The turtle and the spreading sea floor

Members of the order Testudinata have an ancient reputation for getting where they want to go. Aesop had a tortoise that beat a hare by pure tenacity. A modern example of Testudinatal tenacity is a particular breed of green turtle, a subpopulation of the species *Chelonia mydas* that lives on the northeast coast of Brazil. These animals go to Ascension Island to breed. Please note that Ascension Island is 2,000 kilometers out into the Atlantic from Brazil. That seems a long commute just to lay a few eggs. The interesting questions are why and how.

In the May 10 NATURE Archie Carr of the University of Florida and Patrick J. Coleman of the University of Western Australia propose that the answer to both questions lies in a combination of biology and geology, the nature of the beast plus the plate tectonics of the South Atlantic.

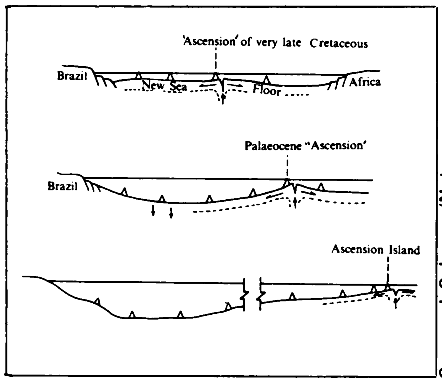
Chelonia mydas likes to eat greens, which it finds in shallow-water protected pastures off the Brazilian coast. But to lay its eggs it wants an exposed sandy shore. The kind of beach built by surf on an off-shore island is ideal for the purpose, more ideal than a mainland beach because the island is likely to lack the egg-eating predators that infest the mainland.

Back when this habit was beginning in the early late Cretaceous, about 100 million years ago, there were probably such islands within hail of the coast, and the turtles' journey was not the Aesopian prodigy it later became. At that time the northeast coast of Brazil was the shore of a gulf of the North Atlantic. The South Atlantic was just beginning to open.

As the South Atlantic opened, the islands moved farther and farther to sea. The mid-oceanic ridge, from which the spreading proceeds, occasionally put up a volcano that became an island. Spreading gradually took the island off the ridge to be succeeded by a new volcano on the ridge. As the old island drifted away from the ridge, it also sank into the basin between ridge and continental slope and went below the waves to become a seamount. Thus to an observer in Brazil with a supernatural longevity it would seem as if the islands were getting farther and farther to sea.

Little by little, by missing old islands and finding new ones, the turtles would learn to swim farther and farther. Those that made it would survive and breed so there was a positive feedback favoring genetic selection for the stamina and the sense to make the swim.

The islands would all lie in a line running west-northwest to east-southeast. This means that at the time they move the turtles could navigate simply by facing the rising sun every morning. This would take them in a gentle arc to Ascension Island. The equatorial current would carry the hatchlings back to Brazil. □



Carr and Coleman/Nature

Plate tectonics moves islands seaward.

Islands, evolution and 'supertramps'

Since Darwin, ecologists and biologists have been using islands as a microcosm to study evolution and to reconstruct the history of colonization. Plant and animal recolonization of Krakatoa, following the violent volcanic explosion there in 1883, provided scientists with one of the best opportunities to study the various stages of species colonization.

Recently Jared M. Diamond, a physiologist and ecologist at the University of California in Los Angeles, saw a similar opportunity to study bird colonization on two volcanic islands, Long and Ritter, and on seven coral islets whose birds disappeared in a tidal wave caused by the Ritter explosion in 1888. (Long also suffered a cataclysmic explosion about two centuries ago.) The islands are located in the Pacific between New Guinea and New Britain. Diamond used the number of bird species on six relatively undisturbed islands in the same area to assess how far the defaunated islands have returned to equilibrium. He reports his findings in the May 17 SCIENCE.

Contrary to the belief that colonization is a slow process, Diamond discovered that colonization can be extremely rapid, particularly on the coral islets. After he experimentally removed all birds from one small island the numbers of bird species returned to original values within a few days, with initial colonization rates approximately one species per hour.

Diamond found bird colonization on the two larger islands, Ritter and Long, to be rapid but only partially completed. Here, bird species numbers obtained a quasi-steady-state in the lowland forest, limited by vegetation growth. Long's lowland bird species number has reached 75 percent of its calculated equilibrium, according to Diamond, and is presently "stuck" at this state because of arrested forest development. Ritter has fewer bird species than Long because its bare-rock terrain supports far sparser vegetation than Long's.

In contrast to its lowland forests, standing cloud banks have kept Long's mountain forest moist. It consequently is as well developed as forest found on the summits of older volcanic islands yet it supports fewer bird species. From this, Diamond concludes that the equilibrium of bird species numbers in the mountain forest has been limited not by vegetation growth but by the slow dispersal of the birds themselves.

Diamond has categorized the bird species found in the area around the islands New Guinea and New Britain into three groups: (1) "sedentary species," those found almost exclusively on the large islands and rarely cross water, (2) "tramp," those present on both the large and small islands, and (3) "supertramps," nine species that reside only on islets.

A remarkable finding in Diamond's survey was the high-population density of birds, mainly supertramps, on Long and two adjacent islands. Long is producing numerous emigrants that are colonizing its two closest neighbor islands. Diamond explains the phenomenon as follows: "Supertramps specialize in rapid breeding and overwater colonization, but they paid a price for these adaptations and are excluded from most islands by competitors [sedentary species] that can harvest resources more thoroughly and tolerate lower resource levels. Whenever the supertramps find islets too small for stable populations to persist for a long time, or else an empty island recently devastated by a tidal wave or volcanic explosion, they breed on a nearly year-round basis, fill the island, and generate new emigrants. By the time these populations have disappeared or been squeezed out by more efficient later arrivals, the supertramps have already ensured their survival as species by finding other transiently empty islands. With the explosion of a large island like Long, the supertramps 'struck it rich' as first arrivals."

Thus, Diamond concludes that initial colonization is rapid and carried out by supertramps. This is followed by a competitive phase between the sedentary species and supertramps, the main mechanism of competition being overharvesting of resources. □