Ecology & Evolutionary Biology Undergraduate Research Fair 2020

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EEB498/EEB499 Posters

Category: Global change and organisms Judges: Andrew Chin (Fortin Lab) & Santiago Sanchez-Ramirez (Cutter Lab)	
Student Name	**Supervisor Name**
Jacqueline Bikker	Chelsea Rochman
Jared Connoy	Njal Rollinson
Paula Pietraszkiewicz	Stephen Wright
Jessica Robichaud	Don Jackson & Cindy Chu
Cassandra Sherlock	Chelsea Rochman
Mariel Terebiznik	Luke Mahler
Justin To	John Stinchcombe
Category: Global change and ecosystems **Judges: Prof. Don Jackson & Megan Greischar (Mideo Lab)**	
Liam de Borst Kerluk	Shelby Riskin
Nikol Dimitrov	Marie-Josee Fortin
Tristan Garry	Marie-Josee Fortin & Martin Krkosek
Hayley McIlwraith	Chelsea Rochman
Phaedra Otwey	Marie-Josee Fortin
Sabina Pang	Megan Frederickson
Tina Wu	Chelsea Rochman
Category: Ecological interactions **Judges: Katja Kasimatis (Cutter Lab) & Ludovic Hermabessiere (Rochman Lab)**	
Lim Comsa	Marie-Josee Fortin
Sydney Gram	Jean-Marc Moncalvo
Sam Imamovic	Ben Gilbert
Jeonghoon (John) Lee	Ben Gilbert
Alejandra Monsivais Ibarra	Ben Gilbert
Zoe Parshuram	Megan Frederickson
Dale Pabesma	John Stinchcombe
Adeena Zahid	Ben Gilbert

Category: Genetics, Evolution, and Environment Judges: Prof. Locke Rowe & Anna O'Brien (Frederickson & Rochman Labs)	
Yiyang (Evelyn) Cheng	Asher Cutter
Daniel Fusca	Asher Cutter
Youngseo (Clara) Jeong	Aneil Agrawal
Amanda Peake	Stephen Wright
Destiny Micha Sibolibane	Art Weis
Malcolm Cassim Thompson	Aneil Agrawal
Yiran (Eve) Zhao	Art Weis
Category: Evolution of Biodiversity and Morphology **Judges: Prof. Adriana Bravo & Karl Grieshop (Agrawal Lab)**	
Varosak Chirachon	Rowan Sage
Shu Han (Julie) Gan	Rowan Sage
Sid Gopalan	Belinda Chang
Milly Hong	Santiago Claramunt
Danté Ravenhearst	Njal Rollinson
Sebastian Scott	David Evans

EEB397Y and ROP Posters

(Note: these posters are not for judging)

Student Name	Supervisor Name
Natasha Dhamrait & Michaela Fink	Art Weis
Aisha Faruqui	Njal Rollinson
Claudia Lacroix	Njal Rollinson
Jacy Newfeld & Sarah Ravoth	Art Weis

Category: Global change and organisms

Jacqueline Bikker

Effects of microplastic exposure on morphology, behaviour, and physiology of the fathead minnow, Pimephales promelas

Microplastics – pieces of plastic smaller than 5mm in length – are a contaminant of concern for both terrestrial and aquatic ecosystems. Microplastics have previously been shown to affect the morphology, physiology, and behaviour of organisms. Here, we investigated the effects of exposure to two morphologies of microplastics – fibres and fragments – on the behaviour, morphology, and physiology of the fathead minnow, *Pimephales promelas*. We exposed adult *P. promelas* to environmentally relevant concentrations of polyethylene terephthalate (PET) fibres or fragments for 28 days. Following exposure, we assessed morphological factors such as body condition, growth, and hematocrit ratio. We assessed behavioural endpoints such as boldness, foraging, and predation. We also assessed several physiological factors; hypoxia tolerance, heat tolerance, and respiration. Preliminary results show that fathead minnow body condition, hematocrit ratio, boldness, foraging, hypoxia tolerance, and heat tolerance are not affected by microplastics exposure or morphology of microplastic. Analyses remain ongoing but will help close the gap in our understanding of how different morphologies of environmentally relevant concentrations of microplastics affect the morphology, behaviour, and physiology of fish.

Jared Connoy

Investigating the Role of Non-Genetic Maternal Effects on Temperature Dependant Sex Determination

Sex ratios have long fascinated biologists, starting with Darwin in 1871. In the last few decades, biologists have moved on to consider the adaptive significance of sex ratios, requiring an understanding of whether or not they are heritable. Organisms exhibiting temperature dependant sex determination (namely turtles and crocodilians) have shown to be ideal for measuring the heritability of sex ratios, however the literature has largely failed to consider non genetic (ie maternal) effects potentially evolved in variation in TSD. Recent research has further shown that maternal effects may be producing female bias in the sex ratio of less fit mothers. It is hypothesized that this is because less fit females will produce less fit offspring, which will be more likely to reproduce if they are female. To address this gap in the research, I collected 5 eggs each from 46 painted turtle clutches (n= 230) in Algonquin park, and incubated them at the temperature which would theoretically produce 50 percent males in each clutch. Clutch sex ratios were however shown to be highly variable. Using data on body condition and size from the females' whose eggs were collected, maternal effects on the pivotal temperature of TSD in this population were estimated using principle components analysis.

Paula Pietraszkiewicz

Leaf disc assay quantifies Amaranthus tuberculatus herbicide resistance in large-scale populations

Amaranthus tuberculatus resistance to herbicides has become problematic for North American agriculture and food production. While much work has been done to characterize mutations underlying resistance, high-throughput methods for quantifying the extent of variation in genotypic, population, and range-wide resistance are limited. This project studies A. tuberculatus resistance to glyphosate using a non-destructive leaf disc assay in a set of 6000 individuals, collected from 14 natural and 14 agricultural populations across the range, with 10 replicates per genotype across 3 different environmental treatments. Leaf discs were collected from all 6000 individuals and suspended in an optimized concentration of glyphosate solution for 24 hours. Their fluorescence was then measured, since chlorophyll fluorescence in these leaf discs is an indicator of photosynthetic activity, and therefore

resistance to glyphosate. This provides a way of quantifying herbicide resistance without the need to spray and destroy entire plants. We hypothesized that agricultural populations would be more resistant to glyphosate than natural populations due to their previous exposure to herbicides. However, gene flow between these populations may play a bigger factor than expected.

Jessica Robichaud

Impact of aquatic invasive species on sport fishes in Ontario lakes

Aquatic invasive species (AIS) are a global environmental concern as they pose a threat to both ecosystems and economies. In Ontario, AIS can utilize the dense connectivity of waterways or mobility of humans to spread lake to lake across the province. While there is research to suggest the presence of AIS can negatively affect aquatic species at lower trophic levels, there is a lack of understanding of how AIS affect top predators. Top predators are economically valuable in Ontario where there is a large industry for sport fishing, thus making their well-being of interest to the province's economy. Using Broad-Scale Monitoring (BsM) data obtained from Ontario's Ministry of Natural Resources and Forestry (MNRF), catch-per-unit-effort (CPUE) and catch-per-unit-effort in weight (CPUEW) data for the popular sport fishes walleye (*Sander vitreus*), lake trout (*Salvelinus namaycush*), and smallmouth bass (*Micropterus dolomieu*) were used to determine if catch changes between lakes with AIS and without AIS. While there was a statistically significant difference in CPUE and CPUEW for walleye where catch was higher without AIS present, we found no difference for lake trout or CPUE of smallmouth bass. However, CPUEW for smallmouth bass was statistically significant and was higher in lakes with AIS present. The results of this study indicate that the presence of AIS may have species-specific affects for CPUE and CPUEW in Ontario.

Cassandra Sherlock

Microplastic ingestion in Tree Swallows (Tachicyneta bicolor): Investigating the use of a non-lethal method for quantifying the number of microplastic ingested in the GI tract

Microplastics may be one of the most ubiquitous pollutants found in our environments. Their presence has been thoroughly investigated in marine and freshwater organisms, but there is little research on their effects on terrestrial organisms. In this study, we investigated the presence of microplastics in a species of nestling terrestrial bird's: tree swallows (*Tachicyneta bicolor*). We had two objectives: 1) To characterize and compare the number of microplastics in the gastrointestinal (GI) tract of two different populations; one nesting at a wastewater treatment plant (WWTP) and the other at the Mountsberg Conservation Area. 2) To determine whether the amount in fecal material corresponded to the amount in the gut to inform whether less invasive techniques could be introduced for monitoring. In total, 90% of the WWTP samples and 85% of the Mountsberg samples contained anthropogenic particles, mainly suspected fibres in the WWTP sample and surprisingly, ~15% of particles were characterized as pellets in the Mountsberg population. A two-sample t-test was conducted and no significant difference was found between sites. There was also no correlation between the number of particles found in the fecal sac compared to the GI tract. This indicates this is not an accurate methodology for quantifying microplastics in tree swallows. Because there was a lack of difference in the number of particles found between sites, this study further supports the notion that microplastics are ubiquitous across ecosystems.

Mariel Terebiznik

The effect of land-use on lizard prey communities across an elevational gradient

Global trends in the intensification of land use have resulted in a modern-day biodiversity crisis. Tropical forests are especially at risk of deforestation from agricultural conversion. Such conversion has been shown to decrease community richness, structure, and stability. However, most prior studies have

focused on vertebrate species, ignoring the vast diversity of invertebrate taxa that constitute the bulk of animal biomass and provide essential ecosystem functions. To understand the consequences of deforestation and land use on tropical insect diversity, I and several colleagues surveyed aerial and ground arthropod communities using sweep netting and pitfall traps, respectively, in both forest and agricultural plots across an elevational gradient in the Andes of Ecuador. Sampled arthropods were photographed for later identification, quantification, and size determination. Using these data, I asked how arthropod abundance, diversity, and size changed with land use type across elevations. Arthropod abundance peaked at mid-elevations. In forests aerial communities had higher abundance than ground communities. The reverse was true for pastures. Forest arthropods exhibited greater alpha diversity than pastures for both aerial and ground communities, but this difference decreased with increasing elevation for ground communities. Beta diversity turnover was lowest in forest-forest comparisons, followed by pasture-pasture comparisons, with forest-pasture plot comparisons having the highest turnover. Arthropods in ground communities were larger than aerial arthropods, with forest arthropods being larger than pasture arthropods for both aerial and ground communities. Understanding the effects of land use on arthropod communities across elevation will help predict the outcome of future deforestation, and increase our understanding of the consequences that human actions have on the natural world.

Justin To

An examination of phenotypic progression in Amaranthus tuberculatus in response to agricultural development and climate change.

Amaranthus tuberculatus is pervasive agricultural weed whose evolution is likely influenced greatly by anthropogenic activity particularly agricultural practices. It has been proposed that recent trends in climate and human activity interplay to influence the evolution of this weed, but the extent is unclear. Here we conduct a mixed effect model analysis to infer the impacts of climate on the phenotypic evolution of *A. tuberculatus*, through analysis of herbarium samples collected in the last 200 years. We also performed germination trials to test the degree of influence of agricultural practices on the evolution of *A. tuberculatus*. Here we report evidence of significant correlation between *A. tuberculatus* inflorescence size and climate. We also report significant evidence of germination potential evolving in agricultural settings. These results can help better adjust existing agricultural regimens to prevent crop productivity decline in the future.

Category: Global change and ecosystems

Liam De Borst Kerluk

Global phosphorus fertilizer balance, development status, and ecosystem constraints

With the world's population increasing at such a rapid rate, finding adequate means of feeding everyone is imperative. As of now, one of the most effective methods of increasing the yields of agricultural crops is using increased nutrient inputs from manure and fertilizer that allow for increased phosphorus for crops. However, the rate of fertilizer application in many countries is much higher than is necessary; and alongside the application of manure, leads to excess phosphorus within the soils, leading potentially to eutrophication from agricultural runoff. In addition, there is the problem of the non-renewable nature of phosphorus due to the rate that it is used, resulting in phosphorus stocks eventually running out. Phosphorus balances determined by the combining of inputs of phosphorus into agricultural systems through fertilizer and manure subtracted from phosphorus outputs from the systems' harvested crops helps evaluate how much phosphorus remains in the agricultural system. When evaluated over time for each country, an indication of phosphorus use is attained and compared against

different explanatory variables. Cropland area, economic development represented by gross domestic product (GDP) per capita, and the soil phosphorus status may be able to explain if a country follows the expected pattern of phosphorus use based on the status and level of development. Results found that economic development is not a predictor for phosphorus balances. Phosphorus balances for neighbouring countries with differing soil constraints for phosphorus-fixing soils showed differing balances over time with greater balances in countries with soils that had high phosphorus fixing ability. Looking at economic development and soil constraints together for tropical regions may a more effective metric of phosphorus balances. These results help better understand how phosphorus is globally used, and how to alter management plans ensuring countries do not use phosphorus in excess; as well as assessing areas of potential reform within the agricultural sector.

Nikol Dimitrov

A Spatiotemporal Assessment of Habitat Quality and Connectivity for the Maintenance of Forest Species in Centre-du-Québec

Abstract: Human activity coupled with the synergistic effects of climate change, has led to severe fragmentation of previously intact forested landscapes. This is concerning for animal species who depend on forested ecosystems for shelter, food, reproduction, and long-term survival. As a result, maintaining habitat connectivity in fragmented landscapes is essential for effective conservation efforts. In addition, understanding the degree to which connectivity and habitat quality change across space and time is paramount when deciding on an appropriate management strategy. Yet, an integration of both spatial and temporal processes in conservation is lacking. This study aimed to address this issue, by using a spatiotemporal modeling approach to compare the effects of three different management scenarios in the highly fragmented region of Centre-du-Québec. To do so, climate simulations were analysed using different projections and landscape disturbance models were used for forest harvesting management strategies. Each strategy was evaluated in its ability to maintain both habitat quality and landscape connectivity for the black bear (*Ursus americanus*) and the American marten (*Martes Americana*) through a 90-year timeframe. Habitat availability was reclassified according to each species' needs and was followed by the estimation of connectivity levels. The management scenarios were then compared for three different climate projections, with the goal of identifying the scenario which promoted the maintenance of both species. A BAU (business-as-usual) management strategy resulted in the greatest long-term maintenance of both species in the current and low-increase climate projections. In the high-increase climate projection, A BAU management coupled with low levels of disturbances was optimal for both species. These results provide guidelines for the conservation of biodiversity in this highly fragmented region and signify the importance of incorporating both spatial and temporal processes when identifying the most appropriate management strategy.

Tristan Garry

Applications of machine learning to the forecasting of short-term sea lice abundances in British Columbia

Wild salmon populations have been negatively affected by farming efforts through the increased disease prevalence brought on by farms. Sea lice have been well-researched in the Broughton Archipelago of British Columbia, Canada. Through such surveys, it was found that sea lice affliction in farmed salmon have been shown to increase sea lice prevalence on wild populations. Therefore, it would be useful to conservation efforts to be able to predict sea lice outbreaks by identifying the environmental factors that affect sea lice occurrence. Indeed, knowledge of the variability in sea lice occurrence due to the environment is crucial for fishery and conservation efforts, yet it has not been fully explored in terms of forecasting. I used regression, machine learning models, and deep neural networks in order to identify the relative importance of climatic factors and standing stock of lice in nearby farms for the prediction

of sea lice occurrence. I found that our current models are unable to consistently accurately forecast short-term sea lice occurrence. I would recommend future modelling efforts to explore the scale of the underlying processes that affect sea lice abundance as well as including explicit spatial factors and local densities. These findings indicate that further research is required in understanding the factors that would allow us to produce short-term forecasts of sea lice abundances.

Hayley McIlwraith

Assessment of Microplastic Contamination at the IISD-ELA Along a Gradient of Anthropogenic Activity

Microplastic contamination is ubiquitous across the globe, even in remote locations. Still, the mechanisms of microplastic transport to such locations are largely unknown. To investigate microplastic contamination and transport in a remote location, we investigated microplastics in several lakes at the IISD-Experimental Lakes Area. In Summer 2019, we sampled surface water atmospheric fallout, and sediments from four to nine lakes. Lakes were selected based on three levels of anthropogenic activity: low, medium and high. We aimed to test the relationship between anthropogenic activity and microplastic contamination; a positive correlation would indicate that local anthropogenic activity is a likely source. However, preliminary results show no relationship. This lack of correlation with anthropogenic activity suggests a greater role for atmospheric transport as a source of microplastics to these remote boreal lakes. This study contributes to our understanding about the global fate and transport of microplastics.

Phaedra Otwey

Assessing landscape connectivity for forest amphibians in the Greater Toronto Area

Land-use change, including habitat loss and fragmentation, has become one of the most catastrophic threats facing species. Suitable habitat is decreasing and distances between such habitat is ever-expanding and often inhospitable, yet species still need to move through the landscape. Geographic range expansion, seasonal migrations, and ontogenetic habitat associations can be easily disrupted in heavily fragmented landscapes. With varying dispersal abilities and habitat requirements, species will be at varying risks for persistence. Species that require multiple habitat types and who have limited dispersal abilities, such as forest amphibians (ie. frogs) – relying on forests and wetlands for their ontogeny – are further at risk from land-use change. This study aims to understand how three species of frogs (gray treefrog, spring peeper and wood frog) are able to move through the landscape of the urban Greater Toronto Area (GTA) to exploit wetland and forest habitat patches. Using ArcGIS and Linkage Mapper, landscape connectivity was assessed for reclassified wetland-forest habitat patches, and for patches containing at least 1 species, at least 2 species and all 3 species of frogs for wetland, forest and wetland-forest patches. As the number of species present increased, so did mean patch size, however for each habitat classification there were very few patches fully representing the three species. Furthermore, cost-weighted to Euclidean distance ratio was highest for all cases in wetland-forest habitat patches indicating the increased difficulty and distance required to move between areas where both habitats are adjacent. Understanding how forest amphibians are able to move through the landscape is crucial for species conservation and can also inform protected area planning for many species requiring both forests and wetlands.

Sabina Pang

Plant microbe mutualisms modulate effects of salinization and eutrophication

Mutualistic interactions often vary in benefits to interactors across environmental gradients. With anthropogenic activities rapidly altering environmental conditions, outcomes of mutualisms may show simultaneous changes, potentially exacerbating or ameliorating effects on species. Global change is highly multifactorial, yet CO2 and temperature remain the primary focus of study, especially for

mutualisms. In particular, winter salt application in urban areas, together with increased agricultural fertilizer use have resulted in widespread salinization and eutrophication that may be concomitant or independent. To test responses of mutualistic interactions across runoff inputs, we exposed the freshwater aquatic plant Lemna minor (duckweed) to fully factorial combinations of relevant salt and phosphorus concentrations, with or without its mutualistic microbiome. Preliminary results suggest that duckweed microbiomes modulate responses to contaminants. Final results will evaluate microbe growth and effects on mutualistic outcomes.

Tina Wu
Seabins in Toronto's waterfront
Nearly 10,000 tonnes of plastic make their way to the Great Lakes every year. Trash mitigation devices such as Seabins help to reduce the amount of plastic debris. PortsTotono installed Seabins in the Outer Harbour Marina and Pier 6 in Toronto's waterfront; debris from these bins were categorized. In the plastic debris, there was evidence of consumer goods, construction, and industry. This study provides information on the diversity of plastic that currently exists in the harbour. Future studies should look at the long-term effects of trash mitigation devices and the drivers of increased debris capture.

Category: Ecological interactions

Lim Comsa
Do habitat preferences differ across different age classes of Eastern Foxsnake (Pantherophis vulpinus)?
The Eastern Foxsnake (*Pantherophis vulpinus*) is an Ontario Species at Risk that has 70% of its range contained within two distinct populations. The *Carolinian* population of Eastern Foxsnake resides in Southwestern Ontario, is assessed as Endangered, and is most threatened by anthropogenic habitat modification. We asked whether the habitat occupancy of Eastern Foxsnakes in a Southwestern Ontario Provincial Park differed across age classes, and what role different survey methods played in assessing this. A dataset containing all Eastern Foxsnakes captured within the park from May 2013 to September 2019 was used for the analysis. We divided snakes into age classes based on capture date and size criteria, and compared the frequency and proportion of snakes in each landscape type per age class to the availability of land cover types. To test how survey method influences the estimation of Foxsnake space occupancy, snakes were also divided into incidental or cover board survey captures, and these groups were compared to the land cover types relatively available within the survey areas. We found that space occupancy differed among snakes of different age classes, and that cover board surveys can account for sampling biases from incidental capture data. By increasing understanding of habitat usage by Eastern Foxsnakes, better-informed decisions can then be taken to prioritize protection or restoration of certain habitat types. These actions support the Ontario Recovery Strategy for the Eastern Foxsnake.

Sydney Gram
COI barcode survey of diversity and host preferences of fungivorous insects in Southern Ontario
Fungi and insects are among the most diverse eukaryotic organisms on Earth, and they have been interacting with each other in complex ways for over 400 million years. In temperate forests, a speciose but often cryptic guild of insects from the Diptera and Coleoptera lay eggs, and subsequently complete their larval development, inside of the fruiting bodies of macrofungi. This study uses DNA barcoding to identify insect eggs and larvae collected from a variety of fungi fruiting bodies (mushrooms and bracket fungi) found in Southern Ontario. The host preferences of identified insect larvae are discussed, taking

into account the hyphal type, freshness, taxonomy, and seasonality of the fruiting bodies in which different insects were found. We find that reference barcode databases for species-level identification of fungivorous flies are largely incomplete, while most beetles were able to be identified from DNA barcodes. Host preference data support the general trend of flies laying eggs in monomictic, fresh mushrooms, and beetles laying eggs in dimitic or trimitic, often decayed fungi. However, there is variation in preference and degree of specialization within these groups.

Sam Imamovic

The Responses of Plant Communities to Herbivory Through Functional Traits

Plant communities can be viewed as the addition of abiotic and biotic filters that in conjunction determine which traits and/or species persist at a site from a regionally available pool of traits and/or species. This study explores the effect and strength of herbivory a biotic filter. A functional trait approach can aid in contextualizing and standardizing the assessment of the filter's impacts. This study looked at Southern Ontario grassland communities at Koffler Scientific Reserve (KSR). Here functional traits of communities with herbivory excluded were compared to functional traits of communities that had ambient levels of herbivory. It was found that only some species show a significant plastic response in their functional traits to herbivory. This study will aid in building models that predict traits and/or species in a community because it quantifies the effect a biotic filter has on a plant community.

Jeonghoon (John) Lee

Performances of functional diversity indices to randomized Poisson and binomial data distributions serving as simulations of sampling errors in species abundances

Functional diversity indices are a staple to the research of ecology and evolutionary biology. New advances are made when researchers publish innovative formulae that capture different aspects of a community's functional diversity. This independent project investigates the performances of five different functional diversity indices when they are confronted with randomized Poisson and binomial data distributions. The five indices chosen are community weighted mean, functional dispersion, functional richness, functional evenness, and Shannon diversity. The randomized data distributions serve as simulations of field sampling errors in species abundances. This research utilized a field-collected dataset of species abundances and functional trait values in a grassland environment. True, original values of the functional diversity indices were calculated using the nonmanipulated dataset. Randomizations of Poisson and binomial distributions were employed to manipulate the dataset and to replicate field sampling errors in species abundances. Errant values of the functional diversity indices were then calculated using the manipulated dataset. Chi-square goodness-of-fit tests revealed that the simulated Poisson and binomial distributions of community weighted mean were not statistically different from the expected distributions. The goodness-of-fit tests also showed that the simulated Poisson and binomial distributions of the other four indices were statistically different from their expected distributions. The data analysis suggests that community weighted mean is the most robust of all the chosen functional diversity indices as its simulated distributions did not deviate from its expected distribution to a significant degree. As such, future researchers should prioritize using community weighted mean above functional dispersion, functional richness, functional evenness, and Shannon diversity.

Alejandra Monsivais Ibarra

The effects of soil moisture on ontogenetic shifts in specific leaf area for ten species of herbaceous plants native to Ontario tall grass prairies and old fields.

Intraspecific trait variation has been shown to have a significant effect on the responses of communities to spatial and temporal environmental gradients and consequently, community structuring (Kraft et al.,

2014; Jung et al., 2014). Given this fact, it is clear that understanding the factors that affect intraspecific trait variation is an important task. Here, this study sought to investigate the effects of soil moisture on one source of intraspecific trait variation; ontogenetic shifts in specific leaf area in ten species of herbaceous plants native to Ontario tall grass prairies. Soil moisture was found to differentially affect ontogenetic shifts across the different species, suggesting that soil moisture does not have a universal effect on ontogenetic shifts in specific leaf area but that rather, species respond differently to this variable through time.

Zoe Parshuram

Testing the effects of non-rhizobia bacteria on growth of Chamaecrista nictitans

Endophytic rhizo-bacteria have been known to develop mutualisms with plant hosts and thrive cooperatively within root nodules (Wang et al 2012). The benefits of the rhizobia's nitrogen-fixing behaviour has led to agricultural applications of the mutualism, in the hope to minimize use of nitrogenous fertilizers to decrease their environmental effects (Lie 1971). In recent years, the prominence of non-rhizobia bacteria in nodules alongside rhizobia has been noted, though many of these bacterial strains have yet to be understood for the effect they have on the host (Martinez-Hildalgo & Hirsch 2017). In this study, it is hoped that nodule-associated bacterial strains *Pseudomonas korensis* and *Variovorax paradoxus* can be understood in their abilities to promote plant growth and nodulation with to without the presence of rhizobia strain *Bradyrhizobia elkanii*, in the host plant *Chamaecrista nictitans*. Based on results from previous studies, the combined treatment of the three strains is expected to yield the highest plant fitness through the selected measurement proxies; plant height, above and below ground biomass, leaf count, root nodule number and nodule weight. From data collected thus far, it appears that change in leaf count has been increased by application of treatments including B. elkanii compared to those without.

Dale Pebesma

The role of mycorrhizal fungi for Medicago truncatula in water-limiting environments

Many species associate with multiple mutualistic partners, however the fitness consequences of multiple mutualists and the mechanisms underlying the maintenance of these mutualisms remains poorly resolved. Here we implement an experimental approach to examine the maintenance of mutual association with mycorrhizal fungi for the model legume *Medicago truncatula* in association with rhizobia bacteria. Though the maintenance of association with rhizobia is well understood for this system, there has been little investigation into why fungal mutualists are maintained at such high levels in natural systems. We inoculated *M. truncatula* with rhizobia and manipulated the presence of mycorrhizal fungi and water availability in a fully factorial design. We hypothesize that fungal mutualists are maintained in association with *M. truncatula* to bolster against water inequality, by providing easier access to water for less energetic investment in water-limiting environments. This study could serve to elucidate which aspects of plant performance are altered by fungal symbionts and in which conditions these may be important. The results of this study could highlight the role of mycorrhizal fungi under changing climatic conditions and test long-held assumptions about the benefits conferred to plants by fungal symbionts.

Adeena Zahid

Historical Contingency and Ecological Convergence in Experimental Successional Grasslands

Community assembly processes determine the short and long-term trajectories of ecological communities. Two traditionally opposing theories of community assembly differ in whether ecological communities in similar environments will converge over time or, in contrast, whether historical contingencies generate distinct trajectories. Recent research has found differing levels of convergence,

with differences often depending on whether species composition or functional trait composition is used to estimate convergence. Here, we used multi-year data from experimental plots at the Koffler Scientific Reserve in Ontario to assess how species and functional traits changed over a 7-year period, and whether these changes are convergent. Functional traits diverged over time both within plots and between plots, while species composition converged among plots, but plot-level diversity diverged. Despite these largely convergent trends, experimentally imposed initial differences in community composition had a significant effect on species and trait differences that were maintained over the 7-year period, meaning that community convergence was constrained by historical contingencies. Our results illustrate how multiple community assembly processes can operate simultaneously to shape species and functional trait trajectories in successional landscapes.

Category: Genetics, Evolution, and Environment

Yiyang Evelyn Cheng

Development genetics and behavior in nematode reproductive isolation

Species diversity has long fascinated by the scientific community. Why do we have such a huge variety of species, and yet we don't see newly generated species every day? Here, I address two exciting phenomena that were observed in the study of speciation using *Caenorhabiditis* nematode family. Firstly, I examined the mating frequency and duration of nematode species with giant sperms in comparison to species that are closely related to them on the phylogeny tree but with regular sperm size. I demonstrated that there is no difference in the intensity of mating activities between species with giant sperms and their relatives with regular sperms. These findings demonstrated that the evolution of sperm gigantism is not directly resulted from a different mating frequency, some other factors are at play. Secondly, I looked at the termination during hybrid embryogenesis between *C. nigoni* and *C. briggsae* using DAPI stain. I showed that the majority of termination occurs during gastrulation. This points us a direction of the possible genetic incompatibility during inviable hybrids. In order to solve the mystery of hybrid inviability, future studies should dedicate to gene regulation during gastrulation in hybrid genetic background.

Daniel Fusca

Temperature-dependent changes in small RNA expression differ between wild genetic backgrounds of Caenorhabditis briggsae

Temperature is a universal element of all ecosystems that influences many aspects of organismal fitness. Through natural selection, populations of a species can adapt to the temperature conditions of their local habitat, leading to temperature-dependent fitness differences between populations. Strains of the nematode *Caenorhabditis briggsae* found at different geographic latitudes are genetically distinct from each other and thus have the potential for local adaptation. At extreme high temperatures, strains from tropical latitudes have higher fecundity than strains from cooler temperate latitudes, whereas the reverse holds true at extreme low temperatures. However, the genetic mechanisms underlying these potential local adaptations are not yet fully understood. To investigate the potential role of small noncoding RNAs in genotype-specific responses to temperature, *C. briggsae* worms from tropical and temperate strains were each grown at 3 different temperature conditions, and small RNA expression was quantified using high-throughput sequencing. Both tropical and temperate strains showed a significant decrease in the expression of PIWI-interacting RNAs (piRNAs) at high temperatures, due to reduced expression of a large piRNA cluster located on chromosome IV. At high temperatures, worms from the temperate strain also showed decreased expression of 22G RNAs antisense to protein-coding genes, but this decrease was not observed in worms from the tropical strain. Reduced 22G RNA

expression was detected along the lengths of multiple chromosomes, suggesting a genome-wide response. These results indicate that differences in small RNA regulation between *C. briggsae* strains may contribute to local adaptations to temperature.

Youngseo Clara Jeong

The effect of sex-limited evolution on the fitness of female Drosophila melanogaster

Intralocus sexual conflict arises when the evolution of the sexes toward their respective fitness optima is constrained by the shared genome. If the sexes are partially released from this constraint by letting a chromosome evolve in a sex-limited way, theory predicts that sexually antagonistic alleles would accumulate. In this experiment, we let chromosomes evolve in a male-limited and female-limited way. We used balancer chromosomes and artificial selection to segregate the focal autosomal chromosomes like sex determining chromosomes. The fitness of the females carrying the experimental chromosomes were assayed after 9 generations of evolution. The results of the fitness assay provide an estimate of the change in female fitness due to sex-limited evolution of the chromosomes, which will indicate whether selection was sexually antagonistic or concordant.

Amanda Peake

Genome-wide analysis of hybridization in a Rumex hastatulus hybrid zone

A hybrid zone is a geographic region where hybridization between two populations may occur. Accumulated genomic differences, such as chromosome fusions and inversions, can limit gene flow between diverged populations. However, hybridization and introgression may still facilitate gene flow across a contact zone. A chromosome fusion, between an X chromosome and an autosome, has given rise to two *Rumex hastatulus* cytotypes on opposite sides of the Mississippi River. Previous research suggests that there is no contemporary gene flow occurring between the two *R. hastatulus* populations despite earlier reports of hybrid individuals found within the contact zone. In our analyses, we use genotyping-by-sequencing data from 234 *R. hastatulus* individuals from both cytotype populations and within the contact zone to determine if hybridization is taking place. A subset of 9312 SNPs are used to perform principal component analysis and generate a non-spatial ConStruct model, both of which indicate the presence of genetically intermediate individuals between the two cytotype populations. Therefore, we can infer that hybridization has recently occurred within the contact zone and may still be ongoing, resulting in genetically intermediate individuals, which contradicts previous evidence that there has been no recent gene flow between the two populations.

Destiny Micha Sibolibane

Heritable Variation between field and greenhouse experiments of Brassica rapa

Measurements of quantitative and qualitative traits of plants allow for the determination of the heritability of traits. Knowledge of such traits are important for determining the mechanisms behind evolutionary change in plants. As a result, several papers have conducted field and greenhouse experiments to estimate heritability and genetic/environmental variance in several plant traits. However, most of these studies have not coordinated their field and greenhouse experiments, nor had a field experiment undergo a climate change scenario. In this study, the same 57 full sibships of *Brassica rapa* used in a field experiment were grown in a greenhouse, and the heritability of *Brassica rapa* traits were determined. From this, the main contributors to heritability were identified, whether it be genetic or environmental variance. Heritability of measured traits were much higher in the greenhouse, due to a decrease in environmental variance (for stem diameter only), as well as genetic variance (for all traits).

Malcolm Cassim Thompson

No Evidence of Sexual Antagonism in Short-Term Sex-Limited Evolution Experiment in Drosophila melanogaster

Intralocus sexual conflict arises when the expression of alleles has opposite effects in the sexes. A mostly shared genome between the sexes constrains the independent evolution of the sexes, preventing males and females from evolving different optimal phenotypes to maximize fitness. In a promiscuous species, an individual's lifetime fitness will differ from its mates', introducing the possibility for alleles to evolve that serve one sex's interests at the cost of the other. Intralocus sexual conflict was investigated experimentally using *Drosophila melanogaster* by artificially removing one copy of chromosome 3 from the shared genome like a new Y chromosome in both sexes. This was accomplished by using individuals that maintained the sex-limited inheritance of this copy of chromosome 3 in a shared environment over 9 generations. Male fitness variation was found to not be significantly affected by the sex-limited treatment of the focal chromosome.

Yiran Zhao

Hitchhiking with a Gene for Competitive Ability: A Biological Simulation with Rapid-Cycling Brassica.

Genetic hitchhiking is a theory predicting that, while a beneficial mutation is selected to fixation, all the genes linked to it would also go to fixation. It is believed to be one of the mechanism that a mild deleterious trait is maintained or even fixed in a population. While many models have been established to show the effect of genetic hitchhiking, they often assume the genes are density independent. However, for genes that influence competitive ability, they are inevitably density dependent. This project aims to examine the effect of the degree of benefit and population density on the hitchhiking ability of the beneficial gene. The experiment used the lab-synthesized Rapid-Cycling Brassica rapa with neutral and deleterious mutations. I simulate a beneficial gene with different degree of early germination time in low- and high-density situations. I predicted a) the deleterious mutants linked with higher degree of beneficial gene will have increased fitness comparing to the wildtypes, and b) the effect of the beneficial gene, as well as the deleterious effect of the mutants, would be exaggerated in higher population density.

Category: Evolution of Biodiversity and Morphology

Varosak Chirachon

Characterizing Previously Unknown Photosynthetic Diversity in Tribulus (Zygophyllaceae)

C4 photosynthesis is the most productive type of photosynthesis in terrestrial environments and has evolved independently in over 60 lineages. The transition from C3 to C4 photosynthesis requires the transitional step such as the C2 photosynthesis found in C3-C4 intermediate species. Lineages with C2 species branching between C3 and C4 clades provide the most insight into the C4 evolution. Tribulus is a genus of warm-adapted plants, comprising of three phylogenetically distinct sister clades. The Tribulus Cristautus clade branches in between the C3 Tribulus clade and the C4 Tribulus clade. To characterize the C3 and C4 photosynthetic diversity in Tribulus, we conducted gas exchange measurements on representative species from the three clades. Our results supported the possibility of a C2 photosynthesis in the previously identified C3 *Tribulus Cristautus*.

Shu Han (Julie) Gan

Does Flaveria linearis subpopulation "Yucatan" characterize the Big Step before C4 Photosynthesis?

The C4 photosynthetic pathway allows plants to produce carbohydrates more efficiently than the C3 pathway at higher temperatures in a low CO2 atmosphere. C4 photosynthesis has evolved

independently in over 65 lineages and its evolution continues to elude distinction. The genus *Flaveria* in the family *Asteraceae* contains a spectrum of C3 to C4 transitional species which includes *Flaveria linearis* that runs a C3-C4 intermediate cycle also known as a C2 cycle. The subpopulation of *F.linearis* from the Yucatan has a CO2 compensation point close to that of C4 species without an evident C4 pathway, which indicates that it is trapping most of the CO2 resulting from photorespiration. We hypothesized that larger or a greater number of chloroplasts in the bundle sheath cells acts as a CO2 trap that allows this near-zero compensation point. This study compared the physiological and enzymatic changes of the species with several others in the genus and found that *F.linearis* Yucatan did have a larger chloroplast size compared to other subpopulations of *F.linearis*. The chloroplast size was comparable with a C4-like species *F.brownii*. In addition, the expression of glycine decarboxylase in the mitochondria were also examined. The results of this study suggest that the enlargement of chloroplasts is a key step that enables the evolution of the C4 cycle.

Sid Gopalan

Site-specific selection in vision genes across reptiles and within ancestrally-diurnal lizards

The anole lizards (Anolis) of the Caribbean, mainland South and Central America have been a long-standing model system in evolutionary biology and ecology. The great naturally-occurring diversity in ecology and morphology of this clade provides much of the needed variation to be able to ask several questions bringing together different levels of biological organization. An important axis of ecological diversity anoles explore is light environment, where they exist along a spectrum ranging from sunnier to more shaded habitats. Though this aspect of anole ecology is known to be of importance, little is known as to whether this axis shapes the evolution of their visual system. With access to genome sequence data for several island anoles, we can begin to understand the connection between genotype, ecology and physiology in this system. We studied 8 visual transduction genes and 2 opsins across up to 27 non-avian reptiles including 7 anoles. Using comparative methods and likelihood-based models of selection, we found strong evidence of accelerated evolution in the channel protein CNGA3 across the entire non-avian reptile phylogeny. We also found that CNGA3 and the receptor kinase GRK7 had selected residues located in domains of potential clinical significance in the human ortholog. Most vision genes appear to be selectively constrained in the ancestrally-diurnal lizards (consisting of Anolis, Pogona and Podarcis), the only exception being GRK7, which showed strong positive selection in ancestrally-diurnal lizards compared to the rest of the phylogeny, as well as selection at an otherwise conserved post-translationally modified residue. These results potentially suggest reptile-wide changes in visual sensing as well as pronounced variation among deep clades that differ in light environment.

Milly Hong

Comparing adaptations for migratory flight efficiency in eastern and western wood-warblers (Parulidae)

Migration is a critical selective pressure on phenotypic adaptations as the inability to successfully reach wintering or breeding grounds may result in death or failure to reproduce. As long-distance migration is energetically costly and time-sensitive, it can be predicted that selection would favour novel migratory adaptations that would increase migration efficiency and minimize energy expenditure. Wood-warblers (Parulidae) are Neotropical-Nearctic migratory birds that use seven migration pathways which could be grouped into two main routes: east and west. Eastern migratory pathways are longer and requires the crossing of seas while western routes are primarily over land. This should create selective pressure for differing evolutionary adaptations in eastern and western wood-warblers. Museum specimens of 47 wood-warbler species were examined for possible variation in flight morphology (i.e. body size, aspect ratio, and tail length and width). Seven morphometric variables representing size and shape of external flight morphology were measured. Analyses with phylogenetic paired t-tests and phylogenetic

generalized least squares suggested that there was no difference in selective pressures on flight morphology between eastern and western wood-warblers. These results contradict previous findings which proposed that flight morphology is correlated with migration ecology.

Danté Ravenhurst

Exploring Barbel Sensory Ultrastructure and Function in the Snapping Turtle, Chelydra serpentine

Sensory organs can vary in size, shape and number across the animal kingdom, and offer species a potential evolutionary tool in sexual selection, communication, camouflage and/or movement. An example of integumentary sensory organs that occurs in fish, amphibians and a number of reptiles are barbels, which are small tentacle-like structures that protrude from the face and head. In fish, of which the barbel literature is extensive, these appendages are functionally tactile and gustatory, whereas the function in reptiles and amphibians has been suggested as mechano-receptive but little literature is available to confirm this. Of the few reptiles that possess barbels, chelonians are highly under researched, with brief research from the late 1960's to 1980's inferring that the barbels of turtles perhaps have a role in tactile water movement sensation that could aid in carnivorous feeding behaviour. However, research on turtle barbel ultrastructure and the connection between morphology and function is greatly lacking. Using a combination of histological methods - in a similar vein to past research - along with unexplored transmission electron microscopy approaches, we aim to uncover the specific sensory ultrastructure of barbels in our chelonian representative, *Chelydra serpentina*, in an aim to further fill in the gap between barbel function and structure.

Sebastian Scott

Postcranial Description of Wendiceratops pinhornensis from the Oldman Formation of Alberta, Canada and a Taphonomic Analysis of the Oldest Monodominant Ceratopsid Bonebed.

Despite the abundance and diversity of ceratopsid dinosaurs in the Latest Cretaceous of North America, research has focused on cranial anatomy with few detailed studies of the postcranial skeleton. This has led to a gap in the understanding of the evolution of the ceratopsid postcranial skeleton, particularly in the early part of their radiation. The early Centrosaurine ceratopsid, *Wendiceratops pinhornensis*, was discovered in Alberta, Canada in a medium density monodominant bonebed from the Oldman Formation (mid-Campanian, ~79 Ma). The *Wendiceratops* bonebed contains abundant well-preserved postcranial material, allowing for the first detailed description of the postcranium in an early ceratopsid. Here, the postcranial skeleton of Wendiceratops is described and compared to contemporaneous Centrosaurines and Chasmosaurines. The curved and elongated distal terminus of the ischium is confirmed as an apomorphic character of *Wendiceratops pinhornensis*, and the material documents a large adult body size consistent with other later members of the clade. Centrosaurine ceratopsids are commonly found in monodominant bonebeds containing hundreds to thousands of individuals of different maturational states, the taphonomy of which has been used to argue for large scale gregarious behavior in this group. At approximately 80 million years old, the Wendiceratops bonebed is ~3 million years older than other well-documend ceratopsid bonebeds that suggest gregarious behavior. Here, we taphonomically assess the bonebed to test whether it represents a mass-death assemblage derived from a large social group. The bonebed represents a lag deposit within a mudstone bearing overbank facies and contains individuals from multiple age classes. It contains over 95% ceratopsid remains, and all identifiable elements belong to *Wendiceratops*. The elements are completely disarticulated but have undergone little abrasion or weathering (both Stage 0), exhibit extensive breakage, but lack signs of scavenging; all factors indicative of a mass death assemblage with moderate hydrological reworking. The taphonomy is consistent with other inferred ceratopsid mass death assemblages, suggesting that the Wendiceratops bonebed is the oldest evidence of herding behaviour in a horned dinosaur.

EEB397Y and ROP Posters

Natasha Dhamrait & Michaela Fink

Seed Aging, Resurrection, and the Invisible Fraction Problem: An Experimental Exploration

Seed storage in seedbanks is essential for representing and conserving plant diversity, serving as agricultural safeguards, and in studying natural plant population evolution and ecology. However, long term seed storage may be damage intensive, diminishing seed viability through DNA/RNA damage, loss of resources, and structural deterioration. Seed banks counter this deterioration process by storing seeds at optimal temperature and humidity levels, which has been shown to slow the aging process. Seed storage stressors may impose viability selection during the seed stage. If traits selected during storage are genetically correlated to post-emergence traits, the resulting generation will show a non-random sample of the phenotypes that would be expected if all seeds are viable. The non-random loss of genetic variants in seed storage is known as the Invisible Fraction Problem and has been experimentally demonstrated in one case. To further explore selection during the seed storage process, we artificially aged Brassica rapa seeds, using a process known to mimic prolonged seed storage, and then compared resulting plants to controls in a greenhouse. Flowering time, leaf number and other traits were measured. Aged and control groups were grown alongside each other for three generations. To account for extraneous environmental variation, a resurrection experiment was also performed, where all three generations of the project were grown simultaneously in a common environment. Results from the first (refresher) generation showed a significant delay in flowering and lower leaf production in plants from seeds that survived storage. It was possible these differences were due direct effects of storage on seed quality, rather than selection. Seed were collected from the two groups, treated equally, and grown for a second generation. Some differences persisted, indicating correlated selection during storage, although multigenerational storage effects are also possible. There were no significant differences between treatment groups in the third generation, indicating that the storage induced stress does not persist across successive generations. Our results suggest that resurrection experiments to detect rapid evolution, such as those made possible by the Project Baseline seedbank, must incorporate a refresher generation, and evaluate the potential for viability selection during seed storage as a bias in measuring evolutionary responses in nature.

Aisha Faruqui

Phylogenetic patterns underlying the evolution of sex-determining mechanisms in turtles

Although temperature-dependent sex determination (TSD) is phylogenetically widespread in reptiles, the adaptive significance remains elusive. It is widely accepted that the explanation for the maintenance of TSD is rooted in the Charnov-Bull framework, which states that temperature affects fitness differently in males and females. TSD may be adaptive if males are produced in the most favourable temperatures, ensuring a high-quality phenotype, and thus, reproductive success. A current hypothesis suggests that since variation in male quality is required for TSD to be adaptive, genotypic sex determination (GSD) should be favoured when there are factors that decrease variation in male quality. One such factor is rapid maturation, and by consequence, smaller male size at maturity. In this study, we use a dataset of 95 chelonian species to investigate body size difference between TSD males and GSD males. We conclude that TSD males are indeed larger than GSD males, which is a novel pattern that supports our hypothesis and provides valuable insight into the evolution and maintenance of sex-determining mechanisms in turtles.

Claudia Lacroix

The evolution of large clutch sizes: the benefit and mechanisms of nest communication in snapping turtles (Chelydra serpentina)

Recently, studies have found that hatchling turtles vocalise within the nest. While some speculate that hatchling vocalizations are important for embryo-embryo communication, few have connected a communicative function to these sounds. Here we provide additional evidence that sound may play an important role in the interchange of information in this group by: (1) characterizing the vocal repertoire of *Chelydra serpentina* hatchlings, and (2) testing to see if group emergence provides an energetic benefit. After approximately 60 days of incubation in the wild, we collected 9 clutches of *C. serpentina* nests from the Algonquin Wildlife Research Station. In the lab, we recorded the nest audio of 1 clutch and set up a 2x2 factorial design with 8 replicate clutches to measure the effect of egg burial depth (shallow or deep) and sociality (presence or absence of siblings). From a random sample of recorded audio, we detected 105 sounds and classified them into 6 different types. Moreover, we found that hatchlings in deep nest treatments spent significantly more time in the nest, while eggs hatching in the presence of siblings pipped sooner than those hatching alone. Though, we cannot conclusively attribute a communicative function to these vocalisations, our study suggests that hatchling vocalizations may be used as a form of communication within the nest.

Jacy Newfeld & Sarah Ravoth

Does Mother Matter?: Investigating maternal effects in seeds surviving heat stress

Seeds are alive, and that means they can also die. The probability of a seed surviving stress may depend on how well they are provisioned by the mother plant. The maternal plant contributes both genes and resources to her seeds—the resulting fitness of the offspring is therefore dependant on the inherited genes and the quality of the maternal environment. We have performed an experiment allowing us to disentangle these genetic and non-genetic impacts of a maternal plant on seed quality. Our approach takes advantage of the fact that Brassica rapa is hermaphroditic. We reciprocally crossed the parental generation to produce sets of seeds that are full siblings, but where half the siblings do not share the same maternal plant. That is, for each family, the parent plants serve as mother to half of the seeds and father to the other half. This allows us to hold genetic contributions constant and isolate differences among plants based on maternal effect. We imposed heat stress on half the siblings, monitored their survival, and quantified their subsequent growth. Our analysis will isolate any maternal effects over and above genetic inheritance that influence seed survival and offspring growth.