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Science: Curiously Square Seahorse Tail Could Inspire Engineering Advances

The tail’s odd shape offers a rare combination of control and flexibility that could prove useful in robotics, defense systems, or biomedicine.

1 July 2015 Meagan Phelan

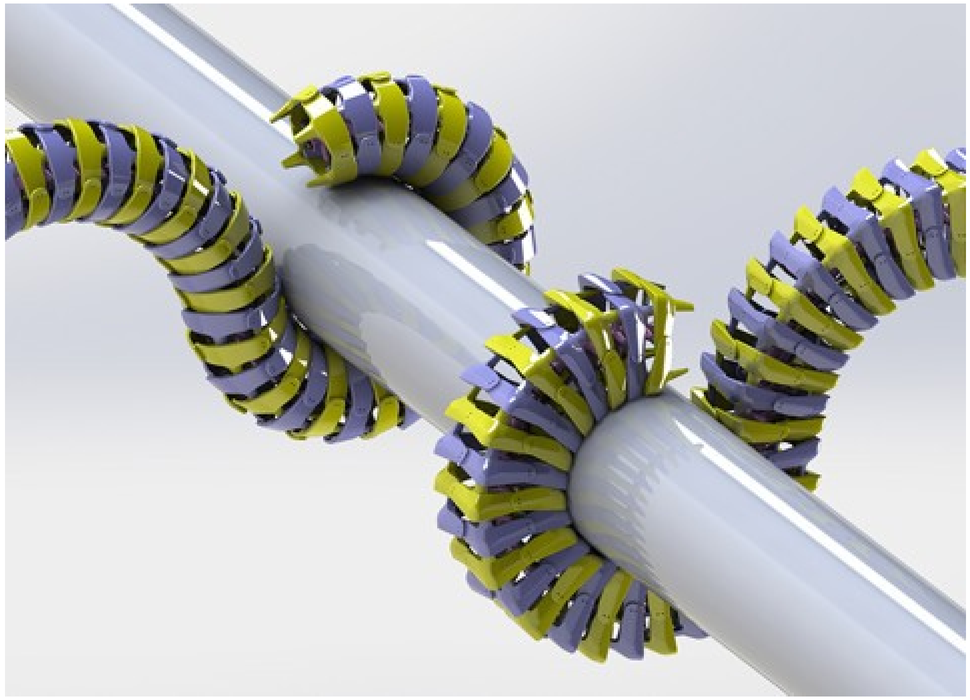
BEING SQUARE HAS ITS ADVANTAGES: THE SHAPE OF THE SEAHORSE TAIL GIVES IT A STRONG GRASPING SHAPE, RESEARCHERS SAY. | FLICKR/AUDDESS (HTTPS://WWW.FLICKR.COM/PHOTOS/AUDDESS/3430319483)/ CC BY-NC 2.0 (HTTPS://CREATIVECOMMONS.ORG/LICENSES/BY-NC/2.0/)

The seahorse tail is square because this shape is better at resisting damage and at grasping than a circular tail would be, a new engineering study (http://www.sciencemag.org/lookup/doi/10.1126/science.aaa6683) published in the 3 July issue of the journal *Science* shows. Insights from the study could inspire advances in robotics, defense systems, or biomedicine, the authors say, teaching engineers how to build devices that are both flexible and strong.

"Human engineers tend to build things that are stiff so they can be controlled easily," said Ross Hatton, an assistant professor in the College of Engineering at Oregon State University, and a co-author on the study. "But nature makes things just strong enough not to break, and then flexible enough to do a wide range of tasks...we can learn a lot from animals that will inspire the next generations of robotics."

While animals such as certain monkeys, lizards, and rodents have soft, cylindrical-shaped tails, the tails of seahorses are organized into square prisms surrounded by bony plates.

"While there may have been some speculation that the shape of the seahorse tail allows the animals to grasp objects more tightly, past research has concentrated more on how the tail's complex musculoskeletal organization, not its shape, affects grasping," said co-author Dominique Adriaens, a professor in the department of evolutionary morphology at Ghent University in Belgium.



THE SQUARE PRISMS OF THE SEAHORSE TAIL (MODELED HERE) PROVIDE MORE SURFACE CONTACT THAN A CYLINDRICAL TAIL MODEL WHEN GRIPPING AN OBJECT. | MICHAEL M. PORTER, CLEMSON UNIVERSITY

To better understand why the seahorse tail deviates from the norm, and what mechanical advantages its curious shape might confer, researchers led by Michael Porter, an assistant professor in the department of mechanical engineering at Clemson University, created a 3D-printed model of the tail that was roughly the size of a soda can, as well as a hypothetical cylindrical version.

The researchers then twisted both models, and hit them with rubber mallets. They found that the square tail shape conveys several advantages compared to its round counterpart.

First, it is more resistant to twisting, better able to return to its natural alignment. This may help protect the animal's delicate spinal cord when it's snatched up by predators, the authors say. The tail's speedy return to its natural shape could also help the seahorse evade predators, snapping the animal back into place close to the reef or seaweed to which it clung as it waited for food.

The outer surfaces of the square tail increase contact area when the tail wraps around an object, the researchers' study further revealed, giving the seahorse better grasping control.

Finally, the square version of the tail is also more resilient, not deforming as drastically as its round counterpart under the same amount of compression.

"When we compressed the 3D-printed models and compared their behavior to solid rings," Porter said, "we found that seahorse tails have joints at the exact locations where the solid rings fail under crushing loads. These [gliding joints] allows the square tail structures to absorb more energy on impact."

THE LINED SEAHORSE (*HIPPOCAMPUS ERECTUS*) USES ITS UNIQUELY FLEXIBLE TAIL TO GRASP A DOWEL. | DOMINIQUE ADRIAENS, UGENT

The seahorse tail's unique traits could inspire applications that require strength, but also the ability to bend and twist in tight spaces. Such applications include search-and-rescue robots, drill sheaths for gas and oil exploration, flexible body armor, motion-assisted human exoskeletons for the military or disabled persons, and medical devices such as those for laparoscopic surgery, in which a slim robotic arm enters the body, twists and turns to navigates organs and bones, and accomplishes a surgical task.

"The plated armor would allow the seahorse-inspired devices to be more lightweight and flexible than traditional hard robots," Porter said, "and more robust and resistant to failure than soft robots."

Porter said his research group at Clemson University is now applying similar methods to develop new structures and robotic systems that mimic a variety of other natural systems.