PHYSIOLOGICAL ECOLOGY

Salt and the Sea Serpent

Despite millions of years living in the ocean, sea snakes still have to watch their salt intake

In 2009, Harvey Lillywhite wanted to know if true sea snakes got thirsty. To catch some, his research team angled a small motorboat toward a distinctive band of water caused by two converging currents in the Papagayo Gulf in Costa Rica. Sneaking up on his quarry, a yellow-bellied sea snake floating on the surface, he gently slipped the venomous animal into a net and then into a bucket. After collecting a dozen or more snakes this way, the physiological ecologist at the University of Florida in Gainesville went back to a temporary lab to test each one. He laid the first one on a towel. After its skin had become dry to the touch, Lillywhite weighed the snake and dropped it into fresh water.

Soon the snake opened its mouth and began gulping down water, increasing its body weight by 13% by the next morning, Lillywhite recalls. He has since observed the same behavior in scores of sea snakes collected over the past few years. But, contrary to decades of academic thinking that sea snakes can thrive on seawater, none would drink salt water that Lillywhite provided—no matter how dehydrated they got. When it comes to sea snakes, the textbooks are wrong, Lillywhite asserts.

Although sea snakes seem exquisitely adapted to the marine environment, with a flattened body, paddle-shaped tail, and glands that secrete salt, salt still dictates where, how, and perhaps even if they live, Lillywhite and his colleagues have found. Their recent study of the global distribution of these reptiles, for example, has revealed that salinity has limited the abundance and distribution of these species. "People assumed that [sea snakes] have salt glands and drink seawater, and that's all there is to it," says William Dunson, a retired physiologist in Englewood, Florida, who studied the reptiles. "But that's not the way it is."

Like marine birds and marine mammals, snakes in the sea evolved from terrestrial ancestors, and the transition required adjusting to a life of avoiding the intake of too much salt and the loss of too much water. Textbooks have long said that salt glands solved this problem for marine birds and reptiles by removing excess salt from ingested seawater.

Yet Dunson notes that his surveys of sea snakes in the 1970s revealed that their salt glands were often very tiny compared with those in other marine animals. That and other observations led him to conclude that the snakes "probably didn't drink [seawater] except when salinity was very low."

Lillywhite himself began to seriously question the dogma in the 1990s after he discovered that a marine snake unrelated to sea snakes required fresh water for survival. He then took a look at sea kraits, which differ from true sea snakes in that they move to land to digest their food and lay their eggs. (True sea snakes never leave seawater and give birth to live young.) Even when dehydrated, the sea kraits refused to drink seawater but lapped up fresh water, Lillywhite and his colleagues reported in 2008. On Orchid Island in Taiwan, sea kraits were also far more abundant close to freshwater springs or rivers entering the oceans and in years when there was high rainfall.

Others were also becoming suspicious that sea kraits couldn't survive on seawater. Xavier Bonnet and François Brischoux at the CNRS Chizé Centre for Biological Studies in Villiers en Bois, France, have observed that in dry periods, sea kraits cease to hunt in water and instead hide on land, waiting to emerge en masse to drink puddled rainwater on rocks when the dry spell breaks. "They just have not been able to adapt to the salinity, and they still depend on fresh water," says John Murphy of The Field Museum in Chicago, Illinois, who studies snakes.

The 60 or so species of true sea snakes live permanently in the ocean, and although there had been some suggestion that they can drink lenses of fresh water that pool on top of the denser salt water, it was unclear whether they needed this supply to survive. To resolve this issue, Lillywhite has been taking periodic trips to Costa Rica, with visits that span the dry and wet seasons. Yellow-bellied sea snakes, like sea kraits, dehydrate in seawater. When thirsty enough, they drink fresh water, never salt water, Lillywhite's team reported in the August issue of *Integrative and Comparative Biology*.

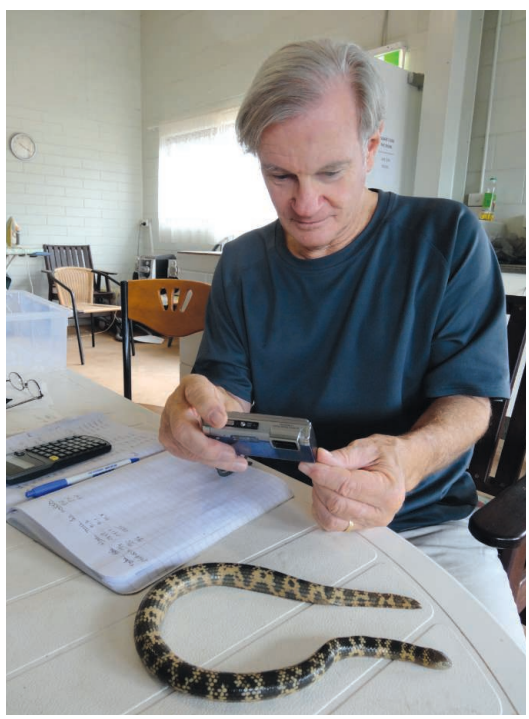
The fieldwork also indicated that these sea snakes don't migrate to rivers or estuaries during the dry season. Instead, they likely take their chances that a good rain will leave fresh water on the sea surface. Yet, Lillywhite notes, "even in the wet season, the storms can be sporadic and spotty."

Thus, he suspects that sea snakes spend a good bit of their lives thirsty, which they seem to withstand quite well. Even with a more than 20% loss of body weight, yellow-bellied sea snakes are fine; just a 12% loss in humans due to dehydration could be lethal. Salt glands, impermeable skin, nasal valves that keep salt water out, and an ability to extract water from feces and possibly from ingested prey may help slow dehydration, he points out.

Additional work by Brischoux and Lillywhite suggests that the overall distribution of sea snakes is influenced by salinity, and, by association, rainfall. With colleagues, they compared the ranges of four lineages of marine snakes—about 75 species in all—to satellite information about the water's salinity. There tend to be more sea snake species in areas with lower salinity or with higher variability in salinity (a likely indicator of heavy rainfall), the researchers reported this month in *Ecography*.

"The whole idea of sea snakes not being completely adapted to the oceans as we thought they were is a very interesting revelation," Murphy says. "Even though sea snakes have invaded the oceans, they are still very dependent on fresh water."

–ELIZABETH PENNISI



Are you thirsty? Harvey Lillywhite has tested hundreds of sea snakes to see if they will drink fresh water.

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