THE UNIVERSITY OF MICHIGAN
DEPARTMENT OF ECOLOGY AND EVOLUTIONARY BIOLOGY

NATURAL SELECTIONS

VOLUME 8 NUMBER 1 FALL 2010

water

WINTER 2011 LSA THEME SEMESTER

Water, water, everywhere

LSA theme semesters promote cross-campus dialog and participation in the exploration of complex issues and topics.

Event highlights

January 12
Water Semester Kick-off
Ice Percussion on the Diag at noon
Cam Davis, President Obama's "Great Lakes Czar"

January 20
Maude Barlow, national chairperson of The Council of Canadians, co-founder of the Blue Planet Project

January 26
Oceanographer and TED Prize winner Dr. Sylvia Earle, "The World is Blue"

February 2
"Our Water, Our Future: A Local Panel."

February 16
Panel discussion with U-M Biological Station alumni who helped form the Tip of the Mitt Water Conservancy

March 29
Dr. Donald Boesch, member of the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling

April 6
Water Tools on the Diag, Marine Hydrodynamics Laboratory

The Water Committee is interested in your thoughts and suggestions. Send your comments to Water2011@umich.edu.

Website: www.lsa.umich.edu/watersemester

THE BIG PICTURE:
ecology and evolution of infectious disease

Why do ecologists study infectious diseases? Isn't that the domain of medical and public health professionals? Well, according to Professor Aaron King, ecologists bring a unique perspective, especially population ecologists who look at how diseases play out in large scale – the scale of whole populations – to complement what can be seen from the patient-centered medical point of view.

"Essentially these are ecological interactions, they involve the interactions of pathogens and hosts," King said. Key biological features of these interactions leave their distinctive marks in patterns that are observable at population levels.

"At the population level, disease systems are like any other ecological system: they can have very complicated dynamics," said Professor Mercedes Pascual.

"Some of the most urgent issues in epidemiology center on what we can't see or measure directly," said Professor Pej Rohani. "Models can help, because different processes can leave different dynamical imprints in the data."

King, Pascual, and Rohani use mathematical modeling techniques to identify patterns and assess the underlying biology of infectious diseases. The implications of these patterns are widespread both for public health and for ecology.

left to right: EEB Professors Aaron King, Mercedes Pascual, Pej Rohani

The three theoretical ecologists have strong biology backgrounds that help to inform their current research. King has researched population cycles of the snowshoe hare and lynx, Pascual studied biological oceanography, and Rohani's doctoral degree was in insect predator-prey systems.

see infectious disease, page 3

Size matters and in this case, smaller is better

This story began innocently enough one day in Professor Elizabeth Tibbetts lab. Graduate student Mandy Izzo was working with some male paper wasps when she noticed how variable their body markings were. She asked her advisor about it, who agreed that it was curious and encouraged Izzo to look into her observations further.

At the time, the consensus among the scientific community was that sexual selection was weak to non-existent in the social insect world. Izzo wasn't convinced and in fact, what started as an interesting side project became Izzo's thesis and her findings are turning the thinking on social insect sexual selection on its head.

Wasps have a lek-based mating system, which means the males form big aggregations and defend tiny arbitrary territories. Essentially, males within a cluster fight among

see size matters, page 3

chair's notes

Dear Friends,

Once again, I write from a hectic but exciting time in the department. Despite the financial constraints, EEB is thriving. Unlike many places that are cutting back, we were given permission to search for four new faculty members to strengthen our program in evolutionary biology, as well as in computational biology and microbial ecology. This has meant a wonderful array of seminars and discussions this fall as we meet a diverse set of candidates for these positions. We also had a review of our graduate program by the Rackham Graduate School that was very positive but also gave us a number of new ideas to make our Ph.D. and master's programs even better.

Deborah E. Goldberg
Elzada U. Clover
Collegiate Professor
and Chair, Ecology and
Evolutionary Biology

In another direction, we are expanding our outreach efforts with the BioKIDS convention and field trip. The BioKIDS project was originally funded by NSF to improve science learning in fifth and sixth grade classrooms, with emphasis on the urban schools of the Detroit Public School district. The project was created by Professor Nancy Songer (U-M School of Education) and Professor Phil Myers (EEB) and continues to be led by them. The BioKIDS Convention takes place annually as a capstone event and has proved to be a very popular and effective way of teaching kids about science and scientists. The first EEB/BioKIDS field trip, held last spring, came about when many of the EEB faculty and grad students visiting the convention asked the kids if they'd ever seen the organisms they studied for their posters, and not a single one of them had! EEB and Songer's group from the School of Education are now combining to make the BioKIDS Convention in winter, followed by a spring field trip, an annual pair of events for Detroit Public School students. Some pictures from the first BioKIDS field trip are on the back page.

The feature article in this issue is on our terrific group of theoretical ecologists working on the ecology and evolution of infectious diseases. As the article notes, the spread of disease over space and time is fundamentally a population dynamic process and ecologists are increasingly making fundamental contributions to our understanding of how and why diseases become epidemic and therefore how to intervene to reduce the spread, e.g., through vaccination schemes. We are immensely proud that we now have one of the strongest groups in the world in this exciting area.

I close on a very somber note. Many of you will remember Chris Psujek, who has been part of the Biology Department and EEB since 1982. Just as this issue of Natural Selections was going to press in mid-November, Chris died, following a long struggle with lymphoma. Chris has run the undergraduate programs for the Department of Biology since 1987, and then the interdepartmental Program in Biology after Biology split into the departments of EEB and MCDB in 2001. She was responsible for the remarkably smooth operation of all aspects of our large and diverse undergraduate programs. We have calculated that Chris helped over 15,000 students during her time in biology with her knowledge, compassion, and patience; a truly incredible legacy. Undergraduates will remember her for her ability to answer just about any question that was thrown at her and graduate students will remember her by the fair and organized way she managed GSI assignments. As a concentration advisor myself, as well as now department chair, I relied heavily on Chris for her amazing breadth of knowledge and her organizational skills, combined with her reliable calm and sense of humor. In 2008, she was honored by LSA with the second annual Kay Beattie Distinguished Service Award. We are still dealing with the shock of her loss but will be deciding on a way to remember Chris in the near future and will make sure it is available on our website for those of you who may want to honor her memory together with us.

My warmest regards to all of you,

Deborah

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student profile

size matters, from page 1

themselves, setting up a dominance hierarchy. The most dominant males are the ones that get the most mates.

"It's something that never made sense to me – we are taught that there's no sexual selection in social insects but the lek-based mating system is the textbook example of really strong sexual selection," she said. "Usually one or two males get all of the females that visit a lek."

So, Izzo explored what aspects of male quality females choose when selecting mates and why. Of course, in order to study sexual selection, researchers have to get the males and females together. Convinced by other scientists that wasps wouldn't mate in the lab, Izzo went to great lengths to set the mood.

After three days of trying various complicated tactics that involved tethering or caging the males, which led to "little wasp temper tantrums," wasps hog tying themselves in string balls or pulling off Houdini-like escapes, Izzo finally just took two males and a female, put them in a box, let them go, and they were mating within a minute!

Once this was working, Izzo paired up males to fight to see what correlated with winning and losing. Surprisingly, males with smaller and more elliptical spots are more likely to win and females found these same males sexier.

Her next step was to use paint to change spots and pair wasps up again. When she took males with big, blobby spots and painted the spots to look smaller, other males gave up and didn't pester them much. This is the gold standard in behavioral ecology research for determining whether something is indeed a signal: when you manipulate a signal, do you get the purported result?

Izzo also did some diet treatments, where she raised wasps on a high or low protein caterpillar diet. She was able to show that the spot size and shape is condition dependent. If wasp larvae had good diets they developed smaller, elliptical spots versus the larvae fed a lower protein diet that developed larger, more irregular spots.

As a follow-up, the behavioral ecologist wanted to know what benefits females get by choosing particular males, beyond the traditional thinking that if you mate with a good male, you get good genes and therefore, have higher quality offspring. What bothered Izzo was that in lek mating systems where female choice is so particular, it seemed like something else might be going on, with so many females mating with just one or two particular males.

Female wasps mate in the fall, hibernate in the winter and emerge in the spring and many females die during hibernation. So, she thought the high quality males might be providing a benefit in their ejaculate compounds that helps the females overwinter.

Izzo did mating trials in the fall and overwintered the females in environmental chambers. The mated females survived longer than unmated

see size matters, page 7

Amanda Izzo

infectious disease, from page 1

Having three powerhouse theoretical ecologists together is unusual. There are only a handful of other institutions in the country that can boast such a critical mass of specialization in infectious disease research. Rohani joined EEB in 2009. The three collaborate on a number of different projects in different combinations and configurations.

King and Pascual research cholera using computational models that seek to quantify the unseen, an impossible feat at the clinical or epidemiological level. Individuals either have visible symptoms or they may become infected but appear healthy (called an inapparent infection). These individuals don't see the doctor so they aren't measured. "At the population scale, these inapparent infections have strong effects on the pattern of outbreaks," said King.

King and Rohani research pertussis (whooping cough), a bacterial infection that is a prominent member of a class of infections that they're all interested in where some people have mild, inapparent infections, and others have severe infections. It's been known for a long time that people lose immunity to pertussis, but it's unclear what the implications of that are for the circulation of the bacterium at the population scale. Much of Rohani's work, including several published papers, has shown that, remarkably, even though people are losing immunity, their subsequent reinfections aren't the primary cause of the spread of pertussis. The two recently

see infectious disease, page 6

First glimpses from hybrid zone genetics

Many of us have been awed by the incredible diversity of species with which we share the Earth. Professor Priscilla Tucker has made this fascination her life's work. Simply put, she researches what gives rise to biological diversity.

Priscilla Tucker

"When we think about biological diversity, we think about independently evolving lineages," said Tucker, who is also a curator at the University of Michigan's Museum of Zoology. "At one point in time they shared a common ancestor, but something happened and the lineages became independently evolving. Either they became isolated geographically and/or the populations stopped sharing the same gene pool. I'm interested in that point. What mechanisms prevent emerging species from sharing the same gene pool?"

Specifically, Tucker is looking at diverging populations of the house mouse. Some recognize these populations as distinct subspecies, *Mus musculus musculus* and *Mus musculus domesticus,* and others refer to them as distinct species, *Mus musculus* and *Mus domesticus*. Their ranges overlap in nature, and where they overlap, they hybridize. However, evidence exists that the hybrid offspring are not fully fertile or viable. Tucker is studying the genetic underpinnings of reproductive isolation between these emerging species in these hybrid zones where mice have been interbreeding for many generations.

Tucker and her fellow researchers collected mice in hybrid zones in eastern Germany, the Czech Republic, and southern Germany. The project is a large collaboration funded by the National Science Foundation and involving the Czech Academy of Science, Charles University in Prague, and Michael Nachman, a professor at the University of Arizona and a former U-M biology graduate student. The project involves an exchange of students between Tucker's lab and the Czech Academy of Science. She also has DNA from mice collected in southern Germany and Austria in the 1980s. All in all, they have DNA data on 1,600 mice.

The mice they're studying are the wild relatives of lab mice that are used in biomedical research. Since the lab mouse genome has been sequenced, they have access to what Tucker calls a "genetic toolkit," which they've used to identify many diagnostic markers that distinguish the populations. Using high throughput technology, they genotyped the mice. For their current study, they have developed over 1,400 markers at a density of one marker every two million base pairs across the mouse genome. These markers, called SNPs (single nucleotide polymorphisms), are found along the DNA sequence.

"We have amazing coverage of the genome for this particular study," Tucker said. Genotyping allows researchers to assess differences in gene flow across these markers in the hybrid population. This is the first time a whole genome has been compared across a hybrid zone. "Many genomes are being sequenced right now, and there will soon be opportunities to assess differences in gene flow on a genome-wide scale in hybrid populations of other species.

"By looking at the extent of gene flow across these hybrid populations, we can observe which regions of the genome are crossing the species boundaries and which are not. We have methods for distinguishing between the two categories and now we're hoping to identify the genes that might be involved."

From a practical application standpoint, what they're seeing in mice in Europe could mimic what would happen when there's hybridization as a result of an invasive species moving in to the range of a natural species. Understanding what happens when two populations that have been separated for a long time meet and start exchanging genes may prove useful in studying the dynamics of invasive species where those species hybridize with native forms.

In the realm of biomedical research potential, many of the hybrid mice show evidence of sterility, particularly in males. If researchers can identify what genes are not moving across the hybrid zone, these genes may be associated with hybrid male sterility and could ultimately be useful for biomedical research in human reproduction.

"I'm very interested in understanding what kinds of genes are actually crossing the species boundary," said Tucker. "We have identified regions of the genome that seem to be moving across the species boundary, which means that there must be genes that are conferring fitness advantages, and they are the ones moving between species.

see hybrid zone genetics, page 7

alumnus profile

Carbon forestry pioneer

Awakening to the sound of gibbons howling at the rising sun in the forests of Central Kalimantan, stepping in fresh tiger scat in southern Sumatra, and working with local forest villagers who tied up logging machinery with heavy vines to retaliate against an illegal logging attempt in Borneo. Just another day in the life of U-M alumnus Gabe Eickhoff.

Eickhoff received his bachelor's of science degree in biology and anthropology in 2003 and has just begun working as an advisor on climate and forestry with the German Agency for Technical Cooperation (GTZ) in Laos. Previously, he worked in Indonesia.

He describes his career as "one part highly technical forest ecology, one part economics and one part cultural anthropology. Combine those with negotiations within the United Nations Framework Convention on Climate Change within developing countries and you've got my field in carbon forestry," he said.

Eickhoff works in an emerging field called Reducing Emissions from Deforestation and Degradation (REDD) – a hot topic nationally and internationally. The premise is simple, he explained. Deforestation drives greenhouse gas emissions and reduces our global capacity to store atmospheric CO_2 in our forests. Reducing deforestation will reduce potential CO_2 emissions. By quantifying how much CO_2 we avoid releasing, say in tons of atmospheric CO_2, those reductions can become a commodity, called carbon credits, which can be purchased on an international carbon market by governments or companies looking to reduce emissions. Proceeds then fund the forest conservation activity and the development of rural villages in forest areas.

"For the first time we have at least one way of valuing standing forests and everything within them. A forest area, simply by existing and being actively protected, generates its own funding for sustainable conservation. If we do it right, meaning that we protect indigenous rights and biodiversity, it will be nothing short of revolutionary. If we can make this work, it will turn the conservation world on its head, but it's hard, very hard."

Globally, two things must happen with respect to the mitigation of climate change, he cautioned. We must reduce overall emissions at home, and reduce the rate of deforestation around the equator.

In Laos, the GTZ has partnered with the Laos Department of Forestry to help them design their national legal system for REDD and design and implement REDD projects in two national parks.

Eickhoff spends about half his time wearing nice clothes in the Department of Forestry advising on regulations and the other half out in forests with his machete measuring trees. "I find this to be a happy balance."

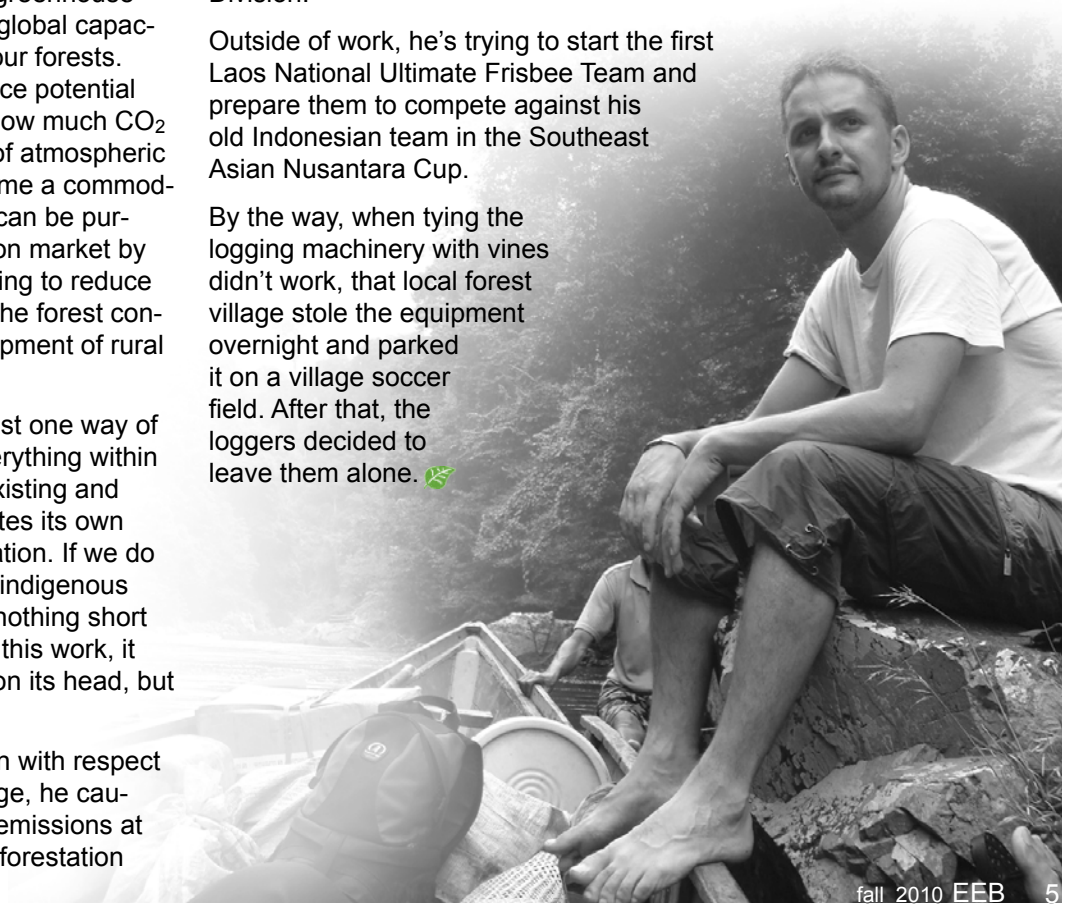
"If we do it right, meaning that we protect indigenous rights and biodiversity, it will be nothing short of revolutionary."

He is a partner and senior associate of Forest Carbon, Indonesia – a one-of-a-kind technical consulting firm in Asia. "We own a plane and fly aerial surveys of forest cover, measure carbon stocks, estimate emission levels from deforestation and help design, develop and implement projects.

Two personalities stand out from his days as a Wolverine. "Professor Michael Wynne was at first a professor, then a mentor, then became a close and long lasting friend who kept up to date on my progress and kept me in line." Professor Bill Fink launched Eickhoff's interests in phylogenetic systematics and gave him a job working in the U-M Museum of Zoology Fish Division.

Outside of work, he's trying to start the first Laos National Ultimate Frisbee Team and prepare them to compete against his old Indonesian team in the Southeast Asian Nusantara Cup.

By the way, when tying the logging machinery with vines didn't work, that local forest village stole the equipment overnight and parked it on a village soccer field. After that, the loggers decided to leave them alone.



Gabe Eickhoff in East Kalimantan Provence of Indonesian Borneo.

infectious disease, from page 3

published a paper in *Science* on this subject, in which they consider whether whooping cough vaccine strategies would be better targeted at adults or children.

In the area of climate variability, King and Pascual are developing early warning systems for malaria and cholera outbreaks in Bangladesh using environmental variables such as sea surface temperatures, rainfall, and temperature, which can provide clues that forewarn of impending outbreaks. Pascual works on malaria in several places at the edge of the disease distribution, for example at altitudinal limits where the temperature becomes too cold for malaria, like the highlands of east Africa, or at desert fringes, where rainfall determines the availability of breeding sites for the mosquito vectors in northwest India. Pascual also studies how climate change influences the dynamics of malaria in the east African highlands.

photo courtesy of ICDDR, Bangladesh

Characteristic temporal patterns of disease spread can help predict the timing and severity of another outbreak. The goal is that early warning systems to predict large epidemics and extreme events will ultimately help with the timely treatment and preparedness for epidemics. “For example, with malaria, interventions include the use of bed-nets and insecticides,” said Pascual.

“It’s easy for clinicians, epidemiologists and immunologists who work in this area at the taxonomic level to get paralyzed by the overwhelming complexity of these biological systems,” Rohani said. “Theoretical ecology has taught us that it is possible to simplify the system and still capture its essence. We’re trying to work out which complexities matter and which don’t.”

In addition to the ecology of infectious disease, King, Pascual, and Rohani share an interest in the evolution of infectious diseases. “When we explore genetic data, we can look for footprints of different evolutionary mechanisms and compare the likelihood of different mechanisms being responsible for those data,” explained Rohani.

Pascual and Rohani have a long-standing interest in vector-borne diseases, such as dengue and malaria, which are caused by a virus and a protozoan parasite, respectively, and are both transmitted via mosquitoes. These diseases are complicated by their genetic variation as well as by the mosquito, which introduces the element of climate change. They also investigate the interaction between the evolution of the influenza virus and its transmission dynamics at the population level.

King and Rohani are involved in a project looking at the dynamics of competing strains in dengue, an infectious disease with multiple, distinct genotypes that compete and/or cooperate with one another. Quantifying the competition and cooperation among the genotypes is important for vaccine development.

The group is always developing new theoretical techniques and tools, new ideas and methods for examining more complex, more detailed models, and different kinds of data. Beyond the direct influence of their published results, many of their techniques are used by researchers at other institutions.

“Some of the most urgent issues in epidemiology center on what we can’t see or measure directly.”

For example, King has developed a general statistical software that is being used to answer all kinds of questions on the population dynamics of various diseases. The software allows researchers to compare the plausibility of different pictures of cholera transmission, for instance, and arrive at which is most consistent and compatible with the data. Complicating factors in making sense of data on disease dynamics include seasonality, loss of immunity, and transmission where there’s an environmental reservoir, meaning the disease is present in birds or bodies of water.

King, Pascual, and Rohani collaborate with others across U-M including colleagues in the Departments of Statistics and Mathematics, the School of Public Health, the School of Natural Resources and Environment, and the Center for the Study of Complex Systems (CSCS). Additionally, they have numerous international collaborations and research sites around the globe. King is jointly appointed in EEB, mathematics and the CSCS. Rohani is jointly appointed with EEB and CSCS. Pascual is affiliated with CSCS, is an external faculty member of the Santa Fe Institute and is an investigator of the Howard Hughes Medical Institute.

Whether they are working directly together or just discussing their work with one another in the halls of the Natural Science Building, this dynamic group of researchers is like a force of nature and EEB is fortunate to have them all here.

faculty profile

hybrid zone genetics, from page 4

"As a result of the study, we have over one million data points that we can analyze. It's amazing that we have this ability to see at such a fine scale. It already has led to some interesting findings and I'm hoping it will lead to some more."

Tucker began working on this project when she came to U-M in 1988. At the time, she had data from seven markers. She thought she had a lot of data then. She's gone from seven to 40 to 1,400 markers and from a single transect to three transects of hybrid mice. She was busy working on other projects and only returned to this project 10 years ago.

One of the best parts of her job, by far, is being constantly surrounded by young people, Tucker said.

The house mouse by any other name: *Mus musculus musculus* and *Mus musculus domesticus*

size matters, from page 3

females. Among mated females, she measured spots of the males that were used as mates. The females who mated with the better quality males lived longer.

"There really is a direct benefit, something is transferred with the sperm that is helping them to survive," Izzo said. "It could be immune resistance, something nutritional, or even a type of 'antifreeze'," she speculated.

Izzo presented these findings in Portland, Ore. at the Evolution Conference over the summer and stunned the room! She won the W.D. Hamilton Award for Outstanding Student Presentation for the entire conference. "Through a simple behavioral experiment, I found something new" she said.

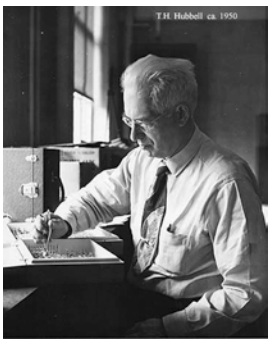
"When you look at the world around you, you can be struck by how much diversity there is in terms of organisms. Sexual selection is one of the driving factors creating diversity.

"Understanding and appreciating the diversity we see has consequences and ramifications for conservation and preservation. You can't save an endangered animal if you can't make it breed in captivity.

"Wasps are small, easily accessible and abundant. We can take the theories that we learn through insects and apply them to pretty much anything else. The specific details won't hold true from organism to organism, but the main concepts will."

UMMZ endowment created to honor Theodore H. Hubbell

An endowment has been established to honor Theodore Hubbell, former director (1956 to 1968) of the U-M Museum of Zoology, and its long term curator of insects. Under his direction, and as a result of his extensive collecting, the museum now houses one of the most extensive collections of crickets, katydids and grasshoppers in the world. After earning his bachelor's and doctorate degrees from U-M, Professor Hubbell taught at the University of Florida before returning to the UMMZ. Over the 70 years of his professional life, Hubbell became the world authority on camel crickets of the western hemisphere where he collected extensively, especially in the eastern and western U.S. and Latin America. He worked mostly at the species level, but incorporated habitat, distributional, and biogeographical data to produce evolutionary interpretations of each group he studied. He published major papers on camel crickets, true crickets and grasshoppers, and even wrote an innovative paper on the evolution of a scarabaeid beetle genus in Florida. Hubbell's dedication to the UMMZ continued long after his retirement. He came to the museum daily, until very shortly before his death, to work on camel crickets and became "everybody's mentor" in the museum.



Theodore Hubbell, circa 1950

A grateful, anonymous student has established the Theodore H. Hubbell Endowment for Systematic Research in Orthoptera "in honor and appreciation for Professor Hubbell's lifelong devotion to the collection of Orthoptera at UMMZ, for his erudite accomplishments in the field of orthopteran systematics, and for his always friendly and insightful encouragement of all students."

The endowment will fund research and field work in Orthoptera, provide assistance for visiting orthopterists to work on or study the collection, and support the maintenance of and acquisitions for the UMMZ Orthoptera Collection.

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EEB/BioKIDS field trip

The field trip to the U-M Dearborn Environmental Interpretive Center was an outgrowth of BioKIDS, a U-M School of Education and Museum of Zoology program that uses technology and hands-on-learning methods to help middle school students ask questions the way scientists do.

U-M hosted a BioKIDS symposium, modeled on a professional scientific meeting, where the kids are the experts, presenting posters to U-M professors and graduate students on organisms they had researched. While the scientists were impressed with the depth of the students' knowledge, they were bothered by the fact that many of the students had never actually seen the animals they were describing. Thus the idea for the field day was hatched and it will become an annual event. Read more, view photos and watch a video here:

http://www.lsa.umich.edu/eeb/news/biokidsfieldtrip2010.html