Remoras don't suck

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Nurse shark Ginglymostoma cirratum with remoras Remora sp. Bimini, The Bahamas. Credit: Wikipedia/GFDL

How does the hitchhiking, flat-headed remora fish attach to surfaces so securely yet release so easily? Suction was thought to be the easy answer, but Brooke Flammang, a biologist at the New Jersey Institute of Technology (NJIT), has proved this long-held conclusion to be only partly true.

Researchers have long studied animals like tree frogs, geckos, and spiders for their adhesive abilities, but what makes remoras unique in this group is they combine three key elements: the ability to securely fasten themselves for long periods of time; attach to different types of surfaces; release quickly without harming the surface.

Understanding the mechanics of this process could help researchers and engineers create or improve designs for any number of devices that need to stick well but then release quickly without harming the host, such as tags for tracking endangered species or bandages that really don't hurt when you pull them off.

Using footage captured by GoPro cameras at SeaWorld's Discovery Cove in Orlando, Flammang and NJIT researchers found that the adhesive disc on the remora's head used to attach to sharks, rays and other pelagic hosts is actually a complex mechanism that includes a modified fin structure with teeny spikes (called lamellar spinules) that generate friction to adhere to the host. Remora head anatomy also differs from other fish in having unusually-structured blood vessels that may be the secret to how they maintain adhesion for hours at a time.

What intrigued Flammang, who studies the locomotion of fishes, integrating sensory biology, physiology, fluid dynamics, and bio-inspired robotics, is how remoras can alter the position and shape of the plates within the disc to change their position or quickly let go. She was able to observe the minute movements of remora disc components through the underwater footage provided by marine videographers.

"Remoras attach to other organisms for a variety of reasons: To find food, get protection, and find mates. Because the animals they attach to are powerful swimmers, they need a durable attachment that won't be compromised by the host organism's swimming, bending body. The adhesive disc the remora evolved from dorsal fin elements acts as a

specialized suction cup that can bend and won't slip," Flammang said.

"We are applying the biomechanics of this mechanism to a robotic prototype that will be able to adhere to both rough and smooth surfaces through a variety of challenging conditions, both in water and air," she said.

Flammang presented her research at the Society for Integrative and Comparative Biology's annual conference in January.

"We have a lot to learn from the natural world. Being able to examine these animals up close can be very valuable to bioengineering. We are proud to support this important work," added SeaWorld Parks & Entertainment's Vice President of Research and Science, Dr. Judy St. Leger.

"In my lab at NJIT, we study the morphology of remoras, how they use muscular and vascular control to manipulate the disc for attachment on different surfaces, and the hydrodynamics of their approach, attachment, and release from a surface," Flammang said. "Live remoras swim in our flow tank - a treadmill for fish - and we capture muscle activity recordings and high speed video of the fish swimming and attaching, as well as and the fluid moving around the fish and the attachment location."

More broadly, she examines the way organisms interact with marine and aquatic environments and drive the evolutionary selection of morphology and function. She seeks to understand, for example, how different fish fins may give an advantage to certain species in a given habitat.

The two remoras (Echeneis naucrates) at SeaWorld's Discovery Cove were valuable candidates for this study because they often attach themselves to a large acrylic panel that divides their dock-themed habitat

from the park's Grand Reef, a nearly 1million gallon tropical environment. Aquarists at Discovery Cove donned scuba gear to capture the underwater footage using a GoPro camera steadied with a suction cup arm to get the shots needed by the research team. Flammang and her colleagues then used mathematical algorithms to visualize motion that is not detected by the human eye.

"The mission of SeaWorld's Discovery Cove is to educate and entertain our guests so they are inspired to conserve our oceans and the animals that reside there by giving them an opportunity to interact with our animals in naturalistic, immersive environments," said Denise Swider, Assistant Curator at SeaWorld. "An added benefit to housing our animals in these unique environments is that our aquarists are able to have closer access to the fish for research purposes. Our team is very excited about the opportunity to be part of this groundbreaking research on such an intriguing fish."

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