A reprint from
American Scientist
the magazine of Sigma Xi, The Scientific Research Society

considerable ingenuity. The reward is that linear programming not only helps find good tours but can also establish lower bounds. That is, a linear programming algorithm can prove that no circuit through a given set of cities can possibly have a length less than x miles; if you then find an x-mile tour, you know it is optimal.

All of these tricks and many others are exploited by the Concorde TSP software. Cook has released a version of this program as a free "app" for the iPhone and the iPad (see http://www.tsp.gatech.edu/iphone/index.html). It solves the Danzig-Fulkerson-Johnson problem in two seconds.

Along with a heady dose of algorithms, Cook also offers a diverting survey of the lore and history of the TSP. The most charming revelation is that the problem's name is more than fanciful: Real traveling salesmen have struggled over their itineraries, without the aid of higher mathematics and computing machinery. Cook cites a 1925 exchange of letters between the home office of the Page Seed Company and Henry M. Cleveland, a salesman covering the New England states. That summer Cleveland made stops in some 350 places in Maine, and he was none too happy with the route suggested by the office.

> Dear Sirs
>
> My route list is balled up the worst I ever saw. Will take half as long again to work it as last year. . . . The river from Bangor down has no bridge and you have those towns down as if I could cross it anywhere. Last year's list was made out the best of any one and I can't see the object of changing it over. I think I have made myself plain.

In Pursuit of the Traveling Salesman is in some respects a condensed edition of an earlier book, *The Traveling Salesman Problem: A Computational Study*, by Cook and three more coauthors: David L. Applegate, Robert E. Bixby and Vašek Chvátal. The new volume addresses a wider audience, with more pictures and fewer equations, explaining how things are done rather than how to do them, but it covers all the same territory as the larger book. The path through that territory seems reasonably close to optimal.

Brian Hayes is senior writer for American Scientist. *He is the author most recently of* Group Theory in the Bedroom, and Other Mathematical Diversions *(Hill and Wang, 2008).*

ENTOMOLOGY

Insect Escape Artists

Elsa Youngsteadt

HOW NOT TO BE EATEN: The Insects Fight Back. Gilbert Waldbauer. xiv + 221 pp. University of California Press, 2012. $27.95.

Rarely does one have reason to compare a moth and a croquet ball, but entomologist Gilbert Waldbauer finds the parallel. In an anecdote in *How Not to Be Eaten*, he recalls searching for a red-banded ball that rolled into the rough during a game. When he finally located it, he realized it had been in plain sight all along—but with its colorful stripe obscured. By searching for red, he had overlooked his target.

The same thing may happen to birds that chase underwing moths *(Catocala)*, Waldbauer writes. Many moths of this genus have bright red, orange, yellow or white hindwings that flash conspicuously in flight but disappear beneath dull-colored forewings at rest. A pursuing bird focused on the bright colors of a flying moth could be stumped when the insect, like the croquet ball, settles with its vivid markings obscured and vanishes in plain view. (The gaudy hindwings serve another function: If threatened, a perched moth will flash the bright wings, often startling its would-be predator and buying time for escape.)

The underwing moths are just one among what must be hundreds of natural history stories chattily recounted in *How Not to Be Eaten*. In the first chapter, Waldbauer draws readers in with an engaging argument for insects' importance in terms of their sheer abundance: They account for 75 percent of all known animal species, he writes, and collectively outweigh all other terrestrial animals combined. That makes them the "most plentiful source of flesh" available to meat-eating creatures (including other insects). But they are not necessarily easy targets. The remaining nine chapters are devoted to insects' defenses and to predators' strategies and counterstrategies, exploring both sides of the evolutionary repartee between eater and eaten.

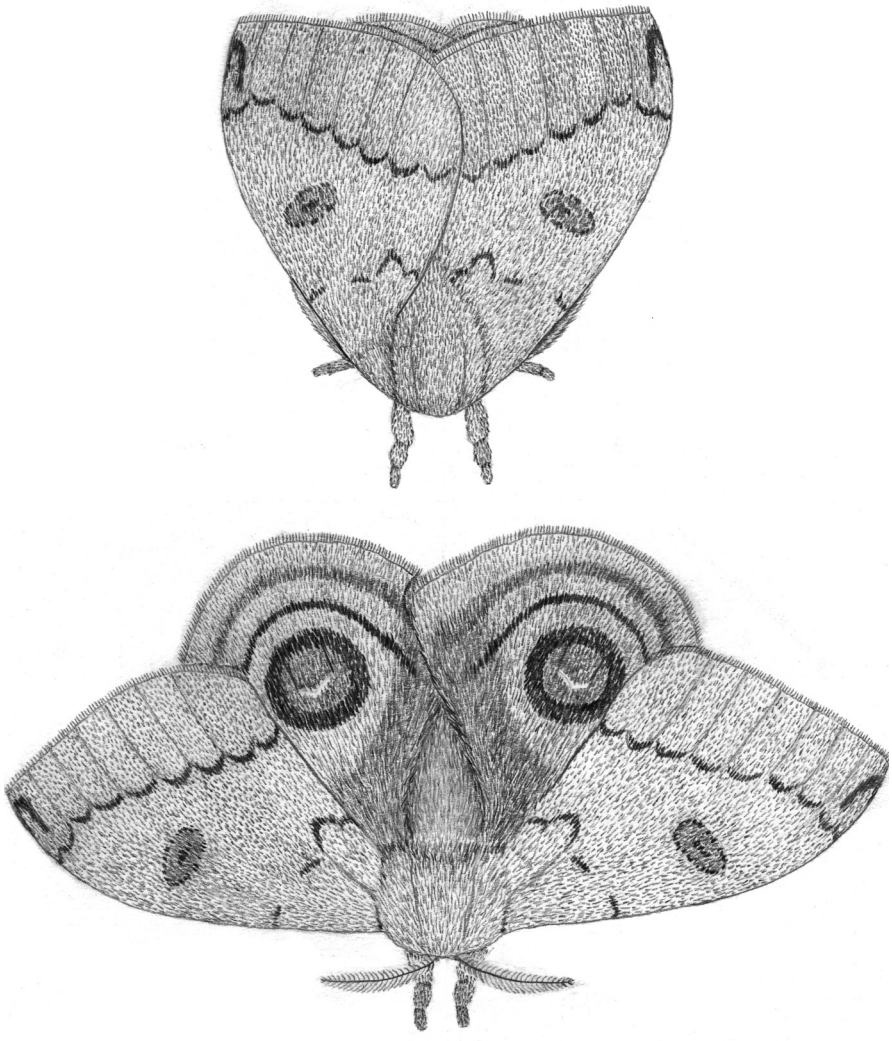
Waldbauer divides insects' defenses into seven often overlapping categories and assigns a chapter to each, providing a parade of insects (and occasionally birds, fish and mammals) to illustrate each strategy. In the chapter titled "Fleeing and Staying Under Cover," for example, we learn about potter wasps that fashion miniature "jugs" out of mud, lay an egg in each, provision them with paralyzed insects (usually caterpillars) and leave their offspring to develop in relative safety. Other defenses include eyespots and startling colors (such as those of the underwing moths), chemical defenses, and "safety in numbers"—the latter exemplified by groups of caterpillars, cockroaches and aphids. In such clusters, any given individual is less likely to be devoured than if it were alone.

Disguise also figures prominently in the repertoire of insect defenses. In one chapter, Waldbauer describes camouflaged insects that match their usual resting places. These species often bear deceptive countershading that makes them look two-dimensional, helping them blend into the background. In another chapter, Waldbauer introduces those insects that present a more specific resemblance to nonfood items such as bird droppings, leaves, twigs or flowers. The book's final chapter deals with insects that have evolved to mimic the appearance of other species that sting, spray or nauseate.

The concepts Waldbauer imparts are straightforward and time-honored; they generally take up just a couple of pages in a standard entomology text. What stands out is the enormous catalog of examples and anecdotes he has amassed to illustrate these basic principles, and his able use of teachable moments to illustrate good (and

faulty) scientific reasoning. For example, an experiment in the 1950s showed that certain small birds indeed jumped away when European peacock butterflies (*Inachis io)* displayed the eyespots on their wings. If the butterflies' eyespots had been rubbed off, the birds were rarely startled. But, tut tut, the experiment included no control! Just as clinical trials must include placebos, Waldbauer patiently explains, the intact butterflies should have been subjected to a similar rubbing treatment, elsewhere on their wings, that left the eyespots in place. A 2005 study recreated the experiments and included proper controls, finally demonstrating that the eyespots do serve to frighten predatory birds.

The author's frequent use of decades- or centuries-old examples sometimes makes the book feel quaint, but this approach also gives well-deserved airtime to delightful old passages penned at a time when formal scientific writing was more narrative than it is today. One of the most memorable descriptions is quoted from a turn-of-the-century report in which naturalist Nelson Annandale describes insects of the Malay peninsula, including a pink praying mantis *(Hymenopus bicornis)* that bears a detailed resemblance to rhododendron flowers. "When the Mantis reached the tip of the twig and found no flowers, it remained still for a few seconds, and then turned and descended with the same staggering gait," Annandale wrote. The account continues until the mantis settles in among a cluster of flowers and captures a large fly, which "was seized, torn in pieces and devoured, notwithstanding the presence of a large crowd of natives who had collected to watch what was happening."



In a chapter on eyespots and flash colors, Waldbauer offers anecdotes of insects, including moths, grasshoppers and stick insects, whose eyespots and other brightly colored features distract or confuse predators. The io moth *(Automeris io)* shown above is nocturnal; during the day, it rests with its eyespots hidden by its front wings. If it is threatened, it spreads its wings to reveal the spots, looking, says Waldbauer, "rather like the face of a small owl." From *How Not to Be Eaten.*

Alas, readers are offered no illustration of the flowery pink mantis. A few black-and-white illustrations, drawn by entomologist James Nardi, are scattered throughout the text, but the most vivid cases of mimicry and camouflage, the intricate jumping mechanisms of several insects, and other painstakingly described examples are left to the reader's imagination (or to Google images). Especially for Waldbauer's target audience of nonentomologists, more visual assistance would have been helpful.

The book's organization also has its pitfalls. Because many insects display multiple defenses, and because some categories overlap, the exposé sometimes feels redundant and fragmented. Interactions between bats and moths are mentioned in three widely spaced chapters before most of the story comes out and we learn that tiger moths (Arctiinae) listen for their predators' sonar and respond with clicking sounds that advertise the moths' toxic chemistry or, in some cases, confuse the bats.

Quibbles aside, the strengths of the book derive from the author's obvious fondness for his subject matter and his decades of experience as a keen observer of nature. Waldbauer is a professor emeritus of entomology at the University of Illinois at Urbana-Champaign, and *How Not to Be Eaten* is the tenth nontechnical book about insects he has authored since his retirement in 1995. The seasoned ecologist won't find much new here, but for the aspiring entomologist or amateur naturalist, there is much to appreciate in Waldbauer's wonderland of astonishing behaviors and colorful creatures. And for the entomologist's friends or family who don't see what's so great about the hexapod world, this book might be just the ticket. Its vivid stories are sure to inspire a closer attention to the small, everyday dramas playing out on spider webs, on flowers and all around us.

Elsa Youngsteadt is programs manager at Sigma Xi, where she coedits the Science in the News Daily *e-newsletter and manages Sigma Xi's research ethics program. She is also an associate editor of* American Scientist *and a freelance science writer. She completed a Ph.D. in entomology at North Carolina State University in 2008; her research focused on chemical communication between ants and seeds in Peruvian ant gardens. Her work can be found online at http://elsakristen.com.*