Bright Colors Taste Nasty

Evolution of Warnings

This Texas grasshopper stays camouflaged when alone, but get a whole bunch eating noxious plants -- which make them taste bad to predators -- and they start sporting bright colors. (Greg Sword/ Nature)

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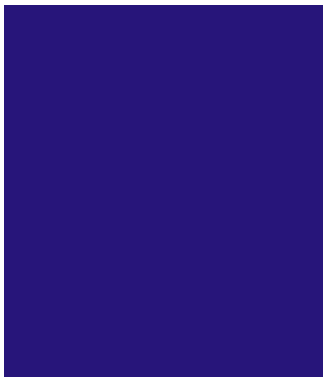
Death at first bite.

That's what succulent little morsels like grasshoppers, frogs and salamanders try to avoid. Some small critters arm themselves with stings, slime or sickening flavor and often advertise their repulsive characteristics by being brightly colored.

They often use the same attention-grabbing colors people use in traffic signs — combinations of red, yellow and black.



This poison-arrow frog advertises to predators that a good meal lies elsewhere. (Art Wolfe/PNI)

Coupling flashy colors with noxious characteristics lets animals go about their business with impunity. Birds do it, bees do it, even monarch butterflies in trees do it.

Biologists have long wondered how such advertising developed. Wouldn't the first few jauntily-colored animals have been easily seen and snatched by predators who didn't realize that flashy appearance was the grasshopper version of a skull and crossbones, not a sign saying, "For good food, eat here"?

"That's the evolutionary problem in warning colors," says Leena Lindström, an evolutionary ecologist at the University of Jyväskylä in Finland. "How can this prey evolve?"

X Marks the Spot

With the help of almond slivers tucked into little paper

SUMMARY

How did brightly colored critters evolve without the pioneers getting munched from the gene pool?

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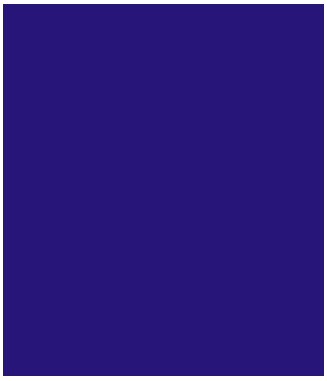
John Endler, evolutionary biologist

pockets and a bird called the great tit, Lindström and her colleagues at the University of Jyväskylä have begun to unravel this evolutionary puzzle.

Their study is one of two papers in this week's issue of the journal *Nature* that begins to explain how warning colors could evolve.



Not all predators may realize that a yellow jacket isn't an easy meal. But the insects also rely on their numbers to allow for some clueless predators to learn the hard way. (Paul Skelcher/PNI)

The great tit, a European bird related to North American chickadees, generally eats both seeds and insects. The researchers wanted to know how distinctive a bit of food had to be before the birds learned to associate a certain appearance with bad taste.

The researchers first taught a group of the birds to open little paper envelopes to eat the almond sliver inside. The envelopes were marked with an X.

After the birds learned that X marked the almonds, the birds were released into an aviary with packets with almond slivers scattered on the floor. Some were marked with X's, while others had various modified X's.

Icky Nuts

The almonds inside packets with the plain X's tasted good, whereas the almonds in the other packets had been soaked in a chloroquinine solution.

The solution tastes awful and the birds don't like the taste. "They wipe their beaks," Lindström says. "You can see from their face that they don't like it."

However, unless the marking on the packet is very different from an X, the birds don't learn to avoid the quinine-soaked almonds. The researchers were surprised; they expected the birds to learn to distinguish the X from all the other markings.

The researchers' findings suggest that to gain from a conspicuous appearance, bad-tasting prey animals must look very distinctive before predators can associate a particular appearance with bad food.

It also means that prey that look just a little bit different don't get singled out.

Therefore, if foul-tasting prey with minor appearance differences evolved, predators would not selectively pick on them, says John Endler, an evolutionary biologist at the University of California,

Santa Barbara.

As those prey became more common, he suspects that predators would learn to recognize and avoid them.

Say It Loud

Biologists agree that for groups of repulsive prey animals, the flashier the better.

"The safety in numbers argument works better if you are brightly colored," Endler says. "Predators learn to avoid you faster."

In that case, the animals are gambling that it's the other guy that will get eaten and teach the predator the lesson of bright colors equals bad taste.

But what if you aren't always surrounded by a fraternity of brightly colored repulsive fellows? One species of Texas grasshopper remains cryptic green when it's all by its lonesome, but changes to flamboyant yellow and black when raised in a group, reports Gregory Sword in this week's *Nature*.

Scientists know that some insects change color when their populations increase. However, no one realized the color change might be associated with foul taste.

You Are What You Eat

The grasshoppers, a species of locust called *Schistocerca emarginata*, taste nasty if they have been feeding on the native plant called, appropriately, skunkbush.

Sword knows: He's tasted the critters.

"They're really bad, just ridiculously bitter," he says. "You need some water to rinse your mouth out. Just chewing on the leaves of the plant is a bad taste, the same flavor."

But if the grasshoppers eat a nontoxic plant like lettuce for 24 hours, he says, "the grasshoppers tasted fine to me."

Sword tested how a lizard, *Anolis carolinensis*, responded to the grasshoppers. The lizard, commonly called the American chameleon and often sold in pet shops, is a native predator of the grasshoppers.

The lizards responded to the grasshoppers the same way Sword did. Once the lizard mouthed the grasshopper's head, the lizard spit out the insect. Sword suspects the grasshopper vomited mushed-up skunkbush into the lizard's mouth.

"The lizards would rub the side of their mouth on the floor of the cage or shake their heads and often run away from the grasshoppers," he says.

Advertising clearly works for these grasshoppers. The next time the lizards had a choice between green grasshoppers and yellow-and-black grasshoppers, 16 out of 17 lizards went for the green.

Plagues, Or Safety in Numbers

Sword is now investigating whether the same phenomenon happens with a close relative, *Schistocerca gregaria*, the desert locust of biblical plague fame.

The desert locust also changes color as its population density increases. Maybe the locust gains a noxious taste from its food plant, shifts into warning color as its density increases, and then is avoided by predators.

That might, Sword says, "free the populations to increase even more and ultimately lead to outbreaks."

Animals may evolve warning color little by little or by getting flashy all at once.

Scientists still don't know which came first — bad taste or bright colors — but it certainly gives them something to chew on. ■