

Firefly Toxins

I was talking with a student a few years ago as she was considering opportunities for summer research. She was (and still is) an ecologist by passion, but she had just completed a very successful year of organic chemistry and was intrigued by the role organic molecules play in ecological systems. One of her options was to work in a lab studying poisons in fireflies. Huh? This was news to me. She eventually went off and studied nitrogen fixation in California, but she had left me with a really interesting new example of the role of organic chemicals in places I had never suspected.

Some, but not all fireflies contain a potent class of toxins, lucibufagins. By now, all keepers of lizards and other small reptiles know this, and they are warned not to feed their pets or charges fireflies; one firefly carries enough toxin to kill a small bearded dragon, one of the most popular and apparently sweetest pet reptiles.

The firefly toxins are steroids (Figure 1), which puts them in the same class as cholesterol, estrogens, and testosterone (Figure 2), but clearly they are very different in their effects on living systems. The steroid ring system is made from four rings attached in the specific way shown in figure 1. Different properties are acquired by adding chemical foliage onto the ring.

Figure 1: The basic steroid system, showing the four rings, labeled A, B, C, & D.

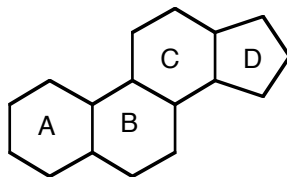
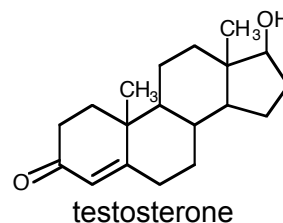
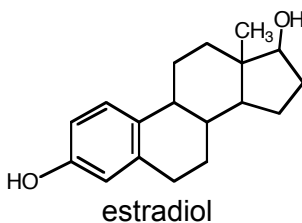
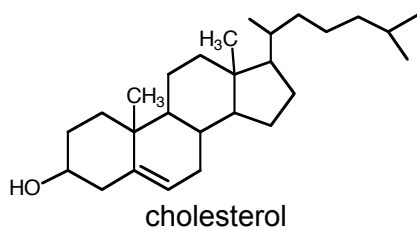
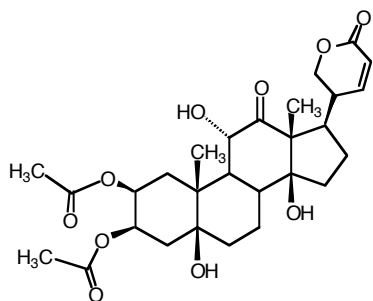


Figure 2: Three common steroid compounds.

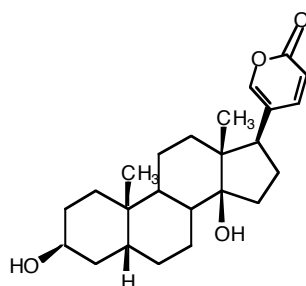


Firefly toxins are kin to other types of natural toxins, including bufotoxins, secreted in some toad skins, and digitalis, extracted from foxglove, the spring flower that Beatrix Potter's gentleman fox sat amongst waiting to lay his claim to Jemima Puddleduck's eggs. All three are cardiac glycosides, compounds that stimulate the heart in very small doses but cause havoc to it in only slightly larger doses.

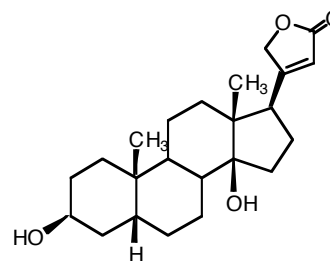
Figure 3: Steroidal cardiac glycosides – compounds isolated or derived from fireflies, toad skin and foxglove that have beneficial effects on the heart in small quantities, and toxic effects in larger doses.



One of the lucibufagins isolated from fireflies.



Bufalin, one of several toxic compounds isolated from toad skin.



One of the cardiac glycosides derived from foxglove

Nature is really good at providing species with ways to protect themselves in a world that is, from their points of view, violent and dangerous. Plants don't want to be eaten and preyed upon, nor do insects, so they make toxins that offer bitterness to a would-be predator and death to one who doesn't pay attention to that first nibble.

The toxin in fireflies is not the chemical responsible for the light they emit, and in fact, not all fireflies have the poison. The female of one species actually acquires it by emitting a fake signal and luring the toxic male firefly of another species to her; once she eats the tricked firefly, she becomes toxic and reaps the benefits of her victim's sacrificial and lustful last act.

How toxic are these compounds? The LD₅₀ of the lucibufagins does not seem to have been studied, although I did find that someone had done tests on dogs, but only to cause heart arrhythmias and not to cause death. Case reports indicate that one firefly will kill a small reptile, and it has been estimated that maybe all it takes is a tenth of a firefly. The LD₅₀ for bufalin (intravenously administered for cats) is 0.14 mg per kg of cat which for a 12 pound cat amounts to about 1 mg, or barely a few small crystals of sugar.

Enjoy fireflies by sight and at a distance, keep your hands off the toads, and be careful if foxglove grows in your garden. Deaths have occurred when people made tea from foxglove leaves, mistaking them for comfrey. Comfrey has its own toxins and is problematic as a tea, but serious mistakes of misidentification took the lives of the persons who made the tea as well as the guests.

<http://www.Nbb.Cornell.Edu/Neurobio/Eisner/Pogona.html>

"Two Cases of Firefly Toxicosis in Lizards" Michael Knight, Richard Glor, Scott R. Smedley, Andres Gonzalez, Kraig Adler, and Thomas Eisner

Thomas Eisner *For Love of Insects* Belknap Press (2003)

Thomas Eisner, Maria Eisner, Melody Siegler *Secret Weapons: Defenses of Insects, Spiders, Scorpions, and Other Many0-Legged Creatures*. Belknap Press (2005)

MSDS sheet for bufalin: <http://www.biomol.com/SiteData/docs/msds/ap303.pdf>