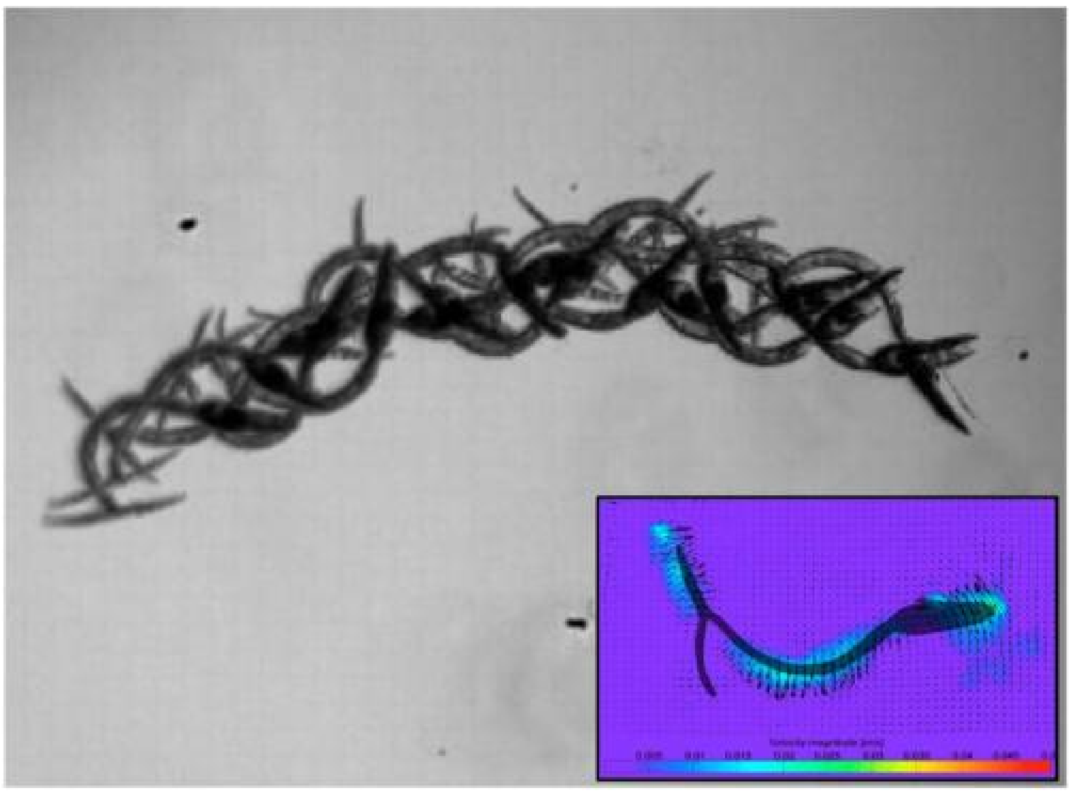
Tropical parasite uses swim stroke not shared by any other creature

November 25 2014



Infectious Cercariae filmed at high speed as the parasite moves from "right to left" in T-swimming modality, with the visualized surrounding flow field.

For many bacteria and parasites looking to get a load of the fresh nutritional bounty inside your body, the skin is the first and most important gatekeeper. Schistosomas, however, scoff at this barrier and burrow right on through.

These waterborne blood flukes, which are responsible for nearly 200,000 annual deaths and 200 million total worldwide cases of Schistosomiasis, are driven by the powerful thrusts of their unique forked tails and chewing enzymes. The parasite's swimming patterns are crucial for its human-seeking chemotactic activity - and are the focus of researchers at Stanford University who ultimately seek to break the chain of infection.

Manu Prakash, an assistant professor at Stanford University, will present his research on the parasite's 'T-joint' swimming patterns at the upcoming 67th Annual Meeting of the American Physical Society's Division of Fluid Dynamics in San Francisco.

Prakash's lab work runs the gamut from small-scale problems to field work. The researchers at Stanford were puzzled, however, when they filmed the parasite swimming at high speeds.

Cercaria, the free-swimming form of schistosoma, gets around by beating its forked tail back and forth. According to mathematical theories developed over the past 50 years, this reciprocal beating at small scales shouldn't enable cercaria to move at all, but merely bob in place, essentially treading water.

Similar aquatic biological creatures have struggled to break this mathematical locomotive paradox by varying their tail strokes to beat in non-symmetric cycles at small scales. For schistosomas, innovation comes from their unusual forked tail, which forms a "T-shape" joint. This passive torsional joint interacts with the fluid in surprising ways to break this time-varying symmetry—hence the researchers call this a T-joint swimmer. Such a simple way to break this symmetry had never been seen before, Prakash noted.

In addition to utilizing this method to swim tail first, cercariae can also switch their swimming direction in a single stroke. They are remarkably efficient swimmers, and they have to be—cercariae lack a mouth, and so must rely on finite energy reserves while swimming between snail and human hosts.

"The hypothesis that we're trying to test is that these two modes, forwards and backward might actually be designed for specific functions related to the task at hand," Prakash said. "We are trying to identify if these swimming strokes have different functions—one designed for swimming fast, and another one for actually generating high forces."

Once the researchers determine this, they can consider ways to block infection by interfering with the schistosomes' ability to find human hosts.

"If we understand the chemotactic machinery of this organism well—where are the sensory neurons, how does it couple to its swimming behavior, how does it couple to its muscles—there are lots of small molecules that we can use to really interfere directly," Praskash said.

In order to enter a human's skin, a schistosome has to generate a great deal of force." It's almost like a motor that's designed to operate at stall forces," Prakash said. "It can produce very high forces while it's not physically actually moving, so there are all these fascinating questions that are connected—why would a system evolve like this?"

Recently, Prakash and his collaborators have been running validation trials for schistosomiasis diagnosis in Ghana, one of many regions in which the parasite is endemic, and intend to start another test field site in Burkina Faso. His lab focuses on both organismic biophysics and what he calls 'frugal science'—a prime example of which is Prakash's innovative 'foldscope,' a 50-cent microscope made out of a foldable sheet of paper.

"Our big picture goal is to really democratize scientific tools and make them very broadly available to people, so we build and design innovative tools, and then we give them to people to explore the world around them," Prakash said. In 2012, Prakash received a $100,000 grant from the Gates Foundation for his work on the foldscope. His TED talk on the microscope in that same year has currently been viewed more than 1.2 million times.

Prakash hopes to bring his frugal science approach into the scope of his schistosomiasis research by studying the same cercariae swimmers out in the field—ideally a pond—in order to identify what methods the schistosomes use to find humans in complex environments.

Future research for Prakash, his graduate student Deepak Krishnamurthy and the rest of the group involves perturbing the fluke's chemotactic ability to identify human hosts after emerging from a snail—thus breaking the cycle of infection.

More information: meetings.aps.org/Meeting/DFD14/Session/M6.3

Provided by American Physical Society