Ecology & Evolutionary Biology
UNIVERSITY OF TORONTO

Undergraduate Research Fair 2022

Program Guide

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EEB Undergraduate Research Fair

Thank you for joining us for the 2022 EEB Undergraduate Research Fair! We are so excited that you will be joining us for a showcase that highlights the incredible fourth-year research projects students have worked on during the Fall/Winter 2021-22 term. The fair is a great way to experience the diversity of exciting undergraduate research in EEB, to hear about new scientific discoveries made by students, and interact with undergraduates and peers.

The students participating in the fair are competing for the *Corey A. Goldman Prize for Best Research Poster in Ecology and Evolutionary Biology*. The prize is named after former EEB Undergraduate Associate Chair Corey A. Goldman, and recognizes the top students within the department for excellence in their fourth-year independent research projects. Cash prizes will be awarded to the best research poster in each category.

All posters will be available for viewing at https://eebuoft.weebly.com. The site will also showcase posters from other research projects that were conducted this academic year by undergraduate students but are not available for judging.

Event Details

Date: Friday, April 8, 2022
Time: 2:00PM – 4:00PM EST
Location: Foyer outside ESC 1050 (https://classfind.com/toronto/room/ES1050)

Event Schedule

2pm-3:45pm	The Research Fair is open! Student researchers will be available to answer questions about their research.
3:45pm-4pm	Brief closing remarks by Shelby Riskin and announcement of winners and honourable mentions

Research Categories

Student	Supervisor	Title
Category: Conservation Assessment & Strategies		
Judges: Stephen Wright & Chelsea Rochman		
Blythe Beynon	Shelby Riskin	Helping Bats Go Viral
Rachel Fallas	Marie-Josee Fortin	Multi-species assessment of habitat connectivity in the Ontario Greenbelt
Henry James	Marie-Josee Fortin	Using network analysis to assess songbird migration in Southern Ontario
Darius Mahdavi	Shelby Riskin	What makes a conservation-focused video effective?
Nicole Regimbal	Shelby Riskin	Acadian Flycatcher threat analysis using community science data
Category: Urban Ecology		
Judges: Nicole Mideo & Caroline Parins-Fukuchi		
Amy Chen	Shelby Riskin	Using community science to investigate the effect of urbanization on tail loss and perching behavior in multiple lizard species
Sarah Eid	Marie-Josee Fortin	Urban Wildlife in Lockdown: Species Responses Trends throughout the Anthropause
Hana Fahim	Emily Darling	Healthy coral cover but low fish biomass observed in urban coral reefs in India
Jacqueline McLean	Shelby Riskin	Untapped Potential: Using community science to assess lizard species habitat preferences and patterns of tail loss across urbanization gradients in the United States
Category: Ecological Interactions		
Judges: Asher Cutter & Linyi Zhang		
Marcus Forbes-Green	Helene Cyr	How Does Physical Disturbance in Young Native Freshwater Mussels Relate to Habitat Refuges and Influence Growth Patterns?
Madeleine Milne	Chelsea Rochman	Microplastic Particles Observed in Multiple Tissues of Lake Ontario Sportfish
Jessie Wang	Megan Frederickson	Dynamics of duckweed-microbe interactions across nutrient environments
Nicholas Ypelaar	Njal Rollinson	Long-term changes in the incubation environment of a freshwater turtle with temperature-dependent sex determination
Category: From Genotype to Phenotype		
Judges: Luke Mahler & Tiziana A. Gelmi Candusso		
Maia Dall'Acqua	Asher Cutter	Characterizing defects in tail reproductive structures of infertile C. latens x C. remanei male hybrids
Mila Gorchkova	Marla Sokolowski	Social behaviours in Drosophila melanogaster larvae are affected by natural variation in the foraging gene.
Peter Hong	Belinda Chang	The Molecular Evolution of Nrl in Squamate Rod Photoreceptor Development
Alexander MacKenzie	Jacqueline Sztepanacz	A multivariate analysis of whether phenotypic covariance matrices are a good substitute for genetic covariance matrices
Category: Evolution & Environment		
Judges: Marie-Josee Fortin & Garth Covernton		
Alice DesRoches	Art Weis	Competitive dominance in *Brassica rapa* early flowering invasion
Martina Gjevori	Santiago Claramunt	Reconstructing the Phylogeny of Charadriiformes (Aves) Using a Total Evidence Approach
Rebekah Jolicoeur Alfaro	Helen Rodd	The role of methylation in transgenerational effects in guppies exposed to Ritalin
Alex Whitwam	Marla Sokolowski	Genetic and environmental components of individual variability

Student Poster Abstracts

Category: Conservation Assessment & Strategies

Judges: Stephen Wright & Chelsea Rochman

Blythe Beynon (Supervisor: Shelby H. Riskin)

Helping Bats Go Viral

Bats generate phobias and elicit intensely negative emotions, such as fear and disgust. This has been exacerbated by the perceived importance of bats as a vector for zoonotic diseases, including in the current COVID-19 pandemic. The increased stigmatization of bats risks threatening bat populations, many of which are already in decline due to disease, human persecution, and habitat loss. Conservation outreach and education are crucial to generating support and encouraging conservation-focused behaviour for organisms like bats. Many techniques for motivating attitudes and actions for wildlife have been tried, including (1) highlighting the charisma of focal species, (2) highlighting the urgency of a focal species' endangerment, and (3) highlighting the important role a focal species plays in an ecosystem. We created four original bat conservation videos to test which technique would have the greatest impact on knowledge, attitude, and behaviour regarding bats; three videos focused on one of the communication techniques and a control video. Before, immediately after and one month after watching one of the videos, a randomly selected sample of Amazon Turk users (n=400) answered surveys measuring environmental attitudes, as well as knowledge and attitudes regarding bats. Additionally, we gave participants two opportunities, immediately after watching the video and one month after viewing the video, to keep or to donate a $1 bonus to a bat conservation organization. All video treatments were similarly effective in terms of the amount donated, as well as knowledge and attitudes regarding bats. However, these factors were all significantly influenced by participant environmental attitude scores. The results of this study can be applied to inform future bat conservation outreach efforts.

Rachel Fallas (Supervisor: Marie-Josée Fortin)

Multi-species assessment of habitat connectivity in the Ontario Greenbelt

Among the many pervasive anthropogenic impacts that threaten Canada's biodiversity, habitat destruction poses the greatest threat to species of conservation concern. Southwestern Ontario is a hotspot for both biodiversity and industrialization, making the preservation of connected habitat crucial for the long-term viability of wildlife populations in increasingly fragmented landscapes. Surrounding the Greater Toronto Area, the Ontario Greenbelt is protected from development to constrain the effects of urbanization and protect undisturbed ecosystems. The aim of this study was to identify habitat patches and corridors of movement that help to facilitate dispersal and preserve connectivity within the Greenbelt. Omnidirectional circuit theory was used to model the probability of movement across the study area according to the presence of suitable habitat and the permeability of intervening land cover types. Northern short-tailed shrew (*Blarina brevicauda*), Blanding's turtle (*Emydoidea blandingii*), and white-tailed deer (*Odocoileus virginianus*) were selected as the focal species of this study to reflect local diversity in habitat preferences and dispersal abilities. Focal species analyses considered species-specific habitat suitability and corresponding landscape resistance parameters as well as generic landscape resistance parameters. The results revealed that greater dispersal ability is associated with larger movement corridors that are less scattered across the landscape. Furthermore, the overlap between high movement corridors was much lower in focal species analyses compared to the generalized analyses. The habitat patches and high-movement corridors identified in this study will help inform conservation managers about potential opportunities for managing connectivity in the Greenbelt.

Henry James (Supervisor: Marie-Josée Fortin)

Using network analysis to assess songbird migration in Southern Ontario

Migratory songbird declines in North America are driven by numerous factors that vary spatially and temporally over the course of a year. There is a growing need to identify important migratory paths to maintain connectivity between breeding and wintering grounds. However, few studies explore movement patterns at scales fine enough to inform local management decisions. Graph theory is becoming increasingly popular in the study of movement ecology, as it provides a means to quantify the importance of sites (nodes) in a network and the paths between them (edges) across a landscape. We used graph theory to investigate songbird migration in Southern Ontario – an important flyway that has experienced intensive urban and agricultural development. Using tracking data collected by the Motus Wildlife Tracking System from 144 receiving stations across Southern Ontario, we constructed migratory networks for seven species across three families (warblers, sparrows, and thrushes) from 2014 to 2020. By designating the receiving stations as nodes and the paths between them as edges, we calculated network metrics to compare graphs across species and families. We identified key sites within the landscape for migration, though node centrality (importance within the network) varied greatly between and within taxonomic families. This suggests that more targeted approaches for songbird species are required to conserve migratory routes through Southern Ontario. Applying graph theory to Motus tracking data is a novel approach to studying bird migration. Despite being limited by the resolution of this tracking data, our study can be used to inform conservation planning of migratory songbirds at a regional scale.

Darius Mahdavi (Supervisor: Shelby H. Riskin)

What makes a conservation-focused video effective?

Communicating the results of scientific research to the general public is essential for conservation biologists and managers in order to increase public awareness, generate donations, or promote buy-in for interventions and policies. Important considerations in conservation communication include the tone (i.e., optimistic vs. pessimistic), and the attribution of responsibility for the decline of species and ecosystems (e.g., individual vs. industry). There has been conflicting evidence for which tone is most effective in environmental communication, and little evidence for communication about biodiversity and endangered organisms specifically. In a previous, similar experiment focusing on a critically endangered species, we found that while optimistic videos evoked greater hope, were considered more trustworthy long-term, and interacted strongly with political leaning, the strongest trend was that participant response to the videos was correlated with their initial environmental values. We aimed to further investigate this pattern using a separate case study and additionally examine the role of attribution of responsibility and its potential interaction with tone on attitudes and behaviour toward a conservation effort. We used a randomized 2x2 experimental design to examine the effect of tone and attribution of responsibility in videos about a charismatic and critically endangered mammal, the orangutan (Pongo spp.). Participants were recruited through Amazon Mechanical Turk and paid $1 USD to watch one of the four videos and participate in both the main and follow-up surveys, with the option to either receive or donate up to an additional $1 USD. We examined the effects of these videos on participants' knowledge, affect, and behaviour. As expected, the strongest predictor of participant response was initial environmental values. Though two of the value scales were strongly tied to political leaning, one, appreciation of nature, was not, suggesting that increasing appreciation of nature may be a valid avenue to increase pro-environmental behaviour without polarizing individuals further. Additionally, the optimistic videos resulted in higher hope for the survival of the orangutan, and the pessimistic videos resulted in better scores on the knowledge quiz. The results of this experiment could

provide valuable insights into science communication best practices for the general public, as well as help science communicators shape their messaging based on their target audience.

Nicole L. Regimbal (Supervisor: Shelby H. Riskin)

Acadian Flycatcher habitat analysis using community science data

Global avian biodiversity is declining due to multiple factors, including climate change, introduced biota, and land-use change. The Acadian Flycatcher (*Empidonax virescens*) is a small Neotropical migrant songbird and habitat specialist which breeds throughout the eastern United States to the Carolinian region of Ontario, yet is endangered only at this northern boundary. Disentangling the drivers of their endangerment can help inform local conservation strategies and have implications on future population trends in the United States. Community science databases, in which members of the public submit organismal observations to online repositories, have created new opportunities for species monitoring. However, the reliability of community science data is open to scrutiny. This paper compares three community science databases: eBird, iNaturalist, and Project NestWatch, and assesses observations of the Acadian Flycatcher or their nesting sites. Using these observations we examined the impacts of climate, introduced species, and land use change by assessing the overall range of the species over time, the presence of introduced species and plant disease known to disrupt their nesting requirements, and the habitat quality surrounding each observation. Our results indicate little range shift over the last decade, low overlap between Acadian Flycatchers' chosen habitat and increasingly common introduced species, and a tendency for the species, particularly in Ontario, to seek out high quality wetland and forested patches in an overwhelmingly agriculturally-transformed landscape.

Category: Urban Ecology

Judges: Nicole Mideo & Caroline Parins-Fukuchi

Amy Chen (Supervisor: Shelby H. Riskin)

Using community science to investigate the effect of urbanization on tail loss and perching behavior in multiple lizard species

Large-scale environmental changes like urbanization have been shown to introduce novel threats and challenges that can alter animal behavior and predation. For non-avian reptiles, urbanization has been reported to bring in novel stressors, such as a change in temperature and the introduction of invasive species. It has also been reported that urbanization leads to greater predation risks, motivating some lizard species to spend more time perched on high surfaces to avoid predation. Community science databases, in which members of the public can report or upload evidence of wildlife observations, can increase our ability to assess the status of wildlife in urban areas, where much of the landscape is privately owned and in which it can be difficult to observe and monitor cryptic or shy species. We used observations from the community science platform iNaturalist to investigate whether urbanization intensity was positively correlated with perching behavior and evidence of tail autotomy in seven closely related lizard species (*Sceloporus magister, Sceloporus occidentalis, Sceloporus olivaceus, Sceloporus tristichus, Sceloporus undulatus, Urosauraus ornatus, Uta stansburiana*). For each observation we used the uploaded photographs to assess the surrounding, substrate, and tail status from more than 3,000 lizards and quantified the urban extent of the surrounding habitat.

Sarah Eid (Supervisor: Marie-Josée Fortin)

Urban Wildlife in Lockdown: Species Responses Trends throughout the Anthropause

The global COVID-19 pandemic has led to an unprecedented halt in human activity, called the "anthropause." This has offered conservation scientists a novel opportunity to investigate its impact on urban wildlife and natural systems. The initial lockdown conditions (2020) of the anthropause resulted in notable public media speculation of an "urban reclamation" by wildlife due to increased reported sightings within areas of high human activity. Despite this, subsequent scientific studies have found discrepancies in the mechanisms by which urban species are responding to changes in human disturbances. Using published scientific literature after initial lockdown conditions have been alleviated in many major urban areas, this project has investigated the trends and species interactions observed by researchers within 2020 and 2021. These trends were then applied while investigating citizen science reportings of urban wildlife from the years 2019-2021 using the platform iNaturalist. Specifically, two pairs of cities in North America were compared regarding their number and type of sightings: (1) Toronto – Chicago, and (2) San Francisco – Los Angeles. While the time period of the study is short, temporal changes in species sightings were found. These findings provide indications that a reduction of human activities have an impact on wildlife recovery in urbanized landscapes.

Hana Fahim (Supervisor: Emily Darling)

Healthy coral cover but low fish biomass observed in urban coral reefs in India

Coral reefs provide a multitude of ecosystem services and are an important habitat for many marine species; nevertheless, they are threatened by human pressures and climate change. Urban coral reefs are expected to be susceptible to increased human pressures due to close proximity of coastal development and commercial activity. Typically characterized by low light and high turbidity, these conditions can limit coral growth and ecosystem function, driving reefs below sustainable thresholds of hard coral cover and reef fish biomass. The Western coast of India presents a unique case study of urbanized reefs to evaluate the status of coral reef ecosystem functioning. Here, I evaluate the ecological status of urban coral reefs at two sites in India, Grand Island and Netrani Island. I also assess whether these reefs retain ecological functions that can support multiple social and ecological goals despite urban pressures. Ecological surveys conducted by WCS India were used to estimate coral cover and fish biomass at 14 sites across Grand and Netrani islands. These values were compared to thresholds of resilient reefs and sustainable fisheries and linear regression models were used to assess the relationship between fish biomass, coral cover, and other factors. Multiple goals were evaluated from correlations among ecological functions and indicators. Most sites were found to have good coral cover, similar across both islands, but only a few have a healthy fish biomass, concentrated in Netrani island. Furthermore, while overall fish and herbivore functions are positively correlated, there is a mismatch between coral and fish functions, which are negatively correlated. It appears these urban reefs are able to maintain some ecosystem function despite increased pressures, but multiple ecological goals are not being met concurrently. Fisheries management should rebuild reef fish biomass, which is below sustainable levels at most sites. Future studies should consider the community composition at these reefs and examine the mechanisms driving the reefs' health. Furthermore, linking data on human pressures and environmental variables can provide further insight into the potential resilience of these reefs and urban impacts.

Jacqueline McLean (Supervisor: Shelby H. Riskin)

Untapped Potential: Using community science to assess lizard species habitat preferences and patterns of tail loss across urbanization gradients in the United States

Land modification, particularly the spread of urban development, is prevalent across the globe and will continue to occur as people increasingly move to urban areas. Urban environments have sometimes been overlooked due to the research challenges they pose for data collection as well as the

misconception that these areas are not representative ecosystems. Our study utilizes the sampling power of community science data and publicly accessible land cover data for the continental United States to compare species distribution, and patterns of behaviour and tail loss of seven closely related native lizard species (genera Sceloporus, Uta, and Urosaurus). Lizards can be difficult to monitor, especially in urban environments, due to their secretive behaviour and cryptic colouration, and the fact that much of the urban landscape is privately owned. Community science lends itself as a powerful tool to address these challenges as it allows for immense data collection across vast spatial, temporal, and taxonomic scales. We assessed photographic and geolocated community science data observations dating from 2016 onwards for evidence of habitat preferences by each of the species, tail loss and regrowth, and mean percent impervious cover for each observation within a 100 m radius buffer region. The goal of our study is to assess the potential of community science to provide insight on the differences in ecology of underrepresented closely related taxa across a growing underrepresented modified landscape. This study highlights the untapped potential of using community science to answer important far reaching questions about increasingly urbanized landscapes.

Category: Ecological Interactions

Judges: Asher Cutter & Linyi Zhang

Marcus Forbes-Green (Supervisor: Helene Cyr)

How Does Physical Disturbance in Young Native Freshwater Mussels Relate to Habitat Refuges and Influence Growth Patterns?

Freshwater unionid mussels are an extremely diverse clade of molluscs, which form a critical component of freshwater aquatic communities and food webs. These organisms are highly endangered worldwide, making their study an important conservation issue. Unionid mussels often live in physically challenging environments. When they are subject to physical disturbance such as waves, they lay down disturbance lines in their shells which are visible under the microscope. In this paper, I examine the relationship between disturbance lines and habitat exposure in juvenile mussels, with a particular focus on site exposure to/refuges from wind and waves in Lake Opeongo in Algonquin Park, Ontario. I also investigate annual shell growth and disturbance lines, as we expect being frequently disturbed and stressed would lower growth. Disturbance lines were quantified and dated under the microscope in mussels collected from Lake Opeongo sites of various levels of exposure. The number of disturbance lines present increased with increasing site exposure and with shallower sediments. Contrary to expectations, annual growth was not reduced in years with disturbance lines present. By understanding which sites are most prone to disturbance, and how disturbance influences mussel growth, we can determine what areas of mussel habitat are most in need of protection.

Madeleine Milne (Supervisor: Chelsea Rochman)

Microplastic Particles Observed in Multiple Tissues of Lake Ontario Sportfish

Microplastics are a pervasive contaminant in the environment. As a consequence, they are ingested by a variety of organisms, including fish. How microplastics move through, and accumulate in, the food web, is not well understood. This includes the translocation of microplastics from the gastrointestinal (GI) tract to other tissues. Here, we sampled five species of sportfish from Lake Ontario and examined their GI tracts and fillets for the presence of microplastics. We observed microplastic particles in both tissues of all fish samples; fish had a mean of 237 particles per fish (SD 334), with the total number of particles in a single fish as high as 1588. The total particles per individual fish were significantly different among species ($p < 0.05$). Fish GI tracts had a mean of 156 particles/fish (SD 317), and fish fillets had a mean of

79 particles/fish (SD 66). The number of particles observed in the GI tract was not positively correlated with the number of particles in the fillet, suggesting that the particles in the gut are transitory and not a predictor of the amount in other tissues. The particularly high number of particles that were observed to translocate to the fillets highlights the need for further research to better understand the mechanisms and consequences of the translocation of microplastics. Further, the presence of microplastics in tissues consumed by humans (the fillets), suggest that fish may contribute to microplastic burdens in humans.

Jessie Wang (Supervisor: Megan Frederickson)

Dynamics of duckweed-microbe interactions across nutrient environments

Duckweeds are floating aquatic plants that inhabit a variety of freshwater ecosystems ranging from tropical to boreal areas. These plants provide a simplified model system to study plant-microbe interactions and how they are influenced by the surrounding environment. As human activities continue to change the environment at an unprecedented rate, interacting organisms will face novel challenges in their surroundings. Nutrient loading refers to the release of nutrients such as nitrogen, phosphorus, and potassium through human activities like agricultural fertilization. At low concentrations, these compounds may have positive effects on plant growth and performance. However, at higher concentrations, nutrient loading can impose stress and hamper plant performance. In the case of nutrient loading into aquatic environments, this practice can lead to the rapid growth of algae, oxygen depletion, and the collapse of ecosystems. In this study, we examined context-dependency in duckweed-microbiome interactions across environmental gradients of nitrogen, phosphorus, and potassium. This allowed a fine-tune resolution of the variation in plant responses to nutrient loading, as well as the identification of "optimum" nutrient levels for plant performance. The results of our study will provide considerations for mitigating the impacts of human activities changing the nutrient landscape of environments.

Nicholas Ypelaar (Supervisor: Njal Rollinson)

Long-term changes in the incubation environment of a freshwater turtle with temperature-dependent sex determination

In species demonstrating temperature-dependent sex determination (TSD), the sex of new hatchlings is determined not by inherited genes, but instead by natural egg incubation temperatures. Changing global climate threatens the survival of species with TSD. In many species that exhibit TSD, population feminization is expected under climate change. Furthermore, extreme warming temperatures have the potential to be lethal to developing embryos. Using 20 years (1983 to 2003) of long-term study data from a population of snapping turtles at the species' northern climatic range limit, we investigate the relationship between nest temperatures, sex ratio, and embryonic survival. We analyzed how mean July nest temperatures (roughly the incubation period when sex is determined) have changed over time; and how temperature has influenced nest survival and nest sex ratios. We find that minimum July nest temperatures decreased significantly over the study period, however mean and max temperature did not change. We also find that July nest temperatures are significantly associated with nest sex ratios. However, we find no significant influence of July nest temperatures on nest survival. These results provide further insight into future survival challenges for species with TSD and the Ontario's largest freshwater turtle in a rapidly changing global climate.

Category: From Genotype to Phenotype

Judges: Luke Mahler & Tiziana A. Gelmi Candusso

Maia Dall'Acqua (Supervisor: Asher Cutter)

Characterizing defects in tail reproductive structures of infertile *C. latens* x *C. remanei* male hybrids

Post-zygotic reproductive barriers that emerge through organismal development separate different species from one another, laying the foundation for the diversification of life on Earth. *Caenorhabditis* is an excellent tool for investigating the mechanisms of speciation because of their quick generation time and well-documented genetic makeup. *Caenorhabditis latens* and *Caenorhabditis remanei* are two closely related species that present defects in reproductive tail structures of male hybrids that contribute to their partial reproductive isolation in an asymmetric manner consistent with Darwin's corollary to Haldane's rule. In this study, I use DIC microscopy to characterize reproductive defects in F1 male tails from reciprocal crosses between *C. latens* and *C. remanei*. The frequency of defects and the distribution of specific defect types will improve our developmental understanding of hybrid dysfunction in Haldane's rule in this system and comparisons with known mutant phenotypes in *C. elegans* will lay a foundation for investigation of genes that contribute to these incompatibilities.

Mila Gorchkova (Supervisor: Marla Sokolowski)

Social behaviours in *Drosophila melanogaster* larvae are affected by natural variation in the foraging gene.

Studying genes involved in social behaviours can broaden our understanding of the evolution of sociality. We studied the effects of naturally occurring Rover and Sitter alleles of the *D. melanogaster* foraging gene on cooperative foraging behaviour, in which larvae form organized groups known as clusters while feeding at high densities, allowing larval groups to dig deeper into the liquid layer of food. This phenotype may be adaptive under certain circumstances, and fitness advantages in adulthood have been demonstrated in flies that cluster as larvae. We found that Rovers and Sitters differ in the frequency with which they form clusters and that this differences was density dependent. At high larval densities sitters formed significantly more clusters than rovers but at low densities neither strain formed clusters. We used genetic alternations in the foraging gene to link cooperative larval foraging phenotypes to the foraging locus. The degree to which rovers and sitters liquified the top layer of food while feeding at high densities suggested the possibility of an extended phenotype. This was tested using transplantation experiments onto food pre-liquified by rover or sitter larvae. Future research will investigate how differences in the regulation of cooperative foraging behaviour in larvae are regulated and maintained in different social contexts.

Peter Hong (Supervisor: Belinda Chang)

The Molecular Evolution of Nrl in Squamate Rod Photoreceptor Development

Photoreceptors are light-sensitive cells located in the retina of the eye, which turn light signals into information for the brain to process vision. Vertebrates overwhelmingly have duplex retinas, containing both rod and cone photoreceptor types. However, the order Squamata, a diverse group comprised of snakes and lizards, commonly have simplex retinas, which only have either rod or cone photoreceptors. This unusual visual adaptation was thought to have occurred through photoreceptor transmutation, where one photoreceptor type became another over evolutionary time. Rhodopsin (Rh1) is the light-sensing protein in rods and acts as a key identifier of rod identity. Neural Retina Leucine Zipper (Nrl) is a transcription factor that plays a major role in the greater network responsible for photoreceptor differentiation into rods by means of activation of the Rh1 promoter. Previous analysis suggests that Nrl may have been the target of selection in squamate evolution, however it is currently unknown whether these changes in NRL were responsible for the evolution of simplex retinas in squamates. Here an assay has been developed to test the activation of the Rh1 promoter by Nrl, which can then be used to characterize changes in the activation across evolutionary time. Specifically, this can be done by

reconstructing ancestral Nrl sequences from along the phylogenetic branch to squamates and comparing Rh1 promoter activation with recent squamate Nrl. This would give greater insights into when and how squamates developed their fascinating and uncommon visual adaptations.

Alexander MacKenzie (Supervisor: Jacqueline Sztepanacz)

A multivariate analysis of whether phenotypic covariance matrices are a good substitute for genetic covariance matrices

Variance and covariance are key parameters in evolutionary biology to predict evolution and the response to selection. The G-matrix encapsulates genetic variance and covariance information while the P-matrix encapsulates phenotypic information on variation. G has been widely used in evolutionary studies, however obtaining an estimate of G is difficult in many cases, as relatedness information between individuals and large sample sizes are required. Cheverud noted that if P could be used as a proxy for G under certain conditions, evolutionary inference could be made without genetic data, and evolutionary theory could be applied in a less restricted form. He postulated that P was a fair estimate of G, and further, was a better estimate than G when morphological traits were studied. To test this conjecture, pedigrees were created, and data were simulated under two heritability levels of 0.10 and 0.55, three trait levels of 4, 8, and 12, four half-sib family levels of 30, 72, 222, and 402, and two multicollinearity levels of low and high. Heritability levels were based on empirical estimates regarding morphological traits and the notion that the environment would be more influential for life history and behavioural traits. Overall, there were 48 total combinations. G and P were compared in three ways, namely comparing magnitudes of squared correlations, comparing similarity of correlation matrices using Pearson-matrix correlation, and a Krzanowski subspace comparison between G and P. In each level of heritability, both the differences in magnitudes and matrix correlations showed increased similarity as effective sample size increased under low multicollinearity conditions, while high multicollinearity results were less clear. Krzanowski subspace comparison was used in two ways between G and P, namely comparing the first quarter of eigenvectors, and comparing the last quarter of eigenvectors. While similarity scores were generally variable between subspaces of G and P, there were greater differences in similarity between the axes of greatest and lowest variation under high heritability, as well as for lower numbers of traits. Overall, under high heritability, low multicollinearity yielded higher similarity between the first quarter of eigenvectors, while high multicollinearity yielded higher similarity between the last quarter of eigenvectors. Given that multiple levels of heritability were used to simulate empirical heritability values for different types of traits, this analysis serves as an introduction to Cheverud's conjecture for non-morphological traits. Future research should simulate many realizations of G to draw general conclusions.

Category: Evolution & Environment

Judges: Marie-Josee Fortin & Garth Covernton

Alice DesRoches (Supervisor: Art Weis)

Competitive dominance in Brassica rapa early flowering invasion

As temperate regions experience increased temperatures and longer summers due to climate change, selection for earlier reproductive maturation is expected to increase, since it serves to extend the flowering window. In some species, early flowering coincides with faster growth. Thus, the larger size of early-flowering genotypes can give them an asymmetric competitive advantage over slower-growing late-flowering genotypes, an interaction that may be magnified as density increases. Competitive suppression of late strains could be reflected in flowering schedules and fitness. This would suggest that genes directly affecting flowering time in a focal plant can also have indirect genetic effects on the same

traits in neighbours. We investigated how competitive dominance could accelerate early strain invasion success by influencing flowering phenology and reproductive fitness in the annual Brassica rapa. We simulated three stages of early flowering invasion (low, intermediate, and high frequency of the "early allele") in a greenhouse experiment that quantified flowering schedules of each genotype. We found that increased planting density serves to delay flowering reproductive maturation, but frequency of the early allele in these high-density plantings is not a significant determinant. Moreover, increasing frequency of the early allele correlated with disproportionately decreased flower production in late strains. This suggests that competitive suppression of late genotypes occurs with increasing early allelic frequency, potentially representing an acceleration of the spread of genes promoting early flowering in these population. Whether this suppression translates to increased reproductive success of early flowering plants and decreased hybridization between the strains will be a topic of further study based on the subjects grown in this experiment.

Martina Gjevori (Supervisor: Santiago Claramunt)

Reconstructing the Phylogeny of Charadriiformes (Aves) Using a Total Evidence Approach

The evolutionary relationships amongst the shorebirds (Charadriiformes) remain contested, with discrepancies between past phylogenies reconstructed using molecular data and those reconstructed using morphological data. Phylogenetic studies of the order Charadriiformes are further limited by the lack of relevant fossils available for analysis. In recent decades, many studies have favoured the use of molecular data for producing robust, well-supported phylogenies, however no investigation has combined both molecular and morphological data to resolve relationships between charadriiform taxa. In order to bridge this gap, I created a character matrix, combining morphological data from Strauch (1978), the most extensive morphological study of the Charadriiformes that looked at 70 osteological characters across 227 taxa, and molecular data from Baker et al. (2007), which used multiple mitochondrial and nuclear sequences to resolve the relationships between 90 shorebird genera. I appended the matrix to include morphological character data from an early Miocene (23-20.5 Ma) fossil charadriiform skull described by De Pietri et al. (2013), which has not previously been placed in a phylogeny. A simple parsimony analysis was used to obtain an evolutionary tree for Charadriiformes. In addition to being the first investigation to use both molecular and morphological character data to resolve the phylogeny of Charadriiformes, this study will add to the ongoing debate about the phylogenetic relationships of the shorebirds. The shorebirds display extensive variations in morphology, behaviour, and ecology between taxa., so constructing a well-supported phylogeny for the order is essential for future comparative studies to understand their evolution.

Rebekah Jolicoeur Alfaro (Supervisor: F. Helen Rodd)

The role of methylation in transgenerational effects in guppies exposed to Ritalin

Methylphenidate hydrocholoride (MPH), commonly known as Ritalin, is a stimulant drug that works through the inhibition of the reuptake of dopamine and is often used to treat attention deficit hyperactivity disorder (ADHD). Recent evidence from the Rodd lab showed that direct exposure of experimental (G1) Trinidadian guppies (Poecilia reticulata) to MPH caused transgenerational changes in the behaviour of their descendants. Guppies are live-bearers, so the G2 fish were exposed in utero to MPH, but the G3 and G4 fish were not. Here, I explore the possibility that DNA methylation was one of the epigenetic mechanisms responsible for the observed transgenerational effects in G4 fish. I extracted DNA from the brains of great-granddaughters (G4) of the parental generation. These females were descendants of (i) two MPH-exposed individuals, (ii) two control individuals, or (iii) one MPH-exposed and one control individual. I assessed the levels and patterns of DNA methylation using reduced representation bisulfite sequencing (RRBS). Since MPH operates on the dopaminergic system and was

shown to cause transgenerational alterations in the exploratory behaviour of guppies, I predicted that levels of methylation would vary for genes associated with that pathway among the descendants of the Ritalin-exposed G1 fish relative to controls.

Alex Whitwam (Supervisor: Marla Sokolowski)

Genetic and environmental components of individual variability

Within populations, behavioural characteristics often vary. Individuals express patterns of behaviour that are often consistent within their own lives, but these patterns can differ greatly from the behaviours of others. This individual variability has been studied in a number of species, including bacteria, flies, and cephalopods; even among genetically identical organisms raised in the same environment, differences in “personality” persist. Potential explanations include stochastic developmental processes that lead to individuals diverging in phenotype as well as differences in microenvironment that impact neurological processes and gene expression levels. In this presentation, I assess the current research on individual variability and the mechanisms by which it occurs. An analysis was also performed on data from a published paper, Burns et al. 2012, which looked at differences in patterns of movement in adult flies in an open field assay. Strains of flies differed in their alleles of the foraging gene, rover or sitter, and were fed or subjected to food deprivation prior to the test. The data from the 10-minute test was assessed for individual variability between and within different strains and experimental conditions. Food deprivation had complex effects on variability; food-deprived individuals showed more consistent patterns of distances moved in both strains, and deprivation increased or decreased the variability of movement between individuals depending on the strain of flies and measurement performed. Individual variability and the ways it is affected by genotype and environment is a burgeoning field, but it shows promise in answering important questions about “personality” and behaviour.