Some Animals Use Gas for Skeletal Support While Molting

May 3 2006

If otherwise healthy humans temporarily lost their skeletons, they could neither protect themselves nor move around. Millions of small animals, however, do lose their skeletons one or more times a year in a risky process known as molting. As arthropods grow, they must shed their tough outer shells, or exoskeletons, to have room to expand.

Working at the University of North Carolina at Chapel Hill, two researchers have now discovered how certain land crabs often survive this highly vulnerable state: The creatures use air in combination with internal fluids to increase pressure inside their bodies.

The higher internal forces create temporary turgidity, much like a child's balloon tightens before being inflated, and the crabs employ that pressure to move their legs and claws for several days until their newly secreted larger shells harden. After that, their exoskeletons can, in the usual way, resist muscle contractions, which thereby produce movement, the researchers said.

A report on the study appeared in April's issue of the journal *Nature*. Authors are Jennifer R.A. Taylor, a doctoral student in the UNC College of Arts and Sciences' department of biology; and her mentor, Dr. William M. Kier, professor and associate chairman of biology.

"To our knowledge, this is the first experimental evidence of a form of skeletal support that relies on a gas to allow movement," Taylor said. "Although we limited our experiments to blackback land crabs I collected in Puerto Rico, we think this could be widespread in insects as well as crustaceans that don't have the advantage of living in water."

In a 2003 cover story for the journal *Science*, Taylor and Kier published results of related tests done on blue crabs, which spend all of their lives in water. In that paper, the two described discovering a previously unrecognized and also likely widespread skeletal support mechanism. The aquatic crabs, rather than remaining flaccid, mostly immobile and almost completely defenseless after molting, switched to a water-based, or hydrostatic, skeleton.

Liquid pressures inside their legs and claws rose significantly higher in the days immediately following the molt than when a suit of protective armor encased the animals.

The new experiments had never been done before, Kier said. With them, the biologists showed with carefully attached force- and pressure-monitoring devices called transducers that internal air pressure in the blackback crab's stomach, claws and legs jumped following molting.

When they removed air from the animal's stomach, pressure declined there and in the claws as well. Measurements revealed that internal pressure corresponded closely with how much force the claws could exert in closing. Within a few days, readings dropped to usual levels.

"This reliance on gas by a land-based arthropod may be more than an adaptation resulting from the low water availability," said Taylor. "It may also be a biomechanical adaptation to the greater gravitational forces associated with life on land."

Kier called the work, which he said was largely Taylor's, "clever, exciting and beautiful."

"At this point, we don't know how widespread pneumohydrostatic skeletons are, but they indeed may have been crucial to the process by which marine animals escaped from the sea millions of years ago and came to live on land," he said.

The National Science Foundation and the Defense Advanced Research Projects Agency supported the UNC studies. The latter, also known as DARPA, has strong interest in exploring how biological principles can provide insights that might boost robotics and other forms of engineering.

Source: University of North Carolina at Chapel Hill