Secrets of water bug wings shed light on heart beats

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A research, led by R.J. Perz-Edwards, Ph.D., of Duke University Medical Center, explains how insect flight muscle works, in particular how insects accomplish something called 'stretch activation,' which has been a scientific mystery for more than 60 years.

The findings are important because ALL striated muscles (which includes heart muscle and skeletal muscle) exhibit stretch activation to varying degrees.

"It's most strongly developed in insect flight muscle, but is also prominent in cardiac muscle, where it probably underlies something called the Frank-Starling Law of the heart – this basically says the more blood that fills your heart during diastole, the harder your heart squeezes to eject the blood," Perz-Edwards said. "Our finding of a molecular tether in a giant water bug potentially offers a new paradigm for understanding stretch activation in other muscles like cardiac muscle."

The team collected real-time X-ray diffraction 'movies' of the insect muscles as they cyclically stretched and released them to mimic their in-flight behavior. The changing patterns in the movies reflect molecular changes in the muscles as they respond to the stretch and contract. From the changes in the movies, the group deduced a new molecular mechanism for stretch activation, which involves a familiar muscle protein used in an unusual way.

"We found there are molecular tethers, which we call ‘troponin bridges’

that literally pull another molecule, called tropomyosin, out of the way when the muscle is stretched," said lead researcher R.J. Perz-Edwards, a lab research analyst in the Duke Department of Cell Biology. "Without the stretch, the motor protein, which is called myosin, can't reach its partner, called actin, to do the muscle's business of contracting because the tropomyosin physically blocks it. But with the stretch the troponin bridges tug the tropomyosin aside and let the muscle contract."

More information: www.pnas.org/cgi/doi/10.1073/pnas.1014599107

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