



**UNIVERSITY OF  
GEORGIA**  
Center for the Ecology  
of Infectious Diseases

# ANNUAL REPORT

FY 2023

Seeking to  
understand the  
host-parasite  
relationship  
in nature



# DIRECTOR'S MESSAGE

As we continue to learn from the global COVID-19 pandemic, the Center for the Ecology of Infectious Diseases (CEID) has diligently pursued academic research and sought diverse stakeholder engagement to better meet the needs of our community, country, and planet. During FY23, CEID was driven to examine the real-world implications of, and relationships between, infectious diseases and their hosts, vectors, and environments. Throughout the year, CEID faculty, staff, and student members actively collaborated on numerous projects, to further equip our dedicated research community to better address the emerging global challenges infectious diseases continue to pose to our planet.

Through our research on infectious disease intelligence, our members work daily to meet global needs and continue to make UGA a top institution for infectious disease ecology. In FY23, CEID and the Institute of Bioinformatics embarked on a cluster hire in **Artificial Intelligence, Data Science, & Infectious Disease Dynamics** under UGA's **Presidential Interdisciplinary Hiring Initiative** to strengthen and enhance UGA's position as a global leader in infectious disease dynamics. In FY23, CEID was also awarded a **Predictive Intelligence for Pandemic Prevention (PIPP) grant of \$1 Million** by the National Science Foundation and hosted a meeting for collaborating faculty, staff, and students from the University of Georgia, the University of Michigan, and the Cary Institute of Ecosystem Studies. In November, CEID hosted a global symposium on Japanese Encephalitis Virus, in partnership with our Global Infectious Disease Intelligence Consortium (GIDIC). Finally, in FY23, CEID established a new working group for the Ecology & Evolution of Macroparasites.

Our members are driven daily to pursue excellence and develop a greater understanding of infectious diseases and their interactions with the world around us. While we have gained deep insights over the last four years, and overcome many new obstacles, CEID will continue to collaborate with researchers, stakeholders, and communities to improve our research efforts and infectious disease intelligence.



*John M. Drake*

# BY THE NUMBERS



**47**

**Faculty**



**107**

**Members**



**385**

**Participants Engaged**

**Peer Reviewed Publications**

**177**



**Working Groups**

**4**



**Seminars & Workshops**

**15**



**NIH Grant Writing Workshop**

**1**

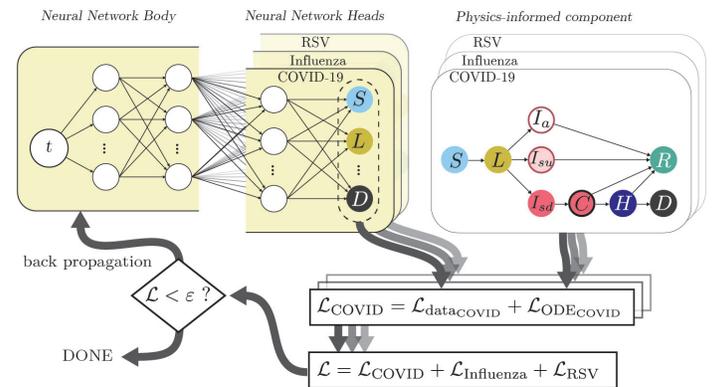


# WORKING GROUPS

## Forecasting

Under the leadership of John Drake and Éric Marty, the **Forecasting Working Group** expanded the scope of its activities, welcomed new faculty members hired as part of UGA's **Presidential Interdisciplinary Hiring Initiative in Artificial Intelligence, Data Science, & Infectious Disease Dynamics**, and began exploring an innovative approach to disease forecasting blending AI, statistical, and mechanistic modeling.

Led by CEID member He Li (School of Chemical, Materials and Biomedical Engineering, College of Engineering), the Forecasting Working Group began working on an innovative approach to time series forecasting of infectious disease blending a mechanistic compartmental model of COVID transmission with machine learning, in a method called PINN (Physics-Informed Neural Networks). Building on the work of CEID's Gaussian Infection State Space with Time-dependence (GISST) forecasting model (E. B. O'Dea and J. M. Drake, 2022, Royal Society Interface) and Li's previous work on physics-informed machine learning methods, the model aims to combine the strengths of mechanistic modeling and machine learning. The pilot project, using COVID-19, will serve as a demonstration of principle for a general method applicable to forecasting a wide range of infectious diseases.



Conceptual schema for a multi-disease, multi-head Physics-informed Neural Network (credit, He Li)

New working group faculty members include Yang Yang (Department of Statistics), Mandev Gill (Department of Statistics), Spencer Fox (Department of Epidemiology & Biostatistics, College of Public Health), He Li (School of Chemical, Materials and Biomedical Engineering, College of Engineering), Ye Shen (Epidemiology & Biostatistics, Institute of Gerontology), Yuan Ke (Department of Statistics), and Ismailcem Budak Arpinar (School of Computing).

In FY23, the working group and working group faculty member Spencer Fox continued submitting forecasts to the CDC's Flu and COVID-19 Forecast Challenges ([covid19forecasthub.org](https://covid19forecasthub.org)) using a range of baseline and next-generation forecast models.

## Ecology & Evolution of Macroparasites

In April of 2023, CEID launched the **Ecology & Evolution of Macroparasites Working Group**, which focuses on how metazoan parasites evolve and are maintained in natural and modified ecosystems.

Systems of interest include arthropod ectoparasites, gut helminths, and others. In conjunction with collaborators from other institutions, the main goal of this working group is to compile a database of macroparasite infections, emphasizing the distribution of burden or infection intensity, that will

allow comparative analysis among host species, parasite species, and ecological contexts. The working group is also supporting the new **Atlas of Macroparasite Abundance (TAMPA)**, which aims to catalog parasite burdens around the world.

This working group will complement the existing working groups on disease forecasting, mapping, and behavior. The working group is open to anyone who wishes to contribute. For more information, please contact John Drake at [jdrake@uga.edu](mailto:jdrake@uga.edu).

# Research Experience for Undergraduates

## Population Biology of Infectious Diseases

The **Research Experience for Undergraduates (REU)** site in **Population Biology of Infectious Diseases** is a nine-week program providing cross training in computational and empirical approaches to ecological research for undergraduate students from across the country. 2023 marked the tenth year of the NSF-funded program. Nine students worked with UGA faculty, postdocs, and graduate students to develop research projects at the intersection of quantitative and experimental studies in infectious disease biology.



**Sofia McDonough** (Florida State University), presents her REU project “Comparing the Performance of Outlier Detection Algorithms in Detecting Antigenic Shifts in Influenza A,” completed with Graduate Research Assistant **Omid Arharmi**, Postdoctoral Fellow **Alpha Forna**, and Professor **Pej Rohani**.

CEID faculty members Sonia Altizer and Alex Strauss were program co-directors, and PhD student Katie Schroeder served as program coordinator. Highlights of this summer’s program included a kick-off lunch reception, a field trip to the CDC, weekly journal club discussions, lectures on disease ecology, and bi-weekly dinners with faculty and postdocs.

The 2023 program concluded at the end of July with poster sessions at the Odum School of Ecology for participants of the Population Biology of Infectious Diseases REU site, and at the Georgia Center for Continuing Education for participants of all UGA REU sites. A closing luncheon was held to celebrate the work of all of the students who participated this year.

REU student projects included a study of avian influenza in blue-winged teals, modelling the effects of environmental noise on mosquito-vectored diseases, and identifying the transmission mode of a nematode parasite in horned passalus beetles. Congratulations to the student-mentor teams for developing and presenting exciting infectious disease projects!



Back row, left-to-right: **Tenacity Murdie** (UGA), **Karin Ebey** (Eckerd College), **Cecelia Pumpelly** (UGA), **Bryna Wilson** (Grove City College), **Sofia McDonough** (Florida State University)

Front row, left-to-right: **T’Kai Adekunle** (Savannah State University), **Ayannah Johnson** (Norfolk State University), **Maya Risin** (Emory University), **Zijing Cao** (Hunter College, CUNY), **Diana Felipe** (Utah State University)

# Heterogeneous Model Integration for Infectious Disease Intelligence

In 2022, CEID was awarded a National Science Foundation grant of \$1 Million under the NSF's **Predictive Intelligence for Pandemic Prevention (PIPP)** program.

**PI John Drake** is leading an interdisciplinary team including CEID members **Pejman Rohani** (Odum School of Ecology, College of Veterinary Medicine) and **Justin Bahl** (College of Public Health, College of Veterinary Medicine), as well as Glen Nowak (Grady College, Center for Health & Risk Communication), and collaborators from the Cary Institute of Ecosystem Studies, the University of Michigan, Georgetown University, and the University of Southern California. Junior researchers include CEID postdoc Sukanta Sarkar.

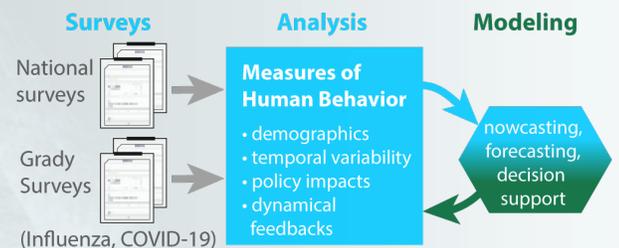
The project's goal is to demonstrate the integration of heterogeneous models from different fields and across scales (epidemiology, zoonotic disease spillover, pathogen evolution, human behavior), using the Systems-of-Systems (SoS) engineering paradigm. The methodologies being developed will be invaluable to national and global efforts in infectious disease intelligence for pandemic prediction and preparedness.

## Demonstration projects

**Knowledge & reasoning engine** connecting multiple knowledge networks concerning disease emergence. (Co-PI Barbara Han, Cary Institute)

**Explainable AI (XAI)**, using human behavior, flu strains, vaccines, & supply chains to explain & predict nonlinearities in infectious disease transmission. (Co-PI Bogdan Epureanu, University of Michigan)

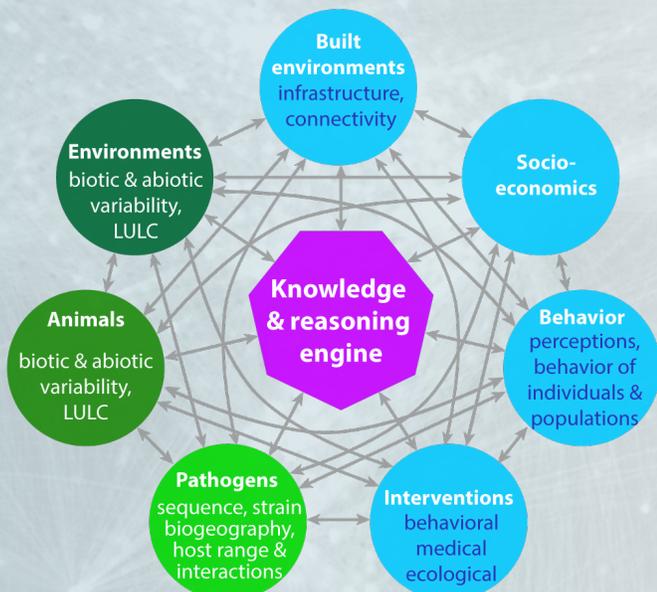
**National opinion surveys** to measure human behavior, health decision making preferences, influences, & receptivity to risk communication; data will inform models for nowcasting, forecasting, scenario analysis and decision support. (Co-PI Glen Nowak).



**Modeling disease transmission & public policy interaction**, using insights from the national opinion survey. (PI John Drake)

**Modeling infection dynamics & pathogen evolution** of co-circulating flu viruses in wild and domestic hosts, with multi-scale empirical evolutionary and phylogeographic data. (Co-PI Justin Bahl)

**Intracellular & within-host viral replication & evolution modeling** for translating virus phenotype to transmission potential. (Co-PIs Rohani and Bahl)



# Public-private Partnership



The **Global Infectious Disease Intelligence Consortium (GIDIC)** is a collaboration between CEID and academia, industry, and NGO partners established to help members identify, prepare for and respond to emerging disease threats.

GIDIC has continued to advance awareness of **Infectious Disease Intelligence** and address challenges of importance to its members. In response to the 2022 outbreak of Japanese encephalitis virus (JEV) in the Australian pork industry, GIDIC hosted a webinar on the development of a JEV spatial spread model for North America, and subsequently organized an international symposium on JEV.

GIDIC held webinars on **Spatial Interaction Modeling** and **Meso-scale Modeling**, for understanding pathogen spread and studying disease transmission in structured, semi-closed environments such as corporations, factories, and universities.

In February, GIDIC released its second annual Horizon Report, a high-level assessment of the most important near-term infectious disease threats, including COVID-19, mpox, avian influenza, bluetongue, and Rift Valley fever.

## Symposium

## Japanese Encephalitis Virus

Emerging Global Threat to Humans & Livestock  
October 17–19, 2022 | [ceid.uga.edu/jev2022](http://ceid.uga.edu/jev2022)

The 2022 Australian outbreak of Japanese Encephalitis Virus (JEV), which severely impacted the country's swine industry and killed 7 people, prompted CEID to convene a panel of subject matter experts to assess the state of knowledge and work towards models of risk and importation. With support from the Swine Health Information Center (SHIC), the Office of the Senior Vice President for Academic Affairs and Provost, and several UGA units, **GIDIC** organized an international symposium addressing the growing threat of JEV to both global human populations and the international commercial pork industry. Over 150 people participated.

Keynote speaker Mark Schipp, Australia's Chief Veterinary Officer, described the spread of JEV from Southeast Asia to Australia via the Torres Strait islands across the mainland, discussing the effects of topography and other factors on the spread among swine and humans.

The symposium featured sessions on the agricultural industry's experience, JEV ecology, modeling importation and spread in North America, and outbreak preparedness. A panel discussion moderated by CEID Director John

Drake engaged Susan Hills (CDC), Michael Neafsey (USDA), and Paul Sundberg (SHIC) in a consideration of the potential impact of JEV introduction into North America.

CEID member and PhD Candidate **Anna Willoughby** presented an AI-driven horizon scan for novel swine pathogens funded by a CEID / GIDIC contract with the Swine Health Information Center.



# Student Profile

## Patricia Torres

Since her childhood in Southern California where she frequently visited the San Diego Zoo, PhD student Patricia Torres grew up with an interest in animals and nature. After completing an AA in English Literature, an AS in Liberal Studies with an emphasis in Math and Science, and a BS in Wildlife Management and Conservation at Humboldt State University, Torres was accepted as an Integrative Conservation PhD candidate in the Warnell School of Forestry and Natural Resources at the University of Georgia.

As an undergraduate student at Humboldt, Torres worked as a Natural Resources Technician for the Wiyot Tribe, where members voiced concerns about the number of ticks on the reservation. She became interested in studying how Indigenous cultural practices intersect with the risk of encountering ticks in the environment.

In her current research, advised by Dr. Michael Yabsley, Torres is exploring the ecological and human behaviors that impact tick-borne disease hazards on Indigenous lands. Her research aims to increase collective knowledge on the drivers of these disease systems to inform the development of safety measures and land management decisions, and Torres' dissertation will focus on tick-borne disease hazards, such as Lyme disease, on Indigenous lands in Northern California.



During her time as a research assistant at CEID in FY23, Torres contributed to several projects including: the **Japanese Encephalitis Virus Information Sharing Network (JEVISN)**, the development of COVID-19 outreach materials in Spanish for a non-profit, CEID's new **Database of Emerging Infectious Diseases**, and the **GIDIC Horizon Report**. Her favorite part of being involved in CEID is "how intellectually stimulating it's been. It has been challenging and I like feeling challenged. I've been able to learn a lot and develop my writing skills and to get to know everyone on the team at CEID."

Torres interned for the United States Fish and Wildlife Service through the Directorate Fellows Program, where she built a catalog of recovery efforts for species protected under the Endangered Species Act. The goal of this project is to create a comprehensive database where recovery activities and associated costs can be stratified by taxa, habitat type, region, etc.

Torres has been elected to serve as a Diversity Committee Representative and Graduate Student Representative at the Warnell School of Forestry and Natural Resources this fall.

# Postdoc Profile

## Alpha Forna

Alpha Forna's interest in disease ecology grew out of his desire to contribute to broader global health problems. His early interest in health sciences and his desire to pursue chemistry and biology as a possible career led him to obtain a bachelor's in pharmacy at the University of Sierra Leone. After obtaining this degree, Alpha completed a master's in epidemiology at the University of Leeds—a significant shift from his pharmacy training—since many pharmacy programs at the time were moving from the traditional narrow focus on dispensing to a more engaging scientific discipline encompassing other health-related issues. It was during this time that his interest in infectious disease epidemiology grew.

For his PhD at the Imperial College of London, Forna focused on infectious disease epidemiology and began looking closely at how infectious diseases interact with their hosts. By examining these interactions, he realized that viruses and hosts are both greatly impacted by their environments, and recognized the important role of the ecology of infectious diseases in understanding global health.

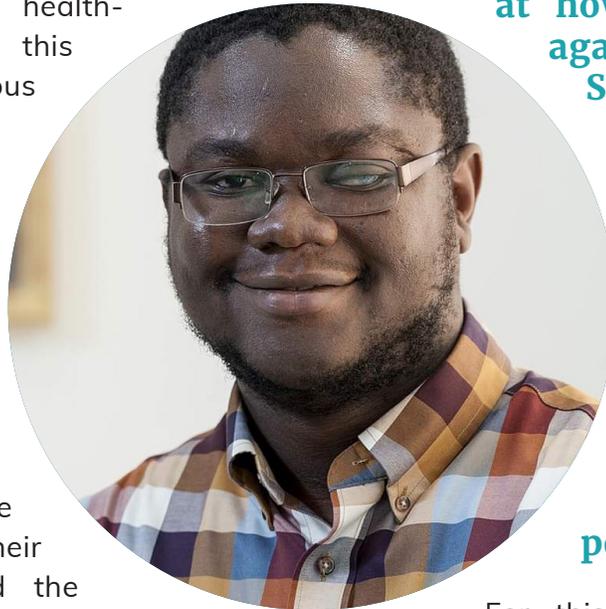
This background led him to the Odum School of Ecology, where he met with Pej Rohani and John Drake at the start of the COVID-19 pandemic to investigate using machine learning to examine influenza. However, due to COVID-19 he was not able to join the lab at the time and took a postdoctoral position in Canada. Once the initial COVID-19 travel bans and restrictions were lifted, Forna was finally able to join the Odum School of Ecology and the CEID.

The ability to meet and work with researchers from across the US has been central to his experience at CEID. "It's nice to be a part of the Center because

you meet other researchers and get to interact with others in the field... Meeting new people all the time, both professionally and informally, has been my biggest takeaway from my time so far..."

Forna's current project focuses on working with the Centers for Disease Control and Prevention (CDC) to predict influenza mutations.

**“Viruses just want to survive in an ecosystem, so we need to look at how humans fight back against evolving viruses... So, as early as possible, we try to see where we can predict and forecast how the influenza virus is changing before it does. We can use this information to inform how we develop vaccines and direct public health policies.”**



For this project, Forna wanted to develop an algorithm to identify influenza A evolutionary outliers and flag different mutated viral components for further investigation. Forna and other researchers created a pipeline that retrospectively identified eight out of nine antigenic transitions and indicate when the virus develops a mutation different enough to require a new vaccine. This type of research can have a direct impact on public health and vaccine development.

For future projects, Forna is generally interested in the bigger picture problems involving the use of machine learning to help inform infectious disease practices and policies.

# Presidential Hiring Initiative

CEID Welcomes four new faculty members hired under the Presidential Interdisciplinary Hiring Initiative. These four new faculty join CEID and the Institute for Bioinformatics as part of a joint cluster hire in AI, Data Science, & Infectious Disease Dynamics.

## Mandev Gill

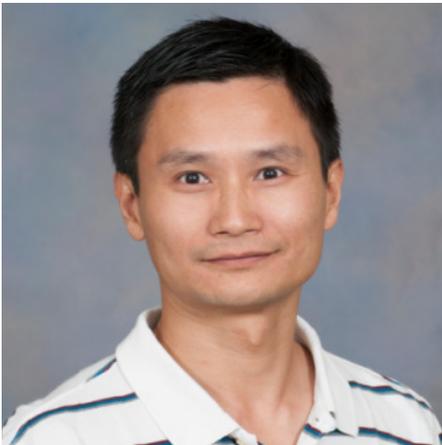


Mandev Gill, Assistant professor in the Department of Statistics at UGA, was captivated by the beauty and elegance of pure mathematics early in his academic career and made it his focus at the University of California. As his studies progressed, he wanted to apply the things that he loved about mathematics to something practical. This ultimately led Gill to a PhD program in biostatistics. A course in mathematical and

statistical methods for genetic modeling led to a collaboration with his eventual thesis advisor.

Gill specializes in phylodynamics, which studies the interplay of evolutionary and epidemiological processes. According to Gill, there are many interesting aspects to this research, including modeling, algorithm development, and software implementation. The field is inherently interdisciplinary, requiring collaboration to address challenging problems. Gill hopes that his research will contribute to a better understanding of infectious disease dynamics, and help inform effective strategies to curb the spread of infectious diseases and lessen their burden. Gill is a member of CEID's Forecasting Working Group.

## Yang Yang



Yang Yang is a Professor in the Department of Statistics at UGA. He obtained his PhD in biostatistics from Emory in 2004, with dissertation topics on statistical models for transmission of influenza and HIV in close contact groups and the evaluation of vaccine and antiviral effectiveness. Yang served as a senior statistician at Harvard's Center for Biostatistics in AIDS Research from 2004 to 2006. Later, he

joined the Vaccine and Infectious Disease Division of the Fred Hutchinson Cancer Research Center as a staff scientist, eventually becoming an assistant professor. His work there focused on developing statistical methods for detecting human-to-human transmission of emerging pathogens and handling high-dimensional missing data. From 2011 to 2022, Yang worked at the University of Florida's Department of Biostatistics, where he developed spatiotemporal models for

multiple pathogen co-circulation and proposed statistical adjustments for various surveillance biases.

After joining UGA, Yang broadened his scope of research to include agent-based modeling, coupling transmission with ecological modeling for zoonotic pathogens, and coupling transmission process with phylodynamics. Yang continues to actively engage in international collaborations with researchers from Asia, South America, Europe and Africa on emerging diseases including avian influenza, Ebola, Zika, MERS-CoV and SARS-CoV-2, with publications appearing in a variety of journals including *Science*, *PNAS*, *Lancet Infectious Diseases*, *PLoS Medicine*, *Nature Communications*, and the *Journal of the American Statistical Association*. Yang is applying his diverse modeling experience as a member of CEID's Forecasting Working Group.

# Artificial Intelligence, Data Science, & Infectious Disease Dynamics

## Spencer Fox



Spencer Fox, an Assistant Professor in the College of Public Health's Department of Epidemiology and Biostatistics, grew up wanting to build robots but later became fascinated by the biological world in high school. After majoring in Biology for his undergraduate degree at Rose-Hulman Institute of Technology in Indiana, he decided to pursue his PhD in Ecology, Evolution, and Behavior at The University

of Texas at Austin. In 2009, the pandemic of influenza A/H1N1 and subsequent concerns regarding HPAI and the Mexican swine flu pandemic ignited Fox's interest in his field.

Fox's research now focuses on addressing the unpredictability inherent to disease outbreaks. His recent work is concerned with the difficult task of improving upon our ability to forecast outbreak dynamics, which is critical to improving public health responses to outbreaks. One of Fox's favorite current projects uses community conversations on sites like Reddit to estimate community mobility and mask wearing rates to predict behavior changes for the COVID-19 pandemic, healthcare needs, and resources needed for future outbreaks.

Fox is an active contributor to CEID's Forecasting Working Group and participates in CDC Flu and Covid-19 forecast challenges.

## He Li



He Li, Assistant Professor in the College of Engineering, uses his background in mechanical engineering from the University of Connecticut (PhD) and the University of Saskatchewan (MSc) to develop multiscale computational models based on physics laws. This includes using numerical methods such as molecular dynamics, dissipative particle dynamics, and the spectral element method used to simulate biological

systems spanning spatial scales from molecular, protein, and cellular levels to multi-cell, vasculature and organ systems. Li's work demonstrates that computational modeling can bridge the gap between microscopic and macroscopic physiological processes while providing innovative approaches to critical problems in biology, medicine, and biomedical engineering.

Li's current research interests include employing AI models from scientific machine learning to boost the capability of predicting the spread of infectious diseases and developing multiscale agent-based models for nowcasting, forecasting, and optimizing intervention strategies.

Li has been spearheading the Forecasting Working Group's effort to apply physics-informed neural networks (PINNs) to the problem of infectious disease forecasting. His aim is to improve the forecasting of infectious diseases in order to enable public health officials and care providers to more effectively prepare for and respond to public health emergencies through improved resource allocation, reduced morbidity and mortality, and improved population health and well-being.

# MEMBER ACCOMPLISHMENTS



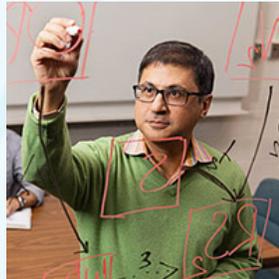
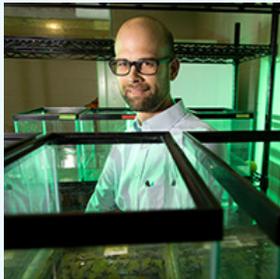
## Lewis Bartlett

Assistant Research Scientist, received a **Project Apis m. & National Honey Board** grant for linking parasite control, nutrition and viral prevalence in honey bees. Bartlett was also elected a **Policy Fellow** for 2023-2025 by the **Entomological Society of America**.



## Jeb Byers

Associate Dean for Research and Operations in Ecology, was named **UGA Athletic Association Professor**.



## John Drake & Pej Rohani

received **\$531,000** from the **National Institutes of Health** (through the Center for Influenza Disease and Emergence Research) for "Computational Methods for Influenza Forecasting."

## Michelle Evans

was awarded the **British Ecological Society's 2022 Rachel Carson Prize** recognizing the best paper by an early career author in the journal *People and Nature*, for the paper "Socio-ecological dynamics in urban systems: An integrative approach to mosquito-borne disease in Bengaluru, India."



## Patricia Torres

was awarded a **Ford Foundation Predoctoral Fellowship** in support of her dissertation on tick-borne pathogens in Indigenous communities in Northern California.



## Richard Hall

Associate Professor, is part of a team that was awarded an **National Science Foundation** grant on the human and ecological impacts of backyard bird feeding. He will oversee development of mathematical models linking emotional response to bird feeder observations, management actions, and ecological consequences for feeder birds, examining the feedbacks between wildlife and human wellbeing.



## Megan Tomamichel

Received the 2023-24 **SEC Emerging Scholars Award**, a competitive award to facilitate professional development.



## Anna Willoughby

PhD candidate, was selected for the 2022 **Cameron Award** by the **American Society of Mammalogists**. The grant supported her fieldwork studying the disease of squirrels in Zion National Park.

