Mini or massive? For turtles and tortoises, it all depends on where you live

February 2 2011, By Kim DeRose

Hawksbill sea turtle in the Caribbean. (Credit: Alexander Jaffe)

(PhysOrg.com) -- Biologists from the UCLA Division of Life Sciences have reported the first quantitative evidence for an evolutionary link between habitat and body size in turtles and tortoises.

The study, whose lead author is a high school student volunteer in the laboratory of UCLA evolutionary biologist Michael Alfaro, is currently available online in *Biology Letters*, a journal of the Royal Society. It will appear in a print edition later this year.

Turtles and tortoises, also called chelonians, represent a diverse group of reptiles that have been present on Earth for more than 200 million years. The 330 species of present-day chelonians can be found dwelling on

remote islands, traveling across vast expanses of ocean, and living in desert and freshwater habitats on every major continent.

Even more surprising than the wide variety of places animals call home is the vast disparity in their body sizes. The largest chelonians weigh over 1,000 pounds and are more than 6 feet in length, while the smallest weigh just a few ounces and would easily fit in the palm of your hand.

Combining statistical computer modeling with genetic data and the fossil record, Alfaro, an associate professor of ecology and evolutionary biology, and his colleagues demonstrated that different environments have specific optimal body sizes for their chelonian inhabitants.

These researchers act as "evolutionary detectives," piecing together how the tremendous diversity in living chelonians today evolved from a common ancestor that lived millions of years ago. DNA sequences from modern chelonians provide important clues for determining the evolutionary path followed by their progenitors, said co-author Graham Slater, a National Science Foundation–funded UCLA postdoctoral scholar in ecology and evolutionary biology.

The results show a surprisingly strong statistical correlation between habitat change and significant adjustments in body size. Chelonians living in marine or island habitats have an optimal body size several times larger than their cousins on the mainland, said first author Alexander Jaffe, a high school student at Harvard–Westlake School in North Hollywood, Calif. Marine turtles have the largest optimal shell length (about 4.5 feet), followed by island tortoises (approximately 2.5 feet), while freshwater and mainland chelonians are several times smaller (roughly 1 foot).

Evolutionary biologist have long assumed there is a connection between habitat and body size in chelonians, but it was not possible until recently

to show quantitative evidence for the relationship, Alfaro said.

Chelonians have had a special place in the history of evolutionary biology due to the attention given them in the writings of Charles Darwin, Alfaro said.

Giant island tortoises found in the Galapagos and Seychelles provide a classic example of "island gigantism," a well-observed phenomenon in which an island-dwelling species evolves to be much larger than its mainland counterparts. Because they provide uniquely isolated habitats, islands are regarded as natural experiments in evolutionary biology, according to Alfaro.

"Our study was focused on testing whether there was any evolutionary signal in support of the idea that being on islands allowed the tortoises to evolve large size," he said.

While it is clear that habitat is an important signal in the chelonian evolutionary tree, the specific ecological conditions that trigger the change in body size are more difficult to determine, Alfaro said.

One of the oldest groups of reptiles, marine chelonians such as early sea turtles might have fallen prey to giant seafaring Mesozoic reptiles, a situation which would make larger size a distinct advantage, Jaffe said. Larger size also plays a key role in maintaining body temperature and allowing for migration across considerable distances.

In the case of the giant tortoises, a larger body size gives them the ability to survive long periods without food, which may be necessary due to prolonged droughts that can occur in island habitats. Large body size also may allow giant tortoises to "raft" across vast expanses of ocean while going weeks without food, a feat documented through observations of giant tortoises with barnacle growth found on the mainland, Alfaro said.

"What is exceptional about chelonians is that they are one of the most distinctive groups of vertebrates, arose early in the history of terrestrial vertebrates, and persisted for a long time," Alfaro said. "Chelonians are good examples of evolutionary survivors."

The main goals of Alfaro's research group include studying the evolution of vertebrates and their subsequent diversity in shape, size and structure. This involves developing methods to identify time periods and locations on the tree of vertebrate life in which unusual amounts of species diversification have occurred, Alfaro said.

An 'incredible opportunity'

Jaffe, a senior at Harvard–Westlake School, started volunteering in Alfaro's laboratory when he was 16, after e-mailing Alfaro about his interest in conducting research. Jaffe spent almost 30 hours a week in the lab for two full summers and was able to turn his results into a first-authored paper — a feat rarely accomplished by high school students.

"Being part of this research group has been an incredible opportunity for me," Jaffe said. "I can't say how grateful I am. Not only did I learn the tools of the trade, especially in the lab, but also what it is like to start off with an abstract question and address it through data collection and interpretation."

Jaffe hopes to study biological sciences and pursue further research in college.

"Alexander was ready to take intellectual ownership of a project," Alfaro said. "In addition to being a very conscientious young scientist, Alexander really showed an interest in the questions that we are asking and in getting the data to answer those questions."

Provided by University of California Los Angeles