FEATURES

RAT POISON'S LONG REACH

Supertoxic rodenticides are building up inside unintended targets, including birds, mammals, and insects. Scientists want to understand the damage—and limit it

By **Dina Fine Maron**, *in Washington, D.C.*

The red-tailed hawk was so weak she couldn't make a sound. She couldn't even lift her beak. Feathers askew, the usually fierce predator lay motionless earlier this year on an examination table here at City Wildlife, a rescue and rehabilitation center. She appeared dehydrated and anemic, and veterinarian Sarah Sirica suspected the bird had been poisoned by eating mice or rats that had consumed powerful compounds known as second-generation rodenticides. The substances block the body's ability to clot blood, and the resulting internal bleeding can cause death within days. When predators or scavengers eat the poisoned rodents they, too, can ingest a dangerous dose.

Sirica drew a blood sample and placed it in a tube. She gently rocked the blood, waiting to see whether it clotted. After a half-hour, it still hadn't—strongly suggesting rat poison was in play. As she waited, Sirica began to rehydrate the bird and injected a dose of vitamin K, which can help restore a bird's clotting ability. Beyond that, there was little she could do but hope the hawk would recover.

Many poisoned animals don't. Around the world, second-generation rodenticides have been implicated in the deaths of predatory birds and the many other kinds of animals that feed on living or dead rodents, including wolves, foxes, skunks, and coyotes. The threat to wildlife—and people, too—has led many nations to impose some limits on how the compounds can be sold and used. But conservation scientists say there's growing evidence that such controls have done little to reduce nontarget poisoning. And they point to recent research suggesting these compounds—which studies suggest can remain in tissues for nearly a year—are more widespread in food webs than previously understood, turning up in amphibians, crustaceans, and even insects.

Such findings have become a catalyst for groups that are now urging the United States and other nations to tighten limits on some rodenticides. Last year, the U.S. Environmental Protection Agency (EPA) concluded in a draft evaluation that rodenticides including second-generation compounds threaten dozens of species, and recommended new restrictions. But industry groups are pushing back, arguing the chemicals are essential to effectively control widespread pests that do costly damage to crops and property and spread

PHOTO: CHIP SOMODEVILLA/GETTY IMAGES

A red-tailed hawk in Washington, D.C., may be about to ingest a dose of rodenticide with its meal.

disease. Others note the compounds can even benefit conservation by eliminating rats that threaten endangered species, including seabirds nesting on islands.

Weighing the costs and benefits of rodenticides is a challenging task, says Cynthia Hopf-Dennis, a wildlife medicine specialist at Cornell University. "If I had my way none of these anticoagulant rodenticides would be on the landscape," she says. But at the same time, she says, rodents are "a problem."

HUMANITY'S WAR against rats and other rodents dates back millennia. In ancient Egypt, some of the earliest depictions of cats show them facing down field rats. People later turned to poisons such as the heavy metal arsenic. Then, in the 1950s, chemists perfected a number of anticoagulant rodenticides, such as warfarin, that could be delivered in powders, pastes, pellets, or baits. They soon became a mainstay of rodent control.

Within a few decades, however, rats and mice began to evolve resistance to many of these compounds. In response, researchers in the 1970s developed an array of second-generation compounds, including brodifacoum, bromadiolone, difethialone, and difenacoum. They are more lethal than the earlier rodenticides; animals may die after eating just a single dose, although the process can take up to a week. They also have much longer half-lives, remaining in the tissues of dying and dead animals for an extended period before losing potency. Some testing suggests that in rat livers, second-generation poisons can stick around for almost a year.

Those traits proved to be bad news for predators and scavengers that feed on rodents, with researchers and regulators compiling extensive evidence that rodenticides were killing a wide range of animals. In the U.S., that evidence—as well as data suggesting household rodenticides posed a threat to children—persuaded EPA in 2008 to impose new rules on 10 rodenticides, including some second-generation compounds. They could no longer be sold in small quantities or in settings such as grocery stores where nonprofessionals could easily acquire them.

Those rules, however, had loopholes that left second-generation rodenticides within easy reach of many consumers. A recent search on Amazon, for example, showed that a buyer could purchase 8 kilograms of a brodifacoum—"the strongest single-feeding anti-coagulant on the market today," according to the listing—for less than $130. Globally, one recent analysis suggests second-generation rodenticides now account for some 60% of sales in the roughly $700 million anticoagulant rodenticides market, which has been growing rapidly in part because of urbanization.

Those trends help explain why wildlife poisonings continue to mount. In Italy, for example, 62% of 186 dead wolves collected from 2018 to 2022 carried at least one rodenticide in their bodies, researchers reported in January. A wildlife clinic run by Tufts University found that 100% of 43 red-tailed hawks admitted to the clinic from 2017 to 2019 carried rodenticides. (All died.) Most were second-generation anticoagulants, and analyses of liver tissue found 91% of the hawks carried two or more. A similar pattern appears in preliminary data shared with *Science* by New York state's Department of Environmental Conservation: Seventy-seven percent of 65 dead raptors found mostly in and around New York City parks from 2018 to 2023 had detectable levels of one or more rodenticide in their livers.

More recently, Flaco, the beloved Eurasian eagle owl that escaped from the city's Central Park Zoo and died about a year later after it flew into a Manhattan building, was found to have four anticoagulant rodenticides in its body. Pathologists at the Bronx Zoo concluded that the poisons and the owl's consumption of diseased pigeons "may have predisposed him to flying into or falling from the building."

The full scope of the rodenticide problem remains elusive, however, in part because relatively few animals ever find their way to a wildlife clinic. Even those that do are rarely checked for rodenticides—a test that in the U.S. can cost as much as $200 per animal. "No one is paying for these patients because they're wildlife," Hopf-Dennis says.

Even when testing reveals rodenticides, it can be difficult to know whether they actually killed the animal. Toxicologists haven't identified lethal doses for raptors, for example, notes wildlife pathologist Nicole Nemeth of the University of Georgia, whose lab probes wildlife deaths for the Southeastern Cooperative Wildlife Disease Study. "It's tricky to diagnose," she says. "We don't know the normal clotting times for raptors or use the same tests we might use in other areas of the veterinary world."

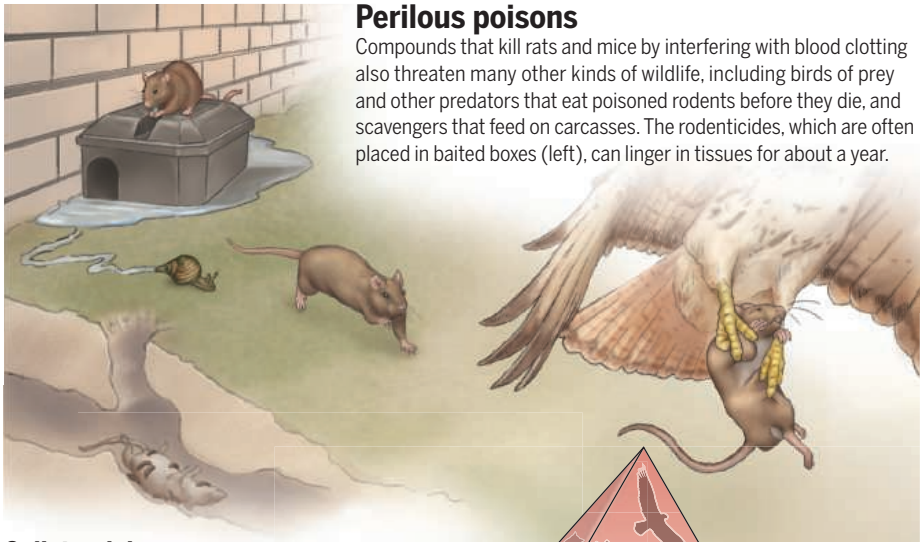
When Nemeth and colleagues tested the livers of 133 dead bald and golden eagles, for example, they discovered more than 80% carried rodenticides. But only in 4% of those cases could they definitively say poisoning killed the eagle, they reported in 2021. Sometimes, she notes, the poison might have had an indirect effect, such as making a bird more vulnerable to colliding with a vehicle.

One thing is clear from data collected by her lab, Nemeth says: The poisoning trend for raptors "has been bad and not getting better. It's really scary … despite regulations we haven't seen a decline."

Other recent studies have found rodenticides lower in food webs. The toxins have been detected in species as varied as geckos, shellfish, ants, cockroaches, and beetles. Brodifacoum has been found in blue cod, limpets, and mussels. In Australia, a study this year identified brodifacoum and other rodenticides in dead frogs. Some animals likely ingest the poisons when they eat contaminated prey, but contaminated soil and even contaminated rodent feces could also pose a threat, researchers say.

PHOTO: SANTA MONICA MOUNTAINS NATIONAL RECREATION AREA

Mountain lion P-22, captured in Los Angeles, suffered from mange. But he also had rodenticides in his blood.

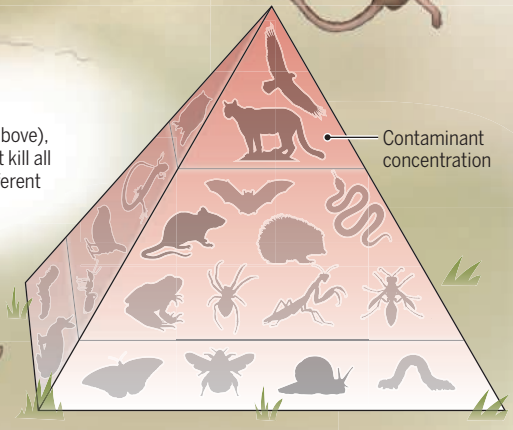


Perilous poisons

Compounds that kill rats and mice by interfering with blood clotting also threaten many other kinds of wildlife, including birds of prey and other predators that eat poisoned rodents before they die, and scavengers that feed on carcasses. The rodenticides, which are often placed in baited boxes (left), can linger in tissues for about a year.

Collateral damage

Nontarget animals, including slugs and snails (above), consume rodenticides. The compounds may not kill all exposed animals, partly because some have different blood clotting mechanisms.



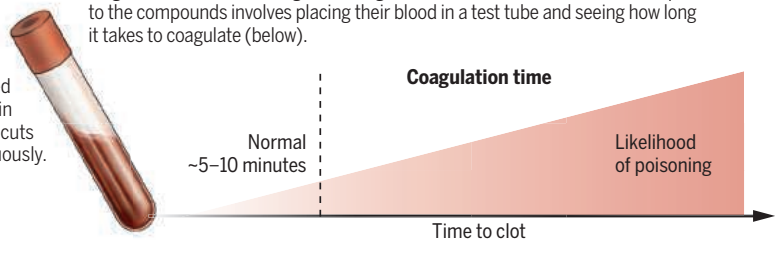
An accumulating threat

The discovery of rodenticides in animals across the food web has raised fears that the chemicals can bioaccumulate from organisms lower in food chains, such as insects, to top predators such as cats and birds.

All in the blood

In red-tailed hawks (*Buteo jamaicensis*), anticoagulant rodenticide poisoning can cause anemia and internal bleeding, hampering function in the brain, muscles, lungs, and other internal organs. A rough test to see whether animals were exposed to the compounds involves placing their blood in a test tube and seeing how long it takes to coagulate (below).

Birds with impaired clotting can sustain bruises and small cuts that bleed continuously.



GRAPHIC: N. BURGESS/*SCIENCE*

Last year, researchers reported that slugs and snails can crawl into bait traps and directly consume the poisons. That is "concerning" says Aimée Code, pesticide program director at the Xerces Society for Invertebrate Conservation. "Invertebrates are the foundational species that support many ecosystems."

In the United Kingdom, a 2020 study found that more than half of 120 dead European hedgehogs had detectable levels of second-generation anticoagulants. The hedgehogs mostly eat mollusks, beetles, and earthworms—species with blood-clotting mechanisms that can protect them from anticoagulant rodenticides. But the hedgehogs are still vulnerable, the scientists noted.

SUCH WILDLIFE DATA, along with continued concerns about accidental poisonings of people, has spurred calls for tighter regulation. In the U.S., for example, pressure from conservation groups prompted EPA to more comprehensively analyze the risks that 11 rodenticides, including four common second-generation poisons, pose to the nearly 1800 plants and animals protected under the federal Endangered Species Act. Hundreds of species are at risk from the compounds, and the agency scientists also found that the four second-generation rodenticides pose a specific threat to about 30 species. That group includes high-profile animals such as the California condor and the northern spotted owl, as well as more obscure creatures such as the Buena Vista Lake ornate shrew and the Puerto Rican boa.

EPA also recommended ways to reduce the threat, such as by restricting where, when, and how the poisons are used, and requiring applicators to search for and remove dead rodents before wildlife can eat them. The agency has also separately proposed classifying second-generation poisons as "restricted use pesticides," meaning only people trained and certified to use the compounds, such as licensed pesticide operators and farmers, could do so.

Such restrictions are a good start, says Jonathan Evans, environmental health director at the Center for Biological Diversity. He's skeptical, however, that they'll do enough to keep people and wildlife safe. He notes that in 2014, California's state government imposed some similar use restrictions on second-generation anticoagulants, but they had limited effect. One analysis by state officials found that 4 years later, more than 85% of tested mountain lions, bobcats, and Pacific fishers (a predatory mammal) carried the poisons. Since then, the state has imposed even tighter rules, allowing second-generation rodenticides to be used only in

agricultural settings and to address public health emergencies, such as an outbreak of the rodent-borne disease hantavirus or the rare cases of plague. Evans would like to see federal officials move in a similar direction.

Other groups, however, oppose tighter federal restrictions, saying they would hamper the use of a vital tool for quickly and affordably combating destructive rodents. EPA's proposed restrictions lack "substantive scientific support" and "will result in multiple detrimental impacts to people and the economy, while achieving no measurable benefit to wildlife and human safety," the Rodenticide Task Force, made up of 13 companies that use or make rodenticides, argued in comments to EPA. It called the proposed measures "unrefined, overbroad, unnecessary, and counterproductive."

EPA is expected to issue its final environmental evaluation in November. Other agencies, including the U.S. Fish and Wildlife Service, will then weigh in on whether they think the agency's regulatory plan will provide adequate safeguards for wildlife, Evans says. EPA estimates its next interim decisions on using these substances—which still won't be the final word—could come in 2025.

At a Wisconsin wildlife center, a technician examines a red-tailed hawk thought to be poisoned by rodenticides.

PHOTO: DANE COUNTY WISCONSIN HUMANE SOCIETY WILDLIFE CENTER

EVEN AS OBSERVERS wait to see what EPA decides, some are launching new efforts to learn more about the rodenticide threat—and develop potential solutions. In Washington, D.C., for example, the city government is backing an effort to send liver samples from dead raptors to a toxicology lab at the University of Pennsylvania for testing. The effort was launched in the summer of 2023, after the number of poisoned birds appeared "to reach truly disturbing levels," says Jim Monsma, executive director of City Wildlife.

"We have to know what compounds are an issue, where they are, and how they are being deployed, before a plan … can be put into action to limit exposure to wildlife," says Dan Rauch, a wildlife biologist with the city's Department of Energy and Environment.

Rodents can be controlled without poisons, says John Griffin, senior director for Urban Wildlife Programs at the Humane Society of the United States. Measures such as rat-proofing trash containers and cleaning up spilled grain on farms can help keep populations in check. Snap traps are still an option. Pilot projects have even tested the use of raptors to catch rodents. (But Evans notes the birds must be placed in areas devoid of the poisons or risk getting poisoned themselves.) Edible chemicals that reduce fertility are another available approach. Yet those compounds cost more than poisons and can take longer to have a tangible effect.

In sub-Saharan Africa, some farming communities have been experimenting with an alternative approach known as ecologically based rodent management. It often involves manipulating the environment to control rodent populations: by clearing grass and brush that provide rodents with cover, for example, or using deep plowing and field flooding to disrupt rat burrows, or even deploying cats or predatory birds.

Farmers in Ethiopia have also used poisons made from local plants that have relatively short half-lives, so they don't accumulate in the food chain. This homegrown option has one major drawback: "The rodents need to consume it multiple times," says biologist Yonas Meheretu of the Swedish University of Agricultural Sciences, a co-author of a recent study of the approach in *Crop Protection*.

Ecological approaches have gained favor in some communities, such as rice farmers in Southeast Asia, Meheretu says. But they are a harder sell in other places. "In urban areas and in slums, for instance, it's almost impossible" to organize community support.

Unfortunately, Griffin says, "There's no silver bullet" for controlling rodents while protecting wildlife. "The way rodents live with us and among us is a problem that's been around hundreds of years, but we have to do more" to curb the harmful effects of rodenticides, he says.

NOT EVERY ENCOUNTER with rodenticides has an unhappy ending. In March, 16 days after Sirica first treated the incapacitated red-tailed hawk, Paula Goldberg, former executive director of City Wildlife, opened the trunk of her Toyota SUV to reveal a small white box perforated with air holes. The box rocked slightly, then jumped. Goldberg grinned as she placed the container beneath a nearby tree. "We'll stay quiet and let the bird do its thing," she said, before she opened the box's flaps.

An explosion of brown and white feathers, a hooked beak, and fierce claws emerged. The hawk flew directly upward, landing on a sturdy branch roughly 30 meters above. It had been released hungry, to help ensure it would go hunting and return to its natural patterns. After a half-hour's rest, it flew to a second tree where it sat, perhaps scouting for its next meal, unaware of any toxins that might be hidden inside. ■

Dina Fine Maron is a journalist in Washington, D.C.