Center for the Ecology of Infectious Diseases

UNIVERSITY OF GEORGIA

ANNUAL REPORT

FY 2021

Seeking to understand the host-parasite relationship in nature

A Letter from the Director

Throughout the last year, we have all been continually challenged to overcome obstacles. From mask ordinances to the first COVID-19 vaccines, the pandemic has shown us the personal, social, and economic impacts that an infectious disease can have on a global scale. Although the world has risen to the occasion to control COVID-19, this is not the first time that humanity has faced a modern pandemic, and it won't be the last. For this reason, the Center for the Ecology of Infectious Diseases (CEID) has continuously worked to develop a community of dedicated faculty, staff, and students who want to understand the core ecological and evolutionary principles that underlie infectious diseases and rise to the challenges in animals, plants, and people.

We spent the last year mapping, forecasting, and analyzing infectious diseases to develop an ever-growing capacity to deal with outbreaks head on. Our collaborative efforts have made CEID an international leader in COVID-19 modeling and pushed our members to engage in globally focused infectious disease research. With projects such as the CDC's annual Flu forecasting challenge and the Department of Defense's Flu and COVID-19 forecasting challenge, we continue to expand our research capabilities.

But we are also looking toward the future. This year, in an effort to better anticipate and prepare for the next pandemic, CEID launched its first private-public partnership, the Global Infectious Disease Intelligence Consortium (GIDIC). GIDIC engages leaders in industry, government, NGOs, and academia who need to be aware of an emerging infectious disease outbreak before social and economic conditions become unmanageable. This collaborative design encourages the open discussion of ideas, welcomes member-specific projects, and exposes our students to the challenges that companies and other organizations face. GIDIC members include Boehringer Ingelheim Animal Health and the Swine Health Information Center, and we continue to have conversations with other organizations throughout the country.

CEID will continue to engage in robust infectious disease research and modeling. The COVID-19 pandemic demonstrated that the global challenges associated with the spillover of novel infectious diseases affect the entirety of our modern society. For this reason, our research at CEID is driven by today's challenges to better address the needs of tomorrow.
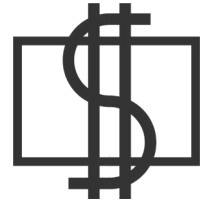
John M. Drake
Director
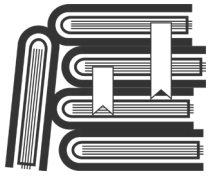
5
WORKING GROUPS

$4,205,966
IN GRANT FUNDS

90
MEMBERS

1
GLOBAL SEMINAR

32
FACULTY AND FACULTY COLLABORATORS

138
PEER REVIEWED ARTICLES

PUBLIC-PRIVATE PARTNERSHIP

Global Infectious Disease Intelligence Consortium

In March of 2021, in response to the COVID-19 pandemic, the Center for the Ecology of Infectious Diseases launched the **Global Infectious Disease Intelligence Consortium (GIDIC).**

GIDIC is a coordinated intelligence partnership between leaders in industry, government, NGOs, and academia to meet and respond to novel threats from infectious disease.

GIDIC helps stakeholders monitor emerging infectious diseases like COVID-19, and assists partners in identifying and advancing strategies for communication, business operations, and public policy during a public health crisis in order to limit human and economic costs.

Members include **Boehringer Ingelheim Animal Health** and the **Swine Health Information Center**. Ongoing discussions with industry contacts in consumer goods, food production, hospitality, insurance, and transportation are helping identify challenges that CEID's research and modeling expertise can help to solve.

Coronavirus
COVID-19 Portal: covid19.uga.edu

The **Coronavirus Working Group** has continued its work tracking, modeling, and analyzing the COVID-19 pandemic, in support of the goals of public health professionals, the research community, and policy makers. The group's effots in forecasting, nowcasting, modeling risk and spatial spread, and intervention analysis have contributed to improving understanding of the pandemic, and have helped catalyze the field of Infectious Disease Intelligence.

22 Modeling Projects
• Contributor to the *CDC Covid Forecast Hub*
• One of 4 contributors to *Department of Defense Flu & COVID-19 Forecast Challenge*

7 Data & Support Projects

7 Situation Awareness Projects
• Data tracking and mapping
• Nowcasting and parameter estimation
• Wastewater surveillance

44 Contributors from across UGA

COVID-19 Forecasts for the U.S.
covid19.uga.edu/forecast

CEID's semiparametric COVID-19 transmission model is one of the most advanced forecasting models in the U.S. It uses anonymized mobile phone data aggregated at the state level to capture the effect of human mobility on transmission. In addition, it captures a latent trend in transmission arising from unknown or hard-to-measure variables like masking and other behaviors. The model was designed for forecasting and scenario analysis, comparing three mobility-based scenarios (return to normal, maintaining reduced mobility, and reducing mobility further to a level resembling "shelter-in-place"). The model demonstrates a clear association between personal choices and societal outcomes.

Human mobility relative to baseline
(50 states, data; Unacast)
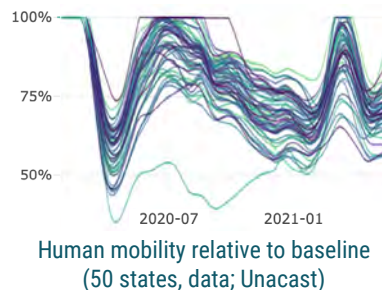
Wastewater Surveillance
covid19.uga.edu/wastewater-athens

In collaboration with CEID, UGA's College of Public Health developed a system to track SARS-CoV-2 virus levels in wastewater for Athens-Clarke County. The system offers a method of estimating trends in community-scale circulation of COVID-19 that does not rely on clinical or surveillance testing of individuals.

COVID-19 Nowcast
covid19.uga.edu/nowcast

CEID's U.S. Nowcast provides current estimates of the number of active infections by state (including pre- and asymptomatic), a significant challenge for public health officials and policy makers. The computationally efficient algorithm uses only case and death notifications and basic knowledge of SARS-CoV-2 to estimate infection dates for the entire population correcting for under-reporting, and then projects forward to the present.

Suppression without Distancing
covid19.uga.edu/suppression

CEID modeled the potential effectiveness of five non-pharmaceutical approaches to suppression of SARS-CoV-2 without intensive social distancing measures. The study in *Proceedings of the Royal Society B* found that targeted approaches aimed at either infected individuals (widespread testing, tracing, and quarantine) or uninfected individuals (certification) can be effective, but must be combined with generalized interventions such as mask wearing and limiting gatherings.

Importation Risk
covid19.uga.edu/us-importation-risk

CEID developed a gravity model of SARS-CoV-2 importation risk for the U.S. Centers for Disease Control (CDC) that considers global disease prevalence and air traffic volumes to estimate risk of importation by port of entry.
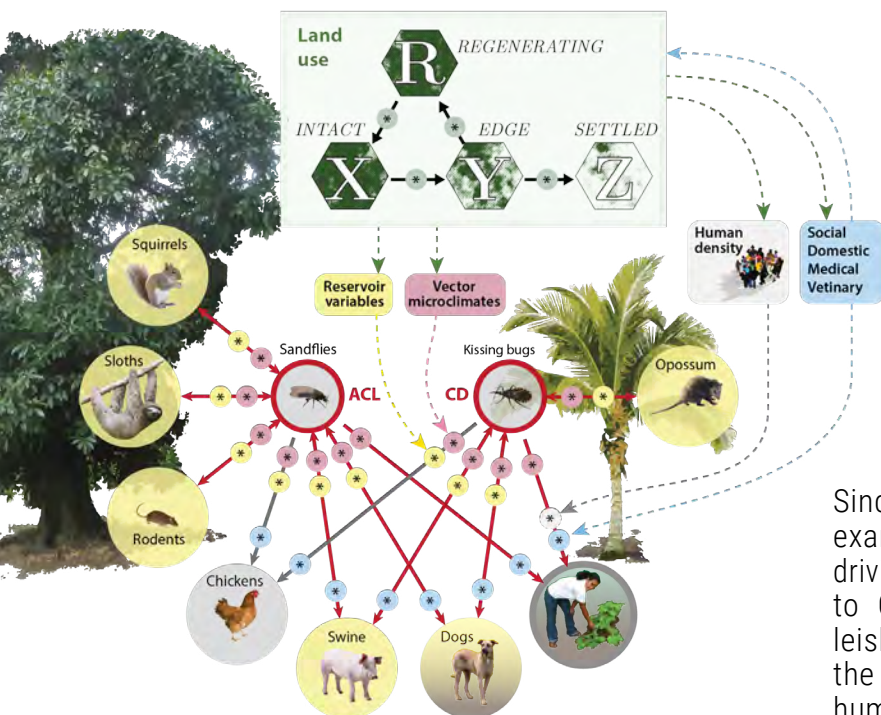
GROUPS

Spillover

The **Spillover Working Group**, led by Associate Research Scientist Patrick Stephens, develops new methods to predict the emergence of zoonotic infectious diseases like Ebola in West Africa. Having received over $2.4 million in funding, the Spillover Working Group is engaged in projects that promote global disease surveillance through predictive modeling and mapping.

Research that was completed this year includes a study to be published in the Royal Society journal *Philosophical Transactions B* on the drivers of the 100 largest zoonotic disease outbreak since 1974, a study of filovirus spillover at ecological boundaries, and a review paper published in *Zoonoses Public Health* examining interdisciplinarity in disease spillover research in order to identify priority areas for future research in zoonotic disease spillover.

NSF Funded Project

Social & Ecological determinants of vector-borne tropical diseases

In 2019, CEID's Spillover Working Group obtained a $1.6 million dollar grant from NSF's Dynamics of Integrated Socio-Environmental Systems (CNH2) program.

The project, entitled *Social and Ecological Determinants of Multi-host Vector-borne Infections in Dynamic Tropical Landscapes*, is a multidisciplinary collaborative effort between researchers at the University of Georgia and researchers at the Gorgas Memorial Institute of Health Studies in Panama.

Since the project's inception, researchers have been examining the anthropogenic and environmental factors driving disease transmission and human exposure to Chagas disease (CD) and American cutaneous leishmaniasis (ACL). The group seeks to understand the interconnected effects of changes in land use, human behavior, and vector-borne infectious disease risk and transmission in Panama.

WORKING GROUPS

Forecasting

The **Forecasting Working Group**, led by Research Associate Eamon O'Dea, is primarily responsible for developing and deploying operational forecasts of infectious diseases for national forecasting efforts. The group contributed to several such national efforts, in close cooperation with the Coronavirus Working Group.

The working group developed a statistical model of SARS-CoV-2 transmission for the *COVID-19 Forecast Hub* (covid19forecasthub.org), a CDC-led effort with over 50 contributed models, forecasting COVID-19 cases, deaths, and hospitalizations. The working group's statistical model serves as a useful benchmark for more sophisticated models and for the COVID-19 Forecast Hub's ensemble model.

The Forecasting Working Group also contributes an ensemble statistical model to the CDC's annual *FluSight: Flu Forecasting* challenge (flusightnetwork.io),

which harnesses mathematical modeling to predict the onset, peak, and severity of each flu season in addition to forecasting incidence four weeks ahead. The flu challenge was suspended in 2020 in favor of COVID-19 forecasting.

The CEID team was one of only four contributors to the Department of Defense's *CLI/ILI Forecasting Challenge*, created to develop collaborative and accurate short-term forecasts of influenza and COVID-19 cases at military treatment facilities.

The working group coordinated with the Coronavirus Working Group on the development of CEID's semi-parametric model of SARS-CoV-2 transmission, providing scenario analysis and forecasts of COVID-19 cases, deaths, and hospitalizations for the 50 US states (covid19.uga.edu/forecast). The working group also develped a next-generation semiparametric SARS-CoV-2 transmission model for deployment in FY 2022.

Mapping

The **Mapping Working Group,** led by PhD student Daniel Suh, creates disease mapping resources and collaborates on projects to map infectious diseases around the world.

The working group hosted several training events on GIS and mapping in R. The group organizes workshops and modeling events throughout the year to advance spatial modeling knowledge and capabilities within the infectious disease research community. The group is currently developing a machine learning species distribution model for a tapeworm of public health concern.
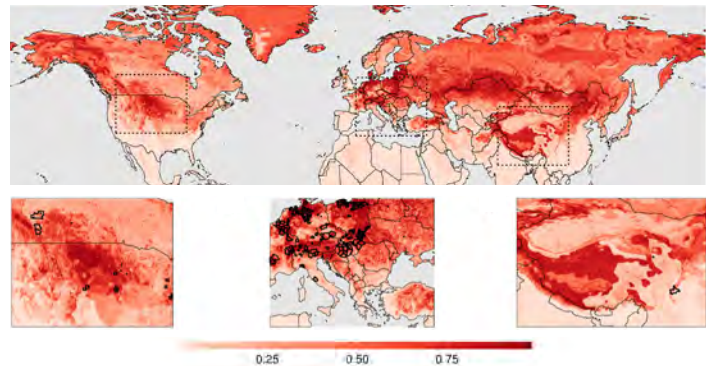
Model of species distribution of *Echinococcus multilocularis*. Detected parasite areas outlined in black. (Work in progress.)

Behavior & Infectious Disease

The **Behavior and Infectious Disease Working Group** is led by Postdoctoral Associates Lewis Bartlett, Emlyn Resetarits, and Elizabeth Warburton.

Created in March 2021, this working group is studying how the behavioral traits of hosts and pathogens can be integrated into a common framework.

This new framework will be used to assess the suitability of host-pathogen systems for answering questions related to behavior and infectious diseases.

The goal of the project is to identify systems with unique promise for investigating hypotheses directed at host and pathogen behavior.

FEATURED EVENT: RESEARCH FRONTIERS IN
Animal Behavior & Parasitism

"Parasites shaped life from the beginning."
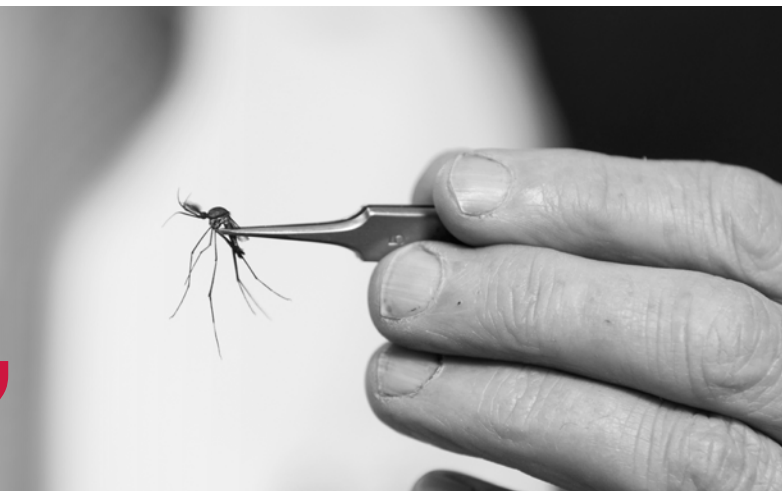
On Thursday May 20, and Friday May 21, 2021, CEID held a two-day virtual symposium on animal behavior and parasitism. Twenty-eight researchers from around the world presented their work and engaged in planning for future research in the field.

Speakers explored aspects of animal host behavior including social avoidance and resistance behaviors, and discussed how these behaviors in turn affect parasite behavior and transmission. Researchers also explored how infection with a parasite alters host behavior.

The keynote speaker, **Dr. Marlene Zuk**, posited that parasites are not always an enemy, saying, "parasites shaped life from the beginning."

Speaking about her research on bubonic plague in the USSR, Zuk explained that attempts to eradicate the plague actually worsened the problem, driving disease-carrying rodents into cities and destroying much of their food and supplies. This illustrated her point that attempting to control or destroy parasites has the potential to cause more harm than the parasite itself.

Attendees participated in discussions on future directions in research during four Q&A sessions held throughout the two-day event.

Recorded presentations and posters by student researchers from around the country are available at ceid.uga.edu/symposium2021.

*This event was made possible by a grant from the **National Science Foundation.***

PROFILES

POSTDOCTORAL FEATURE: LEWIS BARTLETT

by Ethan Hackmeyer

CEID postdoctoral associate **Lewis Bartlett** conducts research to increase the current understanding of host-parasite interactions. Much of his work takes into account how apiculture—the use of bees in agricultural practices—affects honey bee-parasite interactions, and how diseases in managed beehives spillover into wild bee populations.

After earning his PhD from the University of Exeter, Bartlett came to the United States to join the Center for the Ecology of Infectious Diseases (CEID) as part of the Postdoctoral Scholars Program. Now working with the CEID, Bartlett studies honey bee-parasite disease dynamics, the effects of industrial apiculture on hives, and the effects of wild bees coming into contact with industrially-raised honey bees.

Honey bees are a major pollinator of crops such as apples, oranges, onions, pumpkins, and avocados. The honey bee disease research Bartlett specializes in is crucial for the agricultural industry and small farmers. Improving honey bee health not only helps the bees, but also the people who rely on them to pollinate their crops and the millions who incorporate honey bee-pollinated foods into their diets. Since bees support many ecosystems, Bartlett's research with spillover of pathogens from managed bees to wild bees is vital to ensuring the health of these ecosystems.

Currently, Bartlett is conducting a review of efforts to selectively breed bees for disease tolerance. This forthcoming paper will explore the possibility of wild bee disease outbreaks as disease-tolerant domestic honey bees are moved across the country for crop pollination.

Bartlett appreciates the interdisciplinary nature of research at UGA, with researchers connecting through organizations like CEID. He also values UGA's focus on applied research, as his research focuses on practical applications of disease ecology to apiculture. Bartlett cites CEID as a helpful vehicle for the translation of abstract research into practical use, as well as for interdisciplinary coordination between ecological and biological fields.

"The diversity of disciplines represented in CEID's membership enables us all to be better scientists, by broadening our academic perspectives. The concentration of infectious disease experts demonstrates UGA's reputation for excellence in this field."

In addition to research, Bartlett advocates for inclusivity in the field of ecology. As an active member of the British Ecological Society, he promotes awareness of classist and colonial influences in the field of ecology. Bartlett is also involved in LGBTQIA+ organizations that support queer ecologists, including the British Ecological Society LGBTQ+ Peer Mentoring Network. As an international researcher, Bartlett believes it is important to advocate for international scientists, and is currently working with the Teaching and Learning Special Interest Group at the British Ecological Society to develop resources for ecologists who move internationally for their work or studies.

NEW FACULTY ALEX STRAUSS

CEID welcomed Alex Strauss this year as a new member. Strauss joined the Odum School of Ecology and CEID in 2020 to pursue research interests in infectious diseases.

Strauss' interests include the effects of biodiversity loss on disease dynamics, disease transmission in ecological communities, and the impacts of plant pathogens on ecosystem processes.

Growing up, Jeb Byers wanted nothing more than to pursue a career that enabled him to do what he loved—enjoying time outdoors. After spending the junior year of his undergraduate degree studying at Duke's Marine Lab and teaching in Ecuador after graduation, Byers realized his passion was research. Drawn to the Odum School of Ecology for its academic reputation, Byers joined the college as an Associate Professor in 2008 to concentrate on marine ecology research.

Byers' prior research focused on crab parasites, black-gill disease in Georgia's native shrimp populations, and the impacts of climate change on host-parasite interactions. He has now begun studying oyster diseases. As a keystone species throughout the southeastern U.S., oysters play an essential role in preserving the Georgia coast. Byers is mapping the prevalence and density of oyster diseases with an ultimate goal of understanding the factors that drive large-scale patterns in disease transmission.

Byers values the ability to conduct research with both breadth and depth, which CEID membership facilitates. According to Byers, CEID is "a group that brings people together from all disciplines all across campus to interact." Because of the diversity of CEID's membership, Byers has been able to work with other researchers across campus to study marine ecosystems and the impacts of parasites and disease.


STUDENT PROFILE: KAYLEE ARNOLD

PhD student Kaylee Arnold has always had an interest in the impacts of human and environmental disturbances on disease transmission between humans and animals. Having obtained a BS in Biology at the University of Redlands and a MS in Ecology and Evolutionary Biology from Tulane University, Arnold is now a PhD candidate in the Odum School of Ecology and has been a member of CEID since 2017.

Arnold's interests center around understanding the effects that human and environmental disturbances have on zoonotic disease transmission. Under the advisement of Nicole Gottdenker (College of Veterinary Medicine / CEID), her dissertation research focuses on understanding relationships among the gut microbial communities of insect disease vectors, deforestation, and transmission risk to humans and other mammals.

As a member of the CEID Mapping Working Group since 2017, Arnold has contributed to several projects, including a manuscript on the transmission dynamics of *Echinococcus multilocularis*.
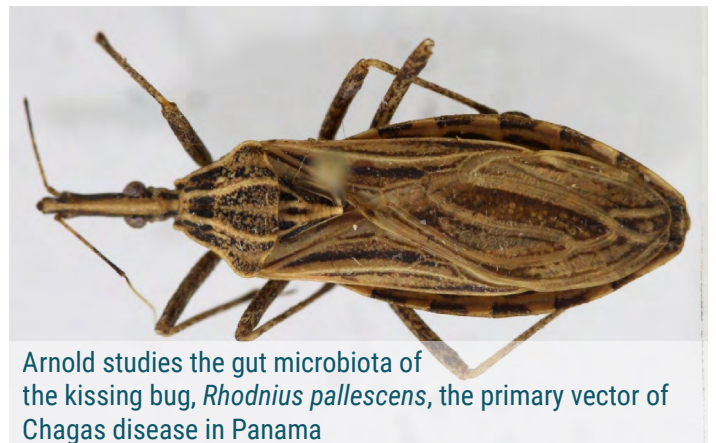

Arnold studies the gut microbiota of the kissing bug, *Rhodnius pallescens*, the primary vector of Chagas disease in Panama

NEWS

Disasters Colliding

Led by **John Drake** (Odum School of Ecology & CEID), researchers from across the university have joined together to study and evaluate the impacts natural disasters can have on low income individuals and their abilities to overcome disease outbreaks.
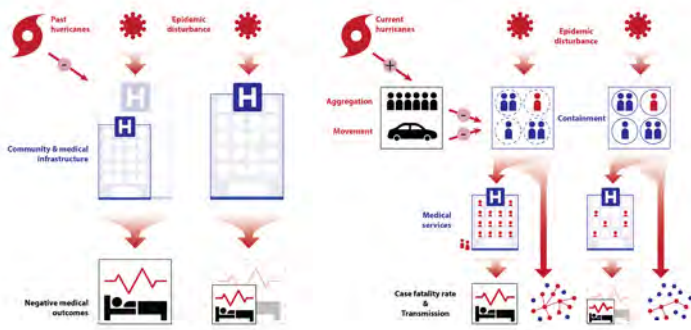
Funded by the *UGA Teaming for Interdisciplinary Research Pre-Seed Program*, the team includes **Brian Bledsoe** (College of Engineering and Institute for Resilient Infrastructure Systems), **Kamal Gandhi** (Warnell School of Forestry),

Éric Marty (CEID), **Marshall Shepherd** (Department of Geography and Director, Atmospheric Sciences Program), **Lynne Seymour** (Statistics), and **Meredith Welch-Devine** (Director of Interdisciplinary Graduate Programs & UGA Graduate School).

With greater socioeconomic disparity, lower-income communities have less resilience against a secondary disturbance after a natural disaster, such as a hurricane or tornado. The **Disasters Colliding** project proposes that lower income families face greater risks during a disease outbreak after a natural disaster because their communities face greater infrastructure damages. Furthermore, natural disturbances often result in greater human movement and can lead to higher disease transmission rates.

This area of research is increasingly important to examine as weather events related to climatic changes are becoming more prevalent and are expected to contribute to the spreading of infectious diseases.

NEW BOOK

POPULATION BIOLOGY OF VECTOR-BORNE DISEASES

Population Biology of Vector-Borne Diseases, the second book in CEID's *Ecology and Evolution of Infectious Diseases* series from Oxford University Press, is now available.

This volume is the first comprehensive survey of population biology of vector-borne disease, and features diverse perspectives of investigators from multiple disciplinary backgrounds. We extend thanks to the many researchers who contributed chapters, and to those who supported our 2018 *Symposium on the Population Biology of Vector-Borne Diseases*, which helped make this publication possible.

POPULATION BIOLOGY OF VECTOR-BORNE DISEASES

edited by
JOHN M. DRAKE, MICHAEL B. BONSALL
AND MICHAEL R. STRAND

ECOLOGY AND EVOLUTION OF INFECTIOUS DISEASES SERIES
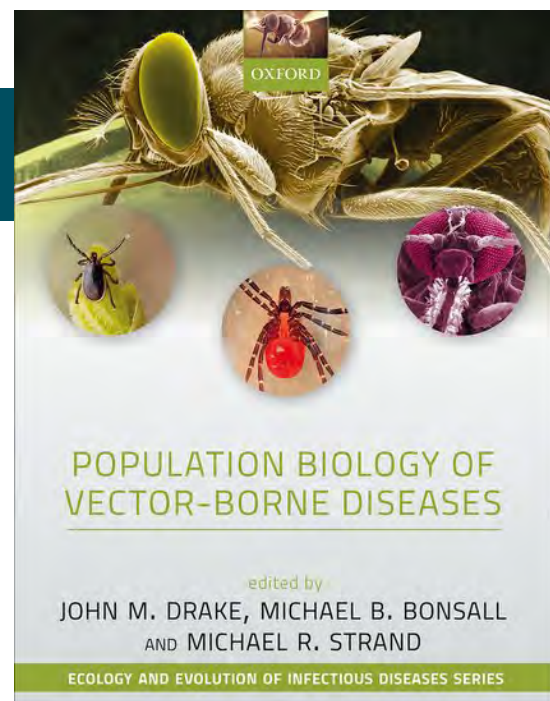
RESEARCH EXPERIENCE FOR UNDERGRADUATES
Population Biology of Infectious Diseases

The Odum School of Ecology held its fifth annual **Research Experience for Undergraduates (REU)** site on Population Biology of Infectious Diseases. Headed by CEID Director John Drake, this REU site affords 12 undergraduate students from universities across the country the opportunity to conduct infectious disease research under the guidance of UGA faculty, for nine weeks each summer.

This year's program, run by CEID's Sonia Altizer, concluded with hybrid poster presentations on July 21 and 22. Projects supervised by CEID researchers included studies on *Hyalophysa lynni* infection in commercial shrimp (Roland Berg, working with Megan Tomamichel and others in Jeb Byers' lab), frugivory and ebola spillover in Africa (Mireya Dorado, working with Patrick Stephen's lab), patient-reported symptoms and influenza triage (Jacqueline Dworaczyk, working in Andreas Handel's lab), *Dracunculus* nematode phylogenetics (Madeline Giner, working in Christopher Cleveland's lab), and hydrogen peroxide preference and

2021 REU Program participants: Roland Berg, Katie Yan, Jacqueline Dworaczyk, Nathan Garcia-Diaz, Carlos Martinez-Mejia, Madeline Giner, Walter Avila, Mireya Dorado, Salil Goyal, Anna Shattuck, Hannah O'Grady, and Kailah Massey.

toxicity in honeybees (Carlos Martinez-Mejia, working with CEID postdoctoral associate Lewis Bartlett).

Funded by grants from NSF and NIH, the **Population Biology of Infectious Disease REU site @ UGA** is supported by the Odum School of Ecology, the Warnell School of Forestry and Natural Resources, the College of Agriculture and Environmental Science, Franklin College of Arts and Sciences, the College of Veterinary Medicine, the Office of the Provost, the Vice President for Research, and the Graduate School.

Population Biology
of Infectious Diseases
REU site @ UGA

reu.ecology.uga.edu

MEMBER ACCOMPLISHMENTS

PATRICK STEPHENS
Lead PI on a 5-year, $2.4 million grant from the *National Institute of Allergy and Infectious Diseases* to study the effects of environmental, spatial, and anthropogenic factors on zoonotic disease spillover.

SONIA ALTIZER
Elected a Fellow of the *American Association for the Advancement of Science (AAAS)* "for distinguished contributions to the field of ecology, particularly understanding ... pathogen spread and evolution."

CLAIRE TEITELBAUM
Winner, best student presentation at the *North American Congress for Conservation Biology* (2020) virtual conference, for her poster "Local and Behavioral Adaptations to Temperature in a Trailing Edge Population."
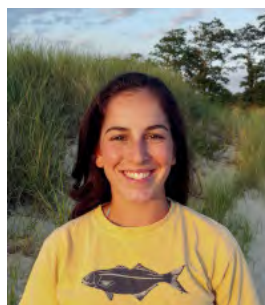
ISABELLA RAGONESE
Awarded a *UGA Sustainability Grant* to retrofit the Odum School of Ecology with window treatments to reduce bird collisions, and engage the UGA and Athens community in avian conservation.

DANIEL SUH
Recipient, Best Student Poster, in this year's meeting of the *Ecological Society of America* for his poster "Exploring the differential competence of communities by observing ranavirus in larval amphibian communities."
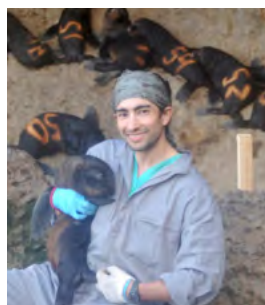
MAURICIO SEGUEL
Recipient, *Robert C. Anderson Memorial Award* (2020) in recognition of significant academic and research accomplishments at the University of Georgia.

KAYLEE ARNOLD
Winner, Best Talk, *Medical, Urban, & Veterinary Entomology* section of *Entomological Society of America*, for her talk, "The gut microbial diversity of a Chagas disease vector varies across coinfection status throughout central Panama."

ANIA MAJEWSKA
Recipient, *Robert C. Anderson Memorial Award* (2020) in recognition of significant academic and research accomplishments at the University of Georgia.