One snake's prey is another's poison: Scientists pinpoint genetics of extreme resistance

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An international research team led by Virginia Tech discovered how snakes evolved the ability to eat extremely toxic species. Credit: Richard Greene

A select group of garter snakes can thank their ancestors for the ability to chow down on a poisonous newt and live to tell the tale.

Common garter snakes, along with four other snake species, have evolved the ability to eat extremely toxic species such as the rough-skinned newt—amphibians that would kill a human predator—thanks to at least 100 million years of evolution, according to Joel McGlothlin, an assistant professor of biological sciences in the College of Science and a Fralin Life Science Institute affiliate.

The nature of that evolution was recently established by McGlothlin's team and will be published June 20 in the journal *Current Biology*.

The international team of researchers discovered that the ability to withstand the toxin that the newt produces evolved following a 'building blocks' pattern, where an evolutionary change in one gene can lead to changes in another.

In this case, over time, amino acids in three different sodium channels found in nerves and muscle changed, allowing select snakes to resist the numbness and paralysis typically brought on by the toxin.

Resistant muscle gives snakes the best protection against the newt's toxin, but there's a catch: resistant muscle can only evolve in species that already have resistant nerves. McGlothlin's team found that the ancestors of garter snakes gained toxin-resistant nerves almost 40 million years ago.

"Garter snakes and newts are locked in a coevolutionary arms race where as the newts become more toxic, the snakes become more resistant," said McGlothlin, who is also affiliated with the Global Change Center at Virginia Tech. "However, without the leg-up provided by those resistant nerves, snakes wouldn't have been able to withstand enough toxin to get this whole process started."

This arms race is most intense in pocketed regions along the West Coast, where rough-skinned newts and garter snakes co-exist.

McGlothlin and his team sequenced three sodium channel genes found in 82 species (78 snakes, 2 lizards, 1 bird, and 1 turtle) and mapped the changes they found to evolutionary trees to date when toxic resistance emerged in each. They found that, as time went on, some groups of snakes built up more and more resistance to the toxin. These changes always happened in the same order, with resistant nerves evolving before resistant muscle.

The next step is to see if this pattern is a general phenomenon in other species. A few bird species can also eat the newt and survive. McGlothlin and his team recently received a grant from the National Science Foundation to test whether birds have built up resistance in the same way as snakes.

This work is not just relevant to understanding what snakes have for dinner. "We think that the garter snake's evolved resistance to the newt's toxin can be used as a model for understanding complex adaptations that involve more than one gene," McGlothlin said.

"This study provides insight into the stepwise evolution of an ecologically important trait (resistance to prey toxins), and revealed that the adaptive benefit of changes to individual components of the trait were contingent on antecedent changes in other components," said Jay Storz, the Susan J. Rosowski Professor of Biology at the University of

Nebraska who was not involved in the research. "This discovery has general significance for understanding the evolution of complex traits."

Provided by Virginia Tech

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