Snake bellies help scientists get a grip

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A brown tree snake moving on a smooth artificial branch.

For many of us, the bodies of moving snakes look like little more than wiggly strands of spaghetti.

However, Bruce Jayne, University of Cincinnati professor of biology in the McMicken College of Art and Sciences, sees a wide variety of anatomy and behavior that allows diverse snake species to crawl and climb almost anywhere, including tree branches with variable bark texture.

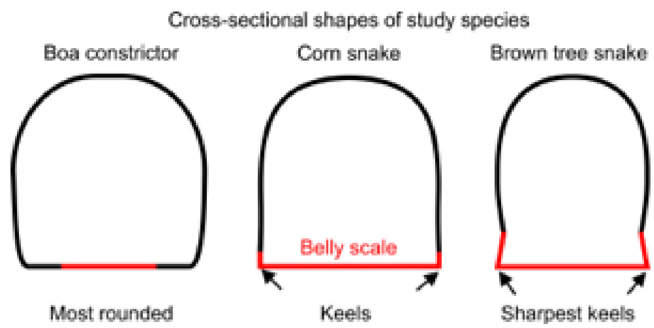
Using three different species to test their tree-worthy talents, Jayne and his students studied stout and heavy boa constrictors, medium-weight corn snakes and the slender and agile brown tree snakes.

Unlike most snakes that have a nearly circular cross sectional shape, Jayne found that brown tree snakes look more like a loaf of bread where the top is rounded but the bottom has corners—called keels—where the skin on either side of the belly is folded. He says these sharply contoured keels are the key for how various tree snakes can exploit subtle nooks and crannies in tree bark to prevent slipping, and propel themselves up a tree quickly, making it easier to get to their prey in a flash with less effort. To a smaller extent corn snakes have this shape, and boa constrictors were the roundest species that Jayne studied.

Acquiring a better understanding for how flat-bellied species like the brown tree snakes lodge their keeled ridge against protrusions and secure themselves in place during climbing could help lead Jayne and others toward many practical applications for biology, mechanics and engineering.

In a featured article in the December issue of the prestigious *Journal of Experimental Biology*, "Why arboreal snakes should not be cylindrical: body shape, incline and surface roughness have interactive effects on locomotion," Jayne shows the gripping advantages of sharper snake-belly keels for more efficient climbing.

Depending on the snakes' shape and behavior, Jayne discovered that variations in surface structure can have interactive effects on their speed and type of locomotion.



Schematic illustration of snake shapes

Taking Serpents To Task

The bark on different species of trees may be nearly smooth or have ridges of considerable height on natural branches. Therefore, Jayne simulated some of this variety of natural branches by using cylinders that were smooth or had pegs interspersed ranging in heights from 1 to 40 mm. He also varied the steepness of his artificial branches.

"Our most notable finding is how the keel helps to prevent slipping and can allow snakes to use a type of crawling that not only is fast but also probably saves energy," says Jayne. "This becomes more important as the surface steepness increases. For example, the brown tree snakes were able to climb straight up a vertical cylinder by only pushing against pegs that were a mere 1 mm high."

Jayne also found how uniquely snakes can cope with different structures in their environment by modifying their behavior. For example, on the steep smooth cylinders that lacked any pegs, all three snake species had an accordion-like movement as S-shaped portions of the snake periodically stopped and squeezed the cylinder while another region of the body was straightened and extended uphill. By contrast, when the pegs were tall enough to prevent slipping and the inclines were shallow, all of the snakes were very adept at balancing and sliding as they pushed against the pegs to propel themselves.

While analyzing the different climbing techniques, Jayne observed that the effects of habitat structure on behavior and speed varied among the different snake species. For example, the boa constrictors and corn snakes were more likely to plod along and grip the pole with the concertina-like motion, whereas for a much wider range of inclines and surface texture the brown tree snakes commonly used seemingly effortless sinuous undulations to slide along the artificial branches.

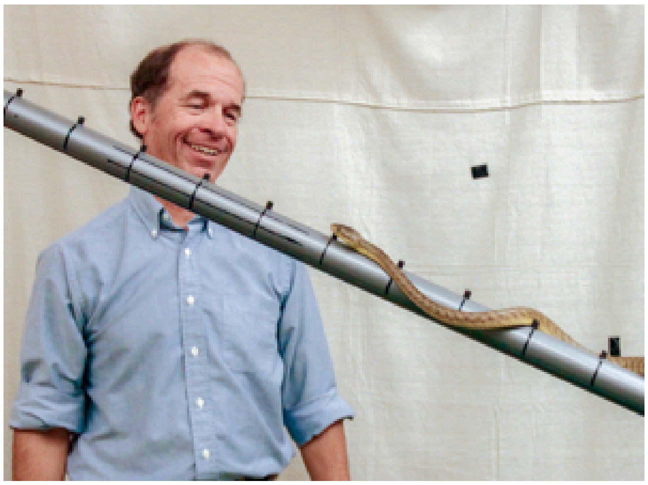
Let The Games Begin

In these snake Olympics to determine the fastest speed, the brown tree snakes were always the gold medalists. Both of the other two species won silver depending on the steep angle and degree of rough surface texture.

Although boa constrictors were slowpokes compared to the corn snakes when pegs were present, the boas had such incredible strength that they were better at gripping and steadily climbing some of the steep surfaces on which the corn snakes failed to make any progress.

"By understanding what allows (brown tree snakes) to move so quickly and efficiently up vertical obstacles, we can hopefully design unfriendly surfaces to prevent invasive species like the brown tree snakes in Guam from getting into areas where they are causing harm," Jayne says.

Jayne says brown tree snakes are not indigenous to Guam, but were probably introduced by cargo ships during and after World War II. Because there are no natural predators to keep the snake numbers in check, they have devastated the native bird species and small mammals. They also have caused great economic damage by gaining access to power lines and creating power outages by short-circuiting those power lines.



Bruce Jayne demonstrates a brown tree snake's rapid climb using its sharp keels on a pole with 10 mm pegs.

On closer inspection, Jayne says that in most cases the snakes didn't actually climb up the utility poles that hold the power line, but rather the guy wires that support them.

Through this research, Jayne hopes to develop a sleeve that can be placed over the guy wire that has the right diameter and surface texture so that it is impassable to the snakes, therefore preventing further power outages. Variations of this application may also prevent the snakes from gaining access to bird nests or to ships via the ropes that secure them to docks.

Jayne's prior interdisciplinary efforts have also included collaboration with engineers to help develop robots using bio-inspired designs. Using snake behavior and shapes can help improve robotic designs such as camera-equipped snake-like robots that can climb flagpoles, up inside pipes and inside tight spaces like fallen buildings or caved-in areas where humans and robots with wheels cannot enter.

More information: K. Knight. Tree snakes keel gets a grip, *Journal of Experimental Biology* (2015). DOI: 10.1242/jeb.135434

Provided by University of Cincinnati