# TORTOISE GENES AND ISLAND BEINGS

## Giant Galápagos reptiles on slow road to recovery

BY BRYN NELSON

Not far from where the Galápagos Islands' most famous loner spends his days, tourists disembark by the inflatable boatload at a modern dock. A path takes them past marine iguanas sneezing brine from their salt-caked nostrils and striated herons roosting in the red mangroves to the Charles Darwin Research Station in Puerto Ayora on Santa Cruz Island. Within the station, another walkway leads to a natural enclosure sheltering a misanthropic Galápagos tortoise named Lonesome George.

The confirmed bachelor has been a potent icon of conservation ever since he was spotted on remote Pinta Island in 1971 and captured the next year by a group of goat hunters. Now in his 60s, 70s, or beyond—no one really knows—George may have lived more than half his life in exile. He is quite likely the world's last pure-bred Pinta tortoise, one of the dozen or so closely related species that still lumber around the Galápagos, an archipelago of 19 islands and dozens of islets about 600 miles west of mainland Ecuador.

Last April, however, the surprise discovery that Lonesome George has a genetic cousin on another island cast doubt, in a hopeful way, on George's one-of-a-kind status. The revelation is just one illustration of how genetics and conservation biology are intermingling to rewrite an oversize reptile's evolutionary past and to reshape plans to safeguard the remaining tortoise species well into the future.

**ON THEIR WAY —** Tortoise hatchlings only a few years old beat the heat at the Charles Darwin Research Station in the Galápagos Islands. These hatchlings, bred in captivity, will be released into the wild at 5 years of age.

**REVIVAL SIGNS** Estimates of how many giant tortoises remain in the Galápagos vary widely, from less than 10,000 to more than 30,000. Nearly everyone agrees that their prospects are improving, however. "If you look at tortoises today compared to 50 years ago, they are so far ahead of where they used to be," says Linda Cayot, Lonesome George's former keeper and a scientific adviser to the Falls Church, Va.–based Galápagos Conservancy.

But tortoise conservation may be a rare bright spot in the struggle to protect the fragile Galápagos ecosystem. The archipelago is so revered for its unique marine and terrestrial life that it was the first World Heritage Site chosen by the United Nations Educational, Scientific and Cultural Organization (UNESCO). In late June, the organization's World Heritage Committee added the caveat "in danger" to the designation to draw attention to mounting threats, including a surge in tourism and rising immigration from Ecuador's mainland. Increased flights and boat traffic have contributed to a 60 percent escalation in introduced species since 2001.

In April, before the UNESCO announcement, Ecuador's President Rafael Correa acknowledged these concerns by declaring the islands' ecosystem a national priority for conservation efforts. Amid the ensuing calls to scale back residency permits and overhaul a broken tourism model, the discovery of Lonesome George's kin sounded a rare hopeful note. Having compared highly variable regions of DNA from cell nuclei, Gisella Caccone and Jeffrey Powell of Yale University and their colleagues reported in the May 1 *Current Biology* that a tortoise on volcano-studded Isabela Island has about half its genes in common with George. The researchers even suggested that George may have full relatives on the same island.

The potential salvation of George's species, the Pinta tortoise, began in 1994. That year, the Yale team collected blood from 27 tortoises living on the slopes of mile-high Volcán Wolf, an active volcano on Isabela Island's northern end. Unlike single-species populations found elsewhere in the Galápagos Islands, the Volcán Wolf tortoises display an unusual combination of carapace shapes. Some are dome shaped, others have Lonesome George's distinctive saddle-back form, and some show characteristics of both types.

By 2002, the researchers had retrieved enough nuclear DNA and maternally inherited mitochondrial DNA from other Galápagos populations to tease out some unexpected links. The Volcán Wolf group seems to include a hodgepodge of lineages arising from multiple colonizations, while Lonesome George appears most evolutionarily related to saddle-backed tortoises on Española and San Cristóbal Islands, more than 180 miles to the southeast. Caccone speculates that some tortoises on the southern islands may have floated on the strong ocean currents that flow northwest to Pinta.

In 2003, a joint expedition by the Galápagos National Park and the Oviedo, Fl.–based Chelonian Research Institute failed to find any signs of tortoise life on Pinta Island but did uncover the skeletons of 15 former male residents. By extracting DNA from those remains and from others stashed away in museum collections, Caccone and her collaborators were able to compile a robust genetic profile of the Pinta species. Later, the researchers found a partial match in the nuclear DNA of a young male tortoise from the previously sampled Volcán Wolf population. The tortoise's mitochon-

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drial DNA indicated that his mother had been born on Isabela. But it was clear that he had a Pinta male for a father, making him a hybrid of the two species.

"We had it all along but didn't know it until we had the new samples from Pinta," Caccone says. Because they have already uncovered one half-match among 27 Volcán Wolf tortoises out of a total estimated population of 2,000 to 8,000, she says, that "the chance of finding another hybrid, or even a pure [Pinta], is pretty high."

Caccone hopes to send three teams back to the steep volcano to collect more tortoise-blood samples next summer. If DNA tests reveal the presence of pure-blood Pintas, researchers could set up a new breeding program.

Discovering more Pinta tortoises would be "thrilling," agrees Johannah Barry, president of the Galápagos Conservancy, "but it would probably not be critical to the restoration of the Pinta Island ecosystem." Beyond the small chance of finding enough individuals to constitute a robust population, she says, back breeding any half-relatives to recover a pure Pinta bloodline could take decades.

How a Pinta father ended up on Isabela remains unclear. A strong current runs the roughly 50-mile route from Pinta to Volcán Wolf, and historical accounts leave open the possibility that tortoises may have washed ashore after being dumped overboard by pirates or whalers.

Genetic studies may allow researchers to reconstruct the history of specific tortoise populations and to determine whether they may have long-lost relatives on other islands. Even so, Caccone warns that genetic patterns are often deceptive within endangered species. Diverse genotypes, normally a hallmark of older populations, can be rapidly depleted through human interference and result in populations with artificially youthful profiles, she says.

**POOL PALS —** A Galápagos tortoise shares a morning swim with a white-cheeked pintail in a duckweed-covered pool in the Santa Cruz highlands.

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**TORTOISE TALES** Millions of years before Europeans first caught sight of the Galápagos in 1535, ancestors of the islands' tortoises were likely roaming the South American continent. Mitochondrial-DNA comparisons suggest that the small Chaco tortoise found in the southern half of South America is the closest living relative of its much larger Galápagos counterparts, although Caccone believes that their common ancestor was also oversize. A combination of genetic evidence and geological estimates of when the islands were formed suggests that tortoises likely arrived no more than 2 to 3 million years ago, she says.

As for how the animals made the 600-mile ocean voyage, the chilly Humboldt Current that flows north from the tip of South America and then west along the equator could have been a conduit. "It's a great highway," Caccone says. Whether carried along on her own or on a floating mat of vegetation, a single female laden with eggs could have founded the entire Galápagos population.

Apart from their size and buoyancy, Galápagos tortoises can stay alive for 6 to 9 months without food or water, an evolutionary adaptation that became a curse when 17th- and 18th-century buccaneers and subsequent waves of whaling crews discovered that the reptiles would provide a plentiful and long-lasting source of meat. The logbooks of whaling ships record crew members often loading tortoises by the dozens into bilges and cargo holds, including up to 100 Pinta tortoises at a time.

At least two species went extinct. And by the early 1900s, American and British researchers had retrieved only a handful of live tortoises on Pinta, all of which were killed by the collectors or died en route to distant museums. The fate of the Pinta population remained murky until 1971, when a snail expert conducting research on the island saw a single tortoise and took a few pictures, unaware that his sighting was anything unusual. Peter Pritchard, director of Chelonian Research Institute, recalls that the researcher casually mentioned his sighting when the two were dining together. "Well, I was flabbergasted," Pritchard says.

Eventually, word reached the Charles Darwin Foundation, which receives its funding from a range of nonprofit organizations, countries, and individual donors and advises the Ecuadorean government on conservation issues. The foundation's research station launched an expedition in early 1972. Pritchard, who was studying marine turtles at the time, joined the trip to look for turtle nesting sites. By the time his boat arrived, he says, a resourceful student had already found the Pinta tortoise, and the expedition's goat hunters had tethered it to a cactus so that it wouldn't disappear.

**MOVING FORWARD** In the 35 years since then, Lonesome George has been living at the research station on Santa Cruz, spurning two female tortoises from Isabela, ignoring frisky males who have provided sex-ed lessons, and spurring a barrage of speculation over what ails him in the reproduction department.

George's keepers have looked into diet, erectile dysfunction, and other bodily functions but have yet to find an answer. Nor do researchers know enough about reptile physiology to try cloning him. In 1994, Cayot learned a sperm-retrieval technique from a German zoo veterinarian and taught a Swiss volunteer how to fondle a rather ticklish George. "She could get the other tortoises to ejaculate in 15 minutes," Cayot recalls. "We worked with George for months and got nothing."

Pritchard says that he has a videotape of George "energetically chasing a female, mounting her, and getting pushed off as she goes under a low branch"—testament to his intact, if unrefined, libido. But if the bachelor tortoise can't, or won't, keep the bloodline going, Caccone hopes that her hunt for a living relative with a stronger inclination will let George off the hook.

In the meantime, conservationists have assisted the wild tortoises on Isabela and other islands with a massive effort to eradicate one of their worst enemies: feral goats. Introduced as a food source by whalers, fishermen, and settlers, goats can chew plants down to the nub. Large herds can tear up the landscape, leading to severe erosion and even ecological collapse. On Isabela Island, goats didn't arrive until the 1970s. Less than 3 decades later, their ranks had swollen to an estimated 75,000 to 125,000.

Project Isabela, run jointly by the Charles Darwin Foundation and the Galápagos National Park, employed helicopters, hunters, and trained dogs to track down the island's unwelcome interlopers. The collaborators also fitted female "Judas goats" with radio collars to betray the locations of male admirers. Last year, researchers announced that the northern part of Isabela was goat free, adding to earlier successes on Pinta, Santiago, and Española Islands.

On Española, a tourist favorite in the archipelago's southern reaches, goats were removed by the thousands in the 1970s, but by then the island's resident tortoise population had dwindled to 12 females and 2 males. Volunteers evacuated the survivors to the Charles Darwin Research Station and set up an emergency breeding program. A third male from Española was later located at the San Diego Zoo and called into service. Remarkably, they and their repatriated descendants now number more than 1,400.

Tortoise-breeding centers are operating on the islands of Santa

Cruz, Isabela, and San Cristóbal. At 5 years of age, most tortoises are too large to be threatened by invasive black rats and Norway rats, and can be resettled on their native islands with about an 80 percent survival rate. The Galápagos Conservancy's Barry says that the impressive track record should be a model for other resource-limited locations. "I think that restoring what we had a hand in removing is a fairly nice spin of the cosmic wheel," she says.

Success in culling the goats has not only made Pinta Island safe for tortoises again but has also intensified calls for their return. Without a major herbivore to break up the vegetation and regulate access to sunlight, botanists fear a loss of diversity among native plants and habitats and have lobbied for a full-scale tortoise reintroduction.

Officially, the Charles Darwin Foundation is neutral on the proposal, though Bryan Milstead, its head of vertebrate research, is leaning in favor of it. Tortoises are the major herbivores in the Galápagos and vital regulators of the ecosystem, he says. If Lonesome George cannot sire a new generation of tortoises for Pinta Island, Caccone's genetic research has shown that "the next best thing would be to bring an Española tortoise there."

Caccone hopes to repopulate Pinta Island with its native species, whether by George or a relative, though she concedes that much will depend on what her team finds on Isabela. She has a precedent, though, for believing that her DNA comparisons may turn up the unexpected. Two years ago, Caccone's team discovered the genetic signatures of three separate lineages on Santa Cruz instead of its presumed single species. Among their finds, the researchers determined that an isolated dome-shelled group of about 100 tortoises known by their geographic location, Cerro Fatal, should be considered a new species and added to the radar of conservationists.

**STANDING PROUD —** A Galápagos tortoise with a distinctive saddle-backed carapace poses at the Charles Darwin Research Station.

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As one species comes into being, taxonomically speaking, conservationists are struggling to keep hundreds of other types of native plants and animals from disappearing. Critically endangered mangrove finches are being terrorized by rats. Any importation of the West Nile virus could decimate the Galápagos penguin population. And guavas are among the hundreds of introduced plants that now far outnumber native ones.

Park officials are still grappling with tortoise poaching in some remote areas of Isabela, and they are reviewing a plan to kill invasive rats that eat native-born hatchlings on Pinzón and other islands. Even so, the evolutionary icons that so intrigued Charles Darwin are adapting better than many other Galápagos species. Although the guava is overtaking native plants, its fruit is fast becoming a favorite among the tortoises. "They're tough beasts, as long as people don't roll them over and chop them open," Pritchard says.

Like Pinta's potentially lost population, tortoises on San Cristóbal were once given up for dead. But on a trip to San Cristóbal in June, Pritchard's group counted 128 tortoises in 4 hours. "Give them a chance," he says, "and they will recover." ■