How bad-tasting species got their markings

Someone who sports dark glasses, a hat pulled down low, a bulging coat pocket, and a swagger is sending a clear message: Leave me alone if you value your life.

Other members of the animal kingdom, such as bumblebees, employ a similar strategy. They have striking colors and markings that warn their predators that they taste bad and may even be poisonous. A recent study provides new details about how these warning, or aposematic, signals evolved. It suggests that unpalatable creatures living in family groups were the first to display them, Rauno V. Alatalo and Johanna Mappes of the University of Jyväskylä in Finland report in the Aug. 22 NATURE.

The Finnish scientists "succeed in uncovering selective forces involved in the initial evolution of anti-predator warning signals," Tim Guilford and Candy Rowe of the University of Oxford, England, say in an accompanying comment.

Many animals with aposematic markings now live in groups. Some researchers have argued that aposematic signals first evolved in unpalatable species that lived in families, as their predators would eat one member of the group but then stay away from similarly marked relatives. But other scientists say that unpalatable creatures could have evolved aposematic markings well before they took to group living.

In their study, Alatalo and Mappes examined the responses of 16 birds called great tits (*Parus major*) to artificial prey, both palatable and unpalatable, that the scientists had marked with novel symbols. Because the birds had no experience with these markings, the researchers assert that the tits' initial reactions probably resemble animals' responses to early aposematic colors and patterns.

Stalks of rye with fat in their hollow stems served as prey for the birds. The investigators dipped some of these stalks in chloroquine, a bitter tasting antimalarial drug. To each stalk they attached a piece of paper marked with a symbol. All palatable items were tagged with shapes that matched patterns on the cage floor; the unpalatable items had markings that either blended with or stood out against the floor.

For one hour every day for three days, the birds searched for the palatable food among different arrangements of the artificial prey. Some items lay 20 to 30 centimeters apart, while others were placed in groups of similarly marked and flavored food.

The palatable food, as expected, proved generally more popular than the chloroquine-flavored prey. The tits, however, ate fewer of the tasty items that lay alone than in groups. By contrast, the chloroquine-flavored items that stood alone were tried more often than those in groups.

Furthermore, among the unpalatable, solitary prey, the birds were at first more likely to taste the conspicuously marked items than those that didn't stand out.

"Altogether, this suggests that initially aggregation would have been beneficial for the aposematic [conspicuously marked] prey," the authors explain.

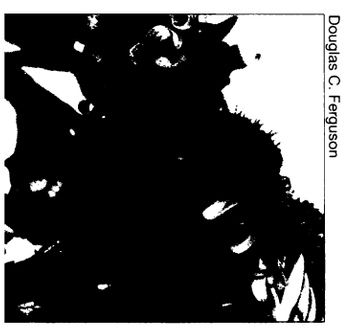
Eventually, the tits learned to largely avoid the conspicuously marked prey.

The second trial tested how the birds would react to another "species" of prey—almond pieces—equipped with the same markings as the rye and, in some cases, dipped in chloroquine. The tits continued to avoid the conspicuously marked prey. This time, however, they hit on as many conspicuous items that were in groups as those that lay alone.

The experiments show that aposematism probably evolved first in groups of unpalatable prey, but that other species that later adopt similar markings may not benefit from group living, the authors conclude.

"Yet we suspect that the controversy is not altogether over," Guilford and Rowe note. Predators may become so abundant in some cases that their aposematic prey still benefit, as other species do, from living in groups. Also, species may happen to evolve new markings during times of low predator populations and not need the additional benefit of a group. — *T. Adler*

Marie Read



Douglas C. Ferguson

*In the lives of many insects and other animals, yellow and black scream "stay away," such as in the case of the harlequin frog (*Atelopus varius*) from Panama (top) and the cinnabar moth (*Tyria jacobaeae*) caterpillar (bottom), shown here resting on a tansy ragwort in Quilcene, Wash.*

Is NO a good cop or bad actor in malaria?

Nitric oxide has suffered from an unsavory reputation for years, with good reason. Not only is the highly reactive chemical guilty by association—it is an ingredient of smog and cigarette smoke—but excess production by brain cells damages nerves during a stroke.

More recently, however, nitric oxide has emerged as the biochemical linchpin in a host of essential bodily processes. Among other things, it conveys molecular messages, helps control blood pressure, aids digestion, boosts erections, and kills tumor cells.

Now researchers in the United States and Tanzania have provocative evidence suggesting that nitric oxide may guard against the ravages of malaria, a mosquito-borne parasitic disease that kills up to 2 million people a year. Their study is the latest to suggest that nitric oxide may be a formidable bulwark in the body's fortifications against infectious disease.

The findings, reported in the August JOURNAL OF EXPERIMENTAL MEDICINE, can be stated simply. "The higher the NO [nitric oxide] concentration [in blood], the lower the parasite load and the milder the illness," says J. Brice Weinberg, a hematologist at Duke University Medical Center in Durham, N.C., and a study author.

The role of nitric oxide in human chemistry is anything but simple, however, and the study, although it is "a nice piece of clinical research," raises many questions, says Lee Hall of the National Institute of Allergy and Infectious Diseases.

The Duke study focused on *Plasmodium falciparum,* the deadliest of the four malaria parasites. These parasites infest red blood cells, where they feast on oxygen-bearing hemoglobin. *P. falciparum* is more dangerous than the others, because a small fraction of the people who are infected develop a severe complication known as cerebral malaria. It is fatal in one third of the cases where it occurs.

Some researchers postulate that cerebral malaria occurs because the parasites alter the red blood cell's membrane, making the cells more likely to clump together against the blood vessel walls. If this blockage cuts off the blood that carries oxygen in vessels nourishing the brain, coma results.

The problem with this theory is that survivors of cerebral malaria usually emerge from their comas without the brain damage typical of oxygen starvation. Other researchers, including Ian Clark of the Australian National University in Canberra, put forth another scenario, in which nitric oxide plays a starring role.

This view hinges on the discovery that *P. falciparum* infection provokes white blood cells to produce tumor necrosis factor, a protein that stimulates the release of nitric oxide. Clark contends that excess nitric oxide disrupts the normal flow of nerve signals within the brain, thereby causing coma or death.

In keeping with this theory, Weinberg

expected to find high concentrations of nitric oxide in patients with severe illness including cerebral malaria. To test this hypothesis, Weinberg's former Duke colleague Nicholas M. Anstey, now at the Menzies School of Health Research in Darwin, Australia, spent a year in Dar es Salaam, Tanzania, collecting blood and urine samples.

Anstey studied 191 children at Muhimbili Medical Centre. Forty of the children were healthy or had noninfectious ailments; the rest were divided into four groups, based on the severity of their malaria.

The results were startling, Weinberg says. "In the sickest patients, the NO concentrations were even lower than the concentrations found in normal Tanzanian children." This phenomenon may be explained by laboratory tests indicating that the children with severe malaria produced excess interleukin-10, a protein that blocks nitric oxide synthesis, he adds.

In contrast, children who were infected but symptom-free had the most nitric oxide. The study concludes: "NO appears to have a protective rather than a pathological role in African children with malaria."

Hall, however, cautions that Weinberg's team reported evidence of nitric oxide only in the blood and urine, not in cerebrospinal fluid (CSF). This leaves open the possibility that nitric oxide plays a dual role in malaria: Nitric oxide may cause severe illness in the brain, in line with Clark's reasoning, but protect against infection elsewhere in the body.

"If they could measure what was going on in the CSF, they might find that concentrations of nitric oxide there are much higher than elsewhere in the body," Hall asserts.

Although certain drugs, including nitroglycerin and sodium nitroprusside, raise nitric oxide levels, Weinberg and Hall agree that tests of these drugs in humans would be premature. If high nitric oxide concentrations in the brain do complicate cerebral malaria, they say, such treatment may do more harm than good. — *S. Sternberg*

Kuiper belt comets not so pristine?

Preserved in the deep freeze of space, comets don't look a day older than they did 4.5 billion years ago, when they formed during the birth of the solar system. At least that's what most planetary scientists have thought. Two researchers now challenge that assumption.

Although comets came in from the cold, they may not all represent pristine relics. A significant number may be mere fragments of objects that originally assembled during the earliest days of the solar system, assert Paolo Farinella of the University of Pisa in Italy and Donald R. Davis of the Planetary Science Institute in Tucson. The researchers base their view on a numerical model that charts the evolution of the Kuiper belt, a flattened reservoir of comets lying just beyond the orbits of Neptune and Pluto (SN: 7/27/96, p. 60).

Astronomers have so far identified 32 objects in the Kuiper belt, each of them at least 100 kilometers in diameter, or about 10 times larger than a typical comet. In addition, the Hubble Space Telescope has found evidence of about 30 smaller, comet-size bodies in the same region (SN: 6/22/96, p. 395). Kuiper belt comets that visit the inner solar system have orbital periods of 60 years or less and move in the same plane as the planets.

Using established estimates of the density and size distribution of objects in the Kuiper belt, the researchers deduce that comets originate when larger parent bodies in the storehouse smash into each other at speeds of up to several hundred meters per second. Such collisions would have cut some of these icy bodies down to comet size. A few of these fragments may also have been compressed by the collisions, which could explain why some comets are less fragile than others, notes Davis. He and Farinella present their work in the Aug. 16 SCIENCE.

The team calculates that Kuiper belt residents larger than 100 km resisted breaking apart during collisions, so they may truly represent pristine bodies from the solar system's formation. However, about 75 percent of the residents that are as small as 10 km in diameter, and virtually all objects 1 km or smaller, arose from collisions of larger parent bodies, the researchers conclude. Their results generally agree with a different, less detailed model proposed by S. Alan Stern of the Boulder, Colo., branch of the Southwest Research Institute.

Scientists have proposed that other comets, those that visit the inner solar system less frequently, come from an even more distant reservoir called the Oort cloud. Davis notes that this reservoir is thought to be so vast that its members would rarely have a chance to collide. Thus, these comets would more likely bear witness to conditions during the early solar system.

Astronomers are just beginning to record spectra of Kuiper belt objects. Tetsuo Yamamoto of Hokkaido University in Sapporo, Japan, notes that if the surface spectra of the smaller objects show a wide range of composition and colors, it would indicate that collisions played a key role in sculpting these comets. — *R. Cowen*

Plastic glows with bright laser light

For 6 years, since they discovered it gives off light when electricity passes through it, scientists in Cambridge, England, have set their sights on a plastic called PPV. Now, the researchers have even higher hopes for the material. They have demonstrated that PPV can emit not just any light, but coherent laser light.

PPV is one of a class of polymers that researchers are developing as light-emitting diodes (LEDs) for use in electronic displays (SN: 10/16/93, p. 246). Getting PPV to produce laser light proves that "it's extremely good for light emission, which was questioned in the scientific community," says Richard H. Friend of the Cavendish Laboratory in Cambridge. That bodes well for polymer LEDs now in development. Friend and his colleagues Nir Tessler and Graham J. Denton report the work in the Aug. 22 NATURE.

To create the laser, the researchers sandwiched the PPV between two mirrors: a thin silver film and a layered material called a distributed Bragg reflector, which reflects visible light with almost 100 percent efficiency. Like any laser, this device produces light by a process called stimulated emission. Shining light through the reflector causes the PPV to emit photons, some of which are reflected back and forth between the mirrors, in turn triggering a cascade of more photons. The photons that are not reflected but pass through the silver film have a single wavelength and are in phase, forming the coherent laser beam.

The light emitted was yellow-green, but polymer laser light could, in principle, cover a range of visible wavelengths, Friend says. Most commercial lasers emit in the red or infrared range. The next big goal is to develop polymer lasers that can be excited by electricity rather than light.

Polymers can be easily deposited over large areas. How that quality can be exploited for lasers remains to be seen, but it's useful when making large, flat LED panels such as computer screens or billboards. With polymers, researchers "don't have to grow single crystals like for other semiconductors," says Alan J. Heeger, chief scientist at UNIAX Corp. in Santa Barbara, Calif.

At the International Conference on Synthetic Metals earlier this month in Snowbird, Utah, Heeger and other UNIAX scientists and a group at the University of Utah in Salt Lake City reported independent evidence of laser-emitting polymers.

"These materials look fantastic," Heeger says. "They will set the community looking in a new direction." — *C. Wu*