates the microbial communities associated with lesions of diseased lobsters and how these communities change temporally and spatially. Microbial samples were collected from lobsters at the site of a new shell disease location, as well as at 0.5, 1, and 1.5 cm away from the site. The16S rRNA gene was amplified and sequenced using high throughput sequencing. The sequences were analyzed with QIIME. The results show that microbial communities on diseased lobster shells are significantly different spatially, but not temporally. The diversity of microbes was lowest at the site of shell disease, and increased with distance from the site. This work elucidates the microbial community composition of shell disease and tracks this community throughout the progression of disease.

P3.84 USHER, CR*; BOUCHARD, SS; Otterbein University ; *cory.usher@otterbein.edu*

growth rate plasticity in larval leopard frogs GROWTH RATE PLASTICITY IN LARVAL LEOPARD FROGS

Compensatory growth is accelerated growth that occurs after a period of growth depression. Such growth can be advantageous because it allows organisms to obtain a larger body size than they otherwise would. Previous amphibian studies suggest that compensatory growth may occur when larval growth is depressed by food availability, but not when it is depressed by predation threat. The purpose of this study was to determine if such a pattern occurs in larval leopard frogs, *Lithobates pipiens*. We reared larvae at low and high densities in 410 L outdoor mesocosms (5 and 50 individuals per mesocosm, respectively). Each density was replicated 10 times, and half of the mesocosms at each density contained a caged Libellulid predator. Each tank received a standard amount of food, so per capita resources varied with density. Predators were fed three *L. pipiens* larvae every other day to generate kairomones. Once larvae reached a standard size, we transferred three individuals from each mesocosm to a set of predator-free mesocosms with *ad libitum food*. We monitored growth before and after larvae were transferred. During the initial growth period, the presence of a predator depressed larval growth, but only at the low density. Larvae from the high density grew at the same rate as those from the low-density mesocosms with predators. This suggests that predators depressed growth at low density, but food availability did at high density. When larvae were transferred to the second set of mesocosms, individuals from the low-density grew significantly faster than those from the high-density. Those from predator-free mesocosms also tended to grow faster than those from mesocosms with predators. Compensatory growth therefore did not occur. However, larvae did exhibit a high degree of growth-rate plasticity, which warrants further investigation.

P3.100 USHERWOOD, JR*; MCGOWAN, CP; The Royal Veterinary College, London, University of Idaho; *jusherwood@rvc.ac.uk*

An energetic account for the higher prevalence of bipedal hopping versus running among smaller animals using intermittent or fast gaits.

Bipedal locomotion has evolved numerous times among mammals and birds. Hopping is generally limited to, or in the case of marsupials at least originated in, relatively small animals. Hopping mammals tend to be fast and hop over considerable distances; in contrast, birds that hop on the ground tend often do so intermittently, with a characteristic start-stop-start progress. If the cost of activating muscle dominates, and muscle must be activated fundamentally to provide the work and power of locomotion, simple scaling laws provide considerable insight. The cost of steady hopping approaches that of running - both dominated by issues of power rather than work - at small size scales and high speeds. Slow hopping, especially among large animals, is predicted to be especially costly due to the relative dominance of vertical work requirements. At small sizes (leg lengths less than 0.2m), a single thrush-like hop stride is predicted to be less costly than a single running stride (starting and finishing stationary). Hopping may confer a range of advantages over running or quadrupedal gaits; differential scaling of work and power provides an account for why smaller, faster animals are less energetically precluded from hopping, and hopping can be more economical for short distances.

P3.119 UYENO, TA*; CLARK, AJ; Valdosta State University, College of Charleston; *tauyeno@valdosta.edu*

Why do some things have loose skins?

Many endoskeletal organisms have tight skins; it facilitates transfer of force from a muscular core to the body surface and then on to the external environment. Indeed, tight and well-connected tensile skins can serve as an exotendon that transmits force to terminal appendages. In highly-pressurized, soft-bodied invertebrates (e.g. nematodes), the tight skin constrains deformation and is a crucial component of the hydrostatic skeleton. The opposite is also true; many organisms and structures have loose fitting skins. Here, however, understanding the relationship between the sheath and core is less well-understood. In this study, we survey biological and engineered examples of structures that benefit from a core surrounded by a loose sheath. Biological examples include whole animals (e.g. loose hagfish and horse skin; floppy vermiform animals), parts of animals (e.g. various meiofaunal proboscides; chameleon tongues; penile foreskins and serous membranes), and human-engineered mechanisms (e.g. climbing ropes; concrete slab slip sheets; loose-tube optical cables.) We then categorize the examples to form a theoretical framework based on whether looseness was primarily adaptive to the functioning of either the core or the sheath. We found that "core adaptations" often involved mobility issues in which the sheath was loose so that the core would not be impeded (e.g. a frog leg during jumping or a hagfish body during knotting). "Sheath adaptation" functions were more varied (e.g. protection; diffusion) but included many "biotribological" examples in which skin folds served to lubricate (e.g. extension of a chameleon's tongue.) With this categorization scheme, we hope to better understand the functional significance of loose skins in biological mechanisms and identify useful design elements for human-engineered structures.

P2.99 VAJDA, A.M.*; BARBER, L.B.; NORRIS, D.O.; SCHWINDT, A.R.; Univ. of Colorado Denver, U.S. Geological Survey, Univ. of Colorado Boulder, Colorado State University; *alan.vajda@ucdenver.edu*

Fish endocrine disruption responses along complex land-use gradients: opportunities and limitations for mitigation by regulation and treatment technology

The urban-water cycle modifies natural stream hydrology, and domestic and commercial activities increase the burden of steroidal and non-steroidal, natural and synthetic estrogenic endocrine-disrupting chemicals, that can disrupt endocrine system function in aquatic organisms. This paper presents results from a series of integrated field and laboratory, chemical and biological investigations into the occurrence, fate, and effects of endocrine-disrupting chemicals in the headwater reaches of major river systems in Colorado, the Chesapeake Bay, and Australia. Our long-term, continental-scale studies show that the occurrence and effects of endocrine disrupting chemicals are relatively low in river headwaters, and increase downstream with increasing anthropogenic activity. We have demonstrated that exposure to environmentally-relevant exposure to wastewater treatment facility (WWTF) contaminants has adverse implications for sexual selection in native fish by disrupting female-choice. We show that exposure to non-estrogenic antimicrobial WWTF contaminants disrupt the diversity and abundance of microbial communities in the fish gut with potential adverse implications for host fitness. We demonstrate significant recovery of reproductive health in wild and experimentally-exposed fish following a full-scale upgrade of WWTF treatment process. Through multi-generational studies we have identified transgenerational consequences of estrogen exposure on fertility that may impact the long-term recovery of exposed populations. Our studies demonstrate the impacts of human populations on the health of aquatic ecosystems can be mitigated by regulatory action and implementation of appropriate WWTF treatment technologies.

P2.83 VAN WERT, J.C.*; MENSINGER, A.F.; Santa Barbara City College and Marine Biological Laboratory, Woods Hole, MA, University of Minnesota Duluth and Marine Biological Laboratory, Woods Hole, MA; *jcvanwert@berkeley.edu*

The effects of temperature, intraspecific calling, and environmental noise on oyster toadfish (Opsanus tau) mating calls

Many animals use acoustic signaling as a form of intraspecific communication. The oyster toadfish, *Opsanus tau*, possess sexually dimorphic sonic muscles surrounding the swim bladder to produce vocalizations, making them an ideal model organism to study bioacoustics. During the breeding season (May - August), male toadfish use boatwhistles to attract females to nests. An *in situ* hydrophone monitored male toadfish in Eel Pond, Woods Hole, Massachusetts, from mid May through late August, 2015. Call number, duration and fundamental frequency was determined, and correlated with water temperature, intraspecific and environmental noise. Ambient water temperature ranged from 13 - 24°C and male toadfish began producing boatwhistles when temperature reached approximately 15°C in late May. On a seasonal scale, the increase in boatwhistle fundamental frequency (110 - 220 Hz) was directly related to higher water temperatures. However, daily variation in fundamental frequency (5 to 15 Hz) appeared independent of water temperature and suggests that toadfish can control fundamental frequency to remain distinct from conspecifics. Anthropogenic (boat motors) and meteorological (thunder storms) noise appeared to depress calling activity. Acoustic signaling is essential in toadfish mating; these results demonstrate that intraspecific and environmental factors may alter fish acoustic behavior and breeding success. Funding by NSF DBI-1359230 and IOS-1354745 grants.

P3.173 VAN KESTEREN, F*; WESTRICK, S; BAUTISTA, T; DANTZER, B; University of Michigan; *freyavankesteren@gmail.com*

Behavioral responses of North American red squirrels to exogenous glucocorticoids, population density, temperature and reproductive state

Animals modify their behavior in response to ecological factors, and one pathway by which behavioral responses may be regulated is through glucocorticoids (GCs). GCs are released in response to adverse situations, and as such often referred to as ‘stress hormones'. However, GCs play roles in many aspects of animal biology, and studies involving artificial increases in GCs have found effects on diverse behaviors in different species. In North American red squirrels (*Tamiasciurus hudsonicus*), population density, which is perceived by squirrels through neighbor rattles, is an important ecological factor. Perceived population density has been found to increase GCs in pregnant females and affect behavior in male and female squirrels. Other ecological factors that may affect squirrel behavior include ambient temperature and reproductive state. Here, we studied the effects of GC supplements, reproductive state, temperature, and neighbor rattles on behavior in a population of wild squirrels in the Yukon, Canada. We supplemented pregnant squirrels with peanut butter containing 12mg of GCs (high dose) or not containing GCs (control dose) daily from mid-pregnancy to five days postpartum. Other breeding females were supplemented during lactation with high and control doses from days 5-15 post-partum. Non-breeding squirrels were also included, with males and females fed control or high doses for 21 days after the end of the breeding season. Squirrels were fitted with radio-collars and behavioral data were collected in seven minute focal sessions. Behavioral data were analyzed to test for effects of GC treatment, sex, reproductive status, temperature, and rates of neighbor rattles on squirrel behavior. Results from these analyses will be discussed.

P3.202 VASSAR, B.M.*; STRAND, C.R.; LEMA, S.C.; Cal Poly State Univ, San Luis Obispo; *bvassar@calpoly.edu*

Sequence and phylogenetic analysis of NeuN and DCX neuronal marker proteins in reptiles and mammals

Neuronal Nuclei (NeuN) and Doublecortin (DCX) are neuron specific proteins that are used in histological studies of brain structure in a variety of vertebrate taxa. Antibodies against NeuN (anti-NeuN) bind to the Fox-3 protein, an RNA binding protein common in mature neurons. Anti-DCX labels a microtubule-associated protein expressed in actively dividing neural progenitor cells and migrating neurons. The *dcx* gene encodes a protein that is well conserved across mammalian, avian, and a few reptilian species, therefore anti-DCX staining has been used successfully across a range of vertebrate taxa. Successful neuronal staining using anti-NeuN has been demonstrated in mammals, birds, and the Testudines order (turtles). However, herpetologists who study neurobiology in squamates have had limited success with anti-DCX and anti-NeuN binding to their respective antigens. All commercially available anti-DCX and anti-NeuN antiserums were designed to mammalian antigens, and significant differences in tertiary structure divergence at the epitope where these antibodies bind may explain the failure of anti-DCX and anti-NeuN immunohistochemistry in many squamate species. This study aims to characterize evolutionary differences in gene and protein structure between two species of reptiles (*Sceloporus occidentalis* and *Crotalus oreganus*) and mammals. We sequenced the *fox-3* and *dcx* coding sequences using 5'-RACE and Sanger sequencing, which allowed us to build phylogenetic trees comparing Fox-3 and DCX deduced protein structures. By identifying structural differences linked to evolutionary variation, new polyclonal antibodies specifically targeting Fox-3 and DCX in reptile brains can be developed to facilitate future investigations of neurogenesis and brain structure in squamate reptiles.

P1.86 VÁSQUEZ , A.M*; MOSKOWITZ, N.A; WARKENTIN, K.M; Universidad de Antioquia, Boston University; *angelly.vasquez@udea.edu.co*

Embryo decisions, metabolism, and development when arboreal eggs are flooded.

Red-eyed treefrogs, *Agalychnis callidryas*, lay eggs on leaves over ponds. Older, more developed hatchlings survive better with aquatic predators, but embryos hatch early to escape from threats to eggs, including risk of suffocation in flooded clutches. The danger in flooding varies with water oxygenation and egg surface exposure. We assessed embryo decisions and developmental consequences in a best-case flooding scenario, submerging individual eggs in air-saturated water. We used a split-clutch design to compare development rates of embryos in eggs in air and water and tadpoles in water, starting at age 4 d when most embryos hatch in <1 h from flooded clutches. We used closed-system respirometry of eggs in air and water, and tadpoles, to compare metabolic rates across environments and oxygen levels at which eggs in water hatched, and tadpoles became oxygen-limited. Few submerged embryos hatched immediately (13% within 12 h of submergence); most hatched after siblings in air. Hatched tadpoles developed fastest and submerged embryos slowest. Hatchlings from submerged eggs were smaller than earlier-hatched sibs from eggs in air. In air-saturated water, metabolic rates of newly hatched tadpoles were higher than those of submerged eggs. Embryos hatched at oxygen levels near those that limited metabolism in newly hatched tadpoles, and metabolic rates tended to show a small increase just after hatching. Embryos submerged individually do not necessarily die, but suffer metabolic and developmental costs, even in well-oxygenated water. They appear to balance the severity of costs against benefits of being more developed at hatching. Submergence of terrestrial eggs may accelerate or retard hatching timing, with varying effects on development rate and hatching stage depending on embryo decisions.

P3.159 VEA, IM*; TANAKA, S; SHIOTSUKI, T; JORAKU, A; MINAKUCHI, C; Nagoya University, National Institute of Agrobiological Sciences, National Institute of Agrobiological Sciences; *isabelle.vea@gmail.com*

Scale insect development and the adult specifier E93: towards an understanding of female neoteny

Scale insects, a hemipteran plant pest group, are well defined by the females retaining juvenile features at the adult stage and different degrees of morphological reductions due to their parasitic life on plants. Although female neoteny is recognized as a feature that originated once in scale insect evolution, its underlying molecular mechanisms have never been investigated. We here assessed whether the transcription factor E93, a conserved adult specifier in insects and regulated by growth hormones, has a role in this female neoteny. We established the expression profile of E93 during male and female development in the Japanese mealybug, *Planococcus kraunhiae* (Kuwana) (Pseudococcidae). Strikingly, while E93 expression peaks towards the end of male development, this transcription factor is never expressed throughout female development. These preliminary results and the potential involvement of E93 in juvenile hormone signaling provides a promising direction towards understanding how this transcription factor in concert with the juvenile hormone can establish such a conserved feature for parasitic life.

P1.65 VELTEN, B.P.*; WELCH, JR., K.C.; University of Toronto, University of Toronto, Scarborough; *brandy.velten@mail.utoronto.ca*

Diversity of myosin heavy chain expression in the avian superficial pectoralis

Avian wingbeat frequencies range from 2-80 Hz, resulting in differences in the contraction rate and shortening velocity of the flight muscles across species. Differential expression of myosin heavy chain (MHC) isoforms among muscles correlates with variation in maximum shortening velocity in both mammalian and avian muscle fibers. Thus, we expected MHC isoform complement in the pectoralis would vary across species in relation to the diversity of mechanical performance during flight. However, studies using SDS-PAGE electrophoresis have shown the adult fast isoform of the myosin heavy chain (MHC) to be the predominant, and often only, MHC isoform in the pectoralis of several avian species that differ in histological fiber type and wingbeat frequency. This finding lead us to previously hypothesize that the adult fast MHC isoform is essential to meet the mechanical demands of powered avian flight, with expression of this isoform in the pectoralis broadly conserved across species. To test this hypothesis, we examined the MHC expression across a greater diversity of avian species with a wide range of body size. MHC isoforms of the superficial pectoralis of 18 species collected in collaboration with the Fatal Light Awareness Program were separated and identified using SDS-PAGE electrophoresis and western blots. We find much greater interspecific diversity in MHC isoforms present in the avian pectoralis than previously observed, counter to our original hypothesis. The adult fast isoform is absent in some species, while a novel fast isoform previously not described in domestic chicken muscle is present in others. Further work is underway to examine whether the observed diversity of avian pectoral MHC expression may correlate with histological fiber type, phylogeny, or other physiological/behavioral factors influencing muscle function.

P2.50 VENESKY, MD; DEMARCHI, J*; HICKERSON, CAM; ANTHONY, CD; Allegheny College, John Carroll University, John Carroll University; *demarchij@allegheny.edu*

Understanding how temperature mediates disease outcomes in a terrestrial salamander

Polymorphic species provide an ideal system to study disease outcomes because different phenotypes can face diverse selection pressures within their shared environments. Previous studies have demonstrated that striped and unstriped morphs of the Eastern Red-Backed Salamander (*Plethodon cinereus*) vary in their seasonal activity and temperature preference. Compared to unstriped salamanders, striped salamanders experience lower mortality in cool temperatures and remain active on the forest floor as the temperature cools in the autumn. Capitalizing on this variation, we conducted a laboratory experiment in which we raised salamanders of both color morphs in cool (18C) and warm (24C) temperatures and then exposed them to a pathogenic chytrid fungus (*Batrachochytrium dendrobatidis*; "*Bd*"). Temperature is known to impact the growth rate of *Bd* and temperature can also mediate outcomes between amphibians and *Bd*. If striped salamanders are physiologically adapted to cool temperatures, we predicted that they would have lower *Bd* infection and prevalence compared to unstriped salamanders, even though *Bd* is thought to grow optimally in cool temperatures. In addition, we predicted that striped salamanders would have higher *Bd* infection and prevalence in warm temperatures compared to unstriped salamanders. Contrary to our predictions, striped salamanders had a higher *Bd* prevalence at cool temperatures and a lower prevalence at warm temperatures. Although these color morphs are known to differ in temperature preference, our results might indicate that they are not physiologically adapted to different thermal optima, at least not as measured within the context of our experiment.

P3.114 VERNER, KA*; MAIN, RP; Purdue University; *kjenson@purdue.edu*

Tibiotarsus bone strains and hindlimb kinematics relative to speed in the guinea fowl

The bone strain environment in the tibiotarsus (TBT) and hindlimb kinematics were characterized relative to speed for 14 week-old male guinea fowl (n=4) during treadmill running. The animals were surgically instrumented with three rosette strain gauges around the circumference of the bone's midshaft. *In vivo* bone strain and 3D kinematic data were collected from the birds while they ran at a range of speeds (0.45-2.68 m/s) on a motorized treadmill. Peak principal strains and their orientation relative to the bone's long axis were determined for several consecutive strides for each animal across the speed range. Average peak principal strains on the posterior, anterior and medial bone surfaces ranged from -60 µ , +123 µ , and -96 µ at 0.45m/s, respectively, to -151 µ , 245 µ , and -161 µ at 2.68m/s, representing 2.5-, 2-, and 1.6-fold increases in strain across the range of speeds tested. Peak principal strains on the medial surface were oriented farthest from the long axis of the bone at 34 and 38 degrees for 0.45 and 2.68m/s, respectively. Changes in metatarso-phalangeal, ankle, knee, and hip joint angles relative to speed were determined and linked to changes in bone strain with speed. At certain speeds, joint angles and strain patterns for the guinea fowl were compared with previously reported data for emu and chickens. In general, TBT principal strain magnitudes in the guinea fowl were lower on all surfaces than what have previously been measured in the emu TBT and chicken TBT. Despite the difference in magnitude, posterior and medial principal compressive strains in the guinea fowl TBT were oriented similarly to those reported previously in the emu TBT and the chicken TBT while GF anterior principal tensile strains were more closely aligned to the long axis.

P1.105 VILLALOBOS, S.G.*; GOSLINER, T; University of Maryland College Park, California Academy of Sciences; *shainagracevillalobos@gmail.com*

Deep Sea Mysteries: A molecular phylogeny of newly discovered nudibranchs (genus Halgerda) from low light Philippine reefs

During the 2014 and 2015 California Academy of Sciences expeditions to the Philippines, advanced SCUBA technology allowed our research to explore deep reefs of the "Twilight Zone". Formally called the mesophotic zone, this low light area from 60m-150m contains a wealth of poorly studied or completely undiscovered species. The purpose of this study was to investigate the molecular phylogeny of nine likely undescribed nudibranch species from the genus *Halgerda* collected during this expedition, most of which were collected from the mesophotic zone. Mitochondrial fragments cytochrome c oxidase I (COI) and 16S as well as nuclear fragments H3 and 28S were sequenced from 34 samples of *Halgerda* species, including the nine recently discovered species and previously un-sequenced species such as *Halgerda formosa* (the type species), *Halgerda batangas*, and *Halgerda tessellata*. Outgroups were chosen from among several other discodorid exemplars. The phylogeny was determined using maximum likelihood and Bayesian analyses. The results confirm that eight of the nine suspected new species are indeed distinct from described species. Molecular data were lacking from the ninth species owing to its fixation in a formalin-based fixative. The data also suggest that the undescribed species from the mesophotic zone form a clade nested within *Halgerda*. This also suggests a single invasion of the mesophotic zone by a shallow-water ancestor and subsequent radiation of this lineage within the mesophotic. This is different from what was found with mesophotic fish in the genus *Chromis*, in which four new mesophotic species each had a different shallow-water sister species.

P3.58 VIRGIN, EE*; ROSVALL, KA; Northern Illinois University, Indiana University; *emilyevirgin@gmail.com*

Interleukin-6, parasites, and death: Why are big chicks better than small chicks?

Behavioral ecologists oftentimes use proxies for fitness because fitness can be difficult to measure directly in the wild. For example, nestling mass prior to fledging predicts survival into subsequent years in many songbirds, suggesting that mass may be a good proxy of quality or fitness. However, the mechanisms underlying this phenomenon are unclear. We hypothesized that immune function may influence offspring quality and survival, and specifically, we predicted that smaller offspring may be less able to mount an effective immune response, thereby negatively influencing survivorship. We tested our hypothesis in a wild population of tree swallows (*Tachycineta bicolor*), in which we used hematological gene expression of the inflammatory cytokine interleukin-6 (IL-6) as a measure of each chick's ability to mount an acute phase response. We found that chicks with ectoparasites were smaller in mass on day 12 post-hatch, they had higher levels of IL-6 gene expression, and they were less likely to survive to fledging, compared to unparasitized chicks. We also report an interaction between parasite status, mass, and IL-6 mRNA abundance, such that mass and IL-6 are positively correlated among parasitized chicks, but there is no such relationship among unparasitized chicks. These findings suggest that, when the immune system is activated (i.e., in the presence of ectoparasites), larger chicks may indeed be better at fighting off diseases, thus accounting for their greater survivorship. Our results shed light on the proximate mechanisms linking nesting growth, immunity, and survivorship, and they highlight how parasites may influence the degree to which offspring mass is a good proxy for quality in songbirds.

P3.80 VOISINET, MP*; VASQUEZ, MC; ELOWE, C; CROCKER, DE; TOMANEK, L; California Polytechnic State University, San Luis Obispo, Sanoma State University, CA; *mpvoisin@calpoly.edu*

Proteomic response of elephant seal pups, Mirounga angustirostris, to prolonged fasting.

Northern elephant seals (*Mirounga angustirostris*) have several key physiological adaptations allowing them to develop from a terrestrial nursing pup to a juvenile able to dive and forage independently in the water. During the approximately 8-week time period between the weaning of the pup and their departure to sea, juvenile seals rely solely on the energy reserves they gained during nursing for all caloric and water demands. While adult elephant seals fast during molting, mating, and lactation, pups fast while undergoing a major transition from a terrestrial to an aquatic lifestyle. The purpose of this study was to understand the fasting-induced adaptive responses of pre- and post-weaning *M. angustirostris* pups using a proteomics approach. We collected tissue from skeletal muscle and the inner and outer adipose layers of both pre- and post- weaning pups (n = 20). After performing first and second dimension gel electrophoresis, we then analyzed the samples using mass-spectrometry-based proteomics. Our initial analysis identified proteins which provide reducing equivalents for biosynthesis or the scavenging of reactive oxygen species (NADP isocitrate dehydrogenase), and proteins related to oxidative stress (Cu-Zn superoxide dismutase) and the cytoskeleton (gelsolin). Through ongoing analysis, we expect to identify significant increases in proteins related to metabolism (transition to beta-oxidation pathways) and oxidative stress (antioxidant proteins), and decreases in cytoskeletal proteins that aid in the development of diving ability in post-weaning pups. This study will provide important information about the adaptive capacity of marine mammals at a critical developmental stage.

P1.126 VON TUNGELN, A.R.*; PERNET, B.; California State University, Long Beach; *anthusarose@aim.com*
Host choice affects fecundity in the gastropod Crepidula onyx
The gastropod *Crepidula onyx* is common in Alamitos Bay in southern California, where it is usually found as an epibiont on the bivalve *Mytilus galloprovincialis* on docks, or the gastropod *Conus californicus* in soft sediments. The two hosts differ in maximum shell length (~10 vs. 4 cm, respectively), potentially affecting the sizes of epibionts. We hypothesized that host species would have large effects on body size and fecundity of *C. onyx*. To test this hypothesis, we quantified body size, sex, and fecundity of *C. onyx* from both hosts. Females of *C. onyx* on *Mytilus* reached larger sizes (mean 38.4 mm length and 300.4 mg dry tissue mass) than those on *Conus* (19.9 mm and 66.9 mg); on average, then, *C. onyx* on *Mytilus* grow to more than four times the tissue mass of those on *Conus*. The body size of females of *C. onyx* had no effect on the number of egg capsules produced, but was positively correlated with capsule size and the number of embryos per capsule. Females of *C. onyx* on *Mytilus* produced broods containing a mean of 16318 embryos, ~2.4 times the number of embryos produced by those on *Conus* (6811). These results are consistent with our initial hypothesis. The two hosts may also differ in quality in other ways. Snails on *Mytilus* can suspension feed at all times, but *Conus* is often found buried in sediment, potentially restricting time available for suspension feeding by epibiotic *C. onyx*. Further, predators of *Mytilus* and *C. onyx* are rare on docks in Alamitos Bay, but predatory gastropods are common in soft sediments, where we have observed them feeding on *C. onyx* on *Conus*. In Alamitos Bay, *Mytilus* thus seems to be far superior to *Conus* as a host for *C. onyx*, and settlement choices by the planktonic larvae of *C. onyx* have large effects on their fitness. It is not yet clear if larvae discriminate among potential hosts at settlement.

P2.95 WADLEIGH, R. L. *; SCHER, C. L. ; ABOLINS-ABOLS, M. ; KETTERSON, E. D. ; Earlham College, Richmond, IN, University of Virginia, Charlottesville , Indiana University, Bloomington, Indiana University, Bloomington; *rlwadle12@earlham.edu*
Competition changes courtship behaviors of male Dark-eyed juncos (Junco hyemalis)
Animals exhibit a diverse array of visual and vocal courtship behaviors that vary across taxa and individuals. This study explores the role that male-male competition and individual quality play in shaping free-living male Dark-eyed Junco (*Junco hyemalis*) courtship. Variation in competition may directly affect the cost of courtship displays, where increased displays may recruit more competitors to the area. However, the effect of competition on courtship success likely depends on male quality, with low-quality males standing at a greater risk of loosing a potential mate than high-quality males. High apparent competition was simulated by repeatedly broadcasting male conspecific song in the focal male's territory, whereas low competition males were left undisturbed. Juncos from both treatments were then exposed to a live female conspecific to measure their courtship behavior. Males from the high-competition treatment approached the female significantly closer than low-competition males. The effect of the competition treatment on courtship behavior depended on male quality - larger males displayed their tail ornaments more than smaller males in high competition, while in low competition size and tail spread were not related. These findings show that male courtship is a plastic behavior that is modified in response to a changing social environment. Furthermore, individual variation in male quality affects how individuals court in alternate social environments. This interaction between quality and social environment on behavior highlights the importance of taking into account individual differences in ecological and evolutionary study of behavior.

P1.83 WAGNER, JT*; CHAVEZ, FH; PODRABSKY, JE; Portland State University; *jtwagn@gmail.com*
Comparative mitochondrial genomics of the anoxia-tolerant annual killifish Austrofundulus limnaeus
The annual killifish *Austrofundulus limnaeus* inhabits ephemeral ponds in the Maracaibo Basin of Venezuela. Permanent populations of *A. limnaeus* are maintained only by the production of stress-tolerant embryos that can enter a state of metabolic dormancy and developmental arrest, termed diapause. *A. limnaeus* embryos are able to tolerate longer periods of anoxia than any other vertebrate yet studied. Because insufficient oxygen supply to mitochondria has long been known to cause electron transport chain dysfunction, the ability of *A. limnaeus* embryonic mitochondria to tolerate such long periods of anoxia is of great interest. Previous work has suggested that in anoxia- and hypoxia-sensitive mammalian models, exposure of cells to low oxygen conditions can result in mitochondrial autophagy (mitophagy) or mitochondrial biogenesis following reoxygenation. Here, we measure changes in relative mtDNA copy number following anoxia/reoxygenation in *A. limnaeus* embryos to give an indication of mitochondrial degradation and biogenesis during normoxic and anoxic conditions. We also describe the first complete mitochondrial genome sequence of *A. limnaeus* and compare its sequence and synteny to other species within the Order Cyprinodontiformes. Interestingly, we did not observe changes in relative mtDNA content following anoxia/reoxygenation treatment in *A. limnaeus* embryos, suggesting that mitophagy or mitochondrial biogenesis may not have a role in *A. limnaeus* anoxia tolerance. However, we did find mtgenome sequence rearrangements that are unique to *A. limnaeus* when compared to other fish species. These results suggest that mtDNA copy number stability may be important for tolerating periods of anoxia, and also indicate that there may be unique mtDNA sequence that can facilitate extreme anoxia tolerance.

P3.128 WAINWRIGHT, DK*; LAUDER, GV; WEAVER, JC; Harvard University; *dylan.wainwright@gmail.com*
A new technique for quantifying biological surfaces in three dimensions
Imaging surface features in three dimensions is often a challenging prospect in biology because many biological surfaces are soft, slimy, or transparent, and surfaces support complex three-dimensional topographies. Traditional techniques such as atomic force microscopy (AFM) provide data at very small scales, but imaging 3D surfaces on the millimeter to centimeter scale can be challenging and time consuming. Here, we showcase a new surface imaging technique able to calculate 3D surface topography with high accuracy on surfaces measuring up to 2 cm across with no image tiling and no z-stacks. Imaging takes ca. 30 seconds to complete and a full 3D surface rendering takes ca. 1 minute. Scans result in approximately 18 million total data points, each with x, y, and z coordinates, permitting highly accurate analyses of the surface. We will present images from a wide variety of biological surfaces, including mammal skin, plant leaves, and fish skin, revealing a tremendous variety of surface morphologies. We also illustrate how this approach can be used to image mucus covered surfaces, and we show several different quantitative metrics that can be extracted from these analyses. Finally, we illustrate steps for 3D printing surfaces measured by this technique.

P2.204 WALDROP, LD*; MILLER, LA; Univ. of California, Merced, Univ. of North Carolina at Chapel Hill; *lwaldrop@ucmerced.edu*

Using a biologically relevant definition of peristalsis to determine the pumping mechanism of valveless, tubular hearts

Although valveless tubular hearts are common throughout metazoans, the mechanism by which these hearts drive fluid flow is under dispute. Traditionally, peristalsis was used to describe the pumping mechanism of many non-chambered hearts, but recently other mechanisms have been used (e.g. dynamic suction pumping) due to observations of fluid flow patterns that presumably rule out peristalsis. However, the technical definition of peristalsis, and the fluid flow patterns that it predicts, is based on a small-amplitude, long-wave approximation which is often violated by pumps found in nature. Here we suggest a definition of peristalsis that can be used to evaluate pumps that is more inclusive and relevant to biological structures: the presence of non-stationary compression sites that propagate unidirectionally along a tube without the need for a structurally fixed flow direction. We present direct numerical simulations of a pump operating under this biologically relevant definition to explore how flows can differ from a technical definition: flow speeds can be greater than the speed of the compression wave; fluid flow can be pulsatile; and flow speed can have a nonlinear relationship with compression frequency when compression-wave speed is held constant. These results demonstrate that our simpler, more inclusive definition is better equipped to assess the pumping mechanism in a biological pump than the technical definition of peristalsis.

P3.209 WALLACE, N.E*; BALTZLEY, M.J.; Western Oregon University; *nwallace11@wou.edu*

Using artificial selection to understand orientation behavior in Drosophila

The fruit fly, *Drosophila melanogaster*, is commonly used to understand the genetic mechanisms of behavior. Using this model organism, we are testing whether *Drosophila* have an innate directional preference based on the Earth's magnetic field and whether this preference has genetic underpinnings. We have performed 15 generations of artificial selection for directional preference using a sequential Y-maze. In the maze, flies make 10 choices of whether to go north or south, and we then select the 20% most extreme flies for breeding. We have bred both north-seeking and south-seeking populations using this method. Our preliminary results suggest that flies do not have a directional preference; however, because each trial in the maze is performed with a large group of flies that are able to interact, each trial is only a single experimental sample. We have begun performing multiple trials using the original population of flies, the 15th generation of north-selected flies, and the 15th generation of south-selected flies. As a positive control, we are also performing similar experiments with light-seeking and dark-seeking flies. Previous research on phototaxis showed that a separation between light-seeking and dark-seeking populations occurs after 10 generations. Ultimately, this experiment will lead to a better understanding of the potential genetics of magnetic orientation and directional preference in *Drosophila*.

P3.113 WALTER, RM*; BALACCO, J; WALTER, Rebecc; Bloomfield College; *rebecca_walter@bloomfield.edu*

Why are some runners better on hills than others?

Distance runners with similar abilities on level terrain often differ significantly in their ability to run on inclines. This study investigates the causes of these interindividual differences in relative incline running ability. One hypothesis is that relative differences in incline running ability are primarily due to differences in uphill running kinematics. Common coaching advice for running uphill includes rapid stride turnover and high knee lift. Runners with more efficient incline running kinematics would be expected to show less of an increase in metabolic rate and heart rate when running uphill. On the other hand, anthropomorphic variables, leg muscle strength, and leg muscle power are also likely to effect on level and incline running differentially. In this study 44 subjects performed incremental treadmill runs to exhaustion at 0o and 10o inclines. The treadmill was started at 2.2ms-1 and 1.8ms-1 for the level and incline trials respectively. Speed was increased by 0.09ms-1 at the end of each minute until subjects could no longer maintain the pace. Relative incline running ability was measured as the ratio of the incline: level distance covered. Subjects' heart rates were measured throughout the trials and their stride kinematics were tracked with a motion capture system. Subjects ran 3.8±1.6 and 1.6±1.0 km in incline and level trials respectively. Incline to level distance ratios ranged from 0.25 to 0.56. Relatively better incline runners had lower incline: level heart rate ratios. Compared to relatively poor incline runners going the same speed, they used longer strides with lower stride frequencies. Maximum stride length on inclines was significantly correlated with relative incline running ability whereas maximum stride frequency was not. This suggests that it many not be beneficial to focus primarily on rapid foot turnover when running uphill.

P2.2 WALTERS, L*; CAMPBELL, D; SACKS, P; JACHEC, S; CONLEY, J; GARVIS, S; Univ. of Central FL, Winter Springs High School, US Naval Academy; *linda.walters@ucf.edu*

Where have all the oysters gone?

Over 40% of intertidal oyster reef coverage of the eastern oyster *Crassostrea virginica* has been lost in Canaveral National Seashore waters since 1943 (east coast of central Florida, encompassing much of the northern Indian River Lagoon). As all of the losses were in primary or secondary boating channels, both anecdotal and correlative data suggest that boat wakes have contributed to this decline. Here we present three important types of evidence to further suggest this is the case. First, we have tracked the movement of intertidal reefs once death begins on the seaward reef edges. Reefs in boating channels move toward shore at an average rate of 1 meter per year, while reef locations away from boat channels have remained stable over time. Second, we have collected data on the burial depth of oysters/oyster clusters in areas near and far from boat channels. Near channels, the depth ranged from 1 - 4 cm, while further from boat channels, oyster burial depth exceeded 20 cm. Third, to experimentally document that dead reefs can result from boat wakes, we ran controlled boat passes to determine what wake heights were generated at oyster reefs in the Park. These results were then utilized in experiments at Florida Institute of Technology's wave tank to observe oyster movement and sediment erosion. Data was analyzed using model selection and regression analysis. We found that wake heights as small as 2 cm were capable of dislodging and moving oysters when the oysters are only buried in the sediment from 1- 4 cm. Combined, these results help explain when and how boat wakes can destroy intertidal oyster reefs, and, thus, can be used to implement boating policies which would contribute to conserving this important ecosystem engineer.

P3.30 WALTERS, K.E.*; DAVIS, E.B.; University of Oregon; *walters@uoregon.edu*

Changes in United States Mammal Diversity over the 20th Century: Implications for Future Response to Climate Change

Biodiversity loss is recognized as a global crisis. Current research strives to quantify and predict the change in biodiversity throughout the world, focusing on a wide range of taxa. However, current predictive models of mammal diversity in the United States suffer from low precision. They are not scaled with adequate spatial or temporal resolution because richness has not been evaluated at a broad spatiotemporal scale. The prediction of changes in mammal diversity are important to land management and conservation efforts, and, without adequate information, the existing biodiversity in the United States may not be fully protected. Our research takes conservation paleobiology in a new direction by using paleobiological methods to analyze a high-resolution record of the changes in mammal diversity in the continental United States through the last 110 years. We collected mammal occurrence data from the online database VertNet and individual museum collections, divided it into ten year increments, and used scripts in ArcGIS 10.2 to produce sampling-standardized patterns of mammal diversity in each decade. We then analyzed the geographic distribution of diversity change over the 20th century. Mammal diversity in the last century increased in two regions: one northern section between 43° and 47° latitude and one southeastern strip from Texas to North Carolina. Diversity decreased throughout the rest of the United States. Our study describes regions in the United States that are experiencing the most severe biodiversity losses which suggests that those regions should be focal areas for conservation efforts. Further directions include testing hypotheses about the role of climate and human population change to influence these patterns of mammal diversity shifts.

P3.105 WARD, A.B.*; MEHTA, R.S.; COSTA, A.; BUCHENAUER, J.; Adelphi University, Univ. of California, Santa Cruz; *award@adelphi.edu*

Push points influence movement patterns during terrestrial and aquatic locomotion in an elongate fish

Aside from being able to move backwards with ease and retract their heads in a startle response, many elongate fishes are known to make terrestrial excursions. During swimming, highly elongate fishes propel themselves using sinusoidal waves, which pass along their bodies, better known as anguilliform locomotion. When highly elongate fishes cross from an aquatic to terrestrial environment, the wave amplitude is greater. More recently, we showed that when provided with vertical substrate in the form of wooden pegs, elongate fishes contact pegs presumably to make forward movements. We have also shown that differences in axial elongation can affect peg use in the aquatic and terrestrial environment. In this study, we provide a more detailed analysis of the different regions of the axial skeleton when ropefish (*Erpetoichthys calabaricus*) move in water and on land through differently spaced peg arrays. We tracked five distinct regions along the axial skeleton. Similar to previous work, we show that distance ratios in the head region were significantly different between environments. The head exhibits more lateral excursion on land compared to in the water suggesting less forward propulsion on land. Linear velocity differed between aquatic and terrestrial trials across the five body regions. We found that in the terrestrial environment, ropefish are moving slower and with more control. Ropefish tended to cover greater distance in a shorter time in water than on land. The spacing of pegs also had an effect on the movement patterns during terrestrial locomotion; fish moved more quickly in more widely spaced peg arrays. This work demonstrates how elongate fishes may be utilizing aspects of their environment for forward propulsion similar to what has been previously seen in limbless tetrapods.

P2.186 WARREN, S.M.*; HOFFMANN, S.L.; PORTER, M.E.; Florida Atlantic University; *swarre16@fau.edu*

Sphyrnid swimming kinematics: a comparison between ancestral and derived cephalofoil morphology

Sharks in the hammerhead family (Sphyrnidae) can be recognized by their dorso-ventrally compressed and laterally expanded heads, called a cephalofoil. The most derived species, the bonnethead shark (*Sphyrna tiburo*), has the smallest cephalofoil, while a more ancestral species, the scalloped hammerhead (*Sphyrna lewini*) retains a more laterally expanded cephalofoil. Previous research showed that Sphyrnids have a greater dorso-ventral range of motion in the anterior trunk region, suggesting a finer degree of control over the cephalofoil. Additionally, the increased area of the cephalofoil correlates to decreased pectoral fin area, further suggesting that the cephalofoil may be used in lift generation. In this study, we examine whole-body swimming kinematics from both the bonnethead and scalloped hammerhead. Using point tracking software, we analyzed synchronized dorsal and lateral video from both species to calculate variables such as velocity, body curvature, tail-beat frequency, tail-beat amplitude, cephalofoil movement, and pectoral fin movement. From this, we quantified the impact of cephalofoil shape on volitional swimming by comparing the more derived bonnethead sharks to the more ancestral scalloped hammerheads. Understanding the role of the cephalofoil in hammerhead swimming could lead to a better understanding of cephalofoil evolution as well as serve as bio-inspiration in fluid mechanics designs.

P1.28 WARREN, K.J.*; BROWNE, W.E.; Univ. of Miami; *k.warren2@umiami.edu*

Characterization of endodermal and muscle cells from Mnemiopsis leidyi primary cell culture

We are interested in characterizing aspects of the ctenophore gut by observing properties of endodermally derived cells as well as giant smooth muscle cells in culture. Therefore we have developed a primary cell culture system which can be utilized to individually isolate these adult somatic cell types from *Mnemiopsis leidyi*, a lobate ctenophore. Our primary cell cultures are derived from tissue explants and maintained in a complex undefined media. These *in vitro* cell cultures can be used to approximate the *in vivo* cellular environment. Approximately 24 hours after explant removal, cultures are screened for the presence of the desired characteristic cell types. We then continue to visually monitor primary cell cultures for proliferation and changes in cell morphology and/or differentiation for several weeks. Cells derived from endoderm often present as clonally proliferative round cells that are heavily ciliated and also contain distinct darkly pigmented organelles. These endodermal derived cells divide approximately once every 24 hours. Terminally differentiated giant smooth muscle cells do not appear to divide in culture and generally present as hyper-elongated cells exhibiting contractile properties. During the first 48 hours, these muscle cells retain a consistent morphology, generally exhibiting a large diameter that is relatively constant throughout the cell body. Over the course of the next several days, the morphology of these cells dramatically changes with the cells bodies developing multiple processes and anasotmosing. Experiments to further characterize these primary cell cultures will facilitate our ongoing molecular genetic analysis of unique aspects of cell differentiation associated with ctenophore development and evolutionary history from a cell biological perspective.

P3.165 WASHBURN, EH*; CROWLEY, ME; CARVALHO, PG; EGELSTON, JN; MCCORMICK, SD; LEMA, SC; Cal Poly, San Luis Obispo, USGS, Conte Anadromous Fish Res Cen; *slema@calpoly.edu*

Nonapeptide hormones and ionoregulation in the fish gill: Inhibition of hypersalinity-induced CFTR expression by an AVT V1-type receptor antagonist

Arginine vasotocin (AVT) has been implicated to regulate salinity tolerance in fish, but AVT's mechanisms of action are not known. Here we examine AVT system interaction with salinity tolerance in the euryhaline Amargosa pupfish (*Cyprinodon nevadensis*). Pupfish acclimated to brackish water (7.5 ppt) were transferred to fresh water (0.3 ppt), seawater (35 ppt), or hypersaline (55 ppt) conditions. Fish transferred to both 35 ppt and 55 ppt exhibited elevated V1a-type receptor *v1a2* mRNA levels in the gill within 24 h, although *v1a2* transcripts returned to baseline levels within 4 days. This transient increase in *v1a2* mRNAs suggests that AVT's effects on the gill might be mediated by a V1a-type receptor. To test this idea further, pupfish acclimated to 7.5 ppt were injected intraperitoneally with either a saline control, 1 µg AVT per g body mass, or 3.5 µg per g mass of a V1-type receptor antagonist (Manning compound). Immediately following injection, fish were either returned to 7.5 ppt or transferred to 0.3 or 35 ppt. Gene transcripts encoding the cystic fibrosis transmembrane conductance regulator (CFTR) in the gill epithelium increased in relative abundance 24 h after transfer to 35 ppt, but the magnitude of this increase was diminished in fish treated with Manning compound. No effect of Manning compound or AVT was observed on Na^+/K^+-ATPase α subunit or $Na^+/K^+/2Cl^-$cotransporter-1 mRNAs, which were also elevated in 35 ppt, or on aquaporin-3 mRNA, which became elevated in fish transferred to 0.3 ppt. The results indicate that AVT acting through the V1a-type receptor is involved in upregulation of CFTR during acclimation to elevated environmental salinity.

P1.57 WEBB, S/J*; DEVRIES, M/S; Scripps Institution of Oceanography, UC San Diego; *sumjwebb@gmail.com*

Surviving starvation: how food availability affects the Aristotle's lantern of the purple sea urchin

Phenotypic plasticity helps animals cope with drastic environmental changes, and plastic responses can sometimes be reversed when conditions are restored. Field studies on the purple sea urchin, *Strongylocentrotus purpuratus*, have suggested that changes in food abundance elicit a reversibly plastic response in the morphology of the Aristotle's lantern (feeding apparatus). Specifically, jaw size relative to body size increases when food abundance is low. This response, however, has only been observed at the population level. To test whether this relationship holds in individual juvenile urchins, we divided 90 purple sea urchins into two food treatments for six months. In the high food treatment, urchins had constant access to kelp. In the starvation treatment, urchins were only given kelp every 12-14 days for 24 hours. After three months, 30 animals were subsampled to assess the relationship of jaw length to test diameter and gonad weight to body size (gonadal index). Treatments were then switched for the remaining 60 animals. At three months, both the test diameter and gonadal index of the starved animals were significantly lower than the animals given constant food. Yet, the ratio of jaw length to test diameter was significantly higher in starved individuals, confirming field observations. Increased jaw size implies that individuals allocate greater resources to feeding morphology, which may improve feeding efficiency during food scarcity. It is predicted that this trait is reversibly plastic within individuals and that jaw length will therefore decrease after previously starved animals have been held in high food conditions for three months. The ability to alter relative jaw size depending on resource availability may have contributed to the success of this kelp forest consumer.

P3.93 WEBBER, MA*; IVANOV, BM; JOHNSON, MA; Trinity University; *mwebber@trinity.edu*

Interspecific variation in blood physiology in Caribbean Anolis lizards

Across vertebrates, red blood cells transport oxygen throughout the body. Generally, the oxygen capacity of the blood varies with temperature and altitude, such that animals inhabiting environments with cooler temperatures and those that occur at higher elevations must compensate for the resulting decrease in blood flow rate and consequential lack of oxygen transport. These compensatory traits can include larger red blood cells, greater hematocrit (the percentage by volume of red blood cells in the blood), and a higher concentration of hemoglobin (a protein in red blood cells that transports oxygen). In this study, we measured these blood physiology traits in adult males in a group of 13 *Anolis* lizard species that occur across a wide range of elevations (10 to 1500 meters above sea level) in the Dominican Republic. We also collected altitudinal data from each population studied, and body temperature measures for a subset of 8 of these species. We observed extensive interspecific variation in each of the hematological traits, but this variation was not associated with microhabitat specialization (i.e., ecomorph) or body temperature, and no phylogenetic signal was detected in the traits. Using phylogenetically-informed analyses, we found marginally positive relationships between hemoglobin concentration and altitude, and between hemoglobin concentration and hematocrit. Together, these results suggest that characteristics of blood related to oxygen transport capacity in anole lizards may evolve in association with a complexity of ecological factors.

P2.134 WEBER, C*; CZERWINSKI, M; CAPEL, B; Duke University , Duke University; *ceri.weber@duke.edu*

Germ cell dynamics during gonad development in the turtle T. scripta

Though many basic developmental processes are highly conserved throughout vertebrates, multiple primary sex-determination pathways have independently evolved. During vertebrate sex determination, a bipotential gonad receives signals that initiate either male- or female-specific development. In the red-eared slider turtle *Trachemys scripta*, egg incubation temperature serves as a sex-determining switch. Critical germ cell dynamics in the turtle gonad are not well understood, especially in terms of how these events are related to or regulated by temperature. Work in other vertebrates suggests that germ cells play a key role in somatic development of the gonad and sex specific proliferation events that influence sex determination have been previously observed. We show that germ cell migration, proliferation, and other dynamic changes occur in the turtle gonad in a temperature and sex specific way.

P1.135 WECHSLER, S*; SPRAYBERRY, JDH; Muhlenberg College; *sw246939@muhlenberg.edu*

Arduino based olfactory stimulus system

The sensory substrates of foraging in bumblebees are incompletely understood - as such this is an area of active investigation. When studying foraging behavior of bumblebees in a laboratory setting, collecting data on an individual-level, rather than a colony-level, greatly increases the sample size and statistical power of the data. Historically, the tracking of individual bees has been done by gluing numbered tags to each bee and manually observing behavior. This technique has serious drawbacks at a primarily undergraduate institution - where students may not have large blocks of time to devote to observation. Open-source RFID reader technology has now made automated logging of individual bees affordable in a liberal arts setting. Utilizing 3-D printed feeder lids that hold an RFID antenna, we were able to successfully log feeding events from tagged bees. However, given that our lab is investigating the role of olfaction in foraging, the issue of a stimulus remained. Pumping air through syringes containing filter-paper scented with essential oil/s can provide an odor stimulus in the foraging chambers housing RFID-equipped feeders. However, constant air flow could weaken the stimulus strength rapidly, resulting in less consistent odor presentation. As such, we designed a motion activated stimulus system. Through the use of an open source arduino microcontroller, a PIR motion sensor turns on an air pump to intermittently puff odor bursts into the foraging chamber/s. The burst length, the inter-burst interval, and the number of bursts are readily customizable. As such, the system can easily be modulated to serve the needs of other research laboratories. The use of automated stimulus presentation and data collection through affordable microcontrollers promises to be an excellent tool for undergraduate researchers.

P1.38 WEICKHARDT, AF*; FEILICH, KL; LAUDER, GV; Harvard University; *aweickhardt@college.harvard.edu*

Evolution of dorsal fin structure and stiffness in percid fishes

The dorsal fin is one of the most varied swimming structures in spiny-finned fishes. This fin can be present as a single contiguous structure supported by bony spines and soft rays, or it may be divided into an anterior spiny dorsal fin and a posterior soft dorsal fin. When the fin is divided, the length of the gap between the spiny and soft portions of the fin can range from almost nothing to a considerable portion of the fish's body length. Computational models have suggested that if the spiny and soft dorsal fins are divided and the soft dorsal fin has a stiff leading edge, then the posterior dorsal fin can exploit vortices shed by the anterior fin, increasing thrust. Based on this putative role of the posterior dorsal fin, we hypothesized that gaps between the anterior and posterior dorsal fin would evolve in tandem with stiffened fin rays at the leading edge of the posterior dorsal to resist oncoming flow and to provide a more robust attachment for intrinsic fin musculature. We studied the evolution of dorsal fin stiffness and spacing across the freshwater perches of the family Percidae. Percid fishes exhibit considerable variation in dorsal fin morphology, with multiple evolutions of the split dorsal fin across their phylogeny. Using x-ray radiography of museum specimens we measured the spacing between dorsal fins (where present). From these specimens, we collected &muCT data from individual dorsal fin spines and rays. We used these data to calculate the spines' and rays' second moment of area, and conducted cantilever bending tests to estimate spine and ray flexural stiffness and Young's modulus. Using phylogenetic comparative methods, we measured the strength of the association between dorsal fin spacing and the stiffness of the fin elements at the leading edge of the posterior portion of the dorsal fin.

P3.88 WEHRLE, B.A.*; NGUYEN-PHUC, B.Q.; DANG, R.K.; KRAJNOVIC, M.; TADIC, Z.; HERREL, A.; GERMAN, D.P.; Univ. of California, Irvine, Univ. of Zagreb, CNRS/MNHN; *beck.wehrle@gmail.com*

Seasonal and sex effects on the digestive physiology of a newly herbivorous lizard

Few studies of diet incorporate analyses of what an animal is digesting. Knowing what an animal actually digests allows us to understand if its physiology and morphology are optimized for its nutritional source. A population of Italian Wall Lizards (*Podarcis sicula*) in Croatia has become primarily herbivorous and morphologically distinct from its source population in ~30 generations, making it a compelling example of rapid evolution. To characterize the changes that occur on this short timescale, we have compared gut structure and enzyme activity across populations of males in a single season. Though the Adaptive Modulation Hypothesis predicts dietary specialization should lead to gut specialization, our previous work has documented few biochemical and histological changes in the herbivorous population's guts from male lizards collected in the summer. Despite these similarities, the herbivorous population had a higher digestive efficiency of plant meals than their source counterparts. Using mixing models with stable isotope data, we reconstructed specific diets for each population. Stable isotope analyses indicate that dietary differences are seasonal, but that the "herbivorous" population consistently has elevated $\delta^{15}N$ values in comparison to the source carnivorous population. Although we found no differences in gut length among males, we measured longer guts in females from the herbivorous population. Thus, we expect to find greater differences in gut enzyme activities across seasons and in females. We compared carbohydrases, proteases, and lipase, making this the most comprehensive study of lizard digestive enzymes to date.

P2.155 WEILER, D.E.*; KOEHL, M.A.R.; University of California, Berkeley; *doriane.weiler@berkeley.edu*

Safety in numbers: Predation resistance as a selective factor in the evolution of multicellularity

Comparative genomic and molecular phylogenetic evidence has revealed a close relationship between animals and choanoflagellate protozoans. Therefore, choanoflagellates that can form colonies are used as a model system to study mechanisms that may have been involved in the evolution of multicellularity in the ancestors of animals. For multicellularity to evolve, there may have been performance advantages that resulted in improved fitness for colonial organisms. This study explored predation as a potential selective pressure. The ciliated protozoan, *Stentor coeruleus*, was used as a model predator because its morphology is similar to that of ciliated protozoans that were abundant in the fossil record before animals evolved. *Salpingoeca helianthica*, a choanoflagellate with both unicellular and multicellular forms, was used as prey. High-speed videomicrography was used to record *S. coeruleus* preying upon *S. helianthica*. Videos were analyzed frame by frame to determine the feeding efficiency (number of prey captured per number encountered in the feeding current) of *S. coeruleus* for single-celled choanoflagellates vs. for colonies. Feeding efficiency was highest for unicellular prey and decreased significantly with number of cells in colonial prey. The mechanism responsible for better predation avoidance in colonial *S. helianthica* was that colonies escaped from the oral pouch of *S. coeruleus* more frequently than did single-celled choanoflagellates. These findings show that formation of multicellular colonies can improve the performance of choanoflagellates in avoiding predation, and suggest that predation might have been a selective factor in the evolution of multicellularity, a pivotal transition in life's history.

P1.152 WEITEKAMP, C.A.*; DEL VALLE, P.; NUGENT, B.M.; SOLOMON-LANE, T.K.; HOFMANN, H.A.; The University of Texas at Austin; *chelseaweitekamp@gmail.com*

Isotocin mediates the "dear enemy" effect in a cichlid fish

Neighboring territorial males of many species exhibit less aggression toward each other than toward strangers, a phenomenon known as the "dear enemy" effect. While this effect occurs across taxa, the neuromolecular mechanisms remain unknown. The oxytocin (OT) pathway serves a critical role in mediating male-female pair bonding in several species and thus is an interesting candidate mediator of male-male bonding. Using the African cichlid fish *Astatotilapia burtoni*, we use male-male bonding in the context of the "dear enemy" effect to investigate the role of isotocin (IT), the teleost homolog of OT. We examine IT receptor expression in the putative homologues of the hippocampus (Dlv), basolateral amygdala (Dm), and in the preoptic area (POA). We find ITR expression is upregulated in "dear enemy" males in the hippocampus and amygdala, while it is downregulated in the preoptic area. To further examine the role of the IT pathway, we use double-labeling immunohistochemistry to identify the role of IT neurons activated in the "dear enemy" context. Lastly, we pharmacologically perturb the IT pathway to prevent the formation of male bonds. Our results demonstrate a critical role of the IT pathway, as well as involvement of several brain regions in the Social Decision-Making Network in regulating male-male bonding in the context of the ethologically relevant "dear enemy" effect.

P1.113 WELCH, A.M.*; BEAM, E.R.; RUBY, A.L.; FALLON, B.; College of Charleston, South Carolina Governor's School for Science and Mathematics; *welcha@cofc.edu*

Salinity tolerance in aquatic and terrestrial stages of southern toads (Anaxyrus terrestris)

Habitat salinization is an emerging concern for freshwater organisms, as rising sea levels, intensified storm surges, road deicing salts and land use changes can all increase salt loading in freshwater systems. Amphibians may be particularly vulnerable to increased salinity due to their semi-aquatic life cycle and permeable skin. Given the complex life cycle typical of amphibians, abilities to cope with environmental challenges may vary among life stages. Although larval amphibians are generally thought to be more sensitive to osmotic challenges than are adults, it is important to understand more about salinity effects throughout the life cycle in order to determine which stages are at greatest risk due to habitat salinization. In this study, we sought to determine salinity tolerance of embryos, tadpoles, newly metamorphosed individuals, and adults of the southern toad, *Anaxyrus terrestris*. Among these life stages, embryos were the most sensitive to salinity, with almost no survival at 6 parts per thousand. Tadpoles also suffered significant mortality at this salinity. The terrestrial stages, however, were able to withstand solutions of this salinity without dehydrating, though both dehydration and avoidance behavior were seen at higher salinities. Our results suggest that elevated salinity is most likely to affect population dynamics when experienced during embryonic development, and that salinity tolerance appears to increase dramatically during the metamorphic transition. In addition, the tolerance adult toads show for a salinity level that was lethal to embryos suggests that adults must alter salinity avoidance behavior during oviposition.

P1.191 WELKLIN, JF*; LANTZ, SM; BOERSMA, JP; SCHWABL, HG; WEBSTER, MS; Cornell University, Tulane University, Washington State University, Washington State University; *jfw96@cornell.edu*

The effect of social environment on plumage, behavior, and androgen levels in Red-backed Fairy-wrens

An organism's phenotype is the product of its morphology, behavior, and physiology. Hormonal variation associated with morphology can often explain variation in behavior, as the relationship between androgens and behavior has been well documented. However, in species that exhibit multiple discrete phenotypes, the relationship between morphology, androgens, and behavior is less clear, and may be closely related to the organism's social environment. Red-backed Fairy-wrens, a small Australian songbird, can breed in either female-like brown, or ornamented red/black nuptial plumage. Males of both phenotypes are equally capable of producing high androgen levels, yet red/black males are more likely to have high androgen levels than brown males during the pre-breeding season. This could be correlated with more social interactions associated with molt into ornamented plumage. Yet, even within ornamented males there exists considerable variation in androgen levels. We present data on the variation in plumage phenotype and its relation to androgen levels, social behavior, and social environment, comparing both between phenotypes and within.

P1.55 WESTNEAT, M W*; MCCORD, C L; University of Chicago; *mwestneat@uchicago.edu*

FuturePhy: Integration of the Tree of Life with Biomechanics Data Layers

Biologists have made major progress in understanding the vast evolutionary Tree of Life, including many aspects of its shape and content, the timing of evolutionary events along its branches, and the patterns and processes of diversification though its history. Despite this progress, a grand challenge remains: to generate and fully exploit large, densely sampled phylogenetic trees, and to integrate resulting genealogies with rich data sources from biodiversity, biogeography, development, morphology, ecology and biomechanics. The FuturePhy project is an NSF-sponsored, three-year program of conferences, workshops and hackathons on the Tree of Life that aims to promote novel, integrative data analyses and visualization, interdisciplinary syntheses in phylogenetic sciences, and cross-cutting uses of phylogenetics to develop and address new research questions and applications. In that context, here we focus this effort by showing several examples of integrating phylogenetic trees with biomechanical data, and discuss the challenges to tree-data integration in evolutionary biomechanics. The solutions to these challenges for a wide range of scientific communities depend on our participation in building publicly accessible repositories for both phylogenetic trees and important trait layers such as ecology, morphology and function. We urge the biomechanics community (and all SICB communities) to participate more fully in data deposition in public repositories, and invite participation by SICB members in upcoming FuturePhy meetings and webinars to discuss integration of large data sets with phylogenetic trees. Supported by NSF DEB-1447321 and IOS-1425049.

P1.140 WESTRICK, S.E.*; HARTSOUGH, L; FISCHER, E.K.; HOKE, K.L.; University of Michigan, Ann Arbor, Colorado State University, Fort Collins; *westse@umich.edu*

Social context leads to differential immediate early gene activation in guppies (Poecilia reticulata)

The social behavior network of the brain plays an important role in mediating social behaviors across vertebrates, but each region of the network plays a unique role. Certain regions of the social behavior network, such as the preoptic area of the forebrain and midbrain, are involved in multiple forms of social behavior including aggression and sexual behavior, but which regions are involved in differentiating these similar social contexts? To determine which regions of the social behavior network are involved in differentiating social contexts, we quantified behavior and immediate early gene (ps6) activity in the brain across multiple regions, including the telencephalic zone and preoptic area. Using male guppies (*Poecilia reticulata*), we observed behavior in two conditions: courtship and competition. In the courtship condition, males were observed interacting with females. In the competition condition, males were observed interacting with other males. We saw elevated activity levels in the anterior preoptic area of fish in the courtship group compared to the competition and control solo males. Additional regions in the social behavior network did not show increased activity in either group, compared to solo males. These results implicate the involvement of the anterior preoptic area in differentiating sexual behavior from aggressive behavior. By looking across multiple regions of the social behavior network in two different social contexts, we were able to identify the unique role of the anterior preoptic area in guppies.

P2.193 WHITLOW, K.*; OUFIERO, C.E.; Towson Univ.; *kwhitl5@students.towson.edu*

Effects of gymnotiform locomotion on swimming performance and efficiency in knifefish

Fish swimming is grouped into two main categories: body-caudal fin (BCF) and median/paired fin (MPF) locomotion, with the former being much more thoroughly investigated. Gymnotiform swimmers, or "knifefish", fall into the latter group, using an elongated anal fin to produce thrust via ribbon-like undulations. Knifefish are found throughout Gymnotiformes and in one family of Osteoglossiformes. Since these orders are not closely related, convergence on gymnotiform swimming may be adaptive for both groups. While theoretical frameworks suggest that knifefish are highly maneuverable, poor accelerators, and inefficient sustained swimmers, little is known about the actual performance of fish from these groups. A previous study on one species (*Xenomystus nigri*) suggests that their ability to perform escape responses is comparable to that of BCF swimming teleosts despite their potential morphological constraints; however other swimming performance measures have rarely been tested across species. To better understand the costs and benefits associated with gymnotiform swimming, we investigated the performance of a BCF swimmer, the giant danio (*Devario malabaricus*); a pure gymnotiform swimmer, the black ghost knifefish (*Apteronotus albifrons*); and two Osteoglossiform knifefish which utilize varying degrees of BCF and anal fin undulations, the clown (*Chitala ornata*) and African brown (*X. nigri*). We captured escape responses, recorded sprint speeds, and gathered cost of transport data on 5-8 individuals from each species. Preliminary size-corrected maximum sprint speed analyses suggest that the BCF swimmer is faster than all knifefish studied. Further analyses, along with cost of transport and escape response results, will provide a better understanding of the transition to this unique locomotor mode.

P2.164 WHITNEY, M.R.*; SIDOR, C.A.; University of Washington; *megwhit@uw.edu*

Mammal-like thecodonty in several Permo-Triassic Therapsids: implications for the evolution of tooth attachment in mammals

Thecodonty has traditionally combined two components of anatomy: the geometry of tooth emplacement in the jaw with deep sockets and the presence of a periodontal ligament anchoring the tooth to the jaw. Extant mammals employ three attachment tissues (cementum, a periodontal ligament, and alveolar bone) in forming a gomphosis between the teeth and jaw. Among fossil synapsids, thecodonty and gomphosis are considered derived states restricted to mammaliaforms and some derived, non-mammalian cynodonts. By contrast, most other fossil synapsids are thought to employ reptile-like ankylosis, where the tooth is fused to the jaw. Here we report on the presence of thecodonty and gomphosis in Permian and Triassic therapsids. Using fossil histological techniques, we examined the geometry and tissues involved in tooth attachment in dinocephalians, gorgonopsians, and cynodonts. Gomphosis appears to be ubiquitous within our sample. However, the extent to which a tooth is implanted into the jaw (i.e. root length) varies markedly. The remnants of the tissues involved in gomphosis were detected in at least tapinocephalid dinocephalians (early herbivorous therapsids) along with some evidence of cementum in gorgonopsians and traversodontid cynodonts. Our findings bring the first appearance of mammal-like tooth implantation back to at least the middle Permian (>260 MA). Additionally, variation in root length and periodontal space across Therapsida and within its subclades suggests that the evolution of tooth implantation in synapsids may be more strongly influenced by factors like diet than phylogeny.

P1.174 WHITTINGHAM, L.A.*; DUNN, P.O.; University of Wisconsin-Milwaukee; *whitting@uwm.edu*

Experimental Evidence that Colorful Males Sire More Extra-pair Young in Swallows

Few studies have found correlations between male traits and extra-pair mating success in birds, and even fewer studies have experimentally manipulated male traits to determine if they are directly related to paternity. As a consequence, there is little evidence to support the widespread hypothesis that female birds choose attractive males as extra-pair mates. Here, we conducted an experimental study of the relationship between male plumage color and fertilization success in tree swallows (Tachycineta bicolor). The sexes are monochromatic, but frequent extra-pair mating suggests that sexual selection could be strong. Previous work suggested that male plumage brightness was positively related to male extra-pair fertilization success. In this study we experimentally dulled male plumage (with non-toxic ink markers) early in the breeding season prior to egg laying. As predicted, dulled males sired significantly fewer young (both within-pair and extra-pair) than control males. Thus, male plumage brightness is an important signal to female tree swallows choosing both within-pair and extra-pair mates.

P2.10.5 WIERINGA, J.G.*; MAHON, A.R.; Central Michigan Unversity, Central Michigan University; *jamingwieringa@gmail.com*
Evaluation of the Reproductive Status of Ctenopharyngodon idella in Western Lake Erie
Invasive grass carp (*Ctenopharyngodon idella*) were first introduced into the United States in 1963 as a biocontrol agent and have since been released or have escaped into multiple freshwater basins. Their feeding on submerged aquatic vegetation destroys food sources, shelter and spawning areas that are vital to native species. Even though grass carp are bred as triploid and still distributed in some regions, diploid individuals have been previously captured in Lake Erie. Recently, multiple individuals have been captured in the Laurentian Great Lakes and while the overall extent of their impact is not fully known, grass carp pose a significant risk to native fisheries populations. With both diploids and triploids being captured in the western basin of Lake Erie, the extent of the population that is reproductively viable has yet to be delineated. In this study, grass carp captured by commercial fishermen and government agencies in Michigan ad Ohio waters of Lake Erie were sampled to determine the reproductive status of this population. Thirty-six individuals were screened between May 2014 and July 2015. Ploidy for each individual was determined by flow cytometry or visualization of nuclear morphology via microscopy. The resulting data are being used to determine the ploidy status of current populations within western Lake Erie. This work will enable management to understand the extent of the current invasion and determine means to manage population expansion.

P3.162 WILLIAMS, C.E.*; GUILLETTE, L.J.; SPYROPOULOS, D.D.; KOHNO, S.; College of Charleston, SC, Medical University of South Carolina, Charleston; *williamsce1@g.cofc.edu*
Effects of Exogenous Estradiol on Gonadal Sex Determination in the American Alligator During in Vitro Culture of the Isolated Gonad-Adrenal-Mesonephric Complex.
Temperature dependent sex determination (TSD) is exhibited by many organisms and is particularly common in reptiles. In this system, the temperature of the developing embryo determines its sex through complex pathways which still are not fully understood. Recent research has revealed that the isolated bipotential gonad is capable of sensing temperature and directing differentiation into an ovary or testis *in vitro* in several organisms exhibiting TSD. However, estrogen signaling also plays a critical role in TSD and exposure to 17 -estradiol (E_2) *in ovo* during the thermosensitive period (TSP) of development results in sex reversal at male-producing temperature (MPT) in species including the American alligator, *Alligator mississippiensis*. At the tissue level, E_2 exposure has been shown to significantly alter sexually-dimorphic gene expression in isolated cultured gonads from the red-eared slider turtle. However, the concentration needed for this effect of exogenous E_2-mediated sex reversal *in vitro* on the isolated gonad-adrenal-mesonephric (GAM) complex in *A. mississippiensis* is not known. Thus, GAM complexes were isolated from embryos one day prior to TSP and exposed to varying concentrations of E_2 or vehicle alone while held at a male-producing temperature in culture for 1-2 weeks. Gonadal sex of the cultured GAMs will be assessed by analyzing sexually dimorphic mRNA abundances such as aromatase and anti-Müllerian hormone via quantitative PCR. These results will provide important additional insight into the role of E_2 in sex determination in organisms exhibiting TSD.

P1.195 WILL, A. G.*; ROSTAL, D.C.; Georgia Southern University, Statesboro; *aw04342@georgiasouthern.edu*
How I Look is How I Feel: Effects and Interactions of Testosterone and Corticosterone on Color Expression in Pogona vitticeps (Bearded dragon).
Sexual-dimorphism is a common trait in animals. Usually through the use of hormones, males and females of the same species can differ greatly in size, coloration, and behavior. In lizards, sexually-dimorphic color signals are used extensively during mate-selection. During mating season male bearded dragons will darken their "beard", the underside of the mandible, as a territorial or confrontational display. Bearded dragons have another color patch on its dorsum that is believed to be hormonally controlled, but is not sexually-selected for. In this study, we will measure how pharmaceutical dosages of Testosterone and Corticosterone, both individually and through their interaction, effect these color patches in male Bearded Dragons. Hormone packets containing supranatural amounts of the respective hormones will be surgically inserted into the lizard's abdominal cavity. This will artificially increase the animals' hormone levels above natural levels, forcing a response if one exists. We will then be comparing the animal's color expression to its circulating hormone levels. Color expression and reflectance data will be measured weekly using digital photography and guidelines set by Stevens et al., 2007. Circulating hormone levels will be determined by a weekly blood draw, and ELISA for testosterone, corticosterone, and estradiol. Testosterone is expected to have a darkening effect on the "beard", but little to no effect on the dorsal color patch. Corticosterone is expected to decrease the melanization of the "beard", but increase the melanization of the dorsum.

P2.76 WILSON, L.C.*; GOODSON, J.L.; Indiana University, Bloomington; *wilsonlc@indiana.edu*
Staying close to weather the winter: Oxytocin and corticotropin-releasing hormone may act together to promote seasonal flocking
At the termination of the breeding season, many bird species abandon exclusive territories and join winter flocks. This seasonal shift in behavior has profound fitness implications, but the neuroendocrine mechanisms that promote seasonal flocking are not well understood. Immunocytochemical data suggest that two peptides, Ile8-oxytocin (OT; or mesotocin) and corticotropin-releasing hormone (CRH) may be important modulators of seasonal flocking. In sparrows, seasonal flocking is associated with increased OT and CRH-immunoreactive fiber density in multiple forebrain areas and in the winter, flocking species have a greater number of hypothalamic cells that colocalize both peptides. To experimentally evaluate how these neuropeptide systems mediate seasonal flocking, we conducted peripheral peptide manipulations in the dark-eyed junco, a winter-flocking sparrow. Wintering juncos were peripherally injected with saline or an OT receptor antagonist (OTA) and were then exposed to either a familiar flock or empty aviary. We labeled tissue for OT, CRH, and c-Fos. Exposure to a flock significantly increases the neural activity of hypothalamic OT neurons in both males and females, irrespective of drug treatment. There was a significant effect of sex and a significant interaction of sex*drug on the activity of hypothalamic CRH neurons. Females have greater CRH neuron activity overall, and there is a female-specific increase in CRH neuron activity in OTA-treated animals. Our date support the hypothesis that OT and CRH may act in concert to promote winter flocking - we find that OT cells are socially responsive and that CRH neuron activity is modulated by OT receptor activation.

P2.109 WILSON, T.J.*; SUTTON, T.R.; PROPPER, C.R.; Northern Arizona University; *tjw84@nau.edu*

The Effects of Wastewater Effluent on Gonadal Development in the American Bullfrog (Rana catesbeiana)

Early life exposure to wastewater effluent (WWE) adversely affects gonadal development in a number of aquatic vertebrates. Amphibians exposed to compounds commonly found in WWE show female skewed sex ratios and high occurrences of intersex gonads. Chronic WWE exposure may influence an organism's ability to adapt and respond to a changing environment. We hypothesized that there is phenotypic plasticity in molecular endpoints associated with gonadal development in animals exposed to polluted or remediated environments. *Rana catesbeiana* tadpoles collected from a reference site and a WWE receiving site were used in a reciprocal transplant experiment where half of the tadpoles from each group stayed in their original water, while the other half was exposed to water from the opposite site for 43-45 days. Gonadal tissue was collected for future gross histological evaluation and analysis of two key genes involved in gonadal development, SF-1 and CYP19. Our preliminary findings show sexual dimorphism of SF-1 and CYP19 expression, as well as elevated SF-1 and CYP19 expression in females originally from the WWE receiving site compared to the animals originally from the reference site regardless of their experimental treatment. Our findings suggest that continuous exposure to environmental stressors such as WWE may have the ability to drive differences in what is considered normal reproductive development. Furthermore, these results demonstrate that animals may not be able to respond to shifts in water quality with changes in gene amplicon abundance affecting gonadal development if they have passed a window of development following an exposure.

P1.199 WILSTERMAN, K*; WILDT, DE; COMIZZOLI, P; BENTLEY, GE; Univ. of California, Berkeley, Smithsonian Conservation Biology Institute; *kwilsterman@berkeley.edu*

RFRP-3 expression and function in reproductive tissues of the domestic cat (Felis catus)

The neuropeptide RF-amide-related peptide-3 (RFRP-3) centrally inhibits release and production of gonadotropins in response to various stressors. However, RFRP-3 is also produced and active in peripheral tissues including testes and ovaries. In these tissues, RFRP-3 mediates the stress response by decreasing local steroidogenesis. Despite the potential contribution of RFRP-3 to stress-related pregnancy complications, the broader functional consequences of its action remains unclear, though it is associated with changes in follicular growth and gonadotropin receptor expression in the ovaries. We aim to describe production and function of RFRP-3 in domestic cat gonads to provide a more comprehensive and comparative understanding of RFRP-3 action in peripheral tissues. We have confirmed that cat gonads express the conserved peptide sequence for RFRP-3. RFRP-3 is also expressed in cat uterus. We are now using in vitro culture to test the effects of RFRP-3 on steroidogenesis by quantifying steroid production in culture media and gene expression in tissue. Comparative knowledge of RFRP-3 production and function not only contributes to our broad understanding of reproductive biology and evolution, but also has the potential to aid in developing fertility control strategies in carnivores.

P2.96 WINZER, S.M.*; MIURA, T.A.; WICHMAN, H.A.; PARENT, C.E.; Univ. of Idaho, Moscow; *winz3977@vandals.uidaho.edu*

Effects of Viral infection on Population Dynamics of Drosophila melanogaster

A great concern in the world of public health is the spread of viral disease through human and wildlife populations. It is becoming more common for individuals to be simultaneously infected with more than one virus resulting in a new array of immune responses. To effectively mount a defense to prevent outbreaks, public health officials must understand the dynamics of viral interaction. We are using *Drosophila melanogaster* as a model organism to understand the dynamics of co-infection. An important aspect of the spread of disease is the dynamic of population growth. Traditionally, *Drosophila* population studies have been limited to either fecundity (the number of eggs produced) or reproductive output (i.e., the number of offspring that survive to adulthood). Here we present a means of measuring both of these variables simultaneously. We use this new method to study the impacts of population density and viral infection upon fecundity and reproductive output.

P2.183 WISE, T. N.*; SCHWALBE, M.A.B.; BODEN, A.L.; TYTELL, E.D.; Tufts University; *tyler.wise@tufts.edu*

Hydrodynamics of linear accelerations in bluegill sunfish, Lepomis macrochirus

As fish swim, their body interacts with the fluid around them in order to generate thrust. In this study, we examined the hydrodynamics of linear acceleration by bluegill sunfish, *Lepomis macrochirus*, which swims using a carangiform mode. Carangiform swimmers primarily use their caudal fin and posterior body for propulsion, which is different from anguilliform swimmers, like eels, that undulate almost their whole body to swim. Most previous studies have examined steady swimming, but few have looked at linear accelerations, even though most fish do not often swim steadily. During steady swimming, thrust and drag forces are balanced, which makes it difficult to separate the two, but during acceleration, thrust exceeds drag, making it easier to measure; this may reveal insights into how thrust is produced. This study used particle image velocimetry (PIV) to compare the structure of the wake during steady swimming and acceleration and to estimate the axial force. Axial force increased during acceleration, but the orientation of the vortices did not differ between steady swimming and acceleration, which is different than anguilliform swimmers, whose wakes change structure during acceleration. This difference may point to fundamental differences between the two swimming modes.

P3.175 WITONSKY, KR*; HYDER, L; BAUGH, AT; Swarthmore College, PA; *kwitons1@swarthmore.edu*

The influence of object neophobia on behavioral coping and hormonal stress responses in great tits (Parus major) selected for divergent personalities.

Novel object assays have been used extensively to explore avian behavior and it has been assumed that exposure to such novelty is mildly stressful—this assumption, however, is rarely tested. We did so here using captive adult great tits (*Parus major*) derived from the fourth generation of bidirectional artificial selection on spatial and object neophobia. The results confirmed this common assumption—we observed a moderate but significant elevation in plasma corticosterone following 10 min of exposure to a novel object in the home cage. The magnitude of the hormonal stress response was independent of selection line and not attributable to human observer effects. Immediately following exposure to the novel object, birds were placed in restraint for 30 min and bled for an additional corticosterone sample. We found that this second stressor induced a strong corticosterone elevation that was selection line dependent, with the fast exploration line exhibiting the stronger response. These hormone results were complimented by estimates of behavioral coping, including the measurement of abnormal repetitive behaviors (ARBs) and locomotor activity in response to the novel object. This component of the study allowed us to test the hypothesis that exploratory personality is genetically correlated with routine forming behaviors such as ARBs—a suite of traits that have been observed in other species—and then link this behavioral variation to the simultaneously measured variation in corticosterone responses. We discuss these results in the context of animal personality research as well as animal models of behavioral and physiological dysregulation.

P1.4 WOODLEY, S.K. *; ANDERSON, M.; DEINER, J.; ENGLE, M.; ROWE, G.; SENKO, J.; TRUN, N.; Duquesne Univ., Mount Aloysius College, City Univ. New York, La Roche College, Univ. Akron; *woodleys@duq.edu*

Incorporating novel research into classrooms using application-based service learning

Traditional upper-level lab courses focus on concepts and techniques. Undergraduate research experience typically comes through individual student participation in faculty research labs. To improve student learning in lab courses and to increase student engagement in authentic scientific research, we are implementing a novel pedagogy called Application-Based Service Learning that incorporates several high impact educational practices, including novel research related to community problems in multiple contexts, disciplines and instititutions. Physiology students studied organismal responses to water quality, reporting gains in understanding and communication. Molecular biology students identified organisms from healthy and polluted waters, reporting increased motivation to work and improved technical skills. Geochemistry students studied the performance of water treatment systems, and reported that the public service component was an additional motivation to participate in the course. In the chemistry courses, students researched methods to detect pollution related to brownfield redevelopment, reporting high satisfaction with the courses and increased understanding of chemistry in their everyday lives. Through a discipline-independent research course, students studied feral cat microbiota, resulting in more students engaged in novel research and research-related activities. Together, results indicate that novel research in a variety of different classroom settings can substantially increase the number of students engaged in authentic research and can produce gains in student learning and attitudes.

P1.138 WOLFF, G.H.*; RIFFELL, J.A.; Univ. of Washington; *gabwolff@uw.edu*

Comparative Immunoreactivity in Olfactory Brain Centers Across Mosquito Species

Although anthropophilic, hematophagous females are the most studied mosquitos due to their role as vectors for Yellow Fever, Dengue, Malaria and other diseases, the Culicidae also demonstrate a wide range of preferences for non-human hosts. Females of some species are less anthropophilic than others, feeding from an array of vertebrate and even invertebrate animals. Male mosquitos as well as some females are non-hematophagous and feed solely on plant tissues and/or sugars. These differences in host preferences make mosquitos an excellent study group for comparing neural circuitry involved in olfaction, learning and memory, and feeding behaviors. Here we use immunocytochemical methods to detect and compare localization of neuropeptides in both males and females across species in the Culicidae, with particular focus on olfactory pathways in the antennal lobe and mushroom bodies. Differential innervation of these structures by peptidergic neurons is discussed in the context of varying host-seeking behaviors across species. In addition, these results support a role for biogenic amines such as dopamine in mosquito olfaction as well as learning and memory of host-related odors.

P2.39 WORLD, C.J.; BERNER, N.J.*; University of the South; *nberner@sewanee.edu*

Tissue-specific modulation of antioxidant defense during seasonal acclimation of Eastern red spotted newt (Notophthalmus viridescens viridescens)

Ectothermic animals that remain active during the winter despite lower temperatures utilize adaptive mechanisms to maintain metabolic activity in the cold to fulfill the energy requirements for survival. Mechanisms that underpin such acclimation include increases in oxidative capacity, membrane fluidity, and O_2 diffusion, which, though beneficial to the maintenance of homeostasis in the cold, may also result in deleterious effects such as enhanced proton leak, lipid peroxidation, and oxidative stress. Our own research shows that the Eastern red spotted newt (*Notophthalamus viridescens viridescens*) increases the polyunsaturated fatty acid (PUFA) composition of cellular membranes in winter, which is in turn correlated with higher metabolic enzyme activity, and a higher rate of whole-animal O_2 consumption. Since PUFAs are especially sensitive to oxidative attack, we hypothesized that the newt must possess defenses to combat oxidative stress and membrane peroxidation to maintain physiologic homeostasis during winter acclimation. To this end we measured lipid peroxidation in liver and muscle tissue of newts collected in summer and winter. We found an increase in the lipid peroxidation of liver but not skeletal muscle membranes in winter. This was correlated with a reduction in the reduced glutathione (GSH) content and of the activities of GSH-dependent antioxidant enzymes in liver, while in muscle GSH content and the activities of catalase and GSH-*s*-transferase (GST) remained unchanged. This work reveals an antioxidant defense mechanism in the newt, the maintenance of which during seasonal acclimation appears to protect membranes from oxidative injury in a tissue-specific manner.

P3.47 WRIGHT, R.M.*; AGLYAMOVA, G.V.; MATZ, M.V.; The University of Texas at Austin; *rachelwright8@gmail.com*
Gene expression signatures of susceptibility to bacterial pathogens in the great star coral, Montastraea cavernosa
Increasingly frequent and virulent coral diseases threaten global reef cover, especially in the Caribbean where outbreaks are exacerbated by warming waters. Some corals appear to be more resistant to these diseases than others, but the physiological mechanisms underlying these differences in susceptibility are unknown. The objective of this research was to identify molecular characteristics associated with differences in susceptibility to bacterial pathogens between individual corals within a population. We analyzed the baseline (pre-treatment) gene expression of twenty-eight genotypes of *Montastraea cavernosa* from a pristine reef, the Texas Flower Gardens Banks, and then subjected those same corals to a bacterial challenge with *Vibrio coralliilyticus*, a putative agent of tissue-loss diseases in corals. Individuals that experienced more mortality upregulated genes associated with growth (e.g. ribosomal proteins) and downregulated genes for intracellular signaling components. These findings reveal the physiological mechanisms underlying differences in disease outcomes between individual corals and increase our general understanding of coral immunity. Furthermore, we could potentially use these gene expression signatures correlating with increased disease resistance as biomarkers to monitor reef health in situ or to select the most robust corals for reef restoration efforts.

P1.40 WRIGHT, A.J.*; HYDE, J.R.; WEGNER, N.C.; Southwest Fisheries Science Center, La Jolla; *alexander.wright@noaa.gov*
Gill morphology, movements, and in vivo temperature measurements of an endothermic fish, the opah, Lampris guttatus.
The opah, *Lampris guttatus*, is the only fish known to exhibit a whole-body form of endothermy and must therefore meet increased metabolic demands to maintain an elevated internal temperature relative to the environment. Accordingly, opah gill structure is specialized to uptake sufficient oxygen to drive the metabolic reactions within its tissues and to optimize heat retention. In this study, gill surface area of the opah was determined across a range of body sizes for comparison with other fishes and to determine the relationship of gill surface area to body mass. It was found that the opah has much larger gills than those of most other fishes and a high gill surface area to body mass scaling exponent (1.16, with most teleosts being between 0.8-0.9). This high scaling exponent suggests a disproportionate increase in oxygen demand as the fish grows, which may consequently allow for an increased capacity for endothermy with size. In addition to gill measurements, a number of opah were outfitted with customized PSATs (pop-up archival satellite tags) with an intermuscular thermocouple to better understand their daily movements and habitat preference in relation to internal body temperature. Fish were observed to frequently make deep dives into cold, nutrient-rich waters, however, the internal temperature of the fish remained significantly elevated above the decreasing ambient temperature. Together, gill and tagging data provide needed insight into the correlation of gill morphology, metabolism, life-history and habitat preference, yielding a better understanding of opah specialization for endothermy in the mesopelagic zone.

P1.53 WRIGHT, N.A.*; WITT, C.C.; TOBALSKE, B.W.; Univ. of Montana, Missoula, Univ. of New Mexico, Albuquerque; *nataliestudiesbirds@gmail.com*
Take-off mechanics in island birds: functional consequences of island evolution
Smaller flight muscles and longer legs are characteristic of island birds, but the consequences of this morphology on performance are unknown. We tested how reduced flight muscles and longer legs affect take-off performance. We measured flight kinematics and leg thrust forces for take-offs of wild birds on the islands of Trinidad and Tobago using a custom-built perch and a high-speed video camera. The large island of Trinidad is continental in its avifauna and predators, while birds on smaller Tobago have reduced pectoral flight muscles and longer legs, and experience lower predation pressures. We found that birds on Tobago had slower maximum velocity ($p=0.008$) and maximum acceleration ($p=0.01$) during take-off relative to conspecifics on Trinidad. Initiation of wingbeats occurred later during take-off in populations on the island of Tobago in two species, the hummingbird Amazilia tobaci and flycatcher Mionectes oleagineus. Lower predation pressures on small, species-poor islands likely permit the slower take-off velocities that result from island birds' reduced flight muscles. Our study produced a novel comparative dataset of take-off mechanics for 16 species from five orders, ranging in body size from 4.1g to 130g. Across this sample, maximum take-off velocity scaled with body mass to a power of 0.16 potentially offsetting adverse scaling of induced power requirements. Pectoral flight muscle mass ranged from 12% to 33% of total body mass. This relative flight muscle size correlated with the timing of wingbeat initiation ($p<0.001$), with larger-muscled birds beginning the first wingbeat earlier in take-off. Birds with larger flight muscles reached peak acceleration later in take-off ($p=0.008$), as expected if wings were more important contributors to take-off acceleration in species with large pectoral muscles.

P2.161 YAP-CHIONGCO, M.*; MOOI, R.; Diablo Valley College, Pleasant Hill, California Academy of Sciences, San Francisco; *rmooi@calacademy.org*
Getting a grip on size, shape, and evolution of ophicephalous pedicellariae in sea urchins
Pedicellariae are numerous, microscopic, jawed structures scattered over the test (calcite body wall skeleton) among spines of many taxa in the Echinoidea (sea urchins and relatives). A pedicellaria consists of a rod-like stem extending upwards from and articulating with a small tubercle on the test's surface. The stem terminates in a set of 2 to 4 intricately hinged, calcite jaw pieces, or valves. There are at least 5 different types of pedicellariae, with varying functions that remain poorly understood. The order Clypeasteroida (sand dollars and sea biscuits) shows high diversity within one type of pedicellariae, the ophicephalous. Ophicephalous pedicellariae consist of 3 toothed valves connected by sophisticated hinges. Proximal to the hinges are calcite loops ("handles") that nest one below the other and connect to the stem through a "strap" made of connective tissue. The strap/handle complex increases the gripping strength of the valves without muscular input. Ophicephalous pedicellariae can provide phylogenetic characters, but little is known about their growth, evolution, and inter-specific variation. Detailed analyses of three species of sea biscuit reveal allometric relationships among components of the pedicellariae themselves as well as the fact that pedicellariae exhibit strong negative allometry with respect to overall test size. SEM and light microscopy from more than 25 species of clypeasteroids, and sister taxa such as the echinolampadoids, reveal important size and shape differences throughout pedicellarial evolution, raising major questions concerning convergence and the conservation of genetic signal to make such complex structures.

P3.145 YORK, J.R.*; LAKIZA, O.; ZEHNDER, K.J.; MCCAULEY, D.W.; Univ. of Oklahoma; *joshuayork@ou.edu*

Role of SoxD in the Evolution of the Epithelial-Mesenchymal Transition in Neural Crest Cells

One of the key events in early vertebrate evolution was the transition from a sessile, filter-feeding lifestyle to one of active predation that was characterized by innovations in morphology, physiology, and behavior, and exploitation of ecological opportunity. The evolutionary success of early vertebrates is linked to the acquisition of the neural crest, a migratory, multipotent cell population that arises along the vertebrate embryonic central nervous system. One of the hallmarks of neural crest cells is the initiation of an epithelial-mesenchymal transition (EMT), a mechanism that promotes the migration of neural crest cells along stereotypical pathways in the early vertebrate embryo. Although a conserved gene regulatory network orchestrates neural crest EMT among gnathostome vertebrates, the evolutionary origins of this network among basal vertebrates are relatively unknown. Using the sea lamprey as an experimental model, we show that a lamprey orthologue of Snail, a master regulatory factor controlling EMT in gnathostomes, is not expressed in pre-migratory or migratory neural crest. By contrast, morpholino-mediated gene knockdown of lamprey SoxD abrogated EMT in neural crest cells, as indicated by persistent expression of EMT markers such as Id and SoxE2 within the dorsal neural tube, and lack of neural crest-derived structures in the pharynx. Together, these preliminary results suggest that SoxD is master regulatory switch controlling EMT in lamprey, and indicate that the mechanism of neural crest EMT in agnathan vertebrates is highly divergent relative to gnathostomes. To further test this notion, we used CRISPR/Cas to generate deletion mutants of SoxD, and subsequently analyzed expression of key EMT regulatory factors, including Sox E2, Twist(s), Sip1 and RhoB.

P2.34 YOU MAK, KT*; LAM, EK; GUNDERSON, AR; STILLMAN, JH; San Francisco State University; *kty2104@barnard.edu*

Body size does not influence thermal tolerance in the intertidal porcelain crab Petrolisthes cinctipes

Tolerance to environmental perturbation may differ among demographic groups within populations, and thus understanding the impact of global warming requires analyses of variation in physiological performance among individuals. Studies on marine invertebrates suggest that large individuals have lower thermal tolerances than small individuals of the same species. We tested for size-specific differences in thermal tolerance using the intertidal porcelain crab, *Petrolisthes cinctipes*, as a model. Based on work in other systems, we predicted that smaller crabs (carapace length 11-14 mm) would have higher thermal tolerance than larger crabs (carapace length ≥18 mm). To test our prediction, we measured the heart rates of crabs during a temperature ramp mimicking field conditions during a hot low-tide period. We used heart rate break point temperature (BPT) as our metric of thermal tolerance, defined as the temperature at which heart rates begin to decrease as temperatures rise. Contrary to our prediction, no statistically significant difference between small (mean BPT = 28.1 ± 1.6°C) and large (mean BPT = 27.0 ± 0.9°C) *P. cinctipes* was observed. Additionally, population demographics, such as gender, may be affected differently by the same abiotic climate changes. As *P. cinctipes appear* to have similar BPTs regardless of size, population-wide changes with larger ecological effects may occur with warming climates.

P1.44 YOUNG, VKH*; BLOB, RW; Clemson Univ.; *vkhilli@clemson.edu*

Comparative limb bone scaling and shape in turtles: relationships with functional demands

Several terrestrial vertebrate lineages include members that have evolved nearly exclusive use of aquatic habitats. Such transitions are often accompanied by the evolution of flattened limbs that are used to swim via dorsoventral flapping. Such changes in shape might be facilitated by changes in bone loading during limb use in novel aquatic environments. Recent studies on limb bone loading during walking and swimming in turtles have found that torsion (twisting) is high relative to bending loads on land, but torsion is greatly reduced compared to bending during aquatic rowing (anteroposterior limb cycles). Release from torsion during swimming could have facilitated the evolution of hydrodynamically advantageous flattened limbs in aquatic species. Because aquatic rowing is considered to be an intermediate locomotor stage between walking and flapping, we predicted that rowing species might show intermediate limb bone flattening compared to terrestrial walkers and marine flappers. To test this possibility, we measured the humerus and femur from museum specimens representing three functionally divergent turtle clades: sea turtles (marine flappers), softshells (freshwater rowers), and tortoises (terrestrial walkers). Analyses showed no difference in scaling patterns across these clades for bone length versus diameter, or either measurement versus body mass. However significant differences in overall limb bone shape are present. For a given mass, softshells show greater lengths and diameters for both the humerus and the femur than either tortoises or sea turtles. Thus, other factors may supersede the influence of locomotor loading on turtle limb design. In particular, the robust limb bones of softshells may provide weight that compensates for a reduced shell and helps them maintain their typical benthic position in water.

P1.23 YOUNG, E.Y.*; SIKES, J.M.; Univ. of San Francisco; *eyyoung@usfca.edu*

Postembryonic polarity modification in the acoel Convolutriloba longifissura

Metazoans establish the bilateral body plan early in embryogenesis by patterning orthogonal body axes with polarity that is unaltered during the lifetime of most animals. While some organisms re-establish/modify body axes during regeneration and asexual reproduction, the acoel flatworm *Convolutriloba longifissura* is unusual in its ability to modify left-right (L-R) axis polarity during longitudinal fission. We have developed *C. longifissura* as a model for studying the mechanisms of L-R polarity modification during postembryonic development. Regeneration experiments have elucidated the temporal dynamics of midline re-specification, suggesting that parallel L-R axes replace the pre-existing midline prior to longitudinal fission. We have characterized the spatiotemporal expression of genes encoding ligands and receptors of signaling pathways with conserved functions in polarity specification and axial patterning. Expression domains of BMP, Hedgehog, Notch, and Slit/Robo signaling components are dynamic prior to and during longitudinal fission. RNAi-mediated gene knockdown and/or pharmacological perturbation of BMP, Notch, and Slit/Robo signals disrupt longitudinal fission and normal midline patterning suggesting a role in modulating changes in L-R axis polarity.

P3.144 YUAN, T*; MCCAULEY, D.W.; Univ. of Oklahoma; *tianyuan@ou.edu*

Insight from Lamprey on the origin of vertebrate myelin

The evolution of large body size in animals required the ability to propagate electrical signals rapidly along neurons for long distances. One solution was to increase the diameter of axons thereby increasing conduction velocity. Vertebrates have solved this problem by forming an insulating myelin sheath that surrounds axons and is formed from glial cells. By insulating small diameter axons, the vertebrate brain can accommodate a larger number of neurons, facilitating the complex connections of the vertebrate nervous system. To study the origin of vertebrate myelin, we are investigating gliogenesis in the sea lamprey, Petromyzon marinus. Sea lampreys are basal jawless vertebrates that lack myelinated axons yet they possess supporting glial cells in both the central and peripheral nervous systems (CNS, PNS), making them ideal for investigating the origin of myelin. Our preliminary data show SoxE2 (Sox10) is expressed in the PNS. However, other genes required for myelination in jawed vertebrates (Krox20, POU3) were not detected in the PNS of sea lamprey. On the other hand, NKX2.2, a gene required for oligodendrocyte differentiation in the CNS of jawed vertebrates is also expressed in the ventral ventricular zone, and later in the marginal layer of the lamprey neural tube. In the CNS of jawed vertebrates, Sox8 and Sox10 are specific to oligodendrocytes. Lamprey SoxE2 (Sox10) is also expressed in the CNS. A lamprey specific SoxE gene, SoxE1, is expressed at motor exit points along the trunk neural tube. To determine the function of SoxE genes and NKX2.2 in lamprey gliogenesis, Morpholino and CRISPR-Cas were used to eliminate SoxE and Nkx2.2 function. By analyzing the regulatory network of lamprey gliogenesis, we expect to determine the ancestral cell type of vertebrate myelinated glia that existed in early vertebrates.

P1.136 ZACARIAS, S*; MURRAY, JA; Cal State East Bay; *samantha.zacarias@csueastbay.edu*

Elucidating the neural circuit involved in chemotaxis in Tritonia tetraquetra

Brains are composed of fundamentally similar cells, making it possible for conclusions derived from simple brains to be applied to more complex systems. The sea slug *T. tetraquetra* is ideal for understanding the neural pathway through which olfactory sensory information is transduced into a motor response because its brain contains few cells which are large and easily identified. The goal of this research is to describe the chemotactic neural pathway, beginning with odorant contact with the rhinophores and ending with a motor response in the form of a change in direction of motion. *Tritonia* use rhinophores to sense odors and have been shown to respond to prey, predator, and conspecific odors with appropriate turning behavior (Wyeth and Willows 2006, Wyeth et al. 2006). Olfactory information is sent to the brain via Lateral Cerebral Nerve 1 (LCN1), while changes in direction of motion are mediated by Pedal Neuron 3 (Pd3) (Redondo and Murray 2005). We initially hypothesized that LCN1 comes into direct contact with turn-inducing neurites of Pd3. Preliminary results show that fluorescent dyes introduced into LCN1 and Pd3 do not co-localize when imaged under confocal microscopy. Backfills done on LCN1 show cell body clusters in the pleural (Pl) and cerebral (Ce) ganglia with occasional cell bodies in the pedal (Pd) ganglion. Dye injections of Pd3 show the axon exiting the Pd ganglion via Pd nerve 3, and dendritic extensions in the pedal neuropil. Our research shows that the sensory transduction circuit for chemotaxis may be more complex than initially thought, with interneurons likely being part of the pathway. Another possibility is that since the association of Pd3 with turning behavior was determined through rheotaxis experiments rather than chemotaxis, Pd3 may not be involved in chemotactic turning.

P1.118 ZANI, PA; WAGNER, EA*; WALKER, B; Univ. Wisconsin-Stevens Point; *Elizabeth.A.Wagner@uwsp.edu*

Effects of drought on reproductive life history of side-blotched lizards

During 2013, drought in central Nevada caused populations of side-blotched lizards to terminate breeding earlier than usual in an apparent shift from reproduction to survival. This led us to investigate which aspects of drought are the causal agent of this shift in life history. To do so we reared side-blotched lizards (*Uta stansburiana*) in identical lab conditions for six months before assigning them to drought (no supplemental watering) or non-drought (supplemental watering) treatment groups. Animals were fed *ad libitum* to test the hypothesis that lack of water, but not lack of food, was sufficient to induce a reproductive response. Body condition was not affected by drought during the lab breeding season. However, as the drought progressed animals lacking water were negatively affected in terms of reproductive timing and success. The availability of water following the drought induced positive effects on body condition, but not immediately. These findings suggest that for desert-adapted reptiles drought conditions and the lack of drinking water alone may be enough to affect life history even if the food supply is not altered in nature.

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Natural and sexual selection act on the size and shape of male fish that obtain copulations by means of coercion

Natural and sexual selection may interact in shaping phenotypic traits. In some species of the fish family Poeciliidae, males obtain copulations by harassing females and thrusting their intromittent organ (gonopodium) towards the female genital pore. Hence, males must swim fast and skillfully towards females. We used *Poeciliopsis infans* as model system and asked if particular sizes and shapes of males are better in gaining copulations. In addition, we asked if the same sizes and shapes have higher survival probabilities, presumably through fast swimming that may help in avoiding predators. We estimated male survival in the wild (natural selection), measured swimming velocity and quantified the number of successful copulations in the laboratory (sexual selection), and used geometric morphometric techniques to measure body size and shape. Our results indicate that larger and streamlined males have higher survival probabilities. We also observed faster swimming velocity in more elongated males. In addition, we found evidence of disruptive selection in terms of mating success. The largest males with deepest bodies as well as the smallest males with thinnest bodies obtained more successful copulations. We provide evidence of a complex interaction between natural and sexual selection shaping the size and shape of these males.

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The earthworm gets a turn: a survey of homeoboxes in the Eisenia fetida genome provides evidence of genome expansion within Annelida

Annelida represents a large and morphologically diverse group of bilaterian organisms. The recently published polychaete and leech genome sequences revealed an equally dynamic range of diversity at the genomic level. The availability of more annelid genomes will allow for the identification of evolutionary genomic events that helped shape the annelid lineage and better understand the diversity within the group. We sequenced and assembled the genome of the common earthworm, *Eisenia fetida*. As a first pass at understanding the diversity within the group, we classified 440 earthworm homeoboxes and compared them to those of the leech *Helobdella robusta* and the polychaete *Capitella teleta*. We inferred many gene expansions occurring in the lineage connecting the most recent common ancestor (MRCA) of *Capitella* and *Eisenia* to the *Eisenia/Helobdella* MRCA. Likewise, the lineage leading from the *Eisenia/Helobdella* MRCA to the leech *Helobdella robusta* has experienced substantial gains and losses. However, the lineage leading from *Eisenia/Helobdella* MRCA to *E. fetida* is characterized by extraordinary levels of homeobox gain. The evolutionary dynamics observed in the homeoboxes of these lineages are very likely to be generalizable to all genes. These genome expansions and losses have likely contributed to the remarkable biology exhibited in this group. These results provide a new perspective from which to understand the diversity within these lineages, show the utility of sub-draft genome assemblies for understanding genomic evolution, and provide a critical resource from which the biology of these animals can be studied.