THE UNIVERSITY OF MICHIGAN
DEPARTMENT OF ECOLOGY AND EVOLUTIONARY BIOLOGY

NATURAL SELECTIONS

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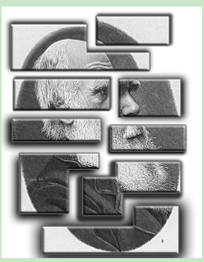
Charles Darwin bicentennial



To celebrate the bicentennial of Charles Darwin's birth on February 12, 2009 and the 150th year since the publication of "On the Origin of Species," a number of events are being held around campus during winter term 2009:

Saturday, Feb. 14: Darwin's Birthday Bash. A lecture on the evolution of sex (in honor of St. Valentine's Day), chocolate birthday cake, a student contest to artistically interpret a passage from "On the Origin of Species," and much more. Exhibit Museum of Natural History.

Sunday, Feb. 15: Identification Day. To highlight the importance of natural history collections, the public is invited to learn about U-M's collections and to bring in their own objects for identification by our experts. Exhibit Museum of Natural History. Party hats and cake.

Thursday, March 5: Special seminars on evolutionary biology with Marvalee Wake and David Wake, professors, Department of Integrated Biology, UC-Berkeley. EEB.

Saturday, March 14: Early Career Scientists Symposium on Using Phylogenies in Ecology. EEB.

Sunday, April 26: "The Blue Lias" or "The Fish Lizard's Whore." This one-woman play, written and performed by Claudia Stevens, is a postmodern musical biography of 19th century paleontologist Mary Anning. Co-sponsored by many units including EEB, Life Sciences Institute, and Women's Studies.

Tuesday, April 28: Life Sciences Institute Symposium. A one-day meeting on recent exciting developments in evolution.

Details will be available on the EEB Web site: http://www.eeb.lsa.umich.edu

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Math models may save lives

Pascual named Howard Hughes investigator

Next time you hear children say they will have no use for math in their future, you can tell them about Professor Mercedes Pascual and how she is using her mathematical skills to potentially save lives.

Pascual has been appointed as a Howard Hughes Medical Institute investigator. The $600 million initiative from one of the world's largest private philanthropies is funding 56 American scientists who are breaking new ground.

More than 1,070 researchers vied for the grants in a national competition. The new HHMI investigators hail from 31 institutions across the country.

Pascual is a theoretical ecologist who builds mathematical models to explore links between climate fluctuations and cycles of infectious diseases such as cholera and malaria. Her models could help identify when and how cholera, malaria and other diseases might become epidemics. This will enable public health agencies to prepare for, or possibly prevent, life-threatening outbreaks.

The Howard Hughes Medical Institute is a non-profit medical research organization. HHMI has invested over $8.3 billion for the support, training and education of the nation's most creative and promising scientists over the last 20 years.

HHMI enters into long-term collaboration agreements with universities and other academic research organizations, where its investigators hold faculty appointments. Under these agreements, HHMI investigators, who are directly employed by the institute, and their research teams, carry out their research in HHMI laboratories located on various campuses. The institute currently employs more than 300 of the nation's most innovative scientists, who lead Hughes laboratories at 64 institutions.

Pascual investigates whether and how global warming and climate variability contribute to the spread of infectious

see Pascual/HHMI, page 3

Arctic tundra to tropics: An undergrad's grand adventures

Ashley Larsen's EEB undergraduate experience has been a whirlwind of excitement, and now the Honors Program student is poised to graduate in December 2008 with the world at her fingertips.

The week following this interview, Larsen was winging her way across the country to visit her current top four picks for graduate study. She's interested in graduate programs in ecology and evolutionary biology, particularly community ecology with a marine or aquatic focus.

During her undergraduate career, Larsen has worked on several different research projects that have taken her from the northernmost reaches of Alaska to the tropics of Mexico. Larsen began her "senior" honors thesis during her freshman year, in the lab of EEB Professor Paul Webb.

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chair's notes

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

Dear Friends,

This year marks another milestone in our development as a department—we began work on our *second* five-year plan. The planning process has enabled us to take stock of how far we have come since we submitted our first plan in 2003, as well as have a series of thought-provoking discussions on our future. The plan will lay out the key new directions that are needed to keep our programs at the frontiers of research and education in ecology and evolutionary biology and use these to develop strategies for hiring new faculty.

In other exciting developments, we are in the midst of searching for three new faculty. As I write, we just finished interviews with three very impressive candidates for a position in microbial ecology. This is part of an interdisciplinary cluster search in microbial ecology that includes departments in the Medical School and School of Public Health, as well as both EEB and Molecular, Cellular, and Developmental Biology in the College of Literature, Science, and the Arts. The interviews drew in faculty from across all those units, as well as from environmental engineering, to hear the candidates' seminars and meet with them. In January, we will interview candidates for a very broadly defined position in evolutionary biology or evolutionary ecology. In February we will interview candidates for a joint position between EEB and the Center for Complex Systems in the ecology and evolution of complex systems.

We inaugurated our Frontiers Master's Program this year, with four outstanding students. As we described in our last issue of Natural Selections, Frontiers is designed to attract a diverse student body, introduce them to the full range of research approaches in ecology and evolutionary biology, and prepare them to continue in a top-ranked Ph.D. program. As we hoped, our first cohort of Frontiers students have wonderfully diverse backgrounds (from a music major to the U.S. Air Force) and are already deeply immersed in a variety of courses and field and laboratory research experiences.

Equally noteworthy are the doings of our individual faculty. As described in our cover article, Professor Mercedes Pascual was appointed a Howard Hughes Medical Institute investigator—one of only two appointed this year at U-M, bringing the university's total to nine, and one of the very few nationwide not primarily associated with a medical school. Mercedes also was named a Collegiate Professor and promoted to full professor this year. Phil Myers was promoted to full professor and curator in the Museum of Zoology. Lacey Knowles and Yin-Long Qiu (profiled in this issue) were promoted to associate professor with tenure; Lacey was also promoted to associate curator in the Museum of Zoology. Trisha Wittkopp, assistant professor, was awarded an Alfred P. Sloan Research Fellowship, intended to enhance the careers of the very best young faculty members in their field of science. Bill Anderson, professor emeritus of botany and curator emeritus of the University of Michigan Herbarium, was presented with the Asa Gray Award at the International Botany 2008 meetings in Vancouver, Canada, the highest honor bestowed by the American Society of Plant Taxonomists for outstanding contributions to systematic botany. Beverly Rathcke received the 2008 Rackham Distinguished Graduate Mentoring Award. John Vandermeer won the Sarah Goddard Power Award, a distinguished service award presented annually to individuals who have demonstrated scholarship, leadership and support of women within the U-M.

Finally, as the Michigan Difference Campaign winds down, I would like to thank all of you who have contributed so generously to the Department of Ecology and Evolutionary Biology and the Program in Biology; since the campaign started in 2004, you (collectively) have given us over $100,000! We are enormously grateful for the many ways this has enriched the research experiences and opportunities of our undergraduate and graduate students. Your gifts have supported summer research opportunities for undergraduate students, travel funds and money for research supplies and field assistants for graduate students, support for students to attend our annual retreat at UMBS and to present their work at conferences, prizes to reward exceptional student achievement, special lectures such as the annual Wagner Lecture on plant evolution, and even an entire annual symposium, the Early Career Scientist's Symposium, now in its fifth year. Even though the campaign is ending, these needs all, of course, remain and we look forward to your continuing generosity.

My best wishes for the new year and, as always, we welcome your news and your visits.

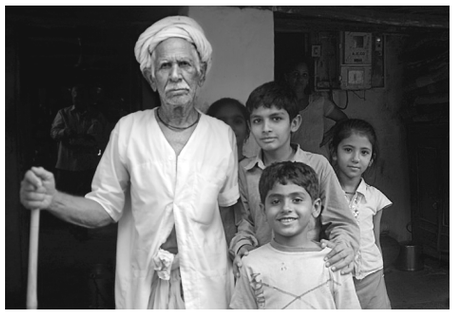
Pascual/HHMI from page1

diseases. In one research project, she and collaborators in Barcelona and Bangladesh found evidence that a phenomenon called the El Niño-Southern Oscillation (ENSO), which is a major source of climate variability from year to year, influences cycles of cholera in Bangladesh. They showed that the coupling between climate variability and cholera cycles has strengthened in recent decades.Pascual is exploring the possibility of using a model developed during this work as an early warning system to predict cholera outbreaks.

Additionally, Pascual and her research group are addressing the connection between global warming and the resurgence of malaria in East Africa. Another developing collaboration with scientists and public health officials in India seeks to understand the relationship between rainfall, immunity and malaria epidemics in desert fringes. Mathematical models and statistical analyses are used to elucidate patterns in long temporal records in the past, to examine the possibility of forecasting the future. In another effort, primarily by previous and current graduate students Katia Koelle and Sarah Cobey, her group developed a model that couples evolutionary change and epidemiological dynamics to explain ups and downs in influenza epidemics during interpandemic periods.

Her models could help identify when and how cholera, malaria and other diseases might become epidemics.

Pascual is a professor in the Department of Ecology and Evolutionary Biology. In 2002, Discover magazine named her one of "The 50 Most Important Women in Science." She was awarded a U.S. Department of Energy Alexander Hollaender Distinguished Postdoctoral Fellowship for studies at Princeton, and in 1999 received a Centennial Fellowship in Global and Complex Systems from the James S. McDonnell Foundation. Pascual is also associated with the U-M Center for the Study of Complex Systems and the Santa Fe Institute.



Part of an extensive family living in Ahmedabad, India where Pascual visited recently. A long-term surveillance and control program is conducted here for urban malaria. Her group hopes to start working on this soon as part of their collaborative project in India.

whirlwind from page 1

Larsen's research in Webb's lab, in combination with classes on the biology and ecology of fishes, helped her develop her thesis on the biomechanics of fish swimming, titled: "Effect of intraspecific variation in caudal fin size on the steady swimming kinematics of goldfish (*Carassius auratus*)."

In the lab, goldfish were placed in a large flume and videotaped to see how swimming motions change in relation to increased velocity and how variation in tail fin shape influenced the power output necessary to overcome drag and recoil. Her thesis investigated how morphology affects habitat selection and competition.

"Paul was a great advisor," she said. "As I started reading scientific literature, he would say 'you should look into this or try that.' I had to read a ton on biomechanics and physics. The topics were incredibly interesting, and he was so good about explaining it and being encouraging."

After intensive reading and numerous discussions with Webb, the data she gathered started to make sense. "It ended up being really cool," Larsen said. The results were unexpected. Despite significant reduction in tail surface area, and therefore frictional drag, they found fish with shorter tails worked as hard as fish with longer tails to maintain position against the current. However, long-tailed fish had a lower maximum swimming speed; at high speeds, long-tailed fish were constrained by tail beat frequency, likely due to billowing of the flexible tail.

In her sophomore year, Larsen received a Research Experience for Undergraduates grant from the National Science Foundation, which took her to Toolik Lake in Alaska to study ecosystem ecology with EEB Professor George Kling. Larsen and Heather Adams, an EEB Ph.D. student, worked in a small glacial lake. Larsen constructed a mass balance of what nutrients and dissolved organic matter (DOM) enter and exit the Arctic lake through its inlets and outlet.

Larsen, Adams and other lab members took water samples from three small inlets to determine the amount of carbon they contribute to the lake, and how rain events might change the relative contributions. They found that the contribution of little inlets was dependent on

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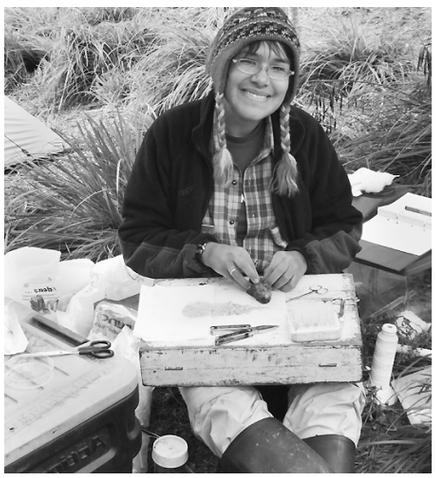
graduate **feature**

Discoveries on top of the world

Lucía Luna's name means moonlight and, fittingly, she loves camping out under the stars in the Peruvian Andes on her research excursions at up to 3,000 meters.

Luna is a graduate student in ecology and evolutionary biology at the University of Michigan. Her advisor is Phil Myers, professor of ecology and evolutionary biology and curator of the U-M Museum of Zoology. Luna is studying patterns of diversification in two Andean rodent species, the soft grass mouse, *Akodon mollis* and the Taczanowski montane mouse, *Thomasomys taczanowskii*. This study has both a molecular and a morphological approach.



Lucia Luna Wong, EEB Ph.D. student, preparing specimens at Cutervo National Park, Cajamarca, Peru, ~3000 m. Photo: Barry OConnor. A photo contest winner (see page 8).

Because the terrain can be difficult to navigate, Andean regions have been largely overlooked by biologists. Recognizing that the region is a leading hotspot in terms of the number of endemic plant species (over 20,000) and terrestrial vertebrates (over 1,500), Luna focused on this area to help attract attention to these remote and environmentally threatened regions. The Peruvian Andes are suffering enormous habitat destruction from deforestation and gold mining.

When she travels to Peru for her research, she works from the Museum of Natural History in Lima, where she connects with an undergraduate student to accompany her. She hires a group of locals to help with research and transportation. The trip from Lima to her field site can take two to three days traveling by small bus, mules and on foot. They stock up on food and other necessities in the small towns along the way, carrying their supplies in duffel bags, backpacks and boxes.

The field work is my favorite part.

"The field work is my favorite part. Because we go to such remote areas, we have nothing," she said. They clear an area, make a camp, pitch tents. Every morning they bring water to camp and build fires for drying specimens and cooking. She especially likes the stories the local people share about their life and the long talks they have together.

Luna is testing two competing hypotheses to explain the origin of new species in the Andes: 1) the montane vicariance hypothesis and 2) the ecological gradient hypothesis. The montane vicariance hypothesis argues that glacial fluctuations in the Holocene and Pleistocene have cyclically isolated groups of species in refuges of suitable habitat, thus promoting isolation and speciation and predicts that sister species or populations will be found in adjacent drainages at the same elevation. In contrast, the ecological gradient hypothesis proposes that speciation took place along elevational gradients as organisms adapted to local environments and predicts that nearby species or populations along an elevational gradient should be more closely related to one another than to populations in different valleys. To test these contrasting predictions, Luna surveyed rodent populations at two different elevations (3,000 and 2,000 meters) and extracted, amplified and sequenced mitochondrial DNA segments (genes Cytochrome b and D-Loop). These DNA sequences were then used to reconstruct the evolutionary hypotheses of relationships (cladograms) to test each model's predictions.

Luna has been focused on the molecular component of her dissertation thus far, with encouraging results. She found that both hypotheses contribute to speciation among the mice she's studying. Mitochondrial DNA data of *A. mollis* populations supports both hypotheses. However, for *T. taczanowskii*, the data reject the ecological gradient model, suggesting that ecological conditions along a slope are not promoting speciation in this rodent.

Another important component of this project is to study the morphological diversity of the populations of mice studied. Usually South American *Akodon* mice living in similar habitats on different mountains are very similar in appearance and, in fact, their current taxonomy is based on this similarity. But is this morphological similarity really due to phylogenetic relatedness, or is it simply the result of different animals living in similar habitats that evolve the same biological traits? To study this, Luna is using a technique called geometric morphometrics to describe how morphology differs across elevations or between mountain top isolates, and to relate shape diversification to genetic distinctiveness. If morphological

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Exploring planet Earth's stunning plant diversity

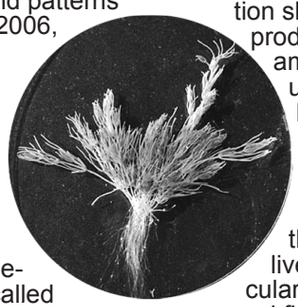
From the microscopic algae of the ocean to the soaring Kapok trees of the rain forest – the flora of planet Earth is truly a marvel and a mystery. Professor Yin-Long Qiu's research has revealed insights into how this incredible biodiversity came to be and he and other evolutionary biologists are beginning to explore the philosophical realm of how our planet became so abundantly beautiful with plants of all shapes, sizes, and types.

Just chat with Qiu for even a few minutes about the nature of his work and you will know how passionate he is about his research into the underlying genetics of plant diversity. Qiu is an associate professor of ecology and evolutionary biology and associate curator of the University of Michigan Herbarium.

Plants are omnipresent in Qiu's life.

"I really enjoy solving puzzles and that's a large part of what genetics is," said Qiu. "In my freshman year of college, the general botany course, in particular plant anatomy, morphology and taxonomy, really captivated my interest. In my sophomore year, the genetics course I took was really fascinating." His undergraduate degree was in horticulture.

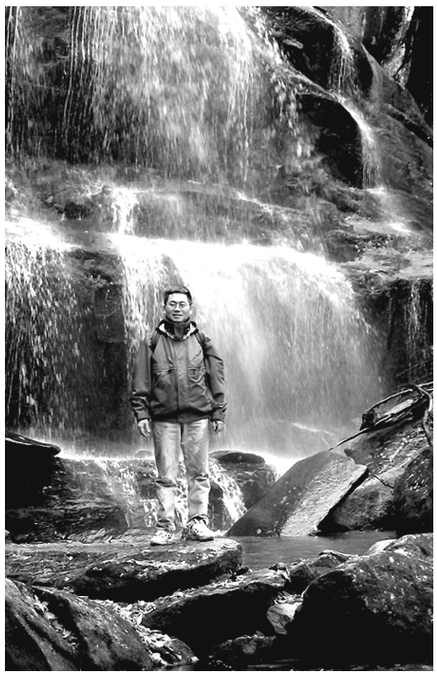
Those interests have guided his academic life for almost 30 years -- from his choice of graduate study in biology to his current research projects. Qiu joined the University of Michigan in 2003 where he and his students use molecular techniques and informatics tools to understand plant evolution and patterns of plant diversity. In October 2006, Qiu and his research team published new findings in the Proceedings of the National Academy of Sciences that help resolve long-debated questions about the origin and evolution of land plants.



According to Qiu, plants began to colonize land with descendents of aquatic plants called charophyte algae. Now free from their watery homes, the sun beat down and the algae were surrounded by an abundance of carbon dioxide, two essential ingredients for photosynthetic plant life. This was the start of a chain reaction that helped land plants proliferate, forming the basis for modern land-based ecosystems and fundamentally altering the course of evolution of life on earth.

Next, plants underwent a key change in their life cycles. Plants exhibit a phenomenon known as alternation of generations, in which two alternating forms with different amounts of DNA make up a complete life cycle. One form, known as a sporophyte, produces spores, which grow into individuals of the other form, called gametophytes. Gametophytes produce gametes—eggs and sperm—which unite to form a fertilized egg capable of becoming a new sporophyte, thus completing a life cycle. While all plants exhibit alternation of generations, some spend most of their life cycle as sporophytes, and others spend more time in the gametophyte phase, with only half the number of chromosomes.

"Early in the history of plant evolution, a shift occurred," said Qiu. "If you look at the so-called 'lower' plants such as algae, liverworts and mosses, they spend most of their life cycle as gametophytes. But if you look at plants like ferns, pines and flowering plants, they spend most of their time as sporophytes. Geneticists, developmental biologists and evolutionists have been wondering how the switch happened and have put forth two competing hypotheses."



Professor Yin-Long Qiu east of Knoxville, Tennessee. *Megaceros aenigmaticus* (a hornwort) grows right under the waterfall.

For each hypothesis, scientists have come up with an evolutionary scheme showing how different plant lineages should be related to explain the generation shift. Studies over the last century have produced conflicting results on relationships among early land plant lineages, leaving unanswered the most critical question of how the shift in alternation of generations occurred. Qiu's group used three complementary sets of genetic data, involving more than 700 new sequences of genes, to resolve relationships among the four major lineages of land plants: liverworts, mosses, hornworts and vascular plants (which include ferns, pines and flowering plants). Their analysis showed that liverworts—tiny green, ribbon-like plants often found along river banks—represent the first lineage that diverged from other land plants when charophyte algae first came onto land, and an obscure group called hornworts, which are found world-wide, but prefer damp or humid locations, are the ancestors of the vascular plants.

Plants: *Chara contraria* (left), *Haplomitrium gibbsiae* (right)

This positioning of liverworts and hornworts, and examination of their life history characteristics, as well as those of early vascular plants, suggest the following step-by-step changes. The sporophyte changed from a completely matrotrophic structure (wherein nourishment is

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supplemented by the mother) on the gametophyte, as in liverworts, to a semi-independent generation in hornworts, and finally to an entirely free-living organism in vascular plants.

"Basically we captured a few major events that happened in the first few tens of millions of years of land plant evolution," Qiu said. "Understanding evolutionary relationships among plant groups is crucial to understanding their biology, just as understanding relationships among primates advances our knowledge of human behavior, anatomy and physiology."

These days, in order to explore the "how" behind the planet's incredible plant diversity, Qiu and his students are studying the evolution of several genes that are likely involved in controlling the initiation of meiosis (when the number of chromosomes is halved during the change from sporophyte to gametophyte). In gymnosperms like cycads, pines, or gingko it can take decades to reach sexual maturity with the ability to produce an egg or sperm. By contrast, herbaceous angiosperms (flowering plants) can reach sexual maturity in less than one year. Over the last four or five hundred million years, plants that reach sexual maturity at different developmental stages and chronological ages, and exhibit different life cycles have been selected to form the major backbone lineages of the plant tree of life, thus generating the dazzling diversity of plants we see today. The life cycle of different plant lineages was a macroevolutionary feature under selection on a time scale of hundreds of millions of years that most evolutionary biologists have managed to neglect, according to Qiu. By studying genes involved in regulating life cycle changes, Qiu and his students hope to unlock nature's secret in shaping plant diversity by manipulating plants' sex life.

Cyathea medullaris

Plants are omnipresent in Qiu's life. His wife, Libo Li, received master's degrees in botany and bioinformatics. One of his two daughters, Jackie, 12, is similarly curious about nature and plants.

"Jackie will find any seed around the yard and put it into a pot," he said. "I was like that when I was a little kid." Qiu's grandparents owned a nursery in eastern China where he spent a lot of time during his early years.

"My earliest memories involve plants. I remember going into the greenhouse and the fragrant aroma of the geraniums and roses."

Qiu has a flower garden in his front yard and a vegetable garden out back. "Gardening can really take my brain away from work. Usually I'm so intense when I do my work that it's hard for me to relax until I spend a day in the yard, getting wet and dirty."

It's looking like Qiu's love of plants will continue to proliferate in the realms of groundbreaking research, writing, teaching – and gardening. "I think I have a green thumb," Qiu said. Indeed.

(with excerpts from a U-M News Service press release by Nancy Ross-Flanigan)

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magnitude of stream flow. During low flow, the smaller inlets added over a quarter of the DOM entering the lake, but the relative contribution decreased markedly during high flow when the larger inlet dominated water influx.

The Arctic is considered a bellwether for environmental responses to climate change for the rest of the world. An increase of carbon in the lake could cause an increase in bacterial processes, which leads to a release of more carbon dioxide, through respiration. Carbon dioxide is considered to be a major contributing factor to the greenhouse gasses that exacerbate global warming.

I have had professors who are very inspirational and really incredible.

Most recently, Larsen's research has taken her to Finca Irlanda in Chiapas, Mexico with EEB Professor John Vandermeer and School of Natural Resources and Environment Professor Ivette Perfecto, to study the interaction of pests and their natural enemies in a coffee agroecosystem. Larsen is currently co-authoring a paper on this research with EEB graduate student Heidi Liere.

Larsen credits her early scientific interests to her athletic and "really outdoorsy" family. She's from New York, and grew up next to a state park, with a pond in her back yard. "My brother, my best friend and I would go adventuring for wildlife back there," she recalled. Her parents are both teachers; her father teaches natural science.

Larsen is not sure about a future career yet, but said, "I would like to go into academia because I love being at a university and I have had professors who are very inspirational and really incredible."

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variation is a good indicator of phylogeny, then a cladogram based on morphological characters should correspond with the molecular phylogeny. If similarity in skull shape is tied to environmental factors, then ecologically similar species should be similar morphologically, and morphology should be correlated with ecological traits rather than genetic relatedness. Luna is just starting the morphological component of her dissertation, taking photographs to analyze shape changes. The results will help shed further light on speciation mechanisms in Andean habitats.

"Understanding the mechanism that has generated the diversity in this region can lead us to better conservation planning of highly biodiverse areas such as the Andean regions," Luna said. "Since so little is known about the fauna in the Andes, we don't know which species are going extinct or are in danger of going extinct."

She was among the first group of scientists (beginning with her field trips as an undergraduate student) to study areas that have become national parks or house biological stations. She has also witnessed the improvement of schools, roads and services in many of the places she has worked. Surrounding rainforests in the Amazon Basin get much attention but the small, remote montane areas tend to be forgotten by the scientific community. It is gratifying to Luna to help bring increased attention and to see that the recommendations she and others are making to locals in charge are making a difference in the lives of so many.

Luna was born in Peru. She spent half her life in the western side of the Andes on the Pacific coast and the other half near the Amazon River. Her mother was a biology student who taught her to dissect "every single critter around," starting with rabbits when she was three years old. She always knew she was going to be a zoologist.

In her three years of field work, Luna has discovered at least two new species of rodent in the high elevations, in addition to two she had previously discovered: *Rhagomys longilingua* ("long tongue," in Latin and Greek) in 2004 and *Thomasomys onkiro* ("mouse" in a native Peruvian language) in 2003. Another Andean mouse, *T. incanus,* is pictured here.

Luna graduates in June 2009. Down the road, she sees herself as a research mammalogist, working in an academic or conservation institution, but always affiliated with a natural history musuem.

"Museum collections often serve as the only scientific documentation of biodiversity, and these collections serve as the raw material for understanding the processes underlying the generation of biodiversity. Ensuring preservation of these important specimens for future generations is one of the great challenges in modern biology. I therefore retain a strong interest in museum curatorial work." She is also strongly committed to continuing her work in the Andean region.

E. Tibbetts

The EEB buzz:
Your alumni news online

Name _____

Degree _____ Class year _____

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Phone _____ E-mail_____

Employer and job title _____

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Prized pictures

EEB student and faculty photo contest winners

Zach Miller, EEB Ph.D. student, and a curious visitor. Photo: Kate Falk.

Professor Barry OConnor looking for mites in mice specimens under his microscope, Cutervo National Park, Cajamarca, Peru, ~3000 m. Photo: Lucía Luna.

Grasshopper atop a sunflower in the early morning. Photo: Former postdoctoral fellow Soochin Cho.

To view the 10 finalists visit:
http://www.eeb.lsa.umich.edu/eeb/graduates/photovideocontest-finalists.html

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