



THE 18-KM² RAT TRAP

Ecuador has successfully eradicated invasive pigs and goats from most of the Galapagos archipelago. Now it is taking on the rats.

BY HENRY NICHOLLS

The helicopter appears as a speck on the horizon, moving slowly on a dead-straight path over the black volcanic island. Beneath it hangs a huge metal cone: an industrial-scale hopper that is sending a steady stream of blue pellets raining down on the scrubby landscape of Pinzón, one of the Galapagos Islands.

Erin Hagen watches through her binoculars. She is standing on the deck of the *Sierra Negra*, one of three vessels moored just off the island on this morning in November 2012. When the helicopter reaches the rocky shoreline, it changes course, heads across the ocean and hovers just above the boat. At Hagen's instruction, a team of conservationists comes to life. Two men stand by to service the hopper. Three others prepare to reload it with more than 400 kilograms of poisoned rat bait. Within three minutes, the loading is complete and the helicopter is heading back to lace Pinzón with more toxic bait. "It's kind of like a pit-stop," explains Hagen, a project manager for Island Conservation, an international non-governmental organization with expertise in the eradication of invasive species. "There's a real buzz from everyone."

Five years ago, most of the major islands and smaller rocky outcrops

in the Galapagos were home to a plague of invasive mice and rats. The rodents feed on the eggs and young of seabirds, land birds and reptiles, and have brought several species — including the rare Pinzón giant tortoise (*Chelonoidis duncanensis*) — to the brink of extinction. In 2007, the Galapagos National Park Service (GNP) and the Charles Darwin Foundation (CDF) developed an initiative code-named Project Pinzón, a military-style plan-of-action to kill invasive rodents on three islands — starting with North Seymour (1.8 square kilometres), then moving on to Rábida (5 square kilometres) and, finally, Pinzón (18 square kilometres) — plus around a dozen smaller outcrops and islets (see 'Rat race').

The effort, costing some US\$3 million so far, is not the biggest rat eradication ever attempted. But it is one of the most high-profile and challenging. Before conservationists and scientists could start attacking the rodents, they had to ensure that their poison would not take out some of the unique — and endangered — mockingbirds, finches, rails, iguanas and tortoises famously described by Charles Darwin. And whereas most rat eradications so far have targeted remote, uninhabited islands, the Galapagos is home to some 30,000 people and receives around 180,000 visitors each year. With so much boat traffic, the risk of reinvasion will be very high, says James Russell, an ecologist at the University of Auckland in New Zealand who has a special interest in rat invasions. "Their real challenge is going to be that biosecurity," he says.

For those involved, the anti-rat campaign is worth the trouble and the risks. It promises to allow unique species to flourish again and, building on the prior removal of feral pigs and goats from much of the archipelago, to make Ecuador a world leader in the eradication of invasive species. "Galapagos is up there in the front line looking to make the next big leap in multi-species pest management," Russell says.

By the time Darwin arrived in the Galapagos in 1835, the rodents had

CAROLYN JENKINS/ALAMY

long since settled in. Mice and black rats were probably the first to arrive, introduced by pirates or whalers in the seventeenth century; since the 1980s, Norway rats have found their way there too¹.

Galapagos experts have little doubt that the rodents have devastated native wildlife, even though the creatures' effects have not been studied systematically. "I just hated the immigrant killers because I could see what they were doing," says Felipe Cruz, a lifelong conservationist who grew up on Floreana, one of four inhabited islands in the archipelago. In the early 1980s, Cruz spent nine months of the year camped in the Floreana highlands deploying a cocktail of rodenticide to prevent rats from destroying eggs and chicks in the most important breeding colony of the Galapagos petrel (*Pterodroma phaeopygia*), a species that has been listed as critically endangered since 1994 (ref. 2).

His dedication was rewarded, says Cruz. "There were more birds, more plants, more lizards. It was like an island within an island." It was also a transformative experience. "It's something that fills me with pride, satisfaction and somehow shaped my life," he says.

SCALING UP

Before long, Cruz had an opportunity to eradicate black rats on a bigger scale: from the entire island of Pinzón, where they were destroying the island's endemic tortoise species by devouring hatchlings. In 1988, "there was a massive, massive drought and we began to see dead rats everywhere," recalls Linda Cayot, then at the Charles Darwin Research Station on the central island of Santa Cruz and now science adviser for the Galapagos Conservancy in Fairfax, Virginia. Cayot and Cruz saw the perfect opportunity to finish what the drought had started, and convinced the directors of the GNP and the CDF to allow a team to spread bait laced with rodenticide.

The rat population recovered after a few months, but Cayot describes the exercise as "a successful failure". The researchers realized that very young rats may not have encountered the bait, and that they needed to apply it twice. "I think we came really close," Cayot says. "We just learned so much about how to run a massive field operation."

This paved the way for an onslaught against much larger invasive mammals — mainly pigs and goats — whose relentless grazing had stripped out much of the vegetation, with knock-on consequences for native herbivores. Project Isabela, a staged initiative that began in 1997 and cost nearly \$10.5 million, resulted in the eradication of invasive pigs from the huge island of Santiago³ and some 140,000 goats from more than 5,000 square kilometres on several islands. According to Cruz and others involved in the project, it is "the world's largest island restoration effort to date"⁴. The effort also gave Galapagos conservationists the confidence to think big, says Cruz. They resolved to launch a new assault on the rats.

In 2007, the GNP and the CDF held a workshop to consider how best to approach the rat problem. This pulled together expertise from around the world, most notably from New Zealand, a country that has some 50 years of experience in the eradication of invasive species ranging from rabbits to wallabies. New Zealand is also the record holder for rat eradication: the 113-square-kilometre Campbell Island has officially been rat-free for almost a decade (<http://eradicationdb.fos.auckland.ac.nz>). "It's a bit of an industry in New Zealand," says John Parkes, a collaborator with Landcare Research, an environmental research organization based in Lincoln, New Zealand, and a key participant in the workshop. "There's lots of research that shows the benefits of removing these exotic species from islands far outweigh the short-term costs imposed by the control technologies themselves."

The workshop resulted in Project Pinzón, which, by working from small to bigger islands, had the aim of "taking on progressively larger

and more complex eradications", says Karl Campbell, senior programme director for Island Conservation. Soon after Ecuador's environment ministry signed off on the plan, the GNP and the CDF set to work on North Seymour, with Island Conservation entering into the project in 2008.

Later that year, with signs of success on North Seymour, Island Conservation approached Bell Laboratories, a company in Madison, Wisconsin, that specializes in industrial-scale rodent control. Would the firm donate sufficient bait — almost 45 tonnes — to cover all the remaining islets and islands identified in the Project Pinzón roadmap? The company, attracted by the philanthropic cause, agreed.

The biggest uncertainty was what impact the active ingredient — an anticoagulant called brodifacoum — might have on non-target species. In birds and mammals, the chemical prevents the repair of capillaries that rupture naturally, resulting in internal bleeding and, if the dose is high enough, death. What was not known was how the "eminently curious" fauna of the Galapagos, as Darwin described it, would respond if exposed to the bait. "We had to start building from scratch," Campbell says. This meant doing a risk assessment for all vertebrates and threatened species that might be affected on the islands yet to be baited.

Among the species of greatest concern were the Galapagos mockingbirds and finches, which might happily peck away at the bait. So, in 2009, graduate student Ana Lucía Carrión Bonilla of the University of San Francisco in Quito set about determining what colour these iconic birds like least⁵. Once she had the answer — blue — Bell Laboratories cooked up a blue version of an existing rat bait. Trials of a non-toxic version were promising: a suite of key endemic species turned their noses up at the bright blue blocks. Subsequent tests showed that a toxic version of the bait killed invasive house mice occupying the small uplifted island of North Plaza. In an added twist, the bait here and on most subsequent islands was spiked with a fluorescent dye to help researchers to track its movement through the environment by tell-tale traces on trails, nests, faeces and the animals themselves. "You go out with a big ultraviolet spotlight and you can see basically where this bait has gone," says Campbell. This suggested that some finches and lava lizards were nibbling at the bait, but were not killed by it.

Although the taste tests indicated that the Galapagos' world-famous tortoises and other reptiles would not gorge themselves on the bait, nobody was taking any chances. "We needed to get some hard data on what to expect if tortoises did eat the bait," says Penny Fisher of Landcare Research. In 2010, Fisher fed the bait pellets to captive tortoises of hybrid origin — which conservationists consider less valuable than

wild-living, purebred animals — then drew blood samples over the course of several weeks and measured how long they took to clot as an indicator of toxic effects. "It was a nerve-racking trial to do," she says. But, for reasons that are not yet clear, the coagulation time remained fairly constant, suggesting that tortoises would not face a serious risk of poisoning.

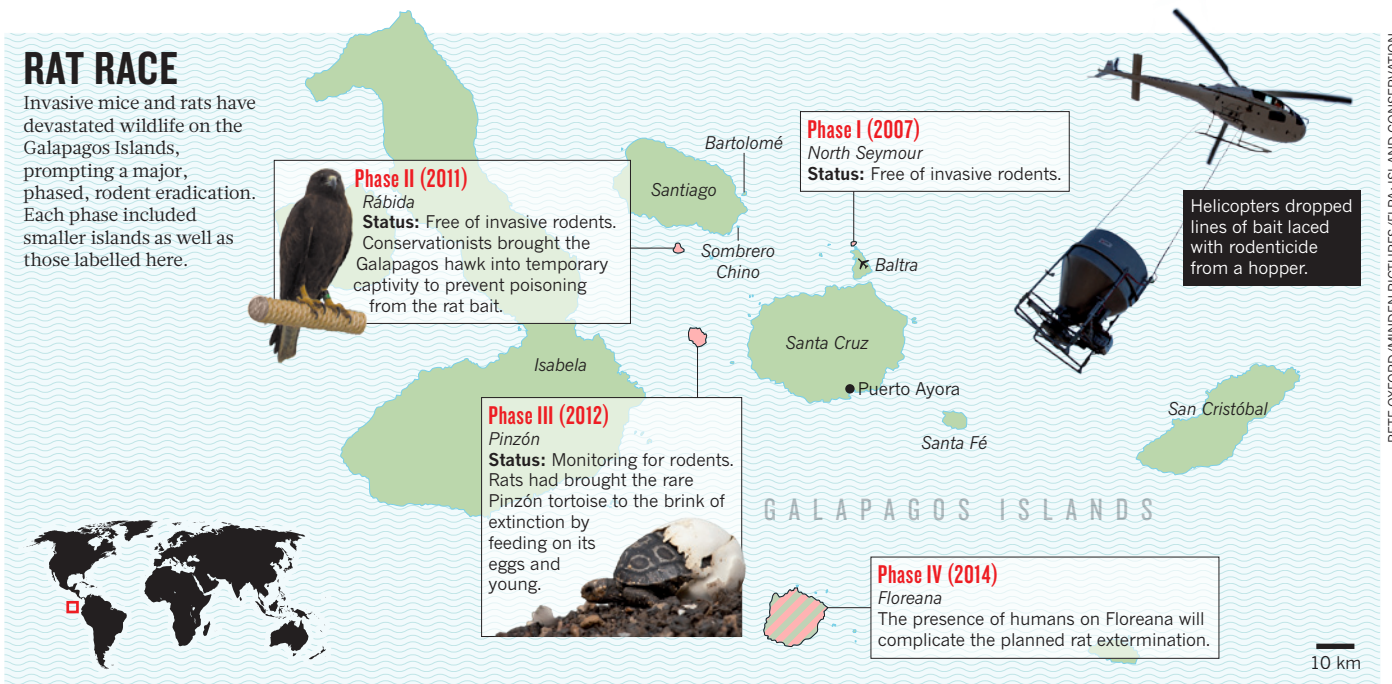
Protecting other species required more drastic measures. The Galapagos hawk perches at the top of the local food chain and, with a diet that ranges from young iguanas to sea lion afterbirth, faced the greatest risk of inadvertent poisoning. So the team decided to bring all territorial hawks into captivity until six weeks after the first bait drop. In January 2011, when the helicopter delivered bait over Rábida and a handful of smaller islets, Julia Ponder of the University of Minnesota looked after 20 hawks in makeshift aviaries on the nearby island of Santiago. All of the birds survived and were released back to the wild. And after a thorough survey in November 2012, the GNP declared Rábida free of invasive rodents.

Now, with a small population of tortoises in captivity as insurance, it was time to prepare for Pinzón itself. The helicopter pilot would need a three-day window of clear skies to bait the landscape with the necessary accuracy, and he would navigate along tight, pre-ordained flight

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RAT RACE

Invasive mice and rats have devastated wildlife on the Galapagos Islands, prompting a major, phased, rodent eradication. Each phase included smaller islands as well as those labelled here.



PETE OXFORD/MINDEN PICTURES/FLPA; ISLAND CONSERVATION

lines just 35 metres apart. “Keeping those lines straight is what makes or breaks a project,” says Hagen. “Then we know we can ensure full coverage.” In the run-up to the operation, Hagen and the baiting team practised loading and dropping bait on an abandoned US military airstrip on the island of Baltra. Then, in mid-November 2012 and with the weather forecast looking good, the operation began in earnest.

SIGNS OF SUCCESS

When Hagen stepped onto Pinzón after the second baiting in December, the island looked much as normal. “Typically what animals do when they are exposed to the rodenticide is go into safe areas because they don’t feel well,” she says. That means the only evidence of mass poisoning is the occasional smell of rotting flesh and perhaps a skeletal rat carcass. It usually takes around two years of monitoring — using traps for live animals, ‘bite cards’ distributed across the landscape, and searches for rat footprints and faeces — before an eradication effort is declared a success.

Assuming the rats are gone, the team will monitor how the ecosystem responds over the next five to ten years. Regular on-the-ground surveys will document how key species fare and acoustic sensors will gather data on the abundance and diversity of bird life from their calls. “For each of these threatened species the ultimate measure will be growing populations, possibly even self-sustaining,” says Nick Holmes, director of science at Island Conservation.

One archipelago-wide indicator will be land snails of the genus *Bulimulus*. Although not as famous as Darwin’s finches, these small snails with pine-cone-shaped shells offer an even more compelling illustration of natural selection’s creative force: there are some 70 documented species, all of which could be descended from a single common colonizing ancestor⁶. But rats feed on them, which might explain why more than 50 of the species are threatened — and their damaged shells offer a good way to quantify rat predation. “Invertebrates in general are going to give us a faster idea of the response to the eradication programme,” says Christine Parent of the University of California, Berkeley, who in years to come will help to monitor Pinzón’s snails for signs of a rebound.

But if there is one certainty in such a complex operation, it’s that not everything will go to plan. Although Ponder and her colleagues succeeded in keeping 60 Galapagos hawks in captivity over the course of the Pinzón campaign, the birds have not fared so well after their release. “We have 16 confirmed dead,” says Ponder. She thinks that the birds dined on small reptiles that had consumed the bait. In future, it

may pay to keep the hawks in captivity for longer.

Even if every last rodent is removed from an island, constant vigilance will be needed to prevent a reinvasion. In January 2011, the GNP and Island Conservation assessed the probability of reinvasion by baiting the islands of Bartolomé and Sombrero Chino, which lie within 500 metres — swimming distance for a rat — of the still rat-infested island of Santiago. In November 2012, they found evidence of rats on both of the treated islands. (Fortunately, Rábida and Pinzón are beyond rat swimming distance of neighbouring islands.)

Tourist vessels and other boat traffic will also need to be monitored for stowaway rats. And there is always the risk of human sabotage, which occurred several times after Project Isabela. In 2009, for instance, some malcontent set six goats down on Santiago, which by then had been goat-free for around three years. The GNP put the cost of monitoring the island and removing these animals at \$32,393, more than \$5,000 a beast⁴.

In spite of such setbacks, Ecuador’s environment ministry is pushing ahead with its programme of ecological restoration in Galapagos. For 2014, the central government has committed several million dollars to attempt the extermination of rats from the 173-square-kilometre island of Floreana, where the human population adds to the challenge. “Dropping poison around people adds a layer of complexity,” says Parkes. But success on an island the size of Floreana would set an example for the rest of the world. It would also make it easier to realize conservationists’ long-standing ambition of reintroducing mockingbirds and tortoises to the island, not to mention the respite it would bring for the Galapagos petrel.

And that would be the realization of a lifelong dream for Cruz. “When I travel between the islands and I get to see groups of petrels flying about, I have to be quite honest,” he says. “My heart beats faster.” ■

Henry Nicholls is a science journalist based in London. His latest book *The Galapagos* will be published by Profile Books in 2014.

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