Marine pest provides advances in maritime anti-fouling and biomedicine

July 30 2014

Ph.D. candidate Beth Falwell prepares a sample. Credit: Clemson University

A team of biologists, led by Clemson University associate professor Andrew S. Mount, performed cutting-edge research on a marine pest

that will pave the way for novel anti-fouling paint for ships and boats and also improve bio-adhesives for medical and industrial applications.

The team's findings, published in *Nature Communications*, examined the last larval stage of barnacles that attaches to a wide variety of surfaces using highly versatile, natural, possibly polymeric material that acts as an underwater heavy-duty adhesive.

"In previous research, we were trying to understand how barnacle adhesives were interacting with surfaces of different chemistries," said Mount, an author on the journal article and founder and director of the Okeanos Research Laboratory in Clemson's department of biological sciences. "Most biofouling researchers assume that cyprid larval adhesive plaques are primarily composed of proteins and peptides, but we discovered that lipids are also present, which means that the composition of the permanent adhesive is far more complicated that previously realized."

The torpedo-shaped cyprid larvae is the last larval stage before the animal undergoes metamorphosis to become the familiar barnacle seen on pilings and jetties along the coast. Once the cyprid has found a potentially suitable spot, it cements itself permanently in place and then undergoes metamorphosis to become an adult calcareous barnacle.

In order to survive and reproduce, benthic—or bottom-dwelling—marine invertebrates like barnacles need to attach themselves in close proximity to each other. These organisms have evolved an array of adhesion mechanisms that allow them to attach virtually anywhere, including nuclear submarines, maritime ships and offshore drilling rigs, and even to animals like turtles and whales.

"The ability of barnacles to adhere to surfaces that have very different physical and chemical properties is unique and provides insight into the

unique physic-chemical properties of their larval adhesive," Mount said.

With funding from the Office of Naval Research, the researchers built a two-photon microscopy system and, in collaboration with Marcus Cicerone at the National Institute of Standards and Technology, employed his innovative technique known as Broadband Coherent Anti-Stokes Raman Scattering to delineate the two different phases of the barnacle cyprid adhesive plaque.

"Using these techniques, we found that the permanent adhesive is made up of two phases: a lipid phase and a protein phase," said Mount. "The lipid phase is released first. We believe that this lipid phase protects the protein phase from excess hydration and the damaging effects of seawater, and it may limit the protein phase from spreading too thin and losing its ability to securely adhere the larvae to a surface."

This is the first finding of functional roles of lipids in marine bioadhesives.

"The application of both two-photon microscopy and broadband coherent anti-Stokes Raman scattering clearly demonstrated the role of lipids, which we traced back to the cement glands and showed that they are produced and contained in a separate subsets of cells," he said.

The researchers' renewed understanding of barnacle cyprid adhesives will advance anti-fouling coatings for the maritime industry in the years to come and help develop a new class of bio-adhesives for medical and industrial applications.

More information: *Nature Communications* 5, Article number: 4414. DOI: 10.1038/ncomms5414

Provided by Clemson University