

DIVING DRAGONS OF THE GALÁPAGOS

MARTIN WIKELSKI

MAX-PLANCK INSTITUT FÜR VERHALTENSPHYSIOLOGIE
DEPARTMENT WICKLER, D-82319 SEEWIESEN GERMANY

To be enthusiastic about a Robinson Crusoe life-style is one thing. To actually live more than half a year on a desert island in the middle of the Pacific Ocean is another, especially if you cannot take along fresh fruits (because of the possibility of introducing exotic plants and insects) and there is no electricity, not to mention refrigerator. One also learns how to get by with very little fresh water when one has to carry every single quart and receives supplies only once a month. But when my two Ecuadorian co-workers, Victor Carrillo and William Revelo, and I landed with our gear on the rocky coast of Santa Fe, in the Galápagos archipelago, we didn't think about the hardships ahead; we were too fascinated by the piles of marine iguanas that were stretched out on the bare lava boulders. They looked like petrified mini-dinosaurs soaking up

the warm rays of the sun. I couldn't believe how tame they were.

I thought back to the descriptions of the lizards I had read: David Porter, who captained the Essex in the early 1820s against British commercial fleets, found "myriads of iguanas, of an enormous size and the most hideous appearance imaginable. At first fearing they would attack... our crew soon discovered them to be the most timid of animals and had, in a few moments, knocked down hundreds of them with our clubs, some of which we brought on board and found to be excellent eating."

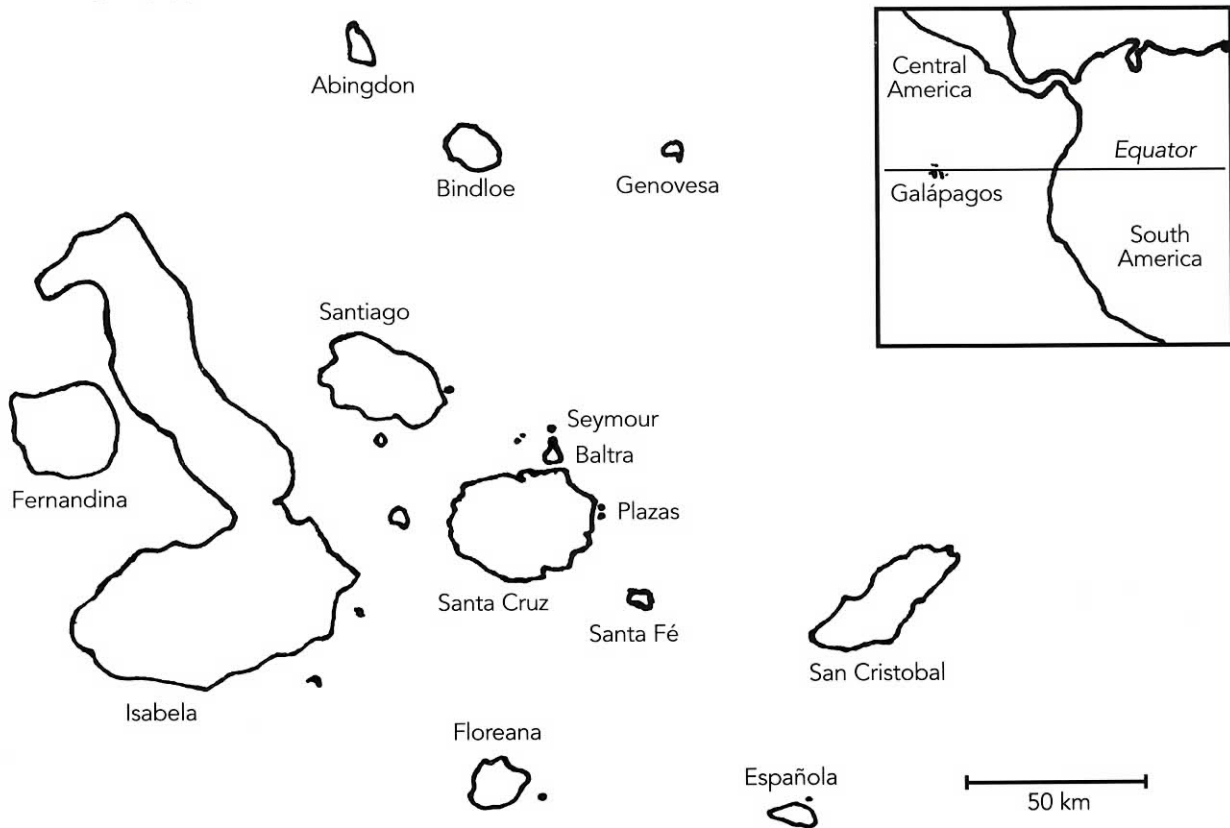
Charles Darwin, on his famous Beagle voyage, never really warmed up to the iguanas: "The rocks on the coast are abounded with great black lizards between three and four feet long; it is a hideous-looking creature, of a dirty black color,



Photograph: Martin Wikelski

The Galápagos Archipelago

(excluding Culpepper and Wenman to the northwest of Fernandina)



stupid and sluggish in its movements.”

I don't, of course, share his view. Marine iguanas are wonderfully unique, the only lizards that feed in the sea, grazing on beds of algae in the intertidal zone and even diving for submerged seaweed. The reptiles' diving ability is truly impressive. Normally the iguanas make shallow dives lasting from two to ten minutes, but they can descend to nearly 40 feet and remain submerged for as long as an hour. Darwin did admire their underwater feats, noting that “a seaman on board sank one, with a heavy weight, thinking to kill it directly; but when, an hour afterwards, he drew up the line, it was quite active.”

Marine iguanas inhabit mainly the southern, wave-exposed coastlines of the 16 or so Galápagos islands, where algae are nourished by cold, upwelling currents. Highly social, the iguanas live in colonies, some with as many as 4,000 individuals per mile. Their ancestors probably reached the archipelago on debris drifting off the South American coast and carried westward by the Humboldt Current. Authorities estimate it would

take at least two weeks to cover the 600 miles from Ecuador, the nearest landfall, to these isolated volcanic mounds. Genetic studies support the hypothesis that the marine iguanas, *Amblyrhynchus cristatus*, and the land iguanas, *Conolophus subcristatus* (which also occur on the islands), represent two separate invasions from the mainland. (The 1992 discovery of submerged islands east of the Galápagos has increased the archipelago's age from four to five million years to 30 million, and challenges this theory.) Reptiles, along with birds, rats, and bats, are among the few higher vertebrates that could survive the oceanic trip. Their low metabolic rate, resistance to water loss, and tolerance for high temperatures made it possible.

Though marine iguanas are noted for their diving capability, only the larger individuals dive frequently; the smaller lizards cool down too fast in the cold currents. Marine iguanas' size varies from island to island, with the larger lizards living on southwestern islands where the Cromwell Countercurrent brings an abundance of nutrients

that support vast algae grounds. Males on the island of Fernandina reach about 10 pounds, whereas the largest males on Isabela tip the scales at 26 pounds, and females weigh six. On Genovesa, the biggest males weigh hardly more than two pounds and females less than a pound and a half, weights so small one might question whether these animals have enough muscle mass to swim in the rough waves. But the sea is calmer around Genovesa and about eight degrees warmer than in the west, permitting even small animals to stay submerged.

Why subtidal feeding evolved appears obvious: as marine iguanas multiplied, algae became scarce, particularly for larger individuals. They began to forage deeper and deeper in the intertidal zone and eventually discovered the underwater algae—and possibly their own diving abilities. Being able to dive for food frees the lizards from dependence on the daily low-tide cycle, which offers only some two hours of optimal feeding.

Ninety-five percent of all feeding activity, however, occurs in the intertidal flats and reefs

exposed at low tide, which are shared by most females, small males, and juveniles. We've never seen hatchlings enter the water. Hordes of bright red Sally Lightfoot crabs also scuttle among the clumps of algae, sharing the iguana's food.

For the most part, the iguanas eat the small, usually less than half an inch long, red and green algae that thrive both above and below sea level. They seem to avoid the brown algae, which do not offer enough nutrients to survive.

How can so many lizards thrive on just algae? There are two answers. First, a reptile in the tropics needs relatively little energy. One ounce of algae per day is sufficient caloric intake for a two-pound marine iguana. And second, algae grow quickly. Some seaweeds double their length and increase their mass up to six times in two weeks.

Shortly before low tide, marine iguanas can be seen warming themselves before entering the cold waves. The bigger animals can store more heat and thus feed deeper and longer. Still, diving lowers the body temperature by about ten degrees, and the iguanas return to shore with body tem-



Male marine iguana, *Amblyrhynchus cristatus*, on Santa Fé. Photograph: Martin Wikelski



Marine iguanas normally feed on seaweed in the inner tidal zone; larger ones often dive for their food.

peratures only slightly higher than sea temperature. The smaller lizards stay higher on the shore. A severe drop in body temperature could weaken their ability to run away from breakers and put them in danger of being swept out to sea, where they may be eaten. Small iguanas, therefore, shuttle between the cold intertidal flats and the warm lava rocks and on some days make up to eight feeding forays during low tide.

It appears that the lizards' biorhythms, synchronized with the lunar cycle of tides, let the marine iguanas "know" when to snack. Feeding by the bigger iguanas, however, is largely determined by water temperature and solar radiation. They can be found swimming around noon time every day, regardless of tide.

To cope with the high salt content of their diets, marine iguanas have the most efficient salt-excreting glands of all reptiles. The glands are located just above the nostrils. By sneezing frequently, the lizards expel the salt in small white geysers, which often give these black lizards a whitewashed look.

After eating, a marine iguana must reset its body temperature and heart rate (from 30 to 100

beats per minute), because the digestive system works best at a constant, relatively high temperature. By flattening their dark bodies against the warm lava rocks, the lizards expose as much skin surface as possible to the sun and the rock surface. The flow of heat from the rocks is controlled by vessels in the marine iguanas' chest, which close and open to regulate body temperature. To prevent overheating, the lizards elevate their torsos and face the sun, thereby diminishing the amount of body area exposed and allowing the cooling coastal breezes to convect heat away. Unable to sweat, most marine iguanas pant when the temperature approaches 104 degrees. Not so the hatchlings; they sometimes enter the intertidal flats with body temperatures of 108 degrees and, in general, have higher body temperatures than all the other marine iguanas. This allows them to digest their food in half the time adults require and supplies the energy needed for fast growth.

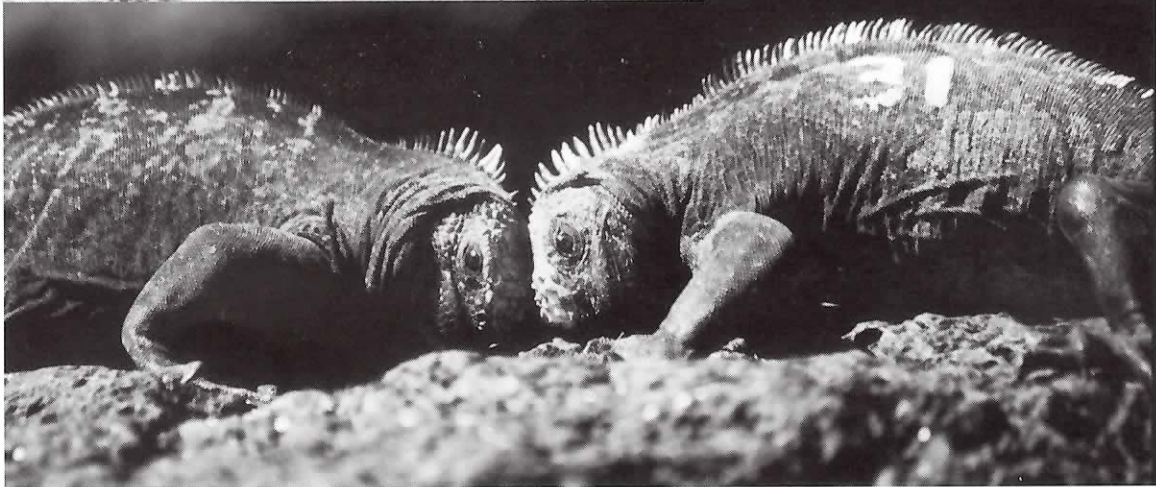
Onset of the breeding season varies from island to island: December to January on Santa Cruz, November to December on Santa Fé, for example. During this period the adult males become aggressive, staking out and defending ter-

ritories against intruders. Males feed less often and allocate available energy to reproduction. Consequently they don't grow and don't shed their skin. On some islands, the lizards' body color changes from black to shades of red, orange, and green. The effect is particularly dramatic on Española, where the males' green back spines conjure up childhood visions of dragons. But this coloration is not, as many might suspect, a signal to other lizards—male or female—about the qualities of that particular male. Females don't choose males according to color, and males don't react to the color patterns of other males. Rather, pigments from the plants they eat build up in the unshed skin, so body color reflects the type of algae they are feeding on. On Española, the color varies because they feed on diverse species of algae; on Fernandina, the iguanas mainly eat sea salad (green algae) and are brownish-green.

Males claim territories in the females' preferred resting places, which may be nothing more than exposed rocks, where they position themselves to appear as large and imposing as possible. Actually, a male's appearance is probably less appealing to a female than his territory; the more desirable the territory, the more opportunities for its owner to copulate. The best territories are above high tide, away from breaking waves, with sunny areas and shady crevices, ideal for the lizards' most time-consuming activities: basking and digesting. Some males occupy transition territories near low tide, waylaying females en route to the algae beds.

Holding onto a territory isn't easy. It allows the claimant little time to eat because another male may take over. Even when an iguana stays put, he often has to face other males who come to challenge him. Much head-bobbing and side

showing will often scare off an encroacher. But if males are of equal strength and size, such encounters can lead to head butting and pushing, and escalate to damaging fights. Many males carry scars from these bouts, which can last for hours or be



Recent studies by the author suggest that marine iguanas are the first reptiles documented to exhibit a lek mating system, in which males, shown fighting here, compete at traditional display areas for high dominance ranking within the group. *Photographs: Martin Wikelski*

taken up again the next day. Exhausted by these exertions, male iguanas are often in no condition to reproduce year after year, so they sometimes “take off” a year, avoiding the “mating scene” and hanging out in bachelor groups while they gather strength for the next season.

In 1990 we saw some of the first marked male hatchlings from 1981 occupying territories and copulating with females (about 6,000 animals have been marked so far). Yet there were no prize males and some didn’t reproduce at all. It probably takes 10 years for males to reach sexual maturity, so we estimate that “old fighters” known since 1981 must be at least 20 years of age.

Females move between territories as they like, but are subject to advances if they stray into a male’s territory. Once a female enters his territory, the male circles around her, nodding. If she stays, he mounts her and, holding her by the neck, drags her around. If the female endures this treatment and remains motionless, the male twists his tail around hers and copulates for up to 25 minutes, though sperm release begins after three minutes.

When walking among territories, females are constantly harassed by small, agile males. Large

er males will often push these smaller males off the females before they can release their sperm. During this year’s field work, we discovered that the smaller males counter this by masturbating and storing the sperm in their cloacal pouches. They can then release the sperm immediately upon mounting a female, before the larger males have a chance to knock them off.

Male defense of the breeding territories goes on for a month, after which the male loses his vivid color through shedding and becomes less aggressive. About the same time, the female begins to look for a nest site. She may have to walk several hundred yards inland in search of a sandy plot, where, together with hundreds of other females, she digs a burrow. This results in a complicated underground tunnel system of nests, and we still don’t understand all the processes that go on during egg-laying. Not surprising, fights erupt over the better sites, particularly those that offer shelter from Galápagos hawks, which on some islands prey on nesting females. When a suitable nest has been prepared, the female lays one to six leathery white eggs about the size of a chicken’s. She guards them vigilantly for a few days to two weeks



Female iguanas mate most frequently with high-ranking males. *Photograph: Martin Wikelski*



With limited nesting areas, females often compete for the best sites to dig their burrows. *Photograph:* Martin Wikelski

to ensure that they are not dug up by other females. Away from the sea, without food and drink for a week and more, the females soon look dirty and haggard.

Incubation takes about 95 days. On Santa Fé, hatchlings emerge in the first two weeks of May. The hatching of thousands of marine iguanas within a short period makes for better chances for survival. Still, many of the babies fall prey to snakes, lava gulls, hawks, and owls, and on some islands, feral cats and dogs. During the first year of life, iguana mortality can be as high as 60 percent.

Working on the Galápagos is somewhat like being in a wildlife paradise. One day, we shared our camp with 18 short-eared owls (some sitting on our shoulders while we read), four land iguanas, 50 Galápagos doves, three hawks, and a whole passel of rice rats, not to mention Darwin's finches, mockingbirds, lava lizards, and geckos. Sea lion pups play in the tidal pools (our bathtubs), and Galápagos and hammerhead sharks, schools of clownish-colored fishes, sea turtles, and lobsters swirl around when we snorkel.



The enormous investment in reproduction is evident from this egg laid by the female pictured. Marine iguanas lay the largest eggs of any iguanid species. *Photograph:* Martin Wikelski

The future of the marine iguanas, however, is unclear. When the project was started 14 years ago by Andrew Laurie, of Cambridge University, only about 4,000 people lived on the islands. Today there are nearly 12,000, and many of the new arrivals are attracted by the economic poten-

tial of the tourist industry rather than the islands' intrinsic beauty. Now, most tourists make supervised three- to seven-day boat trips to visit various islands. Ninety-five percent of the land area is owned and administered by the Galápagos National Park Service. Tourists are not allowed to stay overnight on the islands, are restricted to special areas, and must stay on designated trails. But as more people arrive, there will be more public and political pressure to give away park property for settlers and tourist facilities. Plans are already underway for a several-hundred-bed hotel on Isabela, which would be the end of the gentle boat-bound nature tourism.

In addition, introduced animals, such as cats, rats, pigs, and dogs, prey upon and compete with many native species. The park service is committed to controlling them and thus protecting the wildlife, but money is scarce and sometimes politics intervene. Fortunately, no introduced vertebrates survive on Santa Fé, so we have been able to observe marine iguanas undisturbed...though introduced blood-sucking flies and wasps recently invaded our private Eden.

The text of this article is reprinted with permission from the May/June 1993 issue of Wildlife Conservation.



During nesting season, the Galápagos hawk may prey heavily on female iguanas, sometimes killing them by holding their prey in the hot sand until they overheat. Photograph: Martin Wikelski



To a curious sea lion, an iguana may be an object of play. Photograph: Martin Wikelski