Savitzky Lab

Chemical Ecology & Evolutionary Morphology of Amphibians & Reptiles

Utah State University
DEPARTMENT OF BIOLOGY

WHO WE ARE

Al Savitzky
(with *Rhabdophis tigrinus*)

Helen Plylar, Hannah Wilson, & Megen Kepas, *Ph.D. Students*
(with *Thamnophis elegans*)

RESEARCH FOCUS

Our lab studies the evolution of anatomical, physiological, and chemical adaptations of amphibians and reptiles (primarily snakes) for prey detection, feeding, and predator deterrence.

We combine field studies with laboratory methods, including:

- histology
- light microscopy
- vascular casting
- electrocardiography
- DNA sequencing
- chemical analysis
  - HPLC, MS, NMR spectroscopy

all within an explicit phylogenetic context.

PRINCIPAL COLLABORATORS

Akira Mori
Kyoto Univ.

Shab Mohammadi
Univ. of Nebraska

GuangXiang Zhu
Sichuan Agr. Univ.

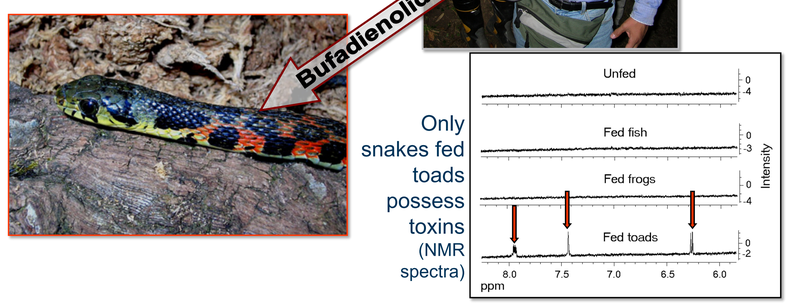
Members of the International Nuchal Gland Project

CURRENT PROJECTS

For the past 20 years our lab has been studying the role that dietary toxins play in the chemical defenses of a lineage of Asian natricine snakes.

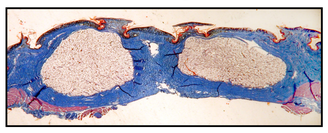
The project began by asking whether the bufadienolide toxins in the nuchal (neck) glands of the Japanese Yamakagashi (*Rhabdophis tigrinus*) are derived from toads (*Bufo japonicus*) consumed as prey, as proposed by Dr. Mori.

They are!



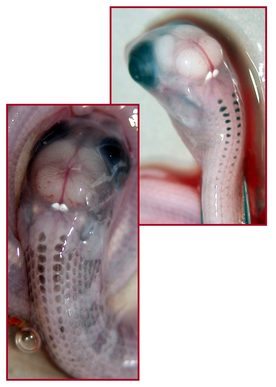
We have also demonstrated that:

- snakes from toad-free areas lack toxins
- females can provision their offspring with toxins before they hatch
- snakes can modify the toxins in several ways (with unknown consequences)
- the nuchal glands are richly vascularized and lack secretory organelles



NEW QUESTIONS

- What variations exist in the morphology of the glands?
- How did the nuchal glands arise, evolutionarily and developmentally?
- Similar toxins occur in a lineage that does not eat toads. What is the source?
  - It's firefly larvae!



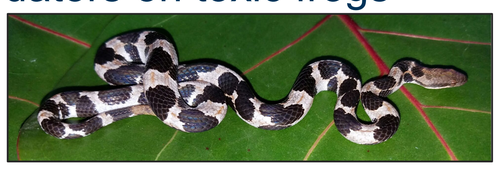
MORE QUESTIONS

- How widespread is toxin resistance? Is it limited to toad-eaters? (No!)
- So what is different about *chronic* toad-eaters?
  - Perhaps it's a difference in kidney or adrenal function
- How do the toxins get to the nuchal glands and why do they concentrate there?

Ancestral state analysis of genetic resistance to toad toxins

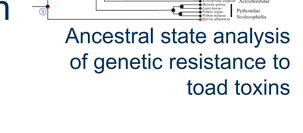
DO OTHER AMPHIBIANS & REPTILES SEQUESTER TOXINS?

- Probably. We'd like to know.
- Target taxa include:
  - Slug-eaters
  - Ant-eaters
  - Termite-eaters
  - Predators on toxic frogs

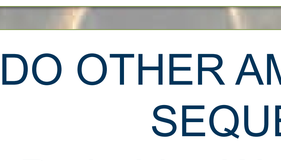


OTHER PROJECTS

- Evolution and morphology of "Dwarf Boas" (Tropidophiidae) in Cuba
- Diversification of infrared-imaging pit organs in Pythonidae



Tropidophis hendersoni
Tropidophis melanurus



Python regius

RECENT PUBLICATIONS

Savitzky, A.H., A. Mori, D.A. Hutchinson, R.A. Saporito, G.M. Burghardt, H.B. Lillywhite, & J. Meinwald. 2012. Sequestered defensive toxins in tetrapod vertebrates: Principles, patterns, and prospects for future studies. Chemoecology, 22(3):141-158.

Mori, A., G.M. Burghardt, A.H. Savitzky, K.A. Roberts, D.A. Hutchinson, & R.C. Goris. 2012. Nuchal glands: A novel defensive system in snakes. Chemoecology, 22(3):187-198.

Mohammadi, S., Z. Gompert, J. Gonzalez, H. Takeuchi, A. Mori, & A.H. Savitzky. 2016. Toxin-resistant isoforms of Na+/K+-ATPase in snakes do not closely track dietary specialization in toads. Proceedings of the Royal Society B, 283(1842):1-9.

Takeuchi, Hirohiko, Alan H. Savitzky, … and Akira Mori. 2018. Evolution of nuchal glands, unusual defensive organs of Asian natricine snakes (Serpentes: Colubridae), inferred from a molecular phylogeny. Ecology and Evolution, 8:10219-10232.

Yoshida, Tatsuya, Rinako Ujiie, Alan H. Savitzky, … Naoki Mori, and Akira Mori. 2020. Dramatic dietary shift maintains sequestered toxins in chemically defended snakes. Proceedings of the National Academy of Sciences, 117(11):5964-5969.

Zhu, Guang-Xiang, Shijun Yang, Alan H. Savitzky, Liang Zhang, Yuqi Cheng, and Jiajun Wang. 2020. The nucho-dorsal glands of *Rhabdophis guangdongensis* (Squamata: Colubridae: Natricinae), with notes on morphological variation and phylogeny based on additional specimens. Current Herpetology, 39(2):108-119.