© 2023. Published by The Company of Biologists Ltd | Journal of Experimental Biology (2023) 226, jeb245982. doi:10.1242/jeb.245982

INSIDE JEB

Streamlining allows fan worms to make a speedy retreat

A *Sabellastarte magnifica* fan worm in an aquarium. Photo credit: Wei Jiang.

Home building is an honourable tradition. Termites construct mounds, birds weave nests and fan worms secrete tubes in which they reside, protruding their feathery tentacles from the top to breathe and dine. Yet, when startled, the diaphanous worms retract almost instantaneously into the security of their homes. Impressed by the worm's high-speed manoeuvre, Zhao Pan (University of Waterloo, Canada), Zhigang Wu and Jianing Wu (Sun Yat-Sen University, China) were curious how the frilly creatures retreat so fast without damaging their delicate tentacles, but first they had to figure out how to see the enclosed worms in action.

'The fast speed and the fact that the tube is not see-through make it hard to understand what happens', says Jianing Wu. However, Michael Bok (University of Lund, Sweden) knew that the worms can relocate if their home is no longer adequate; could the team rehome the worms in transparent glass tubes to get a better view? Collecting six species of fan worm from an aquarium shop in Zhangzhou, Fujian, China, Wei Jiang and Yu Sun (Sun Yat-Sen University) snipped the worms' tubes off at the base and gently squeezed the animals out before offering them a glass tube to crawl into. Once the worms had settled in, Jiang and Sun filmed the animals as they extended their bodies 2–3 times their usual length, contentedly unfurling their tentacles. Then, they startled the worms with a sudden squirt of water.

Impressively, the worms pulled their tentacles in at speeds of up to ~400 mm s^{-1} – faster for their size than the speediest fish in the sea – retracting entirely within 76 ms. But how did the worms power their extraordinary withdrawals? Jiang and Sun measured the quantity of the muscles running along the length of the animals' bodies, which contract when pulling the tentacles to safety, and realised that on average the muscles comprise 43% of the worm's trunk, compared with just 29% for a regular worm, producing contraction forces 36 times stronger than their own body weight. So, fan worms have the muscle mass and power to pull their tentacles to safety in the blink of an eye, but how do the animals protect their fluffy tentacles from destruction when yanked so forcibly?

Filming the tentacles with a high-speed camera (3200 frames s^{-1}), Jiang and Sun saw the barbule-like structures (pinnules), which give the tentacles their feathery appearance when fluffed out, collapse in toward the tentacle until it looked like a stripped feather. Only then did the worms begin to pull their limbs to safety. The pair then calculated how the pinnules' collapse affected how strongly the water dragged on a tentacle, realising that the drag forces were reduced by almost 50% when the pinnules lay flat. In addition, the team discovered that the smooth tentacles would carry 75% less water than when fluffed out, allowing the worm to retract them more efficiently.

The team also noticed pronounced circular ridges running around the circumference of the worm's body when fully extended, which squashed flat as the worm retreated inside its glass tube. Calculating the impact of losing the ridges on the worm's friction while withdrawing into the tube, the team found that the friction was decreased by 89% within the first 7 ms of the manoeuvre, allowing the body to slide almost effortlessly past the tube walls.

Pan and JianingWu say, 'These strategies allow fan worms to execute rapid escape responses', protecting their frond-like tentacles from hungry fish – and they are optimistic that streamlined fan worms could inspire the next generation of robots designed to clean pipes.

10.1242/jeb.245982

Jiang, W., Sun, Y., Wu, Z., Pan, Z., Bok, M. J. and Wu, J. (2023). Rapid manoeuvre of fan worms (Annelida: Sabellidae) through tubes. *J. Exp. Biol.* **226**, jeb245731. doi:10.1242/jeb.245731

Kathryn Knight
kathryn.knight@biologists.com

Inside JEB highlights the key developments in Journal of Experimental Biology. Written by science journalists, each short report gives the inside view of the science in JEB.