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News

Finding the best foot forward

Why a lizard makes it across sand when geckos have more trouble.

Rachel Courtland

Zebra-tailed lizards run across sand at an impressive clip, barely losing speed as the sand gets soft. The gecko is not so lucky; for it, soft sand makes for a hard trudge. Now researchers say the physics behind both animals' movements may be fairly simple.

The large feet of zebra-tailed lizards may help them navigate shifting sands.

D. Goldman

"We think we've discovered a rule that can predict, just from the size of an animal's foot and its mass, how much speed it will lose as we change the material," says Daniel Goldman, a physicist at the Georgia Institute of Technology in Atlanta.

This unifying behaviour could help illuminate the physics of granular systems, about which scientists know surprisingly little. "We still don't understand what happens when we drop a disk or sphere into sand," says Goldman, who presented the results this week in New Orleans at a meeting of the American Physical Society.

The findings could one day help in designing better robots, for planetary exploration or other purposes.

That sinking feeling

"Most swimming problems have been studied in the context of water," notes Arshad Kudrolli of Clark University in Worcester, Massachusetts. Goldman "pushes that boundary in exciting ways, by considering how animals propel themselves on complex surfaces."

To study sand-walking behaviour, Goldman tracked the walking abilities of the Bibron's gecko (*Pachydactylus bibroni*), the ghost crab (*Ocypode quadrata*) and three different lizard species in a bed of glass beads that approximated sand. By varying air flow through the bed, the researchers could change the resistance of the 'sand'. At high enough air flows, the glass spheres started behaving more like a fluid than a solid.

When set to run in the bed, both the crab and gecko encountered trouble in the softer sand. Whereas the gecko moved at a speedy 1.2 metres per second on strongly-packed sand, its feet sank when it was near the fluid limit, so that it crawled along at only half its top speed (see **video** (http://www.nature.com/nature/newsvideo/gecko_10x.wmv) - works best in Internet Explorer, and save to your hard drive then play for best results).

The zebra-tailed lizard (*Callisaurus drachonoides*), however, barely slowed as the sand got soft. Although its speed dropped from 2 metres per second to 1.5 metres per second when moving from hard-packed ground to sand, softening the sand further made no difference in the lizard's speed.

Exactly why the lizards fared better is unclear. "To the eye, there doesn't seem to be a difference in gait," says Goldman. Comparing the properties of the sand with the speed of each animal, he found that the ease with which an animal can move across sand seems to scale as the square root of the area of the foot. "Length matters," says Goldman — and so zebra-tailed lizards, which boast long, jointed toes, have the advantage over the gecko.

Mechanized models

Goldman, however, is not convinced the lizard's success is entirely due to toe length. Other factors — such as the angle of the foot, the length of the stride, and the speed of the stride — may also play a role.

To test these variables, Goldman collaborated with Daniel Koditschek at the University of Pennsylvania in Philadelphia to test robot motion in a larger sand bed, filled with poppy seeds and aerated by leaf blowers.

The kinematics of moving in sand proved to be far more difficult than expected. "In our first experiment, we put the robot in and it went absolutely nowhere," says Goldman.

Eventually the team hit on an algorithm that worked: alternating between slow movement when the robot's feet were in contact with sand and quick movement when they were free (see **video** (http://www.nature.com/nature/newsvideo/sandbot.wmv)). Strangely, the faster the robot was constrained to rotate its feet, the less success it had in softer sand — suggesting that the motion was more complex than they originally expected.

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