THE UNIVERSITY OF MICHIGAN
DEPARTMENT OF ECOLOGY AND EVOLUTIONARY BIOLOGY

NATURAL SELECTIONS

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EEB photo for the ages

The EEB group photo and an identification key were placed in a 100-year time capsule sealed beneath one of the pumas that flank the front entrance of the Museum of Natural History.

Image: Dale Austin. For further information and names: myumi.ch/aA535

chair's note


Photo credit: Dale Austin

Diarmaid Ó Foighil
Chair and Professor of Ecology and Evolutionary Biology
Curator, Museum of Zoology

Season's greetings from Ann Arbor! This is the Department of Ecology & Evolutionary Biology's 17th edition of *Natural Selections* and my sixth and last chair's note - my term as chair ends June 2020. It's been another busy, exciting and productive year for the department with many developments both programmatically and in terms of personnel.

We are now settled in our new homes, both in the new Biological Sciences Building located to the north of Ruthven and in the renovated Research Museums Center on Varsity Drive, and it is great to be able to turn our full attention back to scholarship and education. Among the highlights of the past year was our 15th Early Career Scientists Symposium on *Stable Isotopes in Ecology, Evolution & Conservation* that attracted 120 registrants from 10 universities – *the most new science I think I have ever learned in the space of one day*, according to Fiona Soper, one of the invited speakers. Another highlight has been the continued success of our outstanding, prize-winning faculty and students. Meghan Duffy and Knute Nadelhoffer were elected Fellows of the American Association for the Advancement of Science, Jake Allgeier won a Packard Fellowship in Science & Engineering, Deborah Goldberg won a Distinguished Faculty Governance Award, Trisha Wittkopp won a clutch of awards including a Guggenheim Fellowship and three of our faculty – Dan Rabosky, Stephen Smith and Tom Schmidt – were notably included in the *Web of Science* 2019 List of Highly Cited Researchers (the top 1% in their respective fields over the previous decade). One award deserves special mention. Frontiers Master's student Amy-Charlotte Devitz (and her service dog Fish – see front page bottom right) received a well-earned University of Michigan's Council for Disability Concerns Certificate of Appreciation for her highly effective advocacy regarding scientists with disabilities, including her *Bendy Biologist* blog and national media interviews.

Regarding our highly valued Frontiers Program, Director Tim James has restructured important aspects of it over the past year and these changes have enabled us to obtain four additional years of support from LSA and Rackham. In other notable news, Catherine Badgley has been appointed director of the U-M's fabled Residential College – she is a member of both EEB and the RC. Finally, I would like to share two EEB museums highlights with you, both involving impressive numbers. As the vast Herbarium and Museum of Zoology collections become increasingly digitized, they are attracting intense global interest with >1 million records downloaded in 2018 and an astonishing 1.3 billion views! The UMMZ Herpetology Division's spectacular field recording of predatory Amazon rain forest spiders went viral earlier this year, easily smashing the record for U-M videos with >2.4 million views to date.

We have also undergone many important personnel changes. This issue of *Natural Selections* profiles three highly inspiring new faculty: María Natalia Umaña, Luis Zaman and Hernán López-Fernández who have already added greatly to our program – I invite you to read all about them and their research. At the same time, two esteemed long-term colleagues retired during the year: Barry OConnor (front page with a giant mite on his T-shirt) and founding and long-time chair Deborah Goldberg (front page just below Barry). Barry has moved to the UMMZ as Curator *Emeritus* but Deborah has relocated to Arizona and this is a big loss indeed – it is frankly difficult to envisage EEB without her presence. Our museums program has experienced the greatest turnover in personnel with three long-term collection managers (Janet Hinshaw, Doug Nelson and Bev Walters) retiring and being replaced by three incoming collection managers/research scientists (respectively, Brett Benz, Randy Singer and Brad Ruhfel). Other museums personnel changes include recruitment of our new registrar, Ben Hess, the retirement of Herbarium research scientist and Malpighiaceae expert Chris Anderson, and the poignant loss of the oldest member of the EEB community: legendary fern specialist and Herbarium research scientist Florence Wagner who died in October. Florence celebrated her 100th birthday earlier this year and, together with her late partner Herb Wagner, was the topic of a 2016 *Natural Selections* profile. She is missed.

I invite you to stay in touch with our brilliant, engaged and vibrant EEB community over the coming year using the many electronic portals to our department, its people and their doings, including our website (lsa.umich.edu/eeb), Facebook, Twitter, Instagram, EEBlog, YouTube channel and enewsletter. If you are visiting Ann Arbor, please drop in to see us.

With my best wishes for a peaceful holiday season and a happy and prosperous new year!

Diarmaid Ó Foighil

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An eye toward conservation of natural communities in diverse ecosystems

Growing up in the tropics of Colombia, María Natalia Umaña often traveled through the mountain forests. Drastic landscape changes over short distances of changing elevation along mountain roads captured her youthful curiosity and attention.

Today, an up-and-coming plant community ecologist and a new assistant professor (January 2019) in EEB, she can trace her early scientific interests to this childhood observation.

When Umaña was in high school, her attention turned from the macro to the micro when she noticed how different the insect species were between not-so-distant parts of the forest. Her desire to learn more about the natural history of ants, bumblebees, other insects and other living things she found in nature led her in a beeline to the study of biology.

At the beginning, she was fascinated with insects. Plants were boring, she thought, especially because they're stationary. And then – (cue the music), as an undergraduate at the University of Los Andes, Colombia, she took a class on plant physiology. "I learned about all the different adaptations plants have in order to withstand their environments without being able to move," Umaña said. "In Colombia, we have the wet season and dry season. In the dry season, trees shed their leaves, similar to what happens here during the autumn."

She learned about a study that featured a time-lapse video that revealed how plants move their leaves throughout the day to capture more light.

A few years later, while she was in the Amazon forest armed with knowledge to identify different species, she totally realized the region's astonishingly high tree diversity. "That was when I started thinking of the questions that drive my research today, regarding how we can explain the diversity."

For her doctoral research, she incorporated information on plants' features and functional traits, which provided more

> ***"In order to understand the high diversity in the tropics, we need to understand how plants are interacting"***
>
> ***~ Maria Natalia Umaña***

information on how plants interact. "In order to understand the high diversity in the tropics, we need to understand how plants are interacting."

Umaña uses a combination of fieldwork and computer analyses in her lab to investigate how trees differentially use the environment by applying a trait-based approach. For example, looking at maximum plant height indicates how well a species competes for light, with taller plants having the competitive advantage.

Umaña is on the leading edge of this research that asks how the community composition is explained by variation in

María Natalia Umaña in Madagascar.

traits. In the past, this research was more focused across species and it was believed that the main ecological strategies for plants were well understood. "When I started to look at the intraspecific level, I noticed some of the main assumptions of the functional framework were not necessarily true within species." That surprising finding led her down other paths in trying to understand more about the functional framework of plant interactions.

She explained that comparing data across species assumes individuals of the same species have the same traits. But, "I observed that even within the same species, they are very different. Maybe this tells us something else about their interactions. One project I'm interested in now is trying to understand how intraspecific variation allows us to understand these interactions among individuals of the same species and across different species."

Umaña established experimental plots in two tropical forests (in northeast Puerto Rico and China's Yunnan Province) in 2014 where she set up hundreds of one-square-meter plots of preexisting seedlings, which she tagged and identified. She gathered information on species' abundance and measured growth and survival of more than 2,000 individuals for one year. Then, she collected seedlings for all individuals to help determine whether different traits drive survival in nature.

"What I found is that individual-level trait information improves the predictive power of seedling growth compared

see conservation, page 4

conservation from page 3

to just using mean values for species – the usual approach. This result suggests that trait information at an individual-level is needed to predict local community structure and dynamics."

"I'm interested in trying to understand why there are so many species in the tropical forest and with this information, how we can predict what forest communities will look like in the future with possible implications for conservation, forest management and responses to global change." The ultimate goal is that her data will help maintain natural communities in highly diverse ecosystems.

In a related project, she correlated traits within and across species using data from adult tree leaves collected in Puerto Rico. She tested correlations between traits like leaf area, leaf mass per area, chemical components (percentage of nitrogen, carbon, phosphorous) and leaf thickness. "Traits are supposed to be highly correlated across species but within species the relationships were not always consistent."

A current real world example Umaña published about in January 2019 in *Ecology* was motivated by the recent spate of studies reporting significant increases in the abundance of lianas (vines) relative to trees in Neotropical forests. In this study, she asks about the role of liana dynamics at early life stages in contributing to the observed increases in adult liana abundance. She found that seedling lianas are increasing much faster than trees, drastically altering forest composition and potentially the ecosystem function. She correlated increases of relative liana abundance with forest disturbance and rainfall, finding that lianas thrived in dryer years and more disturbed areas. So, if global warming predictions indicating more frequent and severe drought as well as increased forest disturbance are accurate, lianas will increase.

A new project she has established in Michigan at the E.S. George Reserve aims to find out if above- and below-ground traits are coordinated in their functions and define a single trade-off of resource use and conservation. Do plants with more efficient leaves have more efficient roots? She's collecting roots and leaves of 15 of the most common tree species to determine whether combining the two pieces of information will improve predictions of tree survival and growth.

The majority of the traits researchers have worked on in the past were above-ground because working with roots is very challenging. This was the first time Umaña tried to collect roots from large trees. "I didn't know how it was going to be. In the end, it was time consuming but rewarding. We had to dig, find roots, and track the root to the individual we wanted to collect."

This fall, she is teaching Functional Ecology, a new 400 level class that she has developed. For spring 2020, she will teach Introduction to Plant Biology. She's busy setting up her lab and seeking students.

Her favorite part of her profession is "going to the field for sure." She spends a great deal of time working on the computer and doing analyses but most of her ideas come from the field. "Thinking of plants and observing the trees – it's where all my inspiration comes from." Not surprisingly, she loves to walk, hike and bike outdoors.

As far as what brought Umaña to U-M, "the tropical ecologists here are very famous, tropical ecology is strong at the University of Michigan." Also drawing her interest, "The number of women in the department is high, they're super committed to increasing diversity," something important to her as a woman and a Latina.

For more information about the Umaña Lab, visit sites.lsa.umich.edu/umanalab

María Natalia Umaña retagging trees and remeasuring dendrometers after Hurricane María in Puerto Rico.

Pioneering research: studying life *in silico* and *in vivo*

Luis Zaman's interest in evolution was sparked by an undergraduate computer science class. "It's still amazing to me that we can bottle up evolution in an algorithm, and yet are still just scratching the surface of understanding the biodiversity and complexity it has produced," he said.

Zaman did not expect to attend graduate school after getting his undergraduate degree in computer science from Xavier University. "I thought I'd get a computational job and that would be it." He's unsure exactly what inspired his excitement about continuing on to his doctorate degree in computer science and ecology, evolutionary biology and behavior at Michigan State University.

Luis Zaman with his partner, Heather, and their pup, Lily.

"I worked as a software engineer for a while. The problems and problem-solving were always interesting but there was a different motivation behind asking the questions other people needed answered versus questions I wanted to ask. I felt like grad school was a way to do those kinds of things."

Zaman was promoted to assistant professor in EEB and in the Center for the Study of Complex Systems on Sept. 1, 2019.

Much of the work in the Zaman E^3 Lab (Engineered and Experimental Evolution) focuses on host-parasite coevolution both computationally using populations of self-replicating computer programs (sort of like computer viruses), and experimentally in the lab with bacteria and their viruses (bacteriophage). The lab is deeply interdisciplinary, and broadly interested in ecology and evolution.

"I study host-parasite coevolution using a mixture of computational and microbial experiments. I treat computer systems as another experimental system, much like *E. coli* and elephants are two living systems that can be studied in surprisingly similar ways."

Zaman's computer study is indeed a rare breed at the leading edge of the field. A small number of groups do similar work but only a few of those explore core biological questions using computer systems like his lab does. The applied groups are more computationally inspired by biology and ask questions about evolving better airplanes or trains, for example.

In contrast, using Avida, an artificial life platform, the E^3 Lab studies how host-parasite coevolution drives the evolution of complexity, diversity and evolvability. The programs they study represent individuals, each one runs a virtual computer with instructions that allow it to interact with its environment, do computation and interact with memory. It's "genome" is computer code and its hardware lets it read instructions from one location in memory and write to another. As a result of those processes, programs can create copies of themselves. The E^3 Lab is investigating how these copies evolve.

"Sometimes, it copies the wrong instruction and that's a mutation. Most of the time, mutations break the program, but sometimes mutations are beneficial just like mutations in biological systems. By studying populations of lots of self-replicating computer programs, we can ask basically the same questions as we can with *E. coli*, just faster. And we can do things we can't do with *E. coli*, like stop all mutations or turn off all death.

"I am predominantly drawn to understanding host-parasite coevolution because the constant push-and-pull of antagonistic interactions emphasizes the dynamic and interdependent nature of biological evolution. These antagonistic interactions have been implicated in some fascinating large-scale evolutionary patterns, such as diversification, sexual reproduction, and increasing organismal complexity.

> ***"By studying populations of lots of self-replicating computer programs…we can do things we can't do with E. coli, like stop all mutations or turn off all death."***
>
> ***~ Luis Zaman***

"One of the challenges is that evolution creates diversity and complexity, which then strongly influences further evolution. Untangling this feedback loop between what evolution produces and what then becomes selectively favorable motivates much of my work. Host-parasite coevolution is a prime instance of this complex feedback loop at what I consider the core of evolutionary biology."

He calls what he does a "weird mix of theory and experiments," and said, "I consider myself mostly an experimentalist but a lot of the questions I'm asking are either motivated by or directly trying to get at some of the more theoretical questions

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about how evolution might work. It's hard to put myself in one box." In fact, work in the lab relies on a mixture of computational, mathematical and microbial systems.

Something he's just started working on with his students in the lab this summer looks at how viruses that infect *E. coli* sometimes carry with them beneficial traits for their hosts. "We have to change our perception of viruses of bacteria as not just being parasites but also potentially being mutualists. Some of the questions we're asking around that are how common is this in nature? Some collaborations we're starting with EEB Professor Melissa Duhaime are looking at viruses of bacteria in the ocean. We're seeing what kind of genes they might be bestowing on their hosts, how that interaction changes the ecology of the system, and how evolution can move things from being more parasitic to more mutualistic."

The lab's attempt to understand the general rules of how things coevolve has huge potential impacts on things like vaccine design, public health policy, and certainly could

Luis Zaman and EEB graduate student Juanita Pardo Sanchez. Image: Josie Whelan.

A fascination with Neotropical fish diversity, evolutionary history and conservation

Sometimes, when we look back on our lives, certain moments stand out as defining and maybe even life-altering. For Hernán López-Fernández, one of those moments was when he was 10 years old and his father brought an aquarium home. "Once I discovered fishes, I was never so interested in anything else," he said. He recalls his ever-present interest in natural science and biology. "Much later, I realized that a big part of what I liked about fishes was the diversity of their anatomies and their ecologies, so that is what I have been studying for over 25 years."

The highly regarded ichthyologist joined EEB as an associate professor and associate curator of fishes of the Museum of Zoology in January 2018. "In that role, part of my job is to ensure that one of the three largest research collections of fishes in North America (over 200,000 cataloged samples and 3.5 million specimens) continues to grow and serve as a crucial resource for research in my lab, at U-M and to the scientific community at large. I led two expeditions to South America in 2018 and 2019."

He engages in fieldwork in the Neotropical region of South and Central America. Over the course of his career, most of his research has concentrated in South America, mainly in Guyana, Suriname and his native Venezuela. One of his most remarkable field trips took place along the upper Mazaruni River in the highlands of Guyana, a paradise of biodiversity, in 2008.

"Perched atop the Guiana Shield escarpment 500 meters above the Essequibo rainforests, the upper Mazaruni region is accessible only by small planes when the weather allows. After an hour of flying over lowland forests, sometimes impossibly dense and others painfully scarred by mining, the plane suddenly finds itself in front of a giant wall dripping with waterfalls and impossible flat-top mountains as a background. The reverie is broken by a rough landing on a dirt strip and an unceremonious transfer to the river and its tributaries. From

Hernán López-Fernández at camp with specimens for tissue sampling, U-M Museum of Zoology expedition to the Rewa River, Guyana (2018). Image: Devin Bloom.

there on, rivers are the only highway and tarp-covered camps in the seemingly endless rainforest become home.

"This portion of the Mazurini is incredibly isolated and until we were there it was nearly completely unknown. Arriving to a region where all the fishes are different and some so strange that you are not even sure what family they belong to is incredibly rare. I probably will never again go to a place quite that distinctive. Today we know that, despite having relatively few fish species, nearly all of the upper Mazurini fishes are only found in that small portion of Guyana."

Near the end of that expedition, they encountered an unsettling development that could have far-reaching implications

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provide other health insights. For example, the reason there is one measles vaccine but a different flu vaccine every year has to do with the way these diseases coevolve with our immune system.

In CSCS, he teaches Evolution *in silico* (*in silico* is a newer term that means to do experiments with computer systems on a silicon chip), the first-of-its-kind course he designed. For fall 2020, he's developing an undergraduate Ecology and Evolution of Infectious Disease class.

What Zaman finds most fun about his job are the enlightening conversations. "I think most of the people that end up in this particular space, doing graduate research or postdoctoral research or being a professor, are just really passionate about their work."

Outside of work, he said that coffee is one of his main hobbies – so much so, he roasts his own beans. In his quest for a good cup of coffee after moving to Michigan, he has become an admitted coffee snob.

He also likes to cook and he and his partner, Heather, have an enthusiastic 8-year-old Vizsla named Lily, who still looks (and acts) like a puppy. Sounds like an ideal way to balance out the rigors of science and academia.

For more information about the Zaman E^3 Lab, visit zeeelab.com

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for the region's flora and fauna. They observed gold mining spreading along the length of the main channel. "The effects of gold mining on rivers are well known and documented. Species endemic to the upper Mazaruni evolved to live in the originally pristine waters of the region. If changes to their ecosystem are significant, these extraordinary fish may be in trouble."

> ***"Sadly, we have witnessed firsthand how even the most remote pockets of the world can be altered by human activities."***

The entire region is threatened by mining and the increasing possibility that a hydroelectric dam will be built in the area. López-Fernández is working with colleagues in the School for Environment and Sustainability (SEAS) and Civil Engineering on a project that seeks to understand how the gold mining may be changing these fish communities or changing the flow pattern of the river. He and his team hope that identifying the ecological needs of the fishes will provide useful conservation information for ensuring their survival.

The López-Fernández lab group studies the diversity, evolutionary history and conservation of Neotropical fishes. His research program focuses on the roles of ecological and morphological specialization in driving phylogenetic divergence. Through fieldwork and collections studies, they combine systematics, comparative morphology and ecology.

An overarching question the lab addresses is along the lines of "what are the evolutionary forces that generate hyperdiverse assemblages" like those of tropical fishes coexisting in South and Central American communities, or the rivers of the Congo river basin.

Ultimately, they are trying to understand how biodiversity originates. They are establishing links between modern biodiversity and their ancient environments and ancestors by linking disparate fields such as molecular biology, anatomy, ecology and paleontology through fieldwork in places most people can't even imagine. Sadly, they are studying species that are often threatened even before they can put a name on them.

López-Fernández's main research involves cichlids. "Cichlids are ideal for these and other questions because they are iconic examples of adaptive radiation in vertebrates, but they are also the third most diverse family of Neotropical fishes.

"The Neotropics, South and Central America, are home to the most diverse freshwater fish fauna on Earth. Even though we have an enormous amount of work to do, from taxonomy to macroevolution, this is an exciting time to study Neotropical fishes. We live in a time in which advances in biology allow us to study fishes in ways never before possible. Sadly, we also live in a time in which the very survival of Neotropical fishes is far from certain. It is in our hands to use all this new knowledge to do what we can to preserve the fishes that so fascinate us."

López-Fernández teaches Biology of Fishes as a cross-listed course in the Program in the Environment, EEB and SEAS. He taught a course at the U-M Biological Station over the summer, Michigan Fishes in Changing Environments, with SEAS Professor Karen Alofs.

Favorite parts of his profession are advising students one-on-one on research projects, particularly in research that involves the collection. Also, he said, "I love being in the field in places that may harbor fish species we didn't know about."

Outside of work, his many interests include a love of cooking almost anything. He reads a lot of modern history. "I garden, do a little woodworking and build mostly WWII model airplanes as a way to disconnect from work and more intellectual things."

A number of interesting research projects are ongoing in the lab. Read more about them on his lab website: sites.google.com/site/hlffishes

With appreciation for information and some excerpts from The Found Fishes of the Lost World, *ROM* magazine, Summer 2012 and Entrevista, Bulletin of the Brazilian Society of Ichthyologists.

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Photo finish: frog (once again) leaps to first place

EEB Honorary Photographer at Large Contest 2018

John David Curlis

John David Curlis

Rumaan Malhotra

1st place: John David Curlis "King of the Mountain: The Exquisite Spike-thumb Frog (*Plectrohyla exquisita*)," Cusuco National Park, Honduras

2nd place: John David Curlis "A Very Happy or Very Angry Parrotsnake (*Leptophis ahaetulla*)," Cusuco National Park, Honduras

3rd place: Rumaan Malhotra "Winter Study Break," Upper Peninsula, Michigan

Honorable mentions:

Molly Hirst "Motherly Affection in the Mara," Maasai Mara, Kenya

Molly Hirst "Monkeying Around with Vervets," Mombasa, Kenya

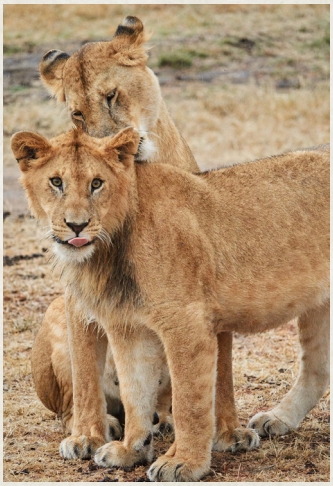
John David Curlis "Lesson's Motmot (*Momotus lessonii*) on a Heliconia Plant," San Luis de Monteverde, Costa Rica

Robert Powers "Mycelium of the Mushroom *Coprinellus radians*," Ann Arbor, Michigan

The 11th annual photo contest was held in memory of David Bay, "photographer at large" for EEB and its predecessor departments for 34 years. The 2019 contest is underway.

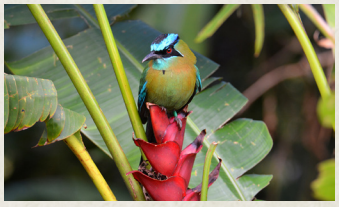
View all of the 2018 photos: myumi.ch/a0m3Z

Honorable mentions



Molly Hirst

Molly Hirst



John David Curlis

Robert Powers