From Not So Simple a Beginning: The Voyage of the Beagle to the Voyage of the Endeavour Retracing the Steps of Charles Darwin in the Galapagos Islands

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FROM NOT SO SIMPLE A BEGINNING: THE VOYAGE OF THE BEAGLE TO THE VOYAGE OF THE ENDEAVOUR

RETRACING THE STEPS OF CHARLES DARWIN IN THE GALÁPAGOS ISLANDS

by

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A Thesis Submitted in Partial Fulfillment of the Requirement for a Degree with Honors (Marine Science)

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University of Maine

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Abstract

This is a natural history exploration of the behavior and distinct features of common vertebrates of the Galápagos Islands. Covering more than 26 species, this journey of observation begins with an in-depth look at Charles Darwin's field notes, and moves through history to examine how the knowledge about these species has changed. It is finalized with my personal experiences after a ten day journey exploring the islands with the crew of the National Geographic vessel, the *Endeavour*. My understanding of the species is solidified through my notes, sketches, films and photographs.

While journeying through the islands I carried a professional-grade GPS unit. Every location and species described is detailed on maps made using MapInfo. A small collection of my photographs and sketches is included as well.
For Cindi

whose heart was filled with adventure
"these islands are not so remarkable for the number of the species of reptiles, as for that of the individuals; when we remember the well-beaten paths made by the thousands of huge tortoises—the many turtles—the great warrens of the terrestrial Amblyrhynchus—and the groups of the marine species basking on the coast-rocks of every island—we must admit that there is no other quarter of the world where this Order replaces the herbivorous mammalia in so extraordinary a manner"

- Charles Darwin, *The Voyage of the Beagle*

Image 1: A marine iguana (*Amblyrhynchus cristatus*) at Punta Espiñosa, Fernandina Island in the Galápagos.
Preface

In the study of wildlife, never will there be a power greater than the power of observation. Through observation we question and therefore learn. Regardless of how foreign a species may appear, given enough time, it becomes familiar to the naturalist. My journey to the Galápagos Islands was a journey of observation and a foundation for future scientific endeavors. Because the islands have seen little change since the time of Darwin, the paths I walked are likely the paths he walked. This is not all we have in common. We were in the Galápagos with the same purpose—observation of the natural world, and with the same commodity—a desire to understand. In his works Darwin observed species through the eyes of natural selection and I attempted to do so as well. He saw them from a simple beginning to the present spectra through evolution.

Both Darwin and I realize that Galápagos Islands are special. Darwin states that "at the Galápagos Archipelago we have a halting-place, where many new forms have been created" (Wilson 2006). I know that the species present there are from not so simple a beginning: since Darwin's time, the understanding of how these species came to exist on the islands is more convoluted than it appears. When I travelled around the islands I found that the species Darwin discussed so many years ago are from a complex evolutionary background. They are the pinnacle of natural selection. All of the species that will be discussed somehow made their way to the Galápagos and further adapted to island life. They evolved and radiated. Many of these species have adaptations found nowhere else on the planet. My goal is to review what Darwin noted, investigate science after him, analyze trending research and explore my own experiences and observations.
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I. Galápagos Islands

When Darwin first visited the Galápagos Islands they were known by much different names. The westernmost island known as Narborough is now known as Fernandina, the largest island Albemarl is now known as Isabela, Indefatigable is now known as Santa Cruz, James as Santiago, Chatham as San Cristobal, Hood's as Española, and Charles as Florena. When Darwin firsts made landfall on the island of San Cristobal on September 17th he describes it rather negatively, "Chatham Island... like the others, rises with a tame and rounded outline, broken here and there by scattered hillocks, the remains of former craters. Nothing could be less inviting than the first appearance. A broken field of black basaltic lava, thrown into the most rugged waves, and crossed by great fissures, is everywhere covered by stunted, sun-burnt brushwood, which shows little signs of life" (Wilson 2006).

After spending several days on San Cristobal the HMS Beagle moved to Florena on September 23rd, and then Isabela and Fernandina on the 29th. Darwin and his ship remained on Isabela until departing for Santiago and Florena on the 8th of October. Darwin's island to island account is rather vague since he did not detail every day but would summarize all of the information in his journal from several days at once.

Darwin visited the Galápagos for almost the entire months of September and October (departing around October 20th) and stayed both on the islands and the HMS Beagle. I was in the archipelago for only two week, during a different time of year (end of February to the beginning of March), and lived only on a ship. There are several species (especially those of birds) that Darwin does not describe that I do. There are two possible reasons for this, either the species were not present (migrating) during Darwin's
months there (less likely) or he saw similar or identical species on the mainland of South America and therefore did not describe the species in detail when he encountered them in the islands (more likely). Therefore, several species I described will not have as much information from Darwin's notes.

The order in which I visited the islands was much different than the order Darwin visited them in. The group I travelled with flew to Baltra Island and departed immediately for North Seymour. After leaving North Seymour we visited Fernandina, spent several days travelling to different areas on Isabela, headed to Santiago, stopped briefly on Santa Cruz and finally visited San Cristobal. This means that Darwin visited an island I did not (Floreana) and I visited several the HMS Beagle skipped (Baltra, North Seymour and Rábida).

Another difference between my journey and Darwin's journey was who we travelled with. Darwin was a young naturalist aboard a ship, alone in his work. I travelled with a group of highly trained naturalists and guides, all born and raised in the archipelago and who had a background either in scientific research or working at the Charles Darwin Research Station (CDRS). Even though Darwin and I had much different experiences (guides, weather, and locations) we both worked to develop a naturalist's perspective on the species of the Galápagos Islands.
Figure 1. A map of the Galápagos Islands with specific trails and species labeled.
Figure 2. A map of the islands with tables listing some species and colony sizes.
II. Marine Iguanas (*Amblyrhynchus cristatus*)

Upon arriving at the archipelago Darwin notes two species of lizard hailing from the genus *Amblyrhynchus* "resembling each other in general form, one being terrestrial and the other marine" (Wilson 2006). Despite no marine lizards having been recorded by naturalists elsewhere in the world, Darwin was not impressed and labeled it as "a hideous-looking creature, of a dirty black colour, stupid, and sluggish in its movements" (Wilson 2006).

Once past his general distaste for the marine reptile he lists several key traits including their swimming habits, diet, and physique. Darwin was most curious about their interaction with the ocean. He knew the species to be aquatic, since he had witnessed them voluntarily swimming, but could not entice one to swim. He describes his surprise at the fact that he cannot chase one into the water. Darwin notes that time and time again he forces one, through chase, to the edge of the water but the lizards would rather be caught than enter. He observes that "they do not have any notion of biting; but when much frightened they squirt a drop of fluid from each nostril" (Wilson 2006).

After his initial chase experiments Darwin moves on to a different approach. He proceeds to grab the lizards by the tail and fling them out into the water as far as he can. The marine iguana always makes a straight line back to shore from where it had been tossed. He becomes more perplexed when he catches the same individual, and tosses it several times, always to have it swim back towards him. His final conclusion, although we will find it later to be incorrect, is that they have no terrestrial predators but must fear sharks.
When examining the method by which they move in the water Darwin agrees with Captain Collnett, who describes them as "alligators in miniature" (Wilson 2006). He states that the lizards swim near the bottom with rapid movements and occasionally use their feet over uneven ground.

While he was in agreement with Captain Collnett, who had travelled to the islands almost 30 years earlier, about the iguanas' swimming he discounts the Captain's notions about their feeding habits. The Captain claims "they go to sea in herds a-fishing" but Darwin was skeptical (Wilson 2006). Darwin proceeds to gather some and dissect them, finding very large and long intestines which he knows to be more common to herbivorous species. Later he discovers that the "stomach contains nothing but the sea-weed" (Wilson 2006). From this evidence he concludes that they feed on bright green and dull red Ulvae which grow in "foliaceous expanses" on the tidal rocks (Wilson 2006).

The last thing he describes about the lizards is their build. To his credit he makes an important evaluation of the species, that they are larger on Albemarle (Isabela) than anywhere else. The individuals he examines there get to be "four feet long; a large one weighed twenty pounds" (Wilson 2006). However he mentions that the average size lizard for the rest of the islands is smaller. He only states in passing that they have tails that are "flattened sideways, and all four feet are partially webbed" for swimming, due the fact that he had already described their swimming habits (Wilson 2006).

Darwin's research has inspired an interest in research of all species inhabiting the Galápagos and being the only known marine lizard in the world, marine iguanas get a lot of attention. One interested researcher, Dr. John Kricher of Wheaton College discusses that marine iguanas, "like common iguanas are vegetarian" but that they are exclusively
residents of the intertidal zone (Kricher 2006). He also mentions that their faces are specially adapted to grazing on algae covered rocks. They have blunt snouts specifically for their foraging strategy.

In his writing Dr. Kricher makes observations that Darwin missed but that do agree with Darwin's dissection research. Darwin saw marine iguanas voluntarily swimming at sea but did not collect those specific iguanas. Dr. Kricher witnessed that the iguanas capable of foraging in deeper water were the largest males. He also noticed that the iguanas were as fearless of people in the water as they were on land which helps to discount Darwin's shark theory that the iguanas are "afraid" of the ocean's sharks as their reason to avoid the ocean.

As already mentioned, one other point Darwin made was the difference of body size of iguanas between Fernandina and the other islands. Several researchers from the University of Washington investigated why "adult body mass varies by more than 10-fold and body length (snout-vent length) varies by ≈ 2.2 fold" (Kricher 2006). They compared iguanas from two islands and found that smaller iguanas had a higher foraging efficiency making them more numerous on that island in comparison. While travelling the islands I made note of this fact as well.

Had I not already known their significance to the scientific world (as the only marine lizard) I might have snubbed these lizards as Darwin did at first. My first encounter with the iguanas occurred on the beach, Las Bachas, while driving up in a zodiac. I noted the tiny lava colored iguanas, dotting the shoreline of Santa Cruz Island from the boat, but was not allowed any time for observation.
When I made my way back to the beach later that day the iguanas had crept up into shoreline vegetation to cool off. Since the area was covered in delicate, fresh turtle nests I dared not even try to get close. Instead I sat and watched them for just a few minutes. I observed their stillness, even the flies could not get them to move. A Darwin finch landed on one's back, no reaction. It began eating ticks off the iguana's long tail, no reaction. It hopped up onto the iguana's back and chirped, no reaction. No wonder I thought they were rocks from the zodiac. As I stood and tromped away I was ignored as well. This was my first experience with their indifference to humans that many observers note.

We later travelled to Fernandina and the marine iguanas basking there were unlike any iguanas we had seen so far. They were everywhere, they numbered in the hundreds and they were massive. The only similarity to the smaller iguanas on Santa Cruz was their complete indifference to our presence. As the group departed our zodiac we had to gently step over the iguanas because they had no intention of moving.

Occasionally one iguana would spray the excess salt out of its nose like snot (to the enjoyment of the elementary school boys in the group). This is the behavior that Darwin noted when he chased and caught the iguanas. To him it was merely a reaction to being caught. To me it was much more. In classes we covered how the salt glands of the iguanas drain excess body salts into their nasal passage ways. Their only method for eliminating this secretion is a blast of air to pass it out of the nostrils. The iguanas were soaking up as much sun as they could get, and the individuals that had been basking all morning had a crustal helmet of salt caking their heads. The white shells made them look as if they were going into battle.
Most of the iguanas were perched up on the lava rocks sunning themselves. Very few were near the water. Darwin also noticed this when he tried to chase the lizards into the water. He attributed the behavior to the danger of sharks. The local guides told our group that only the biggest males risk feeding at high tide because the smaller iguanas lose body heat too quickly and can be swept away by the waves. The young males and females do not have as much strength to cling to the rocks and fight the waves.

I did encounter the larger males. Dr. Kricher was correct in his statement about their not fearing humans even at sea. We entered the water of Fernandina to snorkel and found a thick carpet of bright green algae on the coarse rocks. The males moved through the water near the bottom, gracefully with undulations from the neck to the tip of their tails. Only their heads kept straight to maintain their course. When they found a desirable patch of algae they would grasp the rocks with their long claws and tear at the algae with their snubbed faces. While swimming along I filmed one feeding. I had my camera and face just inches from the creature and yet it seemed completely unaware of my presence.

The only time that the iguanas seemed to be concerned about anything at all was when they were nesting. We were lucky enough to see females digging shallow sand burrows at the coastline. They would dig with their front feet and push sand away from the entrance with their muscular hind feet. This behavior led to confrontations; several agitated iguanas would tussle and then just as quickly resume sunning themselves or digging.

The marine iguanas that I observed had not changed since Charles Darwin first distastefully described them. Though the iguanas had not changed, the research about
them has, and luckily for me, there is a bank of knowledge at my disposal to further my understanding of these sluggish lizards.
Image 2: The larger and more abundant iguana of Fernandina basking in the morning sun (top center). The smaller iguana of Santa Cruz (middle left). A small adult female digging a burrow for laying her eggs (middle right). A large male iguana feeding on Ulva just under the surface of the ocean (bottom left) and large iguanas with crusted salt on their heads (bottom right).
III. Land Iguanas (*Conolophus subcristatus*)

After Darwin's description of the marine iguana, we cannot imagine him to find its terrestrial counterpart more appealing. Surprisingly, he found them less appealing. After quickly making note that they have rounder tails than the marine iguanas and no webbing on their feet he goes on to state that "like their brothers the sea-kind, they are ugly animals, of a yellowish orange beneath, and of a brownish red colour above; from their low facial angle they have a singularly stupid appearance" (Wilson 2006). He also mentions that they are "lazy and half torpid" (Wilson 2006). Luckily, Darwin does not just condemn the appearance of the species on the islands but makes careful notes on their behaviors.

After his description of their stupidity he moves on to describe in detail their burrowing, aggression, and diet. Unlike their marine counterparts, the land iguana maintains burrows for more than just nesting, they also rest in burrows. Darwin explains his frustration because he "could not for some time find a spot free from their borrows on which to pitch [his] single tent" (Wilson 2006). Like the burrowing strategy of the marine iguanas, the land iguana works alternating sides of their body where "one front leg...scratches up the soil, and throws it towards the hind foot" and then the other side repeats the same action until a shallow burrow is formed (Wilson 2006). Darwin recounts watching one dig for an extended period of time and is inspired to pull its tail. He notes the bewilderment of the lizard that shuffles up to examine him.

An extreme difference Darwin discovers between the lizards is their reaction to harassment. He explains that they are "not at all timorous" and when staring at one it will curl its tail, prop itself up and bob its head vertically to "try to look fierce" (Wilson 2006).
Unlike the marine iguana he can get a bite reaction out of this iguana species. Darwin discovers that if held and plagued with a stick it will bite. However, if held by the tail it does not attempt to do so. He also realized that if two are held together on the ground "they will fight, and bite each other till blood is drawn"(Wilson 2006). He finds the species to be food aggressive. Darwin notes that if he takes a bit of cactus and throws it in the middle of a group each attempted to take it from the others and carry it off. Darwin is incredibly amused by this behavior and repeats it several times.

Darwin finds them to be, like all iguanas, herbivorous. The lowland iguanas feed on succulent cacti while the highland species' diet is more diverse. He describes how they eat "deliberately, but do not chew"(Wilson 2006). In the highlands of Isabela he observes them feeding together with giant tortoises on berries of the guayavita tree. He witnesses how the lizards get acacia leaves by crawling up the tree several feet and browsing on vegetation.

One key behavior that Darwin did not note was the nesting habits of the iguana. Dr. Paul Stewart describes that the female land iguanas use the calderas of the volcanoes as nesting sites. Their eggs need the "warmth and moisture" offered by the calderas (Stewart 2007). He notes that on Isabela Island there is a volcano called Alcedo or Wolf where iguanas are found up to the rim, at 1,700 meters, nesting.

Stewart also mentions something else that Darwin did not write about. Darwin never describes journeying up near the summit of Wolf Volcano and that caused him to miss something in his writing. Dr. Stewart notes that at the top of the volcano there are pink iguanas which he states are "undefined as to being a new species, race or perhaps just mutation" (Stewart 2007). We now know this rare iguana to be the pink land iguana.
(Conolophus marthae) that was not found until the 1980's and recently determined to be a unique species.

Dr. Stewart mentioned that the volcanoes were important habitats for nesting land iguanas but further research has yielded more reasons. The iguana species of the Galápagos have one predator, the Galápagos hawk, which feeds on juvenile iguanas and poses no threat to the adults. However, the hawks have an adaptation to follow the nesting patterns of the iguanas and are typically present during hatching. A research study found that the ability of the hatchlings to escape predation on Santa Fé Island is linked to their physical environment. The researchers discovered that the "physiological state of the lizard" was subject to their thermal environment and body temperature which affects their ability to escape predation (Christian & Tracy 1981).

My search for the land iguana began on the island of North Seymour. We landed on the rocky shore of the island to hike into the lowlands where iguanas are common. Ten minutes into the hike we started finding the iguanas. They were massive yellow-tinted lizards, sometimes four feet in length and far more alert than their beach counterparts. When we approached them they would give territorial head bobs. Darwin noted these head bobs as well but did not understand that they had territorial implications. The iguanas had no fear when facing something much larger than themselves. This is due to the fact that adult iguanas have no natural predators and therefore do not need to be concerned, even when something as big as a human approaches.

As Darwin described, certain islands were covered in the large yellow iguanas. Like him, I noticed this bright and distinct coloration. The guides informed us that some of the yellow coloration of the lizards is from a specific type of flower they consume. The
more abundant the flower the more yellow the lizards become. One interesting fact about North Seymour is that it is not listed among the islands Darwin noted to have land iguanas. This is due to the fact that this island did not always have land iguanas.

At the Charles Darwin Research Station, or CDRS, we were informed that there was a point in history when land iguanas were feared to be headed towards extinction. They were captively bred and introduced to North Seymour as a back-up population. The island was used as a contained breeding ground. There are no humans that live on the island and it has dense foliage making it the most suitable island to introduce the iguanas. The program worked perfectly and brought the species from the brink of extinction to being listed as vulnerable on the Red List. In just our two hour hike on North Seymour we found dozens of them. We were amazed at the sheer abundance of land iguanas on this island and later found this would be the most iguanas we would see the entire journey. The CDRS still has some of the original breeding pairs from the effort to re-establish the population.

The only other island we observed land iguanas on was Isabela. Isabela, home to Wolf Volcano, is the true stronghold of the lizard. Here the iguanas were harder to find but were much brighter yellow than the non-native North Seymour population. As mentioned by Dr. Stewart, it is also the location where pink iguanas were first found. The pink iguana lives an elusive life and, according to the naturalists, is incredibly fearful of humans. We did not see them because they are highland iguanas that reside on or near the volcanoes which are not open to visitors.

The last pieces of information that the guides gave us were regarding the lifespan and genders of the iguanas. We were told by local guides that the land iguana can live
over 80 years and that some in the captive breeding program at the Charles Darwin Research Station had been there far longer. We were also informed that they can be sexed based on the size of the spines down their backs. The larger the spines on its back, the higher the probability that the individual is male.

Despite not getting to see the rare pink iguanas, the common yellow version was still an amazing find. This species is not only unique to the islands but confined to just a few of the islands in the archipelago. At the end of my journey I was satisfied to have had the opportunity to see and compare the two species of iguana that Darwin spent so much time observing during his time in the Galápagos.
Image 7-9. A large female land iguana on North Seymour (top center). A feeding iguana on North Seymour (bottom left) and a bright yellow iguana found on Isabela (bottom right).
IV. Lava Lizards (*Microlophus spp.*)

I mention earlier that there are several species that Darwin neglects in his writings. The lava lizard is one such species. Darwin does not completely omit them from his writing, but he does not give them any significant attention. His only mention of them is that they are "small, fly-eating lizards" and that "when watching anything, nod their heads" (Wilson 2006). Darwin brings this behavior of the lava lizards up because he witnesses the head bobbing in the land iguanas as well. He is perturbed about the behavior and admits that he does not understand its purpose.

Had Darwin taken a closer look at the small lizards he could have found something much more intriguing. Lava lizards are a perfect example of adaptive radiation. Adaptive radiation is where a group of organisms develop from a common ancestor into different forms, filling different niches. There are actually seven separate species of lava lizard that are endemic to the Galápagos — these species came about via adaptive radiation. Darwin only noted adaptive radiation in the finches he studied and in his later works. Had he examined the species of lava lizards more closely he would have found another prime example.

While Darwin paid the lava lizards no mind, other researchers had more interest. Dr. David Badger explains that the lizards "habitually adopt lookout posts" to view their territory and bob their heads which explains the head bobbing that baffled Darwin during his journey (Badger 2006). He also mentions that they have a very unique ritual that involves them using their tails as weapons to battle other males without bloodshed. The ritual involves them making a "crack" sound with their tail that is so loud and distinct it
can be heard from several yards away. One final fact he provides is that, while insect
eaters, lava lizards often cannibalize juveniles if the opportunity presents itself.

When I first arrived at the islands I realized that the iguanas were not the only
lizards present. I also noticed the presence of a small, bizarre lizard - the lava lizard. Like
the species previously discussed they had no fear of predators. They climb over the
iguanas and hikers without a care, sometimes perching on an iguana's head for several
minutes at a time. Along the coast and in the arid lowlands of the island they were
everywhere. Every island was crowded with the little lizards.

A particular interest I took in the lizards was their colorations. The females had
vibrant red throats and the males were plain. Both would defend their territory from the
opposite sex but the males were much more territorial and spent more time bobbing their
heads as Darwin noted. In most lizard species, usually a male would have the more
vibrant coloration, either for attracting a mate or for intersexual competition. However in
lava lizards the female is more ornate and the guides informed us that scientists do not
know why this extreme sexual dimorphism exists.

I found the antics of the lizards to be fascinating and sometimes hilarious. You
could sometimes catch a male doing territorial "push-ups" and head bobs while perched
on a marine iguana. Darwin might not have found the lizards too exciting but I was often
surprised by their odd behavior. The lava lizard never failed to capture my attention, but
like Darwin, the guides often neglected these lizards as well.
Images 10-12. A female lava lizard found on North Seymour displaying her red throat patch (top center, bottom left) and a male lava lizard perched on the head of a marine iguana at Punta Espinosa on Fernandina.
V. Galápagos Giant Tortoise (*Chelonoidis nigra*)

Figure 3. A sketch of an adult Galápagos giant tortoise from Isabela Island with a domed shell.
Darwin generally did not take well to the reptiles of the Galápagos Islands, but there was one particular species he did enjoy describing, the Galápagos giant tortoise. When he first sees the tortoises he says they "seemed to my fancy like some antediluvian animals" (Wilson 2006). One reason that Darwin might have found himself lacking harsh words for the tortoises was due to their importance in survival on the islands. The staple of food for the islands' inhabitants and the crew of the HMS *Beagle* were the tortoises, and Darwin notes that they are found "on all the islands of the archipelago" (Wilson 2006). In his observation of the tortoises Darwin describes their habitat preferences, distinct features, dietary inclination, mating habits, and diversity by island.

He begins with an in-depth examination of their habitat. The Galápagos Islands have both damp highlands and arid lowlands. While Darwin finds tortoises in both, he discovers that they have a preference for the damp highlands. He is not only surprised by their vast numbers but the immense size they can reach. Darwin notes that some tortoises produce over 200 pounds of meat and the old males (males without age rings on their shells) are much larger than the females.

Some of the tortoises live on islands where fresh water is not always available. He discovers that these tortoises, and the ones that live in the arid regions, feed primarily on the succulent cacti. Those in the higher regions consume leaves, lichens, and guayavita berries. All of the tortoises need water in some form and Darwin notes how fond they are of it. Some of the larger islands have springs and Darwin admits "he could not imagine what animal travelled so methodically along well-chosen tracks...with outstretched necks" to reach these springs (Wilson 2006). Darwin describes that when the tortoises arrived at the springs they submerge their heads in the water above the eyes and "greedily
swallow mouthfuls" (Wilson 2006). Darwin is surprised by the rate the tortoises move to obtain food or water. He notes that they travel about eight miles every two or three days and can walk sixty yards in ten minutes.

After his observations about their diet and habitat, Darwin describes their mating strategies. He describes the call of the male to be a "hoarse roar or bellowing" that "can be heard at the distance of more than a hundred yards" during the breeding season. He makes note the female never makes a sound and the male only calls when he is mating with or pursuing a female. He observes that the females go on to lay their eggs in shallow burrows and cover them with sand. If the area is rocky, Darwin notes that the females will just drop their eggs in any hole. He describes that when the tortoises hatch the hawks feed on them in great numbers. However, old tortoises are never dead without cause (the locals tell him that some die from accidentally falling down precipices).

Darwin mentions a few other interesting observations he makes about the tortoises. He finds that if he walks up to one it retracts its head into its shell and hisses. When he perched himself on the back of a tortoises he found that he could ride it by knocking on the back of the shell to make it move. He does admit he found it difficult to stay on once in motion. Darwin notes a mistake he made in his writing. Darwin realizes that most species vary from island to island but does not connect this to the tortoise. However, while corresponding with a Mr. Lawson he is informed that the tortoises differ from island to island too. Darwin admits that his collection of shells is mingled and when loading them he did not pay particular mind to their origin.
He is disappointed and states that "it is the fate of most voyagers, no sooner to discover what is most interesting in any locality, than they are hurried from it"(Wilson 2006). He manages to discuss the differences in shells with the inhabitants of the islands and they inform him that "they can distinguish the tortoises from different islands; and that they differ not only in size, but other characters"(Wilson 2006). When looking back through old logs he finds that Captain Porter, who sailed around the Pacific warring on British whaling ships, described the tortoise shells from Santa Maria and Española as having their fronts turned up like a Spanish saddle and the ones from Santiago being darker and rounder. Darwin, himself, never confirms whether this difference is fact or fiction.

Dr. Maurice Burton and Robert Burton of the British Museum of Natural History explain that the population of Galápagos giant tortoises had a large decline during the 19th century. Like Darwin and the crew of the HMS Beagle, other ships realized the value of tortoise meat. Burton describes that during this time the crews took living tortoises on board because the tortoises "could live up to 1 year in the ships' holds, without food or water" (Burton & Burton 2002). The introduction of invasive species did not help the tortoises either (invasive species were already present when Darwin arrived). Burton notes that Pinta in particular suffered when local fisherman brought goats to the island. The goats destroyed the vegetation and the nests of the tortoises became more exposed to predators. Due to the overhunting of tortoises and invasive species several of the subspecies of tortoise are now extinct, so some islands have completely lost their tortoises.
The extinct subspecies of tortoises may have some hope still. A group of researchers doing genetic work on the tortoises found that extinct subspecies "can live on in the genomes of extant individuals of mixed ancestry" (Garrick et al. 2012). There are several ways that the tortoises hybridize that I will discuss later. The researchers discovered the genetics of an extinct subspecies from Floreana in eleven hybrids on Wolf Volcano, Isabela. They point out that given that hybrids are on Isabela Island, there is a possibility that their purebred parents are still present there as well. There could be a chance that all the subspecies of tortoises Darwin saw may not be lost. As this research suggest, if individuals can be captured, they could constitute the core of a captive breeding program for re-introduction.

As Darwin was informed, there are different subspecies of the tortoises on different islands. Due to the various reasons previously mentioned some of the subspecies are now extinct. On my favorite island, Fernandina, the tortoises have all been wiped out. Fernandina is the island with the most recent volcanic activity which limits terrestrial species. The last major eruption is the reason all the tortoises on this island perished. The volcanic eruption destroyed almost the entire island, limiting its plant growth and leaving the tortoises no area of escape from the magma.

Our group found our first tortoises on Isabela after a landing at Urbina Bay. We were told by the guides there was a "slight chance" that we "might" find tortoises. We set a record for the most tortoises found in the shortest amount of time in the area! We discovered thirteen Galápagos giant tortoises and more than half were over 90 years old.

The guides taught us the way to determine a tortoise's age is the number of rings on its shell. There is a ring for every year until around age 90 when all the rings begin to
disappear and the shell becomes smooth. At this point it is impossible to know how old the tortoise is without knowing its history. We found many old tortoises. Some were just sitting on the path and others were in the bushes eating the fruit of poison apple trees (a tree deadly to humans - even drinking rainwater that falls off of it can be fatal). We only watched them feed for a short period of time. We did not want to frighten the tortoises as Darwin did.

Darwin did not know any better but when he described the tortoises retreating into their shells while making a hissing sound he was scaring them. The guides also informed us that tortoises are intimidated by only one thing — height. They are terrified of anything that is taller than them. Tortoises display dominance by stretching their necks to make themselves as tall as possible. Humans, being naturally taller than wild tortoises, only cause them stress.

The only other place we found wild tortoises was in the highlands of Santa Cruz. Here tortoises were relaxing and feeding. On the same island we visited the CDRS in Puerto Ayora, where tortoises are bred to keep populations stable. While at the station we learned about the tortoise subspecies and gender. Tortoises bred at the CDRS are returned to the islands after they are large enough. The CDRS has found that the tortoises have environmental sex determination— meaning the temperature the egg is incubated at determines the gender of the tortoise. Since there are too few females on the islands the CDRS specifically makes 80% of the hatchlings female using temperature control.

While at the CDRS we were also told about the differences among tortoises by island. Darwin mentioned that he had been informed about this but had not witnessed it. At the CDRS we were shown the different shells from every island including the ones
where tortoises were extinct. I noted the difference between the species with a "saddleback" shell versus a "domed" shell. The islands that yielded the saddleback shell required the tortoise to reach higher vegetation and its shell allowed its neck to extend much further than the domed shell tortoise. The domed shell tortoises grazed at a much lower height and did not need to have the ability to extend their neck. The Galápagos giant tortoise is the only species of giant tortoise to exhibit different shell shapes in one species.

In the past, all of the major islands had a subspecies of tortoise with a unique shell shape. Now that several islands have lost their subspecies (to either overhunting, invasive species, or natural disasters) all that remain are empty shells. The guides told us that if the cacti were tall on the island there were no tortoises present. This is because they eat the paddies of the tops of the massive prickly-pears.

Despite the fact that several subspecies are gone from the island, there is still hope. While declared extinct there might actually be some possibility they are not. This is partially thanks to explorers like Darwin that consumed the tortoise. Tortoises can live for long periods of time without food or water and are meaty creatures. Upon their discovery, ships would stop and load up on tortoises for food. If a ship took too many tortoises it could risk sinking, instead of just dumping the creatures out, the ship would often stop at the next closest island and leave the tortoises on shore.

Some individuals were also taken for private collections and still live around the world. This means that tortoise subspecies that are declared extinct could just be misplaced. The CDRS told us that recently blood was taken from the tortoise population
of Isabela and two individuals had DNA that came back as a different subspecies. The subspecies they belonged to was none other than the same as "Lonesome George".

Lonesome George was the last known Pinta Island tortoise and was called the rarest creature in the world by some people. He was accidently discovered in 1971 and after the island was searched he was declared the last Pinta tortoise. He was brought to the CDRS and provided a home— his species was declared functionally extinct. The CDRS hoped to someday provide him with a mate. Sadly, George died on June 24, 2012 before the two individuals of Pinta descent located on Isabela were found again. Despite George's lonely life there is still hope for his subspecies. There are two known Pinta males in private collections and two tortoises from Pinta of unknown gender on Isabela.

I don't believe that I will ever have another experience that compares to walking alongside an ancient, wild Galápagos giant tortoise. I encountered dozens of tortoises that were well over 100 and I like to believe that these tortoises are the direct descendents of the individuals Darwin encountered. After experiencing two days with these giants I not only feel closer to a piece of history but to Darwin.
Images 13-15. A large male giant tortoise on Isabela (top left and right) and a female hatchling being raised at the Charles Darwin Research Station on Santa Cruz (bottom).
VI. Flamingo (*Phoenicopterus ruber*)

Figure 4. Sketch of a flamingo's face and foot and a flamingo in flight.
If Darwin did encounter the flamingo he was lucky. The flamingo is now a red list species on the IUCN and the Galápagos flamingo is now the most endangered species of flamingo in the world. There are several reasons that the flamingo is endangered.

Invasive species, which destroy nests, ruin habitat and transmit diseases, are incredibly harmful to the flamingos. However, the flamingos face a much more menacing threat to their population levels. The El Niño phenomenon "affects food resources, causes flooding of their habitat, and results in decreased reproduction" according to researchers from the Charles Darwin Foundation (Jimenez-Uzcategui 2007). Humans also pose a threat to the flamingos. For decades humans use to use lagoons for landfills or depositing garbage which ruins the flamingos' food source and habitat.

Even though the flamingo population has declined they can still be found on the islands. My first day aboard the ship was not just an introduction to the island — it was the only opportunity to see flamingos. When we landed on Santa Cruz there were two lagoons within walking distance from the beach, Las Bachas. The flamingos of the Galápagos can only feed on the brine shrimp within the lagoons scattered around the islands. Most of the lagoons are not open to the public. Our group was lucky enough to find two lagoons, but it was not the time of year typical for flamingos.

We were on a mission to find one of the rarer species in the archipelago. According to locals there are less than 500 individual flamingos that visit the Galápagos and they are extremely difficult to find. The species is found on the mainland of South America but seeing the Galápagos subspecies is rare. We set off, down the blisteringly hot sand in search of two lagoons rumored to have a few straggling flamingos. After wading through large groups of vibrant Sally Lightfoot crabs and avoiding the delicate
nests of pacific green turtles we caught a glimpse of the lagoon through the trees. Someone made a noise, just enough of a noise, to scare what we were searching for. In an instant two large flamingos were overhead, escaping the lagoon before we could arrive. Their large wings spread so that the black feathers were in plain view. They do not tuck up their feet and necks like other birds; instead they fly with them fully outstretched which makes them a magnificent sight.

When we approached the lagoon, it was empty. Luckily our guide, a native of the Galápagos, said he could find us another lagoon. The lagoon was in the direction that the original pair of birds headed. To get there we had to go back to where we started plus an additional fifteen minutes of walking. Only a few people decided that the journey was worth it in the heat.

As we silently crept up the shore of the lagoon there were three large flamingos slowly sifting through the water with their odd shaped bills. Flamingos feed around seven hours a day and these flamingos were in full feeding mode, completely undisturbed by our presence. We sat and watched them slowly walk, moving their heads side-to-side and filtering the brackish lagoon water.

They were a beautiful sight, and not just because they are rare. Darwin may have placed more of his focus on the reptiles of the islands but I was just as interested in the avian species. I feel that, if I had neglected the birds, I would regret having limited my focus.
Images 16-18. Flamingos travel from one lagoon to another on the island of Santa Cruz (top & bottom left), and a pair of feeding flamingos (bottom right).
VII. Swallow-tailed Gull (*Creagrus furcatus*)

When Darwin describes them, he does not go into much detail about the birds on the islands. This is a loss, but he was more concerned with describing the reptiles of the island, which were far more prevalent. He does make a few short notes about the Swallow-tailed gull. Darwin notes that "considering the wandering habits of the gulls" he is surprised to find that the species of the Galápagos Islands are unique (Wilson 2006). He is surprised that given the large range many gull species occupy that the Galápagos has a unique species. The only other mention he makes of the gull is that the Galápagos species are larger than the species common on the mainland.

There are many researchers that observe the swallow-tailed gull. Dr. D. Snow, in his research on the islands, of the British Trust for Ornithology notices that the gull is built more like a tern than a gull except for its webbed feet that are large, webbed and built for strong swimming. He notes that this species is pelagic and feeds primarily on fish and squid and the food source of the swallow-tailed gull varies seasonally. For the gulls' diet, fish constitute the major component February to July and squid the rest of the months of the year. Dr. Snow also observes that the gull is totally pelagic outside of breeding season and is known to migrate to the coast of Ecuador and Peru. He also mentions that, like most sea birds, the gulls nest in breeding colonies and "no birds in immature plumage (except dependent young) are seen at the breeding colonies" (Snow and Snow 1968). Dr. Snow also observes that the swallow-tailed gull is a social breeding species.

Dr. Nelson of the University of Oxford also spent time observing the swallow-tailed gulls of the Galápagos. He recognizes that the gulls have a "striking vocabulary"
that includes "a scream, snore, rattle and choking" (Nelson 1967). The breeding is highly unsynchronized except in small groups, which is probably socially facilitated. During the time prior to copulation Dr. Nelson witnesses several courtship behaviors. The birds perform what is called a "butterfly flight" that seems to have strictly intra-pair meaning. The male gull also courtship feeds the female and both perform nest site calling. Dr. Nelson also notes that each pair has only a single chick that is highly cryptic and is capable of following its parents a distance from the nest within 48 hours of hatching. The swallow-tailed gull is a particularly rare gull to encounter and is one of several endemic species.

There are several species of gull that are found in the Galápagos Islands. The only one we saw was a particularly rare endemic species on North Seymour — the swallow-tailed gull. Part of the reason that this species is considered so rare is the fact that it is entirely nocturnal and we were lucky enough to see some during the day. Swallow-tailed gulls are the only fully nocturnal gulls or seabird in the world. They are typically more common on the eastern islands and feed on small squid and fish.

When we found them there were about six gulls either sitting on the edge of the cliff or walking around. As we approached they did not seem concerned and continued to preen and call. All of the gulls had the same dusky grey backs, with bright legs and eyelids. The guides informed us that swallow-tailed gulls do not have any sexual dimorphism and it is almost impossible to distinguish the sexes. While I considered them to be a very interesting species, the guides were preoccupied trying to find land iguanas and did not spend very much time informing us about the gulls. I did agree with Darwin when comparing the gulls to their terrestrial counterparts.
Image 19. A swallow-tailed gull, usually nocturnal, out in the early afternoon on North Seymour.
VIII. Great Frigatebird (*Fregata minor*) and Magnificent Frigatebird (*Fregata magnificens*)

Figure 5. A female great frigatebird in flight (top) and male magnificent frigate displaying. The longer feathers behind the head are purple-tinted and glossy (bottom).
Darwin did not mention the frigatebird at all. The same species we found in the Galápagos are found elsewhere in the world and Darwin had probably come across them before. Since he makes no remarks on the species we have to assume that he was already aware of their behavior and distinct features.

Darwin was not in the Galápagos long and probably did not have the time to study the frigatebirds in depth. A group of researchers from the Catholic University of Ecuador did have enough time to determine the age of breeding for great frigatebirds on the islands. The researchers realized that plumage maturation is vital in the ability of a bird to attract a mate. They found a pattern linking plumage maturation and age at first breeding in great frigates that may be an explanation to the slow sexual maturity in all frigate species. Research shows that females "attain full adult plumage at eight to nine years" and males at ten to eleven years (Valle et al. 2006). For most birds this is a lengthy amount of time to reach sexual maturity and there is a distinct period of sub adult plumage in the birds. The researchers speculate that this delay is a result of "moult energetic constraints"(Valle et al. 2006). While on the islands we saw only the adults and young chicks.

When we landed on North Seymour there were frigate birds everywhere. The large, adult male birds had brilliant red gular pouches. The great frigate can inflate its gular pouch to attract females while perched whereas the magnificent frigate has a constantly inflated gular pouch.

While these birds are beautiful to watch while they display, they are far more interesting to watch feed. They cannot touch the water while hunting (or risk drowning) so must grab fish close to the surface. They are also known for being kleptoparasitic on
other birds because they cannot dive into the water to retrieve their own food. They must risk fishing, steal the catch of others (like the swallow-tailed gulls) or eat the chicks of other birds.

North Seymour is a particularly special place for both species of frigatebirds. The breeding schedule of frigates is special only on this island—North Seymour is the only place in the entire world the birds breed year round. A nest rarely contained more than one chick so outside of this island seeing a chick is rare. On North Seymour there were chicks in almost every tree. It was astounding that there was enough food for all of the chicks present.

As I mentioned earlier there are two species of frigatebirds that inhabit the island, the great and the magnificent frigatebird. The great frigate has distinctive green and purple glossy feathers on its back while the larger female has a distinct white patch of feathers covering her chest and throat. The magnificent frigate males have only purple glossy feathers on their backs and females have less white on their undersides with brown banded wings. Observing these species, in their vast numbers, was an amazing site. I had seen frigatebirds in other locations but never in such numbers.
Images 20 & 21. Male great frigatebirds flying and displaying to mates on North Seymour - the only place in the world where they nest year-round.
XI. Flightless Cormorant (*Phalacrocorax harrisi*)

Darwin makes note that while in the Galápagos he collected eleven species of waders and water-birds. He does not describe any of them in detail, or even list what he believes they are. Had he expanded on these species more he may have mentioned the flightless cormorant.

The flightless cormorant has only recently become common in scientific literature. Most of the discussions revolving around the species involve how its population changes during El Niño events. An El Niño event occurs in the tropical Pacific Ocean and refers to warming temperatures of the surface of the ocean. During an El Niño there is low ocean productivity and this negatively affects many species found in the Galápagos. According to Dr. Valle of the CDRS and Dr. Coulter of the Savannah River Ecology Laboratory the population of flightless cormorants dropped approximately 49% during the El Niño event in the early 1980's. Luckily, unlike some other bird populations "between July 1983 and September 1984, the cormorant population recovered" (Valle & Coulter 1987).

More recent research by the CDRS shows that although listed on the IUCN's Red List of endangered species the annual census of the population shows that the cormorant population is stable and steadily increasing. The threats that the remaining cormorants face include "introduced species, uncontrolled fishing with nets, oil and fuel spills and plastic garbage" (Jimenez-Uzcategui et al. 2007). Despite these threats we were able to see flightless cormorants on both islands they inhabit.

The flightless cormorant population is confined to just the islands of Fernandina and Isabela and they are the only known flightless species in the genus. Flightless
cormorants are, in my opinion, one of the most iconic species of island life in the world. They have adapted so specifically to island life that, in terms of what is typically thought of as "evolution" (birds' wing development for flight), they have taken a step backwards. This is related to the fact that they are flightless. Flightless cormorants are descendants of mainland cormorants like those found in California or Florida.

The species we see in the Americas would have travelled to the Galápagos and lost the need to fly due to the abundant nutrients present around the islands year-round. When we look back at the history of birds wings they were originally too small for birds to fly and used in regulation of body temperature. Flightless cormorants have reverted to the small, short wings that only function for temperature control. They also have reduced muscles around their keel or breastbone. Instead of wasting the energy to grow large, muscular wings for flying (when they are not needed) their ancestor mainland cormorant evolved into the flightless cormorant over a long period of time.

They do still share some characteristics with their mainland counterparts. They do not have oil to keep their feathers waterproof and must dry themselves after swimming. They also have the same diving and foot-propulsion swimming style as the cormorants found in the Americas.
Image 22. A flightless cormorant shows off its wings that are no longer large enough for flying and only serve as temperature regulators.
X. Galápagos Penguin (*Spheniscus mendiculus*)

Figure 6. Sketch of a Galápagos Penguin.
Another species that Darwin fails to mention is the Galápagos penguin. This really does surprise me. Darwin probably found mainland counterparts of most of the water birds he encountered, but I would assume not the penguin.

Like the flightless cormorant, the Galápagos penguin population is subject to the negative effects of an El Niño event. Dr. Valle and Dr. Coulter found that the El Niño of 1982-83 eradicated more than 75% of the Galápagos penguin (Valle & Coulter 1987). Unlike the cormorant species the Galápagos penguin population has not been able to recover and the CDRS notes that the current population is still lower than recorded in the 1970s before the El Niño event (Jimenez-Uzcategui et al. 2007).

The Galápagos penguin is obviously strongly affected by the El Niño, but the El Niño events enact deeper damage to the population than is obvious. A group of researchers from the University of Maryland conducted an analysis of genetic diversity in the Galápagos penguin population using its congener the Magellanic Penguin as a comparison. They found that the population has extremely low heterozygosity, about 3%. The El Niño events have worked as a serial bottleneck in the Galápagos penguin population. The reduced population that results from every El Niño increases homozygosity and this inhibits the ability of the population to adapt to changing selective pressures. This homozygosity, coupled with the threat of human impact, leads the researchers to conclude the species is "in particular danger of extinction" (Akst et al. 2002).

The Galápagos penguin is the only penguin north of the equator in the wild. The reason it does well in the Galápagos is because of the presence of the cold Humboldt and
Cromwell Currents (that only weaken during El Niño events). These two currents deliver cold water to the islands and support the rich marine life. The penguins are found over the whole of Fernandina (which is the westernmost island) and the west coast of Isabela. There are scattered populations on a few other islands.

While we did not see very many penguins, however when they were in the water they were highly entertaining. When snorkeling they would approach one of two ways. They would either saunter up at the surface, slowly kicking their back feet with their head perfectly out of the water or would come shooting by flapping their wings underwater. They were impossible to photograph underwater because they were just too quick. The Galápagos penguins are the rarest penguins in the world and are considered endangered. Their predators include sharks, Galápagos fur seals, Galápagos sea lions and some invasive species. Although I have never had an avid interest in penguins, I found the ones in the Galápagos to be quite intriguing.
XI. Blue-footed Booby (*Sula nebouxii*), Red-footed Booby (*Sula sula*) and Nazca Booby (*Sula granti*)

Another group that Darwin completely skipped describing is the boobies. They are named from the Spanish word "bobo" which means "clown" or "fool" due to the way they walk on land. There are three booby species that occur in the Galápagos: the blue-footed, red-footed, as Nazca.

A growing concern with many species that nest in the Galápagos is how tourism affects them. All three species of booby nest in the Galápagos and are observed and photographed both by tourists and researchers. Dr. Burger and Dr. Gochfeld of Rutgers University focused the concern of their research on how human disturbances changed short term behavior in all three species. The researchers made observations about whether the boobies of each species walked, flew or remained at their nest when tourists passed and at what distance the tourists were from the individuals. They found that "the boobies respond to tourists in subtle ways often related to their species" but further studies are needed to see the long-term impact that tourist presence has on the birds (Burger & Gochfeld 1993).

My first encounter with a blue-footed booby was an unpleasant one on North Seymour. During our hike we came across a carcass. Death is part of nature and in North Seymour, where birds are abundant but food is limited, high mortality is commonplace. However, this death stuck out in particular, because it was a blue-footed booby chick that had starved. The guides informed us that booby chicks should have fledged several weeks before we arrived and this chick had most likely failed to fledge and been abandoned. Its
carcass lay untouched on the trail, there are few scavengers on the islands and most likely the booby will remain until it is weathered down to bones.

Just a ways up the trail our mood was brightened. Sitting on a ground nest in a clearing was another booby chick. This one had yet to fledge as well but it was healthy and strong. It stretched it wings and called to its parents as we passed. This chick would probably survive and leave on its first annual migration out of the islands. Just as our guide was explaining to us that we were lucky to have seen this chick since it was past the time of year to see blue-footed boobies we came across an adult female booby. She was standing on a rock, mouth agape, attempting to cool off in the heat of the mid-morning. It was the hot season in the islands and the female booby was attempting to regulate her body temperature. After several minutes of watching her cool herself we headed back to the ship to prepare for morning snorkeling.

My only complaint witnessing the blue-footed booby is that we did not get to witness their famous mating display. The mating display of the blue-footed booby involves a showy dance with wing flapping and stomping. The last fact the naturalists gave us was regarding foot color. The foot color varies in blue-footed boobies. The young do not have blue feet until they reach adulthood and adult's pigment changes depending on their diet.

The next species we encountered, though we only found one individual was the red-footed booby. Red-footed boobies are smaller and all individuals have red feet and a light blue beak. Many are white but there is a brown morph which predominates in the Galápagos Islands. The one individual we saw was a brown morph on a classic plunge-bounce dive. This diving style involves the bird taking the potential energy of being
several feet in the air and turning into kinetic energy for a dive. Once the bird dives it turns back towards the surface and swims up making a "V" shape called a bounce. We watched the bird rise up next to the zodiac, turn down towards the water, extend its wings back, enter the water, and return right back up with a fish.

The third species of booby we saw was the Nazca booby. The Nazca booby was the most common booby on our trip but we only saw around 10 to 12 total. The guides told us Nazca boobies were considered a subspecies of the masked booby until recently but are now recognized as their own species. An interesting difference in the Nazca booby compared to the masked booby is that they have obligate siblicide. A pair has two eggs and the stronger of the offspring forces the other out of the nest where it will die.

The individuals we saw were mostly white with black on their wings, tails and faces. The black on their face was like a mask that wrapped around the eyes and orange beak. We did not see any flying or fishing but according to guides they use the same plunge-bounce style fishing as the other two booby species mentioned.
XII. Finches (Geospiza spp. and Camarhynchus spp.), Galápagos Mockingbird (Mimus parvulus) and Galápagos Flycatcher (Myiarchus magnirostris)

Darwin did not pay attention to many birds in The Voyage of the Beagle and saved much of his work on the birds of the Galápagos until his later works. His only mention of the mockingbird is a note that he collected three species of mocking thrush which he considers "a form highly characteristic of America" and only mentions the flycatcher stating that he found three species (Wilson 2006). Darwin spends much more time discussing finches. Darwin collected several specimens of land birds and notes that most of the groups are finches "related to each other in the structure of their beaks, short tails, form of body and plumage"(Wilson 2006). All together he collected thirteen species, all endemic but one. He observes that all the species feed on the ground in mixed flocks except two that climb and eat the seeds of the cactus-trees. Darwin realizes that in every species the male is black and in almost every species the female is brown. What he is most curious about "is the perfect graduation in the size of the beaks in the different species" and speculates that "one species had been taken and modified for different ends"(Wilson 2006).

Another concept that baffles Darwin are the colors of all the birds, since they are in the equatorial region, he expects to find brightly colored tropical-looking specimen. Instead all the land birds he collects are rather boring. This lead him to the conclusion that "the usual gaudy colouring of the inter-tropical productions, is not related either to the heat or light of those zones, but to some other cause, perhaps to the conditions of
existence being generally favorable to life" (Wilson 2006). This realization, along with several others Darwin makes while examining the finches will help him in his future writings and fame. After examining the small finches Darwin has his evidence for his claims in *The Origin of Species*.

Several researchers from McGill University set out to further their knowledge about the finches of the islands (Abbott et al. 1977). By examining food supply and the interspecific competition between various finch species they concluded that both factors "jointly determine the ecological course of the radiation of Darwin's finches and the resulting pattern of species diversity" (Abbott et al. 1977). They also determined that the initial steps of differentiation were supported by the variation in vegetation across the islands.

The finches were not as prevalent as I expected along the journey and were difficult to observe and photograph. Darwin had the opportunity to collect the birds and keep them in order to make more observations. Our group saw both large and small tree finches as well as small, medium and large ground finches. The finches were almost impossible to distinguish with an untrained eye, often tree finches would be on the ground and ground finches on the trees. The guides pointed them out and gave their name but did not give a description of how they knew which was which. All of the finches were plain colored seed-eaters or insectivores whose beak shape matched their diet of choice. The guides informed us that they are not true finches.

Along the hikes on the islands we really only found two other terrestrial bird species: the Galápagos mockingbird and the Galápagos flycatcher. The Galápagos mockingbird is the only species of mockingbird that does not mock. It is an endemic
species that is fearless around humans and aggressive with other birds. The naturalists informed us that they descended from the Ecuadorian long-tailed mockingbird.

The other species was the Galápagos flycatcher. The flycatcher was another interesting endemic bird. It had no fear and was more concerned with how it looked in the camera lens than anything else. They would land on walking sticks, hats, even fingers if it meant they could look at a reflection of themselves. While I found the antics of all these small birds to be amusing I did not feel that I fulfilled my interest in learning about their behavior, habitat, and diet. Although, I realize that I could probably have spent the entire ten days observing just the birds in this chapter and would still lack a good understanding. Even Darwin, who had a month among the islands to observe and experiment, felt that he was cheated on time in the Galápagos.
Images 25-29. A Galápagos flycatcher perches on a rock to examine its reflection in a camera lens (top center). There are a variety of finches on the islands that have distinct sexual dimorphism with the black being male (middle left) and the brown being female (middle right). The Galápagos mockingbird is the only known species that does not mock (bottom left and right). All these birds were photographed in the early morning on Santiago.
XIII. Galápagos Hawk (*Buteo galapagoensis*)

![Sketch of the underside of a juvenile Galápagos hawk.](image)

Figure 5. Sketch of the underside of a juvenile Galápagos hawk.
Darwin did not spend much time making notes on the Galápagos hawk but did express particular interest in the species. He was surprised by it because he sees characteristics of both "a buzzard and the American group of carrion-feeding Polybori" (Wilson 2006). He believes the hawk, incorrectly, to be more closely related to the buzzard but is surprised and confused when he finds that its habits and calls are more close to that of the hawks found in the Americas. He is, however, quite amused when he finds he can use the barrel of a gun to knock one off its perch on a tree. This set of observations is the only that Darwin makes on the hawk.

Several researchers from the University of Missouri and University of Florida conducted genetic research on the hawks and found them to be one of the most inbred species in the entire world. They sampled ten populations as well as the closest mainland hawk, the Swainson's hawk. The data show that there is little divergence between the Galápagos hawk and its mainland counterpart, indicating that it colonized the Galápagos very recently, "likely less than 300,000 years ago" (Bollmer et al. 2006). If this is correct, the Galápagos hawk would be the most recent arrival of the studied taxa found on the islands. The researchers conclude that the Galápagos hawk is in the "earliest stages of further divergence" (Bollmer 2006).

When we arrived at Fernandina we took a few minutes to sit and watch iguanas bask. It did not take us long to realize that we were not the only ones watching them. Two Galápagos hawks were perched in a tree observing the same colony.

Galápagos hawks are unique birds that feed on insects, snakes, juvenile iguanas and hatchling turtles and tortoises. The only threat of predation a marine iguana faces is
being scooped up by a hawk while basking. However, the hawks can only take the smallest of the iguanas as prey.

To my personal disappointment, we did not witness this behavior first-hand but were lucky to see the hawks. The two individuals we saw are the only hawks found on Fernandina, according to the guides. Like their name suggests the hawks are endemic to the Galápagos Islands. Despite being found nowhere else, they shared many characteristics with mainland hawks. Like most other hawk species the male is much smaller than the female. Since the Galápagos hawk has no predator they are apex predators. The naturalists informed us that typically they hunt in small groups of 2 to 3 with one bird being dominant and that is why two were perched in a tree together.

Darwin may have made some incorrect guesses about the hawks being related to buzzards but his collection of individuals was still vital to the developing understanding of the species.
Image 30. A Galápagos hawk monitors the basking iguanas on Fernandina.
XIV. Galápagos Sea Lion (*Zalophus wollebaeki*) &
Fur Seal (*Arctocephalus galapagoensis*)

Darwin did not describe any marine mammals during his voyage. There were however, two very interesting species hailing from the otariids. The Galápagos sea lion and Galápagos fur seal are both present year-round on and around the islands.

Like many of the sea birds earlier mentioned, the Galápagos sea lion population is directly affected by El Niño events. Twelve breeding colonies are monitored by researchers from the CDRS. These colonies are heavily monitored because the Galápagos sea lion population suffered a 50% decline during the 1997-98 El Niño event (Jimenez-Uzcategui 2007). While this was devastating to the population, there have been more recent problems for the sea lions. An eye parasite that is "related to high incidence of conjunctivitis and eye secretions" has been spreading through the colonies and causing problems for both pups and adults (Jimenez-Uzcategui 2007). Disease is not the only problem facing the sea lions in colonial life.

Generally, colonial life is beneficial for a species. Sometimes it can lead to other issues; one is pup competition between age groups. Two researchers, Dr. Trillmich and Dr. Wolf, examined how colonial life and parental care affects offspring in both Galápagos sea lions and fur seals (Trillmich et al. 2008). Both species wean their offspring at about two years so young pups can be born while their older sibling is still nursing. The pups that are born with an older sibling "grow less in early life (fur seal) and suffer increased early mortality (both species) through direct aggression or scramble competition with the older sibling" (Trillmich et al. 2008). Often, mothers must interfere aggressively in the conflict to defend the younger pup.
The morning we disembarked on the island of North Seymour it was to an obnoxious welcoming committee of Galápagos sea lions pups. The guides estimated all of them (more than fifteen babies on the rocks) were between two weeks and two months old. They were hungry while their mothers were out fishing and they saw us and screamed for us to feed them. They knew better than to approach humans but recognized us as a food source all the same. After wading through the sea of pups we managed to get onto the sandy shore of the island.

The next closest encounter with a sea lion was when we visited Rábida for a kayaking trip. The abundance of marine life was astounding around Rábida. In the short kayak trip the sea lion was the highlight. A large female sea lion came up to the kayaks and pushed them around a bit with her nose. The guides told us she was most likely trying to determine if we were a threat to the pups on the beach. She was big and had a nursing pup on the shore, after several minutes of poking around she went back to her pup, content that we were harmless. The Galápagos sea lions are naturally curious and playful. Their only predators are sharks and orca whales. Since the sea lions only breed in the Galápagos and the population is small they are listed as an endangered species on the Red List.

There is another otariid species on and around the Galápagos. The Galápagos fur seals look like the sea lions at first but have a number of differences including the color of their fur and body size. They don't go near the sand beaches where the sea lions breed but instead stay on the rocky cliffs and hide their pups in sea-level grottos. The Galápagos fur seal is the smallest species of otariids (seals and sea lions) and like the Galápagos sea lion are endangered and fall prey to sharks and orcas. Unlike the
Galápagos sea lions that are found on the mainland the Galápagos fur seals are endemic to the Galápagos Islands.
Images 31 & 32. Though hard to see from a distance the Galápagos sea lion (top) and Galápagos fur seal (bottom) are two distinct species with different habitat requirements.
XV. Galápagos Shark (*Carcharhinus galapagensis*), Scalloped Hammerhead Shark (*Sphyrna lewini*), Whitetip Reef Shark (*Triaenodon obesus*) and Whale Shark (*Rhincodon typus*)

Darwin mentioned that he knew sharks were present around the islands but did not mention species or behavior.

In the Galápagos, sharks are highly protected, but that protection ends as they move towards mainland Ecuador. Although Ecuador has banned shark fishing (for the Asian market) in and around the islands of the Galápagos, the waters outside the Galápagos Islands are heavily fished. Ecuador rarely reports any take on sharks to the Food and Agriculture Organization (FAO) of the United Nations. However, in 2005 a report was released stating that yearly landings on sharks were estimated to be 7,000 tons (about half a million sharks) (Jacquet et al. 2008). Since many of the sharks that visit the Galápagos are merely visitors they face extreme danger when leaving the archipelago. This means that seeing certain shark species in and around the Galápagos Islands is a rare experience and one that I looked forward to when heading to the islands.

My first encounter with a shark in the Galápagos was around 9:00 at night when two large Galápagos sharks cruised around the ship lights. They stayed for about half an hour before disappearing into the darkness of the night ocean. After seeing the sharks we left the area and sailed through the night to reach the next island on the other side of the equator. We would occasionally see a whitetip or two while snorkeling along the coast but we had only one perfect day for snorkeling.
On one snorkeling trip we found whale sharks. Two juveniles, one male and one female, were feeding in the waters around the ship and we happened to be in the right place at the right time. When the ship spotted the sharks we were already in the zodiac and had our snorkeling gear with us. We spent an hour trying to find them in the murky water where they were filter-feeding after the ship spotted them. We were about to give up hope when our naturalist told everyone to dive. All of the people on the zodiac leapt off at once and were desperately trying to catch up to the fast moving shark. I saw her turning and cut to the left. Before I knew it I was right next to her head and she cruised right past me. It was an effort to swim alongside her and only a few people from our zodiac even saw her tail.

It was the second time the ship had seen whale sharks in the area in the past 17 years and the first time one of the guides had seen one in over 7. Whale sharks are not a common occurrence in the islands which made the experience all the more valuable. Because we found the whale shark we ended up missing the evening hike out at Tagus Cove but it was worth it.

Later in the week we went snorkeling at a rocky outcrop known as "León Dormido" or "Kicker Rock". This would be our deepest and most challenging snorkeling of the trip and several nervous people stayed behind. Kicker Rock is literally a giant rock with a split through it. There is no vegetation just sheer cliffs that seemed to go as far into the ocean as they rose above us. The goal was to swim through the split but since the water moves through it in one direction it was more like being slowly sucked through the split.
As we moved through vague shadows played out below us. I took to free diving down twenty or thirty feet to see the shadows below. There was an entirely different world below that was not visible from the murky surface. A pregnant scalloped hammerhead, a school of juvenile Galápagos sharks, mobula rays and crowds of spotted eagle rays. The sheer abundance of sharks below us was incredible. It was probably best that some of the snorkelers did not see what was waiting just feet below them. The sharks are attracted to Kicker Rock because of the abundance of fish and slow moving water in the split. Darwin truly missed a wonderful part of the islands by missing the vast diversity of sharks.
Images 33 & 34. A small female whale shark grazing on minute phytoplankton (top) and a Galápagos shark passing through the channel of the rocky outcrop "León Dormido" or "Kicker Rock".
XVI. Galápagos Rice Rat (*Aegialomys galapagoensis*) & Invasive Species

While traveling the islands, Darwin found a rat but assumes that it was brought by a ship and was "merely a variety produced by the new and peculiar climate, food, and soil, to which is has been subjected" (Wilson 2006). He throws in a disclaimer to this assumption that "no one has a right to speculate without distinct facts" (Wilson 2006). The only mammal he believes to be indigenous is a mouse (*Mus galapagoensis*) that lives in the roofs of buildings. Although he believes the mouse to be indigenous he notes that "it may possibly be an American Species imported" to the Galápagos (Wilson 2006).

When I arrived at the Galápagos Islands the guides went over all of the local fauna. One question that was posed to the group concerned the terrestrial mammals of the islands. Many people assumed that the indigenous mammals were bats. The guides were quick to inform us that only one species of mammal, the Galápagos rat, is truly indigenous.

The rice rat is the only truly indigenous species of land mammal from the islands. Several subspecies are extinct and the rat is entirely vegetarian. The other subspecies' numbers have greatly declined due to the introduction of feral dogs, cats and black rats.

Invasive species are not just detrimental for the rice rat but for all of the species native to the islands. When Darwin journeyed to the islands feral pigs and goats had already been introduced. He mentions them briefly but states that locals rely more heavily on the tortoise for meat. Since before Darwin's journey horses, pigs, goats, rats, dogs, cats and other invasive species have been plaguing the island.
Darwin may not have seen the direct effects of the invasive species but after watching a young boy killing birds for food he came to a conclusion about invasive species. In a letter he wrote to Dr. Henslow, a Cambridge professor, he stated that "we may infer what havoc the introduction of any new beast of prey must cause in a country, before the instincts of the indigenous inhabitants have become adapted to the stranger's craft of power" (Moorhead 1969). Darwin is partially correct in his statement, the only flaw is: what if the indigenous inhabitants can't adapt to the "stranger's craft of power"? This is why invasive species have caused so much damage.

Researchers from the CDRS note that of the twelve endemic rodent species recorded in the Galápagos only four are left (Jimenez-Uzcategui 2007). Some species were extinct before the arrival of humans to the islands but the more recently extinct species were likely eradicated by black rats through competition, cats through predation, and disease passed from other mammals (Jimenez-Uzcategui 2007).

The Galápagos island of Pinta is a success story for eradication of one invasive species. Over the course of 30 years goats were eradicated completely from Pinta and 41,000 were removed during the initial hunting effort (Campbell et al. 2004). Twice the island was incorrectly declared goat free but when goats were discovered the local people did not give up in pursuing them. The Galápagos Islands are proof that even with limited resources island ecology can be restored post invasive introduction.

The only invasive species we saw on the islands were in the cities (dogs, donkeys, cats etc.). This is because there is currently a huge effort to eradicate invasive species. The Galápagos Islands are one of the most successful eradication stories for invasive
species in the world. As mentioned earlier, goats have been eliminated on several islands. The goats were shot from the air using helicopters until they were eradicated. Several islands are not completely void of the destructive species. There is also a successful story for eliminating the black rat. Rice rats are vegetarians and black rats are not. By setting rat traps with poisoned meat the eradication teams can kill just black rats without harming other species. There are several islands that no longer allow pets, while this may seem strict the citizens of the Galápagos are more than willing to work to restore their islands and take pride that many of the endemic species are still present and thriving.
Image 35. A dog and donkey that belong to the workers of a sugar mill. A heavy reminder of the problem that invasive species have caused in the islands.
XVII. Summary

Darwin was not always the scientist we think of today. When he joined the crew of the HMS *Beagle* he was only 22 and "had never thought of himself as a serious naturalist, a professional naturalist, or indeed eligible for any scientific job" (Moorhead 1969). His experiences as a naturalist were limited to his geology classes and discussions with his Cambridge professor Dr. Henslow. Likewise, when I journeyed to the Galápagos I was 20 and still working on my third year of an undergraduate career. Darwin and I may have had some similarities in age and experience while on the islands but we had something else in common. We both were astounded and inspired by the species we encountered.

Darwin summarized his awe with just a sentence about the species. Towards the end of his discussion on the Galápagos he states "that several islands posses their own species of the tortoise, mocking-thrush, finches, and numerous plants, these species having the same general habits, occupying analogous situations, and obviously filling the same place in the natural economy of this archipelago, that strikes me with wonder". It is this wonder that leads Darwin to ask questions and to eventually write *The Origin of Species*. Darwin also began to formulate his theory of evolution in the Galápagos. He states that "here, 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 being on this earth". As Darwin witnesses the changing of the species from mainland to island and from island to island, he is struck with the notion that this could be the key to understand how life diversified on Earth.
I have found that nothing is more inspiring to an ecologist than seeing the diversity found in the Galápagos. The wonder that the iguanas, the birds, and the tortoises inspire is almost overwhelming. As I stated in the beginning, the greatest power a naturalist has is observation. Through my observations, and the observations made by Darwin, the Galápagos is not as alien as it first appears. The Galápagos is not some anomaly that cannot be understood. It is a place that allows science to become clearer. The islands are like a window that allows one to glimpse into the secrets of evolution, of adaptive radiation, of existence.
Images 36 & 37. National Geographic’s *Endeavour* and my home for ten days.
XVIII. Bibliography


Author's Biography

Kathleen A. Carroll was born in Phoenix, Arizona on June 11, 1991. She graduated from Mesa Mountain View High School in 2009 while maintaining a five year volunteer position as a keeper assistant at the Phoenix Zoo. Double majoring in wildlife ecology and marine biology, Kathleen is also a member of Xi Sigma Pi. She has received the George Currier Award, Carl McLaughlin Award and University of Maine Presidential Scholarship. She also has received credits for independent research in South Africa, Mozambique and Ecuador.

Upon graduation, Kathleen plans to work on an advanced degree in zoology and wildlife conservation.

Image 38. Me with several members of the Young Explorers Club, a group aboard the ship intended to educate children under 13 about the Galápagos Islands. I led ecological discussions in the library on the ship while at sea.