

"VOYAGE TO THE GALAPAGOS" SHOW 1001

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EPISODE OPEN

ALAN ALDA: Charles Darwin once rode on one of these. And it was something about their shells that gave him the first clue that living creatures change over time.

ALAN ALDA (Narration): The giant tortoises of the Galapagos Islands are among the many unique animals here...

ALAN ALDA: OK, I'm sorry, I'm sorry.

ALAN ALDA (Narration): ...that got Darwin to thinking about how new species come into being. Today, the islands' creatures still amaze their visitors...and provide insights into how evolution works.

ALAN ALDA: I'm Alan Alda. Join me, and the creatures that inspired Darwin, as we Voyage to the Galapagos.

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DARWIN'S EDEN

ALAN ALDA: In 1831, at the age of 22, Charles Darwin set off on a voyage that would change not only his life but ours as well. The naturalist on the British Naval ship *The Beagle*, Darwin traveled around South America and beyond. What he saw on an isolated group of islands out here in the Pacific began an intellectual voyage that would last some 20 years, and would culminate in the then shocking idea that living things are not designed according to an unchangeable plan, but

instead are shaped by the world around them. When the Beagle finally anchored here in the Galapagos in September of 1835, Darwin was very excited about coming here. He was really fascinated with the geology of the place, particularly the volcanic origin of these islands. But when he actually set foot on the shore, he was very disappointed in this place. In fact, this is what he wrote: "Nothing could be less inviting than the first appearance. A broken field of black basaltic lava is everywhere covered by a stunted brushwood, which shows little signs of life. The dry and parched surface, having been heated by the noonday sun, gave the air a close and sultry feeling, like that from a stove."

ALAN ALDA (Narration): Six hundred miles off the South American coast, the Galapagos Islands are actually the tips of volcanoes that have pushed their way above the ocean surface. The oldest islands were formed some 2 - 3 million years ago. The youngest -- including the biggest, Isabela -- are a few hundred thousand years old -- with volcanoes that still erupt. My visit to the Galapagos is to take me to over half the dozen or so major islands -- including one whose volcanic origins are only too apparent.

ALAN ALDA: These rocks look like they're laid out in a circle.

LYNN FOWLER: Yeah, this is Devil's Crown. It's an old eroded crater that's very shallow here in the middle.

ALAN ALDA: We're in the middle of a crater, a volcanic crater?

LYNN FOWLER: Yeah, it's not going to erupt though, don't worry.

ALAN ALDA: How do you know?

LYNN FOWLER: It's old. It's all eroded.

ALAN ALDA: A lot of old things erupt. Me! I'm really surprised at how lush it is...

ALAN ALDA (Narration): My guide on the trip is Lynn Fowler, a biologist who has spent much of her life in the islands.

ALAN ALDA: What is this trail?

LYNN FOWLER: Oh, that's a land iguana trail.

ALAN ALDA: So at the end of this trail we might find an iguana?

LYNN FOWLER: We might find one. Let's see...

ALAN ALDA (Narration): And here, as if waiting patiently for our arrival, is a creature that Darwin was not immediately impressed by.

ALAN ALDA: When Darwin first saw these land iguanas, he thought they looked slow and stupid. In fact, there's a funny story he tells about that. Darwin was watching a land iguana burrow, making a hole somewhat like this one. And Darwin gave the tail a little yank. And the iguana backed out of the hole and looked at him, as if to say, "What did you do that for?"

ALAN ALDA (Narration): What Darwin interpreted as stupidity in the islands' land iguanas is in fact an extraordinary indifference to humans that's shared by all the Galapagos animal life -- and that Darwin repeatedly noted in his account of his voyage. He took advantage of it in his several encounters with the Galapagos Islands' most famous residents, the giant tortoises.

ALAN ALDA: "As I was walking along I met two large tortoises, each of which must have weighed at least two hundred pounds. These huge reptiles, surrounded by the black lava, the leafless shrubs, and large cacti, seemed to my fancy like some antediluvian animals. I was always amused when overtaking one of these great monsters, as it was quietly pacing along, to see how suddenly, the instant I passed, it would draw in its head and legs, and uttering a deep hiss fall to the ground with a heavy sound, as if struck dead. I frequently got on their backs, and then giving a few raps on the hinder part of their shells, they would rise up and walk away; -- but I found it very difficult to keep my balance".

ALAN ALDA (Narration): Today, visitors to the Galapagos usually pay their respects to the handful of giant tortoises that are housed at the research station here named for Charles Darwin -- though getting to feed them is a privilege reserved for the foolhardy.

ALAN ALDA: My problem is I not only saw ET, I also saw Jurassic Park!

ALAN ALDA (Narration): In Darwin's day, the giant tortoises were still being hauled away by the thousands to provide fresh meat for whaling ships.

ALAN ALDA: That's a little too close to my fingers, you can have it.

ALAN ALDA (Narration): The governor of the Galapagos told Darwin that he could tell by the shape of its shell which island a tortoise came from. This saddle-backed tortoise, for instance, comes from the island of Espanola. At the time, Darwin paid little attention to the Governor's claim. But it was to be the foundation for everything that followed. Soon he saw for himself how creatures could be recognizably different from one island to the next. These mockingbirds, like the saddle-backed tortoise, are from the island of Espanola.

DAVE ANDERSON: These mockingbirds are having a flick fight. They flick their tails and wings back and forth. It's a territorial display between two big groups of mockingbirds that are families, and they're disputing what's going on at the territorial boundary. So they do this big display saying, you know, if you cross over this boundary, this is what's going to happen to you. It's going to be bad.

ALAN ALDA (Narration): Dave Anderson is one of the few biologists with permission to come to the Galapagos year after year to pursue his research. The rules governing his visits are strict -- and everything he brings in must go out. Mockingbirds are a constant presence in his camp on Espanola, and they seem eager to volunteer for a show-and-tell.

DAVE ANDERSON: On this island, the mockingbird species is larger than on other islands, and on this island the beak is long and curved, they use that to move dirt around, they dig more on this island than on other islands. Also the breast feathers are whitish and speckled and some of the other species are much cleaner in the breast. The point is that nearby islands have very different looking birds. It's no problem for even an amateur birder to know the difference between species of mockingbirds.

ALAN ALDA (Narration): In addition to the Espanola mockingbirds, two other islands have their own distinct species. Then there's a fourth species, common across most of the islands -- including here on the northeasternmost island, Genovesa.

ALAN ALDA: They all look a little different, depending on the island they come from?

DAVE ANDERSON: Yeah, so for example, those Espanola birds had a lot of speckling on their breasts, and this one doesn't, this one's got a clean white breast. Looks cleaner all around. Those Espanola birds look sort of ratty and dirty.

ALAN ALDA: You're going to let him go?

DAVE ANDERSON: We can try hypnotizing him.

ALAN ALDA: Can he fly if he's hypnotized?

DAVE ANDERSON: He'll go to sleep.

ALAN ALDA (Narration): Mockingbirds joined the giant tortoises on Darwin's list of creatures that for some mysterious reason were slightly different on different islands.

DAVE ANDERSON: I will now make this mockingbird wake up.

ALAN ALDA: You didn't even give him a post-hypnotic suggestion!

ALAN ALDA (Narration): During his five weeks in the Galapagos, Darwin visited only four of the islands... yet he managed to collect hundreds of specimens of birds, animals and plants.

LYNN FOWLER: Ciao Henry.

ALAN ALDA: This was one of the islands Darwin landed at?

LYNN FOWLER: Yeah, this is Floreana. It was his second stop, actually, in the Galapagos.

ALAN ALDA (Narration): By now, Darwin was becoming increasingly excited by the natural history of the islands. Everywhere, he was seeing what he called "aboriginal creations", animals and plants found nowhere else, what biologists now call endemic species. On Floreana alone, he identified 21 endemic plants.

ALAN ALDA: So what plants here are endemic to this island?

LYNN FOWLER: Here we've got *Lecocarpus*, this little yellow daisy. And this here with the hairy leaves, this is *Scalesia delosa*.

ALAN ALDA (Narration): And once again, Darwin noticed that different islands had their own unique versions -- including a species of *Scalesia* that grows into a 30 foot tree. But there was something else besides the uniqueness of the plants and animals here. They seemed to Darwin to bear a striking resemblance to those he'd just seen in South America. And a tremendous idea began to germinate: perhaps here in the Galapagos he was close to nothing less than the origin of species.

ALAN ALDA: "The natural history of these islands is eminently curious, and well deserves attention. Most of the organic productions are aboriginal creations, found nowhere else; there is even a difference between the inhabitants of the different islands. The archipelago is a little world within itself, or rather a satellite attached to America, whence it has derived a few stray colonists.... Hence, both in space and time, we seem to be brought somewhat near to that great fact -- that mystery of mysteries -- the first appearance of new beings on this earth".

ALAN ALDA (Narration): It would be two more years, the Beagle's voyage finally over, before the "mystery of mysteries" began to resolve itself in his mind. It happened as he was puzzling over another group of creatures that, while he was here, he hadn't paid much attention to -- the little birds now called Darwin's Finches. back to top

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EVOLVING BEAKS

ALAN ALDA: And this goes down, right?

ALAN ALDA (Narration): We're setting up a mist net to catch one of the group of birds that has become literally synonymous with Darwin and his theory of evolution.

ALAN ALDA: This needs to be loose like this?

DAVE ANDERSON: Yeah, what happens is the bird flies in and doesn't see it, and so it carries the net out with it with its momentum and then sags down hanging like this in a little bag.

ALAN ALDA AND DAVE ANDERSON: Pssht, pssht, pssht.

ALAN ALDA: Can they hear that?

DAVE ANDERSON: You can also go like this: squeak, squeak.

ALAN ALDA: You do that when you've been here too long?

DAVE ANDERSON: Birders act like they know what they're doing and they make this little squeaky sound and they all pretend like it's making a difference. I don't know whether it does or not.

ALAN ALDA: Pssht, phsst. You got one, you got one!

DAVE ANDERSON: It's a sharp-beaked ground finch!

ALAN ALDA (Narration): Our bizarre calls have netted us a bird from one of the 13 different species of finches in the Galapagos -- birds that are today known collectively as Darwin's Finches.

ALAN ALDA: Now what is this again?

DAVE ANDERSON: This is the sharp-beaked ground finch. This is the smallest ground finch on this island. It's got a pointy little beak that's great for grass seeds.

ALAN ALDA (Narration): Today, Darwin's finches are in all the textbooks as the classic example of how living things adapt to their environment. Each of the 13 species in the Galapagos has a different beak that suits its lifestyle -- from feeding off cactus flowers to using twigs to dig out insects from the bark of trees. A group of species known as ground finches are the most common. This is the large ground finch, with a thick, heavy beak perfect for cracking open large tough seeds. The sharply-beaked ground finch, by contrast, eats mainly small seeds.

DAVE ANDERSON: If you gave this guy a gram of small seeds to eat, it would get done a lot faster than this guy.

ALAN ALDA: Because he's got too much beak in the way?

DAVE ANDERSON: He's got too much equipment, it's big and bulky. He can handle it but not fast enough.

ALAN ALDA: So he'd have to spend more energy on feeding himself and he needs the energy to do it.

DAVE ANDERSON: Yeah, his net intake would probably be negative.

ALAN ALDA: So although he could be eating all day long he could eventually starve to death.

DAVE ANDERSON: Yeah, he's got expenses, overhead he's got to pay...

ALAN ALDA: Yeah, too much overhead...

DAVE ANDERSON: And you look at the body sizes and he's got more overhead than this one.

ALAN ALDA (Narration): Contrary to legend, Darwin himself didn't pay much attention to the dull little birds that often hopped around his feet. He collected several dozen while he was here, but didn't even bother to label them or note which island they came from. But by a delicious twist of fate, it's the finches on one of the Galapagos Islands -- an island that Darwin didn't even visit -- that have become the single best proof that his theory of evolution is no longer only a

theory but an observable fact. As we approach the island, I can see why Darwin never landed here.

ALAN ALDA: You mean, on the face of that cliff.

DAVE ANDERSON: Right there, yeah, it looks a little worse from here than it really is. Or perhaps not.

ALAN ALDA: It's not only a cliff. The cliff sticks out on the top!

ALAN ALDA (Narration): The island -- called Daphne Major -- is only a mile or so across. For some quarter century now a team of biologists, and a string of graduate students -- including, briefly, Dave Anderson -- have been coming here every year.

DAVE ANDERSON: Alright! This guy's like a spider!

ALAN ALDA (Narration): The researchers single purpose has been to weigh and measure every one of the few hundred ground finches that share this lump of volcanic rock with low, rather scrubby vegetation, some seabirds and not much else -- apart from the occasional grumpy sea lion.

ALAN ALDA: Just passing through. Why do people go to all this trouble of getting on this thing? What's the significance to science of Daphne Major?

DAVE ANDERSON: Well, there are some folks who call Daphne Major the laboratory of evolution. It's a really great place to see evolution actually happening because the system, the biological system, is relatively simple. Not too many components and for the finches it kind of boils down to what seeds are here and what tool do I have to crack those seeds.

ALAN ALDA (Narration): The main ground finch here is about halfway in size between the two species Dave and I looked at earlier. What the researchers have found is that when small seeds are plentiful -- usually in rainy years -- the beaks of the birds born the following year are also, on average, smaller. When there are plenty of large seeds, in drier years, the next generation has beaks that are larger. This is evolution. And it's driving force -- Darwin's great insight -- is natural selection. Here's what's happening. In every generation of finches, there's a range of beak sizes, some a little smaller than the average, some a little larger. When small seeds are plentiful -- when there's been plenty of rain -- the smaller-beaked birds are the more efficient eaters. So they thrive and produce more offspring than the larger-beaked birds. The result is that in the next generation, there are more small than large-beaked birds. The average beak size is smaller than the last generation. The population has evolved. When conditions change,

and a dry year brings more large seeds than small, then large-beaked birds do better. They leave more offspring, and the population shifts toward a larger average beak size. Smaller to larger, larger to smaller. It's these subtle shifts in beak size that the researchers here have so meticulously documented.

DAVE ANDERSON: The really significant thing they found is that oscillation back and forth, the size of the beak really does change over short periods of time. And they know exactly why. It's because their food supply changes.

ALAN ALDA: And that's a case of actually seeing evolution in progress, to see it as it happens?

DAVE ANDERSON: Yeah, yeah, the really cool thing about this, for everybody, scientists and everybody else, is that there's no question that it is evolution happening in front of our eyes. We don't have to think of evolution as something we only get from the fossil record or theorizing about. You can go to a place like Daphne Major, where it's simple, and you can actually see evolution happening almost on a monthly basis, certainly an annual basis.

ALAN ALDA: You know, it's interesting, I've often heard people say -- people sympathetic to the idea of evolution -- that you have to take a little bit of it on faith. But you don't have to take any of it on faith?

DAVE ANDERSON: Not any more. Not after this study.

ALAN ALDA (Narration): It's wonderfully appropriate that evolution should move from theory to fact in a study of Darwin's Finches ... because it was while Darwin himself was trying to make sense of his haphazard finch collection that the idea of evolution first occurred to him. With it, he could explain not only why different islands have different finches -- but also different mocking birds -- different plants -- different tortoises. From the time their ancestors arrived in the archipelago, the animals on different islands have gone their own independent ways, shaped by the conditions they found themselves in, until eventually they became -- different species. As for how their ancestors got here -- well, we're coming to that...

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LIZARDS OF THE SEA

ALAN ALDA (Narration): Getting here was no problem for the ancestors of the Galapagos sea lion. Lynn Fowler has promised me an underwater rendezvous with a sea lion pup -- and, this being the Galapagos, there's an eager volunteer. The Galapagos sea lion, like most of the creatures here, has changed since it arrived, evolving into a smaller version of its California cousin.

ALAN ALDA: I saw his face like this, and it's like, so what are you going to do, what do you want to do?

ALAN ALDA (Narration): Sea lions can swim. But how did land animals get here way out here in the Pacific Ocean? The explanation I've heard was that they came on floating rafts of vegetation. But iguanas and tortoises are hefty creatures.

ALAN ALDA: So they had to have had a pretty hefty raft to get here.

LYNN FOWLER: Well, there are big chunks of land that come down some of those rivers on the South American continent. And they float way out here, 600 miles.

ALAN ALDA: An actual chunk of land? I thought it was just like, you know, twigs or branches.

LYNN FOWLER: No, there are chunks of land that even have standing trees that have been seen floating way out to sea in the ocean. And those could easily bring several species at once to a system like this.

ALAN ALDA (Narration): Of all the immigrants here, few have adapted so successfully to island life as the marine iguanas. Wherever you go along the shoreline, iguanas will be on display -- sometimes literally.

ALAN ALDA: He's green on the top and red along his body. What does that....

LYNN FOWLER: Yeah, that's a breeding male. That's the color that....

ALAN ALDA: Oh, that's a signal he's ready to breed?

LYNN FOWLER: That's right. He'll set up a territory and try to attract some female to it. So that's a big breeding male. Beautiful, isn't it?

ALAN ALDA: What does he do to attract females? Oh the head-bobbing thing. Kind of cool....

LYNN FOWLER: Right. Look, I can do 20 push-ups, I'm the man for you! He's a beauty though, isn't he? Doesn't that look like Godzilla?

ALAN ALDA (Narration): Charles Darwin, had he ever heard of Godzilla, might have agreed.

ALAN ALDA: "It is a hideous-looking creature, stupid, and sluggish in its movements.... When in the water this lizard swims with perfect ease and quickness, by a serpentine movement of its body and flattened tail -- the legs being motionless and collapsed by its sides. I opened the stomachs of several, and found them largely distended with minced sea-weed."

ALAN ALDA (Narration): Darwin put his finger on just those adaptations that have made the marine iguana fit so perfectly into its island home.

ALAN ALDA: All he wants are his greens, uh? I mean, vegetables....

LYNN FOWLER: Yeah, all that sea lettuce, ova, is his favorite food.

ALAN ALDA (Narration): The ancestors of these creatures were like all the other lizards in the world, swimming only when they had to.

ALAN ALDA: He made it, up the cliff.

ALAN ALDA (Narration): But the Galapagos marine iguanas, as their name implies, have turned to the sea to sustain them, eating as virtually their only food the bright-green algae that grows all along -- and beneath -- the shoreline. Not only have they become expert swimmers. They have also developed the ability to digest the algae with the help of a bacterium that lives in their hind-gut. This specialization has made the marine iguanas the lords of the seashore. But it has also left them extremely vulnerable. Martin Wikelski has witnessed their vulnerability first hand.

ALAN ALDA: What was this like during that last great El Nino?

MARTIN WIKELSKI: Well, it was horrible. Those guys are about ten percent of all the animals that were here....

ALAN ALDA: There were ten times as many?

MARTIN WIKELSKI: Ten times as many. And they were going to forage; they were trying to get the last bits of algae, and then slowly walking up the beach. So they would just put one foot forward and still try to go up but then really bake in the sand literally. And they just all died in front of our eyes. So we had I think we had like 400 dead animals in just a few weeks. Pretty amazing.

ALAN ALDA: Now was that because all this green we see here was not here?

MARTIN WIKELSKI: Yeah. All this green you see was totally black. There was absolutely nothing growing on these rocks.

ALAN ALDA (Narration): The cause of the devastation was the 1997-98 El Nino, a plume of unusually warm water that wreaked havoc with weather patterns all over the globe. Its impact on the Galapagos was more direct, bathing the islands in warm water and driving out the cold nutrient-rich currents that normally sustain the marine life here. Everything on and around the islands that lives off the sea suffered. But the marine iguanas, whose sole food source withered away, suffered the most. But it turns out that even during good years, the marine iguanas here on the island of Genovesa have to struggle to make a living.

ALAN ALDA: Why do we see so many smallish iguanas here?

MARTIN WIKELSKI: Right. This island gets the least of the nutrients. And that means that this algae -- you probably saw iguanas foraging already?

ALAN ALDA: Yes

MARTIN WIKELSKI: They sometimes have these huge algae pastures, and they just get a mouthful of algae every bite. But here they only have a tiny little carpet of algae and they constantly have to scrape it off.

ALAN ALDA: So that selected out the big ones.

MARTIN WIKELSKI: Right, absolutely.

ALAN ALDA: The big ones that might be born here just aren't going to get enough nutrients.

MARTIN WIKELSKI: Yeah, absolutely.

ALAN ALDA: That's interesting. So there they are. That's the product of natural selection right there.

ALAN ALDA (Narration): But even among these smaller-than-average animals, some of the males are clearly larger.

ALAN ALDA: This big guy has walked through the entire collection, doing that nodding thing to announce his territory, right? But is he the only one in this whole batch that's dominant like this?

MARTIN WIKELSKI: He's the hot shot. He's definitely the prize male, because you see all these females around here? They all like to hang out with him. So the females are the ones that choose in this system, and the males try to do their best to get chosen.

ALAN ALDA: The females are attracted to this big handsome guy -- this ugly thing here, but....

MARTIN WIKELSKI: He's not ugly!

ALAN ALDA: I know you come here every day and you kind of like the way they look now. But I'm telling you, I just got here and....

MARTIN WIKELSKI: You should be here 30 days and you'll like them.

ALAN ALDA: Yeah, OK, OK.

ALAN ALDA (Narration): Yes, Martin actually does spend the entire 30 days the iguanas here are deciding on mates, watching to see which males the females pick. It's an important decision.

MARTIN WIKELSKI: Each of these females only has one egg. It's absolutely amazing, they have about 25% of their body mass in one egg.

ALAN ALDA: So it really counts who they choose.

MARTIN WIKELSKI: Absolutely.

ALAN ALDA (Narration): Martin is trying to understand why, if the big guys are so popular, the group here also contains a number of much smaller males, who instead of showing off keep a deliberately low profile.

MARTIN WIKELSKI: See that guy? He was sort of sneaking up on the female, trying to get her. That's one of these small sneaker males that hang out in the territory (and they try to sort of sneak up on the females). They're about the females' size, so the male can't tell them from females. So they just try to sneak up on females and try to mate with them, if they can.

ALAN ALDA: So in a way he gets an advantage. He gets a chance to sneak up because he's a female impersonator right up until the last moment.

MARTIN WIKELSKI: Right.

ALAN ALDA (Narration): There must be some reason the females accept the sneakers or natural selection would have long since have eliminated them. Martin's hypothesis is that keeping smallness genes around provides the females with a sort of insurance policy against those brutal El Nino years, when being big can be fatal.

MARTIN WIKELSKI: That seems to be a sort of long-term strategy. They can't really know when the next El Nino hits, so sometimes they might choose a small male as a mating partner to have smaller offspring, and sometimes they might choose a bigger one.

ALAN ALDA: One year you try it big, one year you try it small, and you protect yourself all the way around. He's not going to mind this, coming in his face...?

ALAN ALDA (Narration): In the course of testing his insurance idea, Martin has caught thousands of marine iguanas here on Genovesa. The least I can do is lend a hand with one.

ALAN ALDA: Now he's probably on to this. He's not going to like this at all.

MARTIN WIKELSKI: Ah, that's a good one. Excellent.

ALAN ALDA: I had good beginner's luck.

ALAN ALDA (Narration): This iguana was first caught and marked by Martin when it was a hatchling. Twelve years later, it's one of the kings around here.

MARTIN WIKELSKI: But if another El Nino comes and the guy's too big, then we basically find his body on the beach someday. This is the first one of the season, so we'll give him an "A."

ALAN ALDA (Narration): The paint will make it easier to keep an eye on him.

ALAN ALDA: Is it possible that this will turn out to be some cue to the females that this guy should be avoided at all costs?

MARTIN WIKELSKI: That's a good point.

ALAN ALDA: Do they take any visual cues?

MARTIN WIKELSKI: Many people at conferences ask me, and we did test it, because we know that in other lizards it would make a big difference. But in those guys it doesn't. So the females don't go for coloration, they don't care about the markings we put on them, and they probably only go for the size and for the behavior.

ALAN ALDA: Yeah, but this guy is now clearly a movie star. Aren't they going to notice that?

MARTIN WIKELSKI: That is true. So that's it for this guy. I can let him go.

ALAN ALDA (Narration): Martin Wikelski isn't the first scientist to catch and release marine iguanas here in the Galapagos.

ALAN ALDA: "I threw one several times as far as I could, into a deep pool left by the retiring tide; but it invariably returned in a direct line to the spot where I stood.... Perhaps this singular piece of apparent stupidity may be accounted for by the circumstance, that this reptile has no enemy whatever on shore, whereas at sea it must often fall a prey to the numerous sharks. Hence, probably, urged by a fixed and hereditary instinct that the shore is its place of safety, whatever the emergency may be, it there takes refuge."

ALAN ALDA (Narration): Late one afternoon, Lynn and I found ourselves stepping carefully to avoid marine iguanas lounging before bedtime all over the waterfront of the island of Fernandina.

LYNN FOWLER: Oops, almost stepped on its tail.

ALAN ALDA (Narration): I remember my surprised and delighted reaction to the first marine iguana I saw only a few days ago. But already they've become simply a part of the place. But just watch them for a while. What an extraordinary story they tell. For hundreds of thousands -- perhaps millions -- of years, they've lived and died here, slowly sculpted by that living and dying from the land creatures they once were into the imperious masters of their new marine environment. It's a story that, for one giddy moment, it seems to me they deserve to hear.

LYNN FOWLER: No, I'm serious. There's this guy Charles Darwin who says it's so. Look, you have to believe me. You all descended from some lizard, a long time ago. Can I see a show of claws? Who believes that?

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MASKED KILLERS

ALAN ALDA (Narration): I should have known from my first encounter with a bird called the masked booby that this is a creature with a strange sense of right and wrong.

ALAN ALDA: OK, OK, OK!

LYNN FOWLER: We got a little close to the guano ring there.

ALAN ALDA (Narration): My second encounter came in the company of Dave Anderson.

DAVE ANDERSON: All right, Alan. Here we've got a nestling masked booby with its parent who has conveniently stepped aside so we can put a band on its chick.

ALAN ALDA (Narration): Dave has been studying masked boobies for half his life -- trying to understand a singularly gruesome fact...

DAVE ANDERSON: We gently grab the bird.

ALAN ALDA (Narration): ...that this young booby, all fluffy and apparently innocent, may well have committed murder.

DAVE ANDERSON: This is maybe a 35, 40 day old masked booby chick, and it can give you a good nip. So if you would like to hold this bird....

ALAN ALDA: It can give you a good nip so if I would like to hold it. Is that like an actual sentence?

DAVE ANDERSON: Now don't squeeze it. Get up around the head...

ALAN ALDA (Narration): Not only is this baby booby a natural born killer. The creature it may have killed was its own sibling.

DAVE ANDERSON: We're going to give this bird a name. Probably already has a name but this is what I'm going to call it: 95289.

ALAN ALDA (Narration): Dave Anderson wants to know why the murder occurred. Even more, he wants to know why the parents did nothing to stop it.

DAVE ANDERSON: And we'll put this little chick back in its home. The chick needs to calm down. There.

ALAN ALDA (Narration): To answer these questions, Anderson has been coming here to the island of Espanola for 20 years. Masked boobies breed in colonies -- and things start off romantically enough.

DAVE ANDERSON: Some of these birds don't have a mate. And so when they're trying to find one, they check out different possibilities. And they get together and they maybe have a date for an afternoon where they give each other little gifts -- twigs, stuff like that -- and if they're not compatible they'll know pretty quickly, and if they are compatible maybe they'll continue. It's a lot like a species we know

pretty well. Most birds in other species make a nest and masked boobies don't. But the building of a nest and the accumulation of materials, showing what a great twig you've got is still part of the ritual. So it's another way of saying, "I'm in the family way, are you, do you like this twig, maybe if we like the same kind of twig we might be able to get together...."

ALAN ALDA (Narration): But once the wedding bells have rung, the harsh reality of masked booby family life begins.

DAVE ANDERSON: This parent has two chicks under it. One of them hatched about seven days ago, and the other one hatched out of this eggshell about two days ago. When the second chick hatched it was a smaller size and less capable, and the first chick is going to push this helpless second chick out of the nest, if it behaves like normal masked booby chicks.

ALAN ALDA (Narration): For the first few days, the chicks amicably share their nest. But on day five, things turn nasty. Apart from food, the main thing the parent is providing for the chicks is shelter from the glaring sun. The older chick is trying to push the younger out from the shade -- to a slow but certain death. Throughout the struggle the parent remains aloof and apparently indifferent.

DAVE ANDERSON: The parent is not going to do anything about this siblicide, we call it siblicide, the killing of a sibling. If it's like most masked booby parents it will simply watch or look around or do something else, but it will not help this poor offspring that's being killed by its own sibling. The first time I saw this happen, I couldn't believe what bad luck the B chick had. Its closest relative in the world is throwing it out of the nest to die on the hot ground of sunstroke. It's sort of a miserable thing to see. I've seen it enough times now that I accept that that's the normal way of booby life. But it is kind of shocking the first time you see it.

ALAN ALDA (Narration): Shocking -- and in Darwinian terms, baffling -- at least at first sight. After all, that's the parent's own genes lying there dying.

ALAN ALDA: I don't understand the economics of this. If she's going to lay two eggs, and everybody knows that the first one is going to kill the second one, why expend all that energy, to lay a second egg?

DAVE ANDERSON: It seems like a waste.

ALAN ALDA: Yeah.

DAVE ANDERSON: In terms of natural selection, selection is going to maximize the excess benefit over the cost. Certainly the benefit has to exceed the cost. In this case, there's a benefit to laying the second egg because they have lousy

hatching success. They only hatch about 60% of the eggs, even if you eliminate accidents and stuff. Something about fertility or embryo development causes 40% of them to die. So if you're going to get one chick, gotta have one chick, you're prepared to pay the price of a second egg, even though it's expensive, because if the first one fails, the second can take its place.

ALAN ALDA: It seems to me that once you've gone to the trouble of laying two eggs, and you have a good shot at having two healthy adults come out of that, isn't your purpose better served to let both of them live?

DAVE ANDERSON: Yeah, good question. If you experimentally stop the siblicide from happening, and make them play nice, and then challenge the parent to bring back enough food for two, about 30% of the time, they can do it. She doesn't stop feeding. If there are two chicks in front of her, she'll feed 'em, you know, open mouth, put in food, that's what she does. And if there are two of them there, she'll put it in at twice the rate. So you say, well, they definitely should be stopping the siblicide from happening. However, if you follow those parents another year, you find out in the year after they raised two chicks, they take it on the chin in terms of survival. Particularly the moms. Regular moms survive at about 92%, from year to year. And the experimentals, that have had to raise two chicks, survive at about 75%. And that's a huge cost.

ALAN ALDA (Narration): A cost that in terms of natural selection simply cannot be sustained.

ALAN ALDA: This is really fascinating. But on the other hand, I'm spending just a few hours talking to you about this, and you're spending your life on it. How did you get led to that?

DAVE ANDERSON: It's a problem that on the surface seems fairly easy to address, the problem being, why lay that second egg, given that you lay the second egg, why not try to raise two chicks. But to actually look at how selection acts on the individual, you really ought to have a long-term perspective. And following the lifetime consequences of a long-lived animal may take up most of your career. Some of the birds that I have initiated a study of as babies are going to outlive my career.

ALAN ALDA (Narration): But many won't. Even chicks that have won the battle of the nest fall prey to mockingbirds, pecking them for their blood. And then there are the constantly marauding frigate birds, always looking to snatch a chick from its nest.

DAVE ANDERSON: I mean you either get killed by your sibling and your parents don't care. Or if you manage to survive that process, then when your parents

leave you alone a frigate bird might come down and drop you from a hundred feet in the air.

ALAN ALDA (Narration): Dave Anderson's life among the masked boobies of Espanola has given him unusual access to the daily struggle that drives evolution. And it isn't a pretty sight.

DAVE ANDERSON: Life stinks for most organisms most of the time, and we maybe don't realize it so much looking at continental systems as opposed to here, because here the animals do their suffering out in the open. Particularly these boobies. They just have a miserable life you wouldn't wish on your worst enemy. All these terrible thing that can happen to you. And it's really apparent to us because they're not hiding it. They don't have a history of trying to hide from creatures like us, and they just do it in front of us. We can sort of participate in the community as a kind of ignored observer, walking down the back alleys of their lives, and they sort of let us do it.

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PARADISE LOST?

ALAN ALDA (Narration): Among the more recent immigrants to the Galapagos are humans. When Darwin came in 1835, people lived scattered in small fishing and farming communities throughout the archipelago. With people came animals that would never have made here it on their own: chickens, dogs, cats; goats, pigs, cattle. Today, there are strict rules governing where people and their animals can live. Ninety-six per cent of the land is National Park, off-limits to anyone not accompanied by a guide like Lynn Fowler. But while people can be controlled, the animals they've brought with them can't. We're climbing a peak overlooking Santiago, one of the four islands on Darwin's itinerary.

LYNN FOWLER: When Darwin camped there....

ALAN ALDA: That's all Santiago over there?

LYNN FOWLER: Yeah...there were so many land iguanas on it that he could hardly find a place to pitch his tent, because of the land iguana burrows. But, they're extinct now. They're extinct from Santiago.

ALAN ALDA: Really? How did that happen?

LYNN FOWLER: Dogs and pigs -- and rats. They go right in....

ALAN ALDA: Rats attack the iguanas?

LYNN FOWLER: They go right in to the land iguana burrows and eat the eggs and kill the hatchlings.

ALAN ALDA (Narration): One of the Galapagos natives worst hit by humans and the animals they brought with them is the giant tortoise. Originally decimated by whalers hauling them off for food, they have since had to compete with pigs and goats that have gone wild and run rampant over many of the islands. Thirty years ago, the population of the characteristically saddlebacked tortoises of Espanola was down to just 13 -- 12 females and a male. Brought here to the Charles Darwin Research Station on the island of Santa Cruz, these 13 tortoises -- aided by a second male recruited from the San Diego Zoo -- have since produced hundreds of offspring. Lavishly fed, and kept safe from rats until their shells are strong enough to protect them, the youngsters here can look forward to a long life.

ALAN ALDA: Don't be shy. How old is he?

ROS HERMAN: This one's about a year and a half old.

ALAN ALDA: And how old will he get to be if he's lucky?

ROS HERMAN: Well, we can guarantee that they'll live to between 60 and 90 years old. But history books and stories that are a bit difficult to confirm say anything up to 150, 200 years.

ALAN ALDA (Narration): The project owes its success largely to this man, Cruz Marquez, who with his colleagues has had to invent the captive breeding process as they went along. A critical realization was that the sex of the hatchlings depends upon the temperature at which the eggs are incubated -- 29.5 degrees Celsius gives you females, 28 degrees Celsius and you get males.

ALAN ALDA: Sounds like you must have to have a pretty sophisticated system here to keep the temperature what you need it to be.

ROS HERMAN: We have an incredibly sophisticated system. We have a hairdryer, connected to a thermostat here, on continuous cycle.

ALAN ALDA (Narration): Despite the shoestring budget, the captive-breeding program has resulted in some 800 Espanola tortoises being returned to their native island. Making this possible was an ambitious -- and successful -- program aimed at ridding the island of goats, the tortoises' main competitor for resources.

But many of the islands -- including the biggest, Isabela -- remain over-run with goats as well as pigs. Their eradication is a principle goal of people trying to preserve the islands' unique biological heritage -- people like the Darwin Research Station's Howard Snell.

HOWARD SNELL: We're coming into Elizabeth Bay off the coast of Isabela, the largest island in the Galapagos. And these are the Marielas Islets.

ALAN ALDA (Narration): But for some introduced species, eradication is all but impossible. Rats, for instance, have been in the Galapagos as long as ships have visited here. They appear to have invaded the Marielas Islands only recently -- but now may be threatening one of the Galapagos' most unexpected inhabitants.

HOWARD SNELL: Penguins in the Galapagos Islands are the northernmost penguins in the world. So, it's a unique kind of penguin. But unfortunately, the penguins in Galapagos aren't doing particularly well. When El Nino events come in to the archipelago, which happens every so often, the water gets very very warm, and the normal fish life around here begins to die off. When that happens, penguin populations crash. In 1982-83, they crashed by over 50%. This year, '97, '98, they crashed again. And the thing that confuses us is they don't recuperate after those crashes. Now that worries us because of course if populations crash every so often and never recuperate, they can go extinct.

ALAN ALDA (Narration): Howard suspects rats are the culprits, invading the rock crevices where penguins lay their eggs and raise their chicks. So he's conducting an experiment to see what can be done to save the penguins -- short of the impossible task of ridding the Galapagos of rats entirely.

HOWARD SNELL: Now what we're trying to do is to use these islands, these small islands, as models for the rest of the Galapagos. And we're removing the rats, by poisoning them, from some of the islands and leaving them on others. The idea is to try and measure how few rats we can remove to increase penguin reproduction. That way we can invest enough money to increase penguin reproduction, but not so much money that we can't do other things also. It's really about trying to divvy up limited resources for the conservation of the biology of the Galapagos Islands.

ALAN ALDA (Narration): Those resources may become a little less limited in the future, thanks to the latest alien species to invade the Galapagos Islands -- ecotourists, who come by the thousands each year. These tourists bring in millions of dollars for the tour operators, but until recently little or nothing for the wildlife. Now that's changing.

SVEN-OLAF LINDBLAD: There are about 60,000 people a year who visit the Galapagos, and I'm of the belief that those 60,000 people can be a major part of the future of these islands. Companies like ourselves who benefit and indeed profit from being able to bring these visitors here are in a position to be able to make a difference. And in the last year, in the year since we've been here, we've raised about a couple of hundred thousand dollars from our guests for the Galapagos. And when you think that we represent 5% of the tourism for these islands, and you multiply this kind of an activity times 20, all of a sudden tourism could in fact sustain places like the Charles Darwin Research Station and the National Park and they wouldn't have to struggle so much for funding on an annual basis.

ALAN ALDA (Narration): But there's an irony here. Tourists bring in not only dollars -- they have also attracted thousands of Ecuadorians to the islands to work in the tourism industry. Together, tourists and residents pose a new threat to the islands' ecosystem.

HOWARD SNELL: Because there are sixteen to twenty thousand people who live here in the Galapagos Islands, five supply ships run out here two or three times a month each, and there are three 727s a day that fly into the Galapagos Islands, all that activity brings in a tremendous amount of material. Tons and tons and tons of food and construction material come to the Galapagos every year. Somewhere in those packages are the introduced species of tomorrow. It's not purposeful nowadays, but it's every bit as damaging as if it was.

ALAN ALDA (Narration): I've come to see for myself one of the worst of these alien invaders. Charlotte Causton of the Darwin Research Station is showing the way.

ALAN ALDA: What are all these little white things?

CHARLOTTE CAUSTON: These are the cottony cushion scale, it's an introduced scale insect, that was introduced in 1982 into the island of San Cristobal, and since then has spread to none other islands in the archipelago, and attacks over forty plant species. In the absence of its natural predators it's just gone haywire.

ALAN ALDA: How was it introduced?

CHARLOTTE CAUSTON: We're not sure. We think it was introduced in some acacia trees that were imported into the islands, but then again it could have been from citrus. It was definitely on a plant and accidentally introduced. No one brought it in on purpose.

ALAN ALDA (Narration): The cottony cushion scale is one of hundreds of non-native insects that have recently sneaked into the islands. And Charlotte is one of only two entomologists.

ALAN ALDA: If you have to go after them species by species, find out what they do, what harm they cause, and how you can protect against them -- and by the time you find out about one species, you've probably got another 300 on your list, right -- how does that make you feel?

CHARLOTTE CAUSTON: It's daunting, the prospect.

HOWARD SNELL: The magnitude of the problems that face the Galapagos Islands can seem overwhelming. And in fact they are overwhelming. But the one thing that the people here who are motivated to preserve biological diversity in the Galapagos Islands keep in the forefront all the time is that this is one of the last oceanic archipelagos in the world where we have an opportunity to maintain a pristine environment. There are 95 to 96% of the species that ever occurred on the Galapagos Islands that are alive today. Some of them are in a bad state. Some of them may go extinct before long if we're not successful at restoration efforts for them. But the point is we have an opportunity here. The world, actually -- it's not just Ecuador, it's not just the Research Station, it's not just the National Park Service -- but the world has an opportunity to preserve biological diversity in a pristine state.

ALAN ALDA: Now, now, what about this? Why should anybody else, who's not a scientist, care about preserving the Galapagos? If the Galapagos disappears as a unique place, gets run over by introduced species, so what?

DAVE ANDERSON: There's a genetic, a bank of genetic information, and it can be squandered or it can be preserved in its current state. The analogy is often made with a library, that you wouldn't go into a library and wantonly destroy a whole bunch of stuff to make shelf room to put knick-knacks on. Well, here we've got creatures that have been coming up with solutions to particular problems for a long, long time, and there will be problems in the future that will need some of these solutions. They're here. We should preserve them.

MARTIN WIKELSKI: I think it's also a place of joy and insight into natural processes and you can't really predict what people will find here in the future. But like Darwin was inspired by this laboratory of evolution and I think many people will in the future. And you came because you find it interesting. So I think it really will continue to be a lab of evolution, where you can really see these processes happening.

ALAN ALDA (Narration): It was late one afternoon, after Lynn and I had been out snorkeling, that the magic of the Galapagos -- its ability as Martin said to provide joy and insight -- crystallized for me. Here we were on the equator, talking to penguins whose ancestors came from the Antarctic. In spite of the waves and the razor sharp rocks, we were mesmerized.

ALAN ALDA: You know, to get that close to penguins, it's an experience I've never had before, and it's really a sensational experience. But you're here all the time. What's it like for you?

LYNN FOWLER: As I said the other day, when you asked me why I was still here after twenty years, it's incredible, isn't it? Something happens different every single day. You never get tired of these islands.

ALAN ALDA (Narration): Charles Darwin spent just five weeks in the Galapagos, amazed as is every visitor by the tameness of the animals and birds, and by a sense of being in a world apart, in time and in space. But what stayed in his mind like a slow burning fuse was the same creature or plant turning up in different forms -- even different species -- on different islands; a circumstance, he wrote in the Voyage of the Beagle, "that strikes me with wonder."

ALAN ALDA: "It is the fate of most voyagers, no sooner to discover what is most interesting in any locality, than they are hurried from it; but I ought, perhaps, to be thankful that I obtained sufficient materials to establish this most remarkable fact in the distribution of organic beings. Reviewing the facts here given, one is astonished at the amount of creative force, if such an expression may be used, displayed on these small, barren, and rocky islands."

ALAN ALDA (Narration): Some 20 years later he identified his "creative force" as natural selection. And the world changed forever.

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