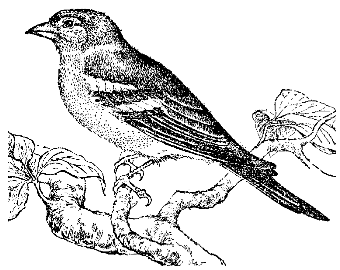
The Beak of the Finch

A Story of Evolution in our Time

By Jonathan Wiener



On a desert island in the heart of the Galapagos archipelago, where Darwin received his first inklings of the theory of evolution, two scientists, Peter and Rosemary Grant, have spent twenty years proving that Darwin did not know the strength of his own theory. For among the finches of Daphne Major, natural selection is neither rare nor slow; it is taking place by the hour, and we can watch.

Darwin's finches are extraordinarily variable not only in the depth, length, and width of each mandible, and in the relative lengths of the upper and lower mandibles, but also in their wingspans, their body weights, and the lengths of their legs. Darwin's finches are even variable in the length of the hallux, or big toe.

If living things are well made, Darwin argued—if they are admirably adapted to their places in nature, contrivances more elaborate than watches—then even the slightest variations must make a difference to the individual animals and plants that are saddled with them. Some variations must help living things run better, some worse, and some—a very few variations, arising only once in thousands of generations—might help them fit into an entirely new spot in the economy of nature.

The beak of the bird makes a natural test of this step in Darwin's argument, not only because the beak is so easy to measure, but because it is so obviously vital to the life of the bird. Darwin's finches can't put food in their mouths with their wings. They can't use their claws either, any more than we can dine comfortably with our feet. They have to use their beaks. Beaks are to birds what hands are to us. They are the birds' chief tools for handling, managing, and manipulating the things of this world (*manus* meaning hand).

The shape of a bird's beak sets tight limits on what it can eat. Although the bones and the horny sheaths of the mandibles are a little more flexible than they look—a woodcock can poke deep down into the mud, part its beak at the very tip, and grab an earthworm—still, these are not many-jointed and articulate instruments like our hands. Each beak is a hand with a single permanent gesture. It is a general-purpose tool that can serve only a limited number or purposes. Wood-peckers have chisels. Egrets have spears. Darters have swords. Herons and bitterns have tongs. Hawks, falcons, and eagles have hooks. Curlews have pincers.

There are about nine thousand species of birds alive in the world today, and the variety of their beaks helped confirm Paley's belief in an inventive God. Flamingos' beaks have deep troughs and fine filters, through which the birds can pump water and mud with their tongues. Kingfishers' beaks have such stout inner braces and struts that a few species can dig tunnels in riverbanks by sailing headlong into the earth, over and over again, like flying jackhammers. Some finch beaks are like carpentry shops. They come equipped with ridges inside the upper mandible, which serve as a sort of built-in vise and help the finch hold a seed in place while sawing it open with the lower mandible.

But plain or fancy, each beak can do only so much. The flamingo's beak is good for filtering pond water. The hawk's is good for ripping up a rabbit, a fox, or another bird. If the flamingo and the hawk ever tried to trade jobs, the hawk would drown in the pond scum, and the flamingo would get its eyes poked out.

During their first field season in 1973, the Grants and the Abbotts measured not only finch beaks but also finch behavior. They staked out eight sites of twenty-three thousand square meters. At each site they marked off a grid of reference points by tying red flagging tape to hundreds of cactus bushes and torchwood trees. Each morning they would crisscross one of the grids with binoculars, notebooks, and stopwatches, and see what the finches ate for breakfast.

The Grant team discovered that the ground finches were concentrating on about two dozen different species of seed. So the members of the team put each other these two dozen kinds of seeds between the points of a vernier calipers and measured them as carefully as they measured the birds' beaks. They also measured the seeds' hardness with the McGill nutcracker. This is a gadget that Peter Grant designed with the help of an engineer at McGill University, in Montreal, his first teaching post. The McGill nutcracker is a pliers with a scale attached. Squeeze a seed with the pliers, and the scale shows how much force it takes to crack the seed open. Modern physicists measure force in a unit they named for the founding father of their science: the newton. To crack a grass seed, which is a speck about the size of a poppy seed, takes very little force, less than 10 newtons. A big cactus seed, the size of a peppercorn, takes more than 50 newtons. Cracking the toughest seeds in the Galapagos requires a force of 250 newtons, which is enough to lift more than a thousand cactus finches into the air.

Peter Grant combined the measurements of seed size and seed hardness and rated each kind of birdseed as the finches might themselves, in a sort of Struggle Index. The small soft ones of *Portulaca* score the lowest on this index, only 0.35. The big hard seeds of *Cordia lutea* score highest, almost 14. Any of the finches can handle *Portulaca* in its beak, but very few are up to *Cordia.*

By the end of their first stay on the islands, the members of the Finch Unit thought they knew the finches' tastes in seeds, fruits, insects, leaves, buds, and flowers. On Daphne Major alone the team mad watched and made notes while medium ground finches at 4,000 meals. They knew exactly what the finches were eating them with. And most of the ground finches were eating the same seeds and fruits, just as Darwin had seen in his first glance on San Cristobal.

Before Peter Grant left the island, the acting director of the Charles Darwin Research Station, Tiitte de Vries, gave him some advice. He reminded Peter than in the Galapagos the first half of each year is wet and the second half is dry. The Grant team, like Darwin, Beebe, Lack, and all the rest, had visited the birds in the wet season. But the dry season might be the time to watch life squeeze out of Darwin's finches.

The Grants came back a few months later. Even from the air they could see the difference as they flew in to the small airport on the island of Baltra (built by the United States Sixth Air Force during World War II and maintained now by the Ecuadoran Air Force). Everywhere the lava was brown, black, red; almost not green below the highlands of Santa Cruz. At the research station, de Vries told them that there had been no rain at all at the station in the months of April, May, June, and July.

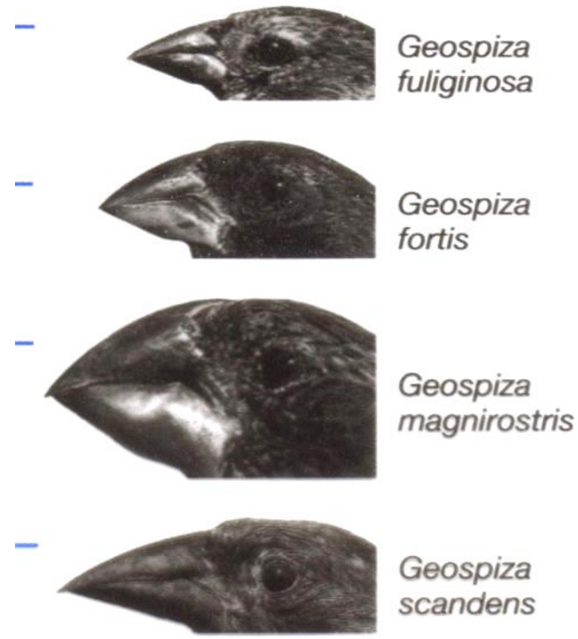
The Grant team recaptured many of the birds they had caught during their first trip, and dangled them again in the spring balance. The finches had lost weight, and when the members of the team counted the seeds on the same plots as before, they could see why the birds might be hungry. There was not much bird food on the ground anymore. The plants had dropped all their leaves and seeds and had stopped making new ones, and the birds had eaten so many of the old seeds that their platter was almost clean. At the study site on the island of Genovesa, the volume of finch food was down by 84 percent.

Not only was there less food for the finches, there was also less variety. Only about half of their favorite kinds of food were left. And in the wet season most of the seeds on the ground had been so small and soft that the average seed had rated only 0.5 on the Struggle Index. The seeds that remained were mostly big and tough, and the average was higher than 6.

Magnirostris has the biggest beak and the most powerful jaw muscles of any of the finches. It is the only finch that is strong enough to break and rip off the Grants' metal bands from its ankles. *Magnirostris* was now concentrating on the big, heavy seeds, the seeds that almost none of the other finches can crack.

The long, thin beak of the cactus finch (*Geospiza scandens*) is another of the most distinctive-looking beaks among the ground finches. Cactus finches were now taking advantage of their beaks' special talents and dining almost exclusively on cactus seeds.

It was the same with all six of the ground finches. Now that they were reduced to tough foods, the birds' tool-kit beaks were determining what the birds ate. They had become specialists, and each bird's specialty was set by the shape of its beak.



Today when they lecture on the selection event of 1976, Peter Grant and Peter Boag plot the effects of the drought in three curves. The curves start in March 1976, when the island of Daphne Major was still green and lush. They end in December 1977, when the cactus flowered and the worst of the drought was over.

All through the drought the total mass of seeds on the island went down, down, down. The average size and hardness of the remaining seeds when up, up, up. The total number of finches fell with the food supply: 1,400 in March 1976, 1,300 in January 1977, and fewer than 300 in December.

Next they take the finches by species. At the start of 1977 there were about 1,200 *fortis* on Daphne. By the end of the year there were 180, a loss of 85 percent.

At the start of the year there were exactly 280 cactus finches on the island. By the end there were 110, a loss of 60 percent.

Of the smallest ground finches, *fuliginosa,* there were a dozen on the island at the start of 1977, and only one of them survived the year.

At least, Grant and Boag took a look at the beaks of the survivors. They know how variable the beaks are. They know how much the variations matter. They know how the plants were doing, what the weather was doing, how life on the island was squeezing the finches. They know all these figures with unprecedented precision, as well as the dimensions of the finches that made it through the drought and the finches that did not.

Among *fortis*, they already knew that the biggest birds with the deepest beaks had the best equipment for big tough seeds like *Tribulus*; and when they totted up the statistics, they saw that during the drought, when big tough seeds were all a bird could find, these big-bodied, big-beaked birds had come through the best. The surviving *fortis* were an average of 5 to 6 percent larger than the dead. The average *fortis* beak before the drought was 10.68 millimeters long and 9.42 deep. Variations too small to see with the naked eye had helped make the difference between life and death. The mills of God grind exceedingly small.

Not only had they seen natural selection in action. It was the most intense episode of natural selection ever documented in nature. One result was a bizarre tilt of the sex ratios on the island. At the start of the drought there were almost 600 males and 600 females. By the end of the drought more than 150 of the males were still alive, but only a pitiful remnant of the females. Males are typically larger than females by 5 percent, with proportionately bigger beaks, so the males generally had an edge.

In other words, among the males the biggest survived, and among females the biggest survived, but many more males survived than females. And what made the difference between life and death was often “the slightest variation,” an imperceptible difference in the size of the beak, just as Darwin’s theory predicts.

Many people—even biologists, even today—find the power of slight variations hard to believe. “Once, just as I was beginning a lecture,” says Peter Grant, “a biologist in the audience interrupted me: ‘How much difference do you claim to see,’ he asked me, ‘between the beak of a finch that survives and the beak of a finch that dies?’

“ ‘One half of a millimeter, on average,’ I told him.

“ ‘I don’t believe it?’ the man said. ‘I don’t believe a half of a millimeter really matters much.’

“ ‘Well, that’s the fact,’ I said. ‘Watch my data then ask questions.’ And he asked no questions”

Natural selection by itself is not evolution. It is only a mechanism that, according to Darwin, can lead to evolution. As Peter and Rosemary Grant put it, natural selection takes place within a generation, but evolution takes place across generations.

In the drought of 1977, they had seen and documented natural selection in action. The decimation of the finches by selection had been as ruthless as the aristocratic breeder of bulldogs in Darwin’s day who said, “I breed many, and hang many.”

But eh finch watchers did not yet know if the episode would translate into an evolutionary chage. They only knew that according to theory, it was possible, since the beak variations are heritable: the changes that are wrought upon one generation can be passed on to the next, becoming muffled and compressed or stretched and warped, over the years, as they pass down the line of the generations and onward into the future.