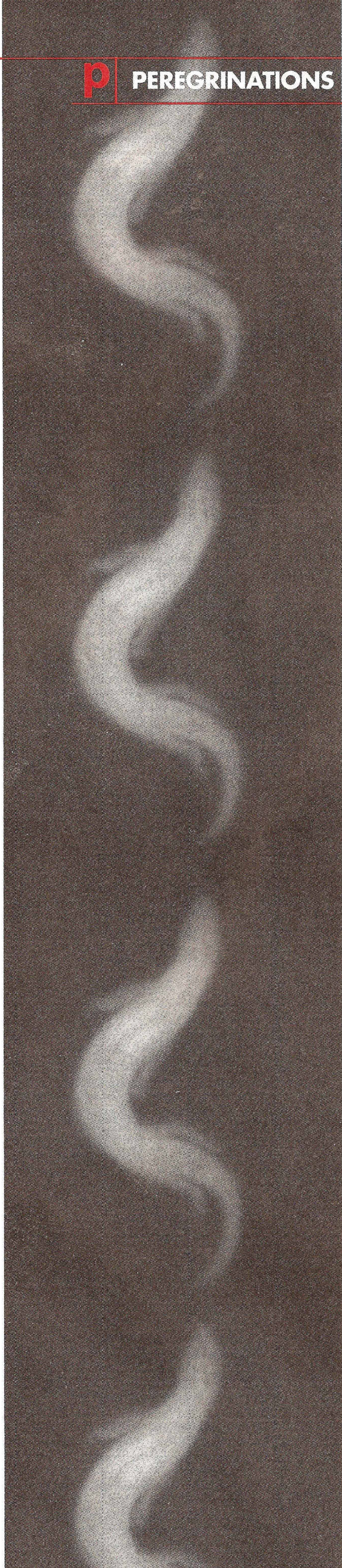
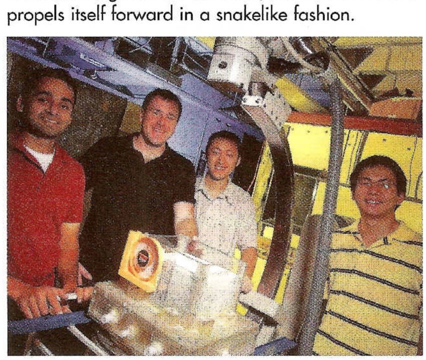


Sandfish lizards do the locomotion

Physicists, biologists, mathematicians and engineers have formulas to characterize movement over hard ground, but they still have much to learn about locomotion over more fluid surfaces, such as sand or mud. To find out more, physicists at Georgia Institute of Technology in Atlanta have studied various animals that "swim" in sand, such as the aptly named sandfish lizard (*Scincus scincus*), a species of skink.

"We would like to understand how biological organisms interact with media with complex physics to gain understanding of this part of biology," said Daniel I. Goldman. He was the lead researcher of a study published in the July 17, 2009, issue of *Science* that explored how sandfish lizards propel themselves forward while moving beneath the sand's surface.

Shown at left is an x-ray image of a sandfish lizard moving beneath the surface of granular media. When moving beneath the sand, the sandfish lizard propels itself forward in a snakelike fashion.



Researchers (from left) Ryan D. Maladen, Daniel I. Goldman, Yang Ding and Chen Li surround the high-speed x-ray imaging system they used to study the dynamics of motion over fluid substances. A container with glass beads resembling sand is in the foreground, and an x-ray source and visible light camera are seen at top. An x-ray camera, below, is not shown. Georgia Tech photos by Gary Meek.

The experimental apparatus consisted of a transparent container measuring 21.5 × 18 cm filled with spherical glass beads – approximating sand – 10 cm deep. Tiny holes on the bottom allowed air to be blown in, thus varying the beads' volume fraction, or density. The clear box was positioned between an x-ray source and a high-speed visible light video camera above and a high-speed x-ray video camera below. Both cameras operate at 250 fps.

After the sandfish was released from an adjacent holding pen, it dived into the container, guided to a particular location by a Plexiglas barrier. By using synchronized x-ray and visible light videos, the researchers studied the parameters of the sandfish's movement. Natural markers visible to x-rays, as well as opaque markers attached to the back and limbs, enabled the investigators to identify the animal's midline and to track it with Matlab software. The weight of the markers, 0.04 g, was much less than the sandfish's average weight of 16 g.

Contrary to a previous study of the sandfish lizard using nuclear magnetic resonance, published in 2008, this investigation found that sandfish do not use their limbs for locomotion beneath the sand. Instead, they use their entire body to propel themselves forward in a snakelike motion.

Regarding the discrepancy, Goldman speculates that container size might be the key. "In our x-ray studies, we have observed that, when the container size is just a little larger than the animal, or the animal is close to a solid surface, it will use its limbs." The team was a bit surprised to find that the volume fraction does not determine the sandfish's travel speed.

Goldman is uncertain why the high-speed x-ray method was not used before, but because of the temporal and spatial resolution of the device and the relatively low cost, his team will continue using the technique. Results of the study may specifically benefit the researchers' goal to build a robot that can move over and within sand, mud or rubble.

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