Study will parse evolutionary shift between life in water and on land

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Andrew Short searching for transitional-stage water beetles alongside a waterfall in the Andes. Credit: KU News Service

Occasionally, a crux of evolutionary success is summed up with the phrase "only the strong survive." But that's not right exactly. Really, it's a knack for rolling with changes that characterizes most thriving organisms.

Few changes are more radical than the transition from living in water to living on land—a species must rework how it breathes, moves, feeds and reproduces in the process. But creatures do manage to make this drastic shift from aquatic to terrestrial existence, and vice versa. Once upon a time, even ancestors of humans were likely to have made the daunting leap.

Now, with a $700,000 CAREER award from the National Science Foundation, a researcher at the University of Kansas' Biodiversity Institute will investigate how developments over time allow an organism to shift between water and land-based living. Andrew Short, assistant professor of ecology and evolutionary biology at KU, will analyze this phenomenon in South American water scavenger beetles—and in the process learn more about the mechanics of evolution itself.

"While many animals have shifted between aquatic and terrestrial habitats, what sets water scavenger beetles apart is that they have done it many times," Short said. "Most major groups only have one or a few transitions. It is roughly analogous to having done an experiment one time versus many times—you can't look for patterns if something only happened once. Because water-land transitions occurred more than a dozen times in this group, we can try to find common causes and effects."

The Faculty Early Career Development Program (CAREER) at the National Science Foundation is one of organization's most prestigious awards to junior faculty who excel in their role as teacher-scholars.

Short's team will trace the development of physical traits in the group of beetles called Hydrophilidae to pinpoint the number, timing and placement of habitat shifts and test for changes in diversification rate between habitat types. In the process, the researcher estimates he'll describe more than 100 species that will be new to science.

Crystal Maier of KU and Vanessa Kadosoe (University of Suriname) search for beetles in a wet rock surface in central Suriname. Credit: KU News Service

"We'll use both anatomical features and DNA sequences to reconstruct the evolutionary history of these beetles," Short said. "Using genomic

data is critical in cases where a group has a messy ecological history, as morphology may not accurately reflect evolutionary history. We pair that with the natural history of the species we are studying, to see what sequence of habitats a species might occupy as it moves from water to land. For example, our work has documented habitats like small waterfalls are likely serving as a stepping-stone between aquatic and terrestrial habitats. We'll also focus on features of the insect that closely track with the kind of habitat it lives in—such as leg adaptations for swimming."

Short said that land and water-based habitats each pose distinctive advantages and obstacles for adaptation, requiring total reconfiguration of the most essential of biological tasks.

"When we think of moving between water and land, the first and most obvious issue animals deal with is how to breathe," he said. "For example, some aquatic insects have effectively sealed their respiratory system and absorb oxygen directly from the water. This system is essentially non-functional in a dry environment. Similarly, just like us, terrestrial insects can't survive underwater unless they can keep water from getting into their trachea. But oxygen is just one thing. How insects move, eat and mate all differ between water and land and a lineage that jumps from one habitat to the other must adapt how it does all of these things."

Short's curiosity about species that jump the water-land divide was piqued as a student: "While I was working on my doctoral degree, I did some fieldwork on a mountaintop in Hawaii," he said. "At a single site, there were species of water scavenger beetle living in the streams, in the waterfalls, and in the trees. Even though they were very closely related, they didn't look anything alike. I became fascinated in how this group of beetles had colonized such radically different habitats in such a short period of time."

The new research should help clarify how species around the world might respond when faced with sweeping environmental instability tied to climate change.

Andrew Short and his field team from the University of Guyana and local indigenous communities search a rock seepage for beetles in the Kusad Mountains of Guyana. Credit: KU News Service

"One part of this project is to determine when in the past these habitat shifts occurred," Short said. "If many of the shifts occurred during the same period of time or during times with similar climatic conductions,

this may indicate that climate plays a significant role in facilitating water-land transitions. We will also be looking to see how fast these shifts can occur—for example, over 50,000 years or 5 million years—which will allow us to see how quickly animals can adapt to new or changing habitats."

Along with deepening the scientific understanding of evolutionary adaptation, Short's NSF CAREER award will fund several independent undergraduate research projects each year in his lab, as well as the work of two doctoral students.

Additionally, Short is developing a new undergraduate field course based on this work that will focus on biodiversity discovery and assessment.

Radicitus ayacucho, a new genus and species of transitional water beetle that Short's lab recently described from northern South America.

"Starting in 2016, I'll offer a course each spring semester that will teach the theory and practice of determining how many species live in a particular habitat or region," he said. "This includes a tropical field

expedition that will be conducted in South America and involve students from universities in Guyana and Suriname."

Researchers and students from the National Zoological Collection of Suriname and the University of Guyana will be partners in the project.

Provided by University of Kansas