Why Rattle, Snake?

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“This is the weirdest trip to the zoo, ever,” I think to myself. I’m in a back room of the Fort Worth Zoo, surrounded by stacks upon stacks of white Rubbermaid containers, each containing some flavor of dangerous snake—little drawers of poison. Beside me, a man again presents one of these snakes with the fuzzy head of a decapitated teddy bear, mounted on a long pair of tongs. He opens and closes the bear’s “mouth” using the trigger on the device, doing his best impression of a hungry snake predator. But the snake in front of us, *Agkistrodon taylori*, for whom I drove halfway across the country, still refuses to vibrate its tail.

I’m here to study the evolution of the rattlesnake rattle. But *A. taylori* isn’t a rattlesnake—it’s a rare species of Mexican cantil viper closely related to rattlesnakes. I’m here to film its defensive behavior because to understand rattlesnake evolution, you must first understand rattlesnakes’ closest relatives.

He Has a Bell

Rattlesnakes are a diverse group of thick-bodied snakes within the viper family. There are 36 species, all of which live in the Americas. North Carolina is home to three of these species—the timber, eastern diamondback, and pygmy rattlesnake. All rattlesnakes are venomous, and all but one carry with them a sound-producing instrument on their tail called a rattle (the Santa Catalina Island rattlesnake has subsequently lost its rattle). The structure is such a unique trait that it has attached itself to the name for these animals in nearly every language that has encountered it: *rattle*snake to English speakers, *bell*snake in Spanish (“serpiente de cascabel”), and “he has a bell” in Cherokee (“utsa’nätï”).

Myself and a team from UNC-Chapel Hill became interested in exploring the rattle and its origins a few years ago. But we certainly weren’t the first people captured by this evolutionary novelty. Throughout history, there have been numerous attempts to explain the purpose of the rattle. The device has been variously purported to: warn “enemy snakes” that a dangerous rattlesnake was passing through, spread “poison dust” into an attacker’s eyes, and to charm and attract prey like a Siren’s song, bringing it within range of a rattlesnake’s “hypnotic eye.” There’s even the bewildering proposition that rattlesnakes purposely make noise with their rattle before attacking, to give their prey a chance to escape.

Unfortunately for the mice and squirrels of the world, evolution is rarely so benevolent. The only widespread use for the rattle supported by research is that it is a warning. Like the growl of a dog, the rattle means “come closer and you’ll be sorry.” Potential rattlesnake predators and large grazing animals (which might inadvertently trample the snakes) have both been observed to deliberately avoid buzzing rattlesnakes. And if you have ever seen the effects of these snakes’ hemotoxic venom, which causes excessive bleeding, extreme pain, and necrosis, you’ll understand why animals heed the threat.

In science, this type of adaptation meant to warn potential enemies is known as "aposematism." Poison dart frogs evolved bright colors to warn predators that they would be an unpleasant meal. Tiger moths use loud ultrasonic vibrations to warn bats of their unpalatability. And rattlesnakes, despite being deaf to most airborne sound, evolved a musical instrument attached to their tail, which advertises their dangerous bite.

The rattle itself is composed of overlapping rings of keratin—the same protein that makes up human fingernails. These rings are linked together loosely so that they bump into one another when the tail is shaken, producing a unique buzz sound.

It Runs in the Family

So where did the rattle come from? This question has preoccupied researchers for centuries—even Charles Darwin mentioned it in a letter to his mentor, John Stevens Henslow.

Let's start with what we know. First, we know that rattlesnakes add a new rattle segment each time they shed their skin. This connection between rattles and shedding has led many to believe that the rattle structure originated from incomplete shedding of the skin at the base of the tail. If this retained shed skin helped rattlesnakes better warn coyotes or unwary bison of their dangerous bite, then natural selection could have sent it all the way to fixation. This could have paved the way for the evolution of the rattle.

But you don't need a rattle to shake your tail. Many snake species besides rattlesnakes vibrate their tails defensively. If you've ever had a run-in with a feisty black racer or ratsnake then you know firsthand how passionately these snakes buzz their tails against the ground. This behavior has been documented in species from many different snake groups, and may serve a similar aposematic role as in rattlesnakes, or may be used to draw attention away from a snake's vulnerable head.

With all these other tail-buzzers in the world, the question arises: why did the rattle only evolve in rattlesnakes? Our team went all the way to a Texas zoo (and a lot of other zoos) to answer this question. Our goal: to film defensive tail vibration in as many species as possible in order to understand what makes rattling unique in rattlesnakes and their closest relatives. Knowing this could shed light on how the rattle evolved.

Faster Than a Hummingbird

Back in Fort Worth, my hand is getting tired from holding our slow-motion camera (safely mounted at the end of a long pole), which continues pumping away at 480 frames per second despite the nonplussed cantil in front of us.

Then, almost imperceptibly, we see the tail begin to quiver, at first in fits and starts. A few seconds later we have what we came all the way to Texas to see—full-blown tail vibration in a close rattlesnake relative. And we can already tell—it's *fast.*

Folks have known for a long time that the rattlesnake rattle moves quickly. Capable of vibrating their tails up to 100 times per second for over an hour, rattlesnakes are the champions of the reptile world when it comes to fast, sustained muscle movement. Even warm-blooded hummingbirds, renowned for their fast wingbeat, can't lift a feather to the speed of the rattlesnake rattle.

But what our team learned from filming the tail behavior of snakes like the cantil is that the movement is also fast in rattlesnake relatives. We found that the more closely related a snake is to rattlesnakes, the faster it vibrates its tail. Close cousins like copperheads, bushmasters, and cantils clock in at 30-40 rattles per second, while more distant relatives like parrotsnakes and lanceheads rattle just 10-20 times per second.

This finding suggests that rattlesnake ancestors evolved a high rattling speed *before* they evolved a rattle. It's possible that this fast rattling speed could have facilitated rattle evolution, perhaps if retained shed skin helped protect the tail from getting damaged while vibrating at high speeds.

There's a lot we still don't know about rattlesnake evolution. For example, how could simple retained skin have evolved into such a complex structure as a rattle? We don't yet know the answer to this question, but by delving ever deeper into the enigmatic world of rattlesnakes and their kin, we can begin to understand their origins. Knowing this will help us better answer perhaps the biggest question in all of evolution: where do new adaptations come from?