Researchers find that clasper development in male skates is controlled by hormonal regulation of the Shh pathway

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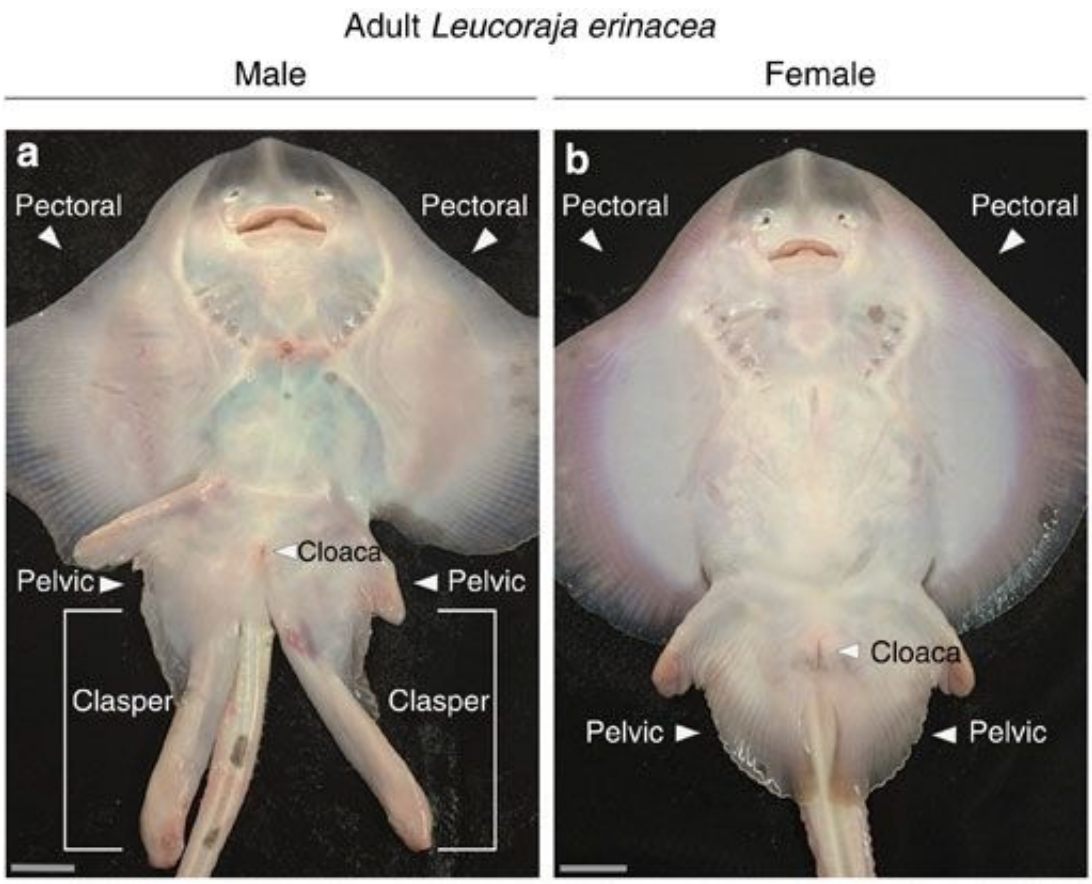

Morphology and development of L. erinacea claspers. Credit: *Nature Communications* 6, Article number: 6698 doi:10.1038/ncomms7698

(Phys.org)—A small team of researchers with affiliations to the

University of Florida and Howard Hughes Medical Institute has found that clasper development in skates is controlled by hormones that regulate the Sonic hedgehog (Shh) pathway. In their paper published in the journal *Nature Communications*, the team describes how they studied early development in skates which led to their discovery.

Scientists believe that one of the earliest developments of copulatory organs are claspers—penis-like structures that tend to grow in pairs off of fins and are used to deliver sperm through tubes to females. They still exist in modern creatures such as sharks and skates, though scientists do not know still why they grow in pairs, as only one is needed for reproduction. In this new effort the researchers wanted to better understand how the creatures might have evolved such organs and what mechanism controls their growth. To find out, they incubated several specimen skate eggs and then raised the hatchlings, noting in particular the time period during which the claspers emerged.

The researchers found that the claspers tended to develop during the late stages of pelvic development, which allowed for zeroing in on what was instigating their growth. They found that it was tied to a genetic circuit (gene) called the Sonic hedgehog pathway, aka, Shh—which prior research has shown drives appendage development in vertebrates, including humans. As it turned out, the Shh remained active longer in males than in females. Suppressing the Shh in males caused limited development in males, and forcing it to remain active in females caused claspers to grow. They also found two other genes Hoxd13 and Hand2 played a role in activating the Shh network. Continuing their research, they discovered that it was the presence of androgen that kept the Shh network running longer in males than in females—it was specifically found to regulate the Hand2 gene. Thus, the researchers conclude, at some point as the skates (and other chondrichthyans) were evolving, sex hormones became the predominant means by which appendage development could be instigated. They suggest the same sort of

mechanism might be at play in other organisms, including penis development in vertebrates.

More information: Molecular development of chondrichthyan claspers and the evolution of copulatory organs, *Nature Communications* 6, Article number: 6698 DOI: 10.1038/ncomms7698

Abstract

The earliest known vertebrate copulatory organs are claspers, paired penis-like structures that are associated with evolution of internal fertilization and viviparity in Devonian placoderms. Today, only male chondrichthyans possess claspers, which extend from posterior pelvic fins and function as intromittent organs. Here we report that clasper development from pelvic fins of male skates is controlled by hormonal regulation of the Sonic hedgehog (Shh) pathway. We show that Shh signalling is necessary for male clasper development and is sufficient to induce clasper cartilages in females. Androgen receptor (AR) controls the male-specific pattern of Shh in pelvic fins by regulation of Hand2. We identify an androgen response element (ARE) in the Hand2 locus and present biochemical evidence that AR can directly bind the Hand2 ARE. Together, our results suggest that the genetic circuit for appendage development evolved an androgen regulatory input, which prolonged signalling activity and drove clasper skeletogenesis in male fins.