Companion guide book to the exhibition “Galápagos” of the Zoological Museum of the University of Zurich, Switzerland
Galápagos

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“The Galápagos Islands is one of those places that has literally changed the way that we look at the world. Having been fortunate enough to visit there myself, I am delighted that so many others can now enjoy and be inspired by the natural treasures found there. I am so pleased that my Foundation for Building Community is working with the Charles Darwin Foundation, the Galápagos Conservancy and local authorities to address the huge challenges posed to the natural environment by ecotourism and human settlement on the Islands. I hope that their work to create new Eco-pattern books for buildings and infrastructure can ensure that people and Nature are in harmony in this very special place.”

Grégoire Koulbanis
Geographer & Master in Environmental Sciences
Film Director
Expedition Leader for the late Captain Cousteau

“I travelled from North to South and from East to West, all over the five continents. After thirty years of expeditions in the most incredible and inaccessible places, under the sea and above the water, where I filmed and studied nature, I can state that I loved Africa for the unique beauty of its terrestrial wildlife and I loved the Great Barrier Reef for its magnificent sea life. But if I had one place to chose, just one place, this would be the Galápagos Islands. It is the only place, where both underwater and terrestrial biodiversity will take you beyond what you could ever dream. And as Charles Darwin wrote: “I am fully convinced.”

Grégoire Koulbanis
Geographer & Master in Environmental Sciences
Film Director
Expedition Leader for the late Captain Cousteau

“Several enjoyable years in Ecuador allowed me and my family the opportunity to discover the Galápagos Islands and their special and unique environment. The preservation of the islands should be supported by all of us for the benefit of future generations so that they may enjoy the diversity of its wildlife and its exquisite beauty.”

Peter Brabeck-Letmathe
Chairman of the Board of Nestlé


Reto Ringger
President of the board of WWF Switzerland,
Founder of Globalance Bank and SAM Group

“Quedé encantada con la belleza natural y el ambiente tan especial de las Islas Galápagos. Pocas veces en mi vida me he sentido tan conectada con la naturaleza y el universo. Fue maravilloso y me llenó de energía. Llevó ese mágico momento consigo y desearía que todos pudiesen tener esta experiencia.”

Patricia Guerra
Honorary Consul of Ecuador in Zurich
Partner of Meyerlustenberger Lachenal, attorneys-at-law

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The Galápagos Islands were created by volcanic eruptions, which continue to shape them even today. Only a relatively short time ago, new habitats for plants and animals emerged – in complete isolation – in the middle of the ocean. The islands are located at the equator in the tropics, but the climate is subject to significant seasonal variations, because warm and cold ocean currents meet here and interact with each other. Above all, the region is extremely arid. That’s why plants adapted to dry climates predominate. However, the higher an island, the greater the variety of plant communities. These, in turn, provide ideal conditions for land snails, which are herbivores and use the plants for shelter. A single snail species, originating from the South American mainland, evolved into over 60 species on the Galápagos Islands.
Volcanic Islands

The Galápagos Islands are of volcanic origin. On Isabela and Fernandina, some volcanoes are still active. The westernmost island, Fernandina, is the centre of volcanic activity. Below it, a magma chamber of molten rock is located deep down in the earth's interior. This hotspot is the origin of the Galápagos Islands.

1. Hot magma presses into the fissures of the Nazca Plate (NP) and creates chambers close to the surface.
2. The heat of the magma melts the earth's surface crust, causing a volcanic eruption on the ocean floor.
3. - 5. With every eruption, new layers of lava increase the size of the volcano until it breaks the ocean surface to form a new island.

The Galápagos Islands are located on the Nazca Plate, which moves towards South America at a rate of about 6 cm per year. While the islands move, the hotspot – the origin of the volcanic islands – stays in the same place.

Completely isolated islands

The Galápagos Archipelago is completely isolated in the middle of the Pacific Ocean, about 960 km off the west coast of South America. It consists of 19 main islands (larger than 1 sq. km) and many smaller islands as well as numerous islets and rocks. They are spread over more than 120,000 sq. km of ocean and consist of a total land surface of about 8,000 sq. km.

"... as far as the eye could reach we saw nothing but rough fields of lava, that seemed to have hardened while the force of the wind had been rippling its liquid surface [...] About half way down the steep south east side of the island, a volcano burns day and night; and near the beach a crater was pouring forth streams of lava, which on reaching the sea caused it to bubble in an extraordinary manner." – This is how Captain Lord Byron described a volcanic eruption in 1825 as he lay at anchor off Fernandina during his long journey to the Sandwich Islands.

The crust and the upper part of the earth’s mantle (lithosphere) consist of plates: seven major plates and many small ones, which are more or less mobile. The largest plates carry continents such as South America, Africa or Eurasia. Smaller plates can carry islands, such as the Galápagos Islands on the Nazca Plate.

Hot magma presses into the fissures of the Nazca Plate (NP) and creates chambers close to the surface. The heat of the magma melts the earth’s surface crust, causing a volcanic eruption on the ocean floor. With every eruption, new layers of lava increase the size of the volcano until it breaks the ocean surface to form a new island.

The Nazca Plate (NP) moves above the fixed hotspot (HS), the magma chamber. On its journey atop the Nazca Plate, the volcano gradually loses its connection to the magma chamber and becomes extinct. The magma chamber creates a new volcano. The old island is eroded mainly by wind and weather, causing it to decrease in size until it disappears from the ocean surface.
The dry climate on the Galápagos Islands is very atypical of the tropics. The same can be said of the warm season between January and May with frequent, heavy rains, and of the cool and very dry season between June and December with only little precipitation in the island lowlands. This anomaly can be explained by the ocean currents that meet and interact here in the Pacific Ocean. Two currents carry cold water: the Peru Current (Humboldt Current) from the Antarctic and the Equatorial Undercurrent (Cromwell Current) from the deep sea. Together they are responsible for the cool, dry season. The Panama Current brings warm tropical water from Central America and affects the warm season. The little precipitation that does occur during the dry season is a light drizzle called garúa, which often stops around noon.

At irregular intervals about every 3 to 6 years, significant changes in ocean current conditions lead to a much warmer and rainier season called “El Niño.” “El Niño”, which is Spanish for the Infant Jesus, is known by this name because the phenomenon is the strongest at Christmas time. “El Niño” is both a blessing and a curse: in the interior of the island, it leads to times of plenty, but it has severe consequences for the sea and the coastal areas. For example, the rising sea level floods bird breeding sites and the nesting grounds of sea turtles and Marine Iguanas. In 1982 and 1983, the water temperature became so warm that it caused the death of most of the green algae on which Marine Iguanas mainly feed. As a result, the populations of this species declined dramatically. There are also very cold and dry seasons, which are called “La Niña.”
Volcanic Islands

Greater plant diversity on high islands

Most of the islands are not high and have a very dry climate. Only plants that are highly adapted to drought can be found on such islands. However, on high islands, there are up to five different zones with different plant communities. These differ from each other in the amount of water they need. In the lowlands, the climate is very dry; only plants that are adapted to drought can survive here. In higher zones, the air is more humid, and there are more plants that need moisture. The reason why the air is more humid higher up is because it rains there more often: the air in higher areas is cooler, so the clouds that gather there cool down, causing precipitation. However, on very high islands another dry zone exists above the clouds.

The various zones do not run parallel to each other around the islands and they are not the same in all areas. For example, the dry zones in the southeastern part of the islands are rather narrow, because clouds accumulate mostly on this side, leading to more frequent rainfalls even at lower elevations.

Greater plant diversity on high islands

4 The Humid Zone is the only zone with regular rainfall, and plant growth is mostly lush. The dominating plant here is the “sunflower tree” (Scalesia), while shrubs also grow on some islands. In higher regions, mosses and ferns can be found as well, for example the Galápagos tree fern, which can grow to more than 3 m in height. The trees are literally overgrown by epiphytes, which turn brown during the dry season. Only seven islands are high enough to have a Humid Zone.

5 At the top, in the High-altitude Dry Zone, for the most part the same plants occur as in the low-altitude Dry Zone: cacti, grasses and shrubs.

6 In the Transition Zone, the climatic conditions are both dry and humid, which is why drought-tolerant plants can be found as well as evergreens. The trees are covered with epiphytes (“air plants”), and the ground, if the soil quality allows, is carpeted with grasses, mosses and ferns.

7 The Dry Zone is the largest in terms of surface, harbouring the largest number of plant species. Most cacti grow here.

8 The Coastal Zone only provides habitat to plants which can tolerate high salinity, such as mangroves.

Epiphytes, or “air plants”, usually grow on trees, where they benefit from the light as there is hardly any shade. Since it is more difficult to ensure a supply of water and nutrients without contact to the ground, epiphytes have adapted to this situation in numerous ways in the course of evolution. For example, they collect rainwater with dense leaf rosettes or use bird-nest-like root networks in order to maximize the surface and absorb what few nutrients are available.
Plant diversity means snail diversity

Gastropods, more commonly known as snails and slugs, are not among the most spectacular creatures and therefore hardly attract the attention of Galápagos travellers. However, if they looked closely, they would find as many as 118 species. Terrestrial gastropods depend on plants for nutrition as well as for cover. The greater the plant diversity, the greater the variety of habitats for snails and slugs. This is why more gastropod species have evolved on high islands than on low islands, because high islands have more vegetation zones. One example is the genus *Bulimulus*, which does not even have a common name.

*Bulimulus*, the inconspicuous record holder

Land snails of the *Bulimulus* genus are small and inconspicuous, with a shell less than 3 cm long and white to dark brown colouring. However, with over 60 species, this genus makes up more than 75% of endemic land snail species, that is, land snail species that exist exclusively in Galápagos. Thus, it exhibits the highest degree of adaptive radiation (species diversification) of all animals in the archipelago.

Highly successful ancestor

The genus *Bulimulus* includes a total of 162 species and is found exclusively in Galápagos and South America. There is evidence to suggest that all *Bulimulus* snails in Galápagos originated from a single mainland snail species. Española, one of the oldest islands, was first populated by a single species; now there are 16. From Española, the *Bulimulus* snails found their way to Floreana and from there to Santa Cruz, San Cristóbal and the other islands. Almost every island was initially populated by just one or two species, and these are the ancestors of all the other species that developed on each island in the course of evolution. In this way, *Bulimulus* snails populated all the main islands and were very successful in adaptive radiation. They can be found in all vegetation zones.
The colonisation of remote oceanic islands requires exceptional abilities but is also a matter of luck. Firstly, plants and animals have to survive the difficult journey, secondly they have to encounter islands in the vast ocean, and finally they have to be able to cope with the living conditions on these islands. Only relatively few succeed, so the number of species on such isolated islands is always limited. The Galápagos Islands are home to several invertebrates, birds and reptiles, but only a few mammals and no amphibians. However, under the influence of the living conditions on the islands, new species evolved, unique species that don’t exist anywhere else in the world. It’s no wonder that it was the Galápagos Islands where Charles Darwin made the observations that answered his lifelong question “What is the origin of new species?”

Humans populated Galápagos relatively late. The inhospitable climate and the lack of fresh water were too much for all but the most intrepid, and real settlement only began after 1832. Thanks to this fact, a major part of the unique natural environment has been preserved. However, since 1980 it has been seriously affected by the rapid growth in population and tourism.
The Beagle was 27 m long and 7 m wide and carried 74 men. The tourist yachts that cruise the waters of the Galápagos Archipelago today are approximately equal in size and accommodate some 24 people. This comparison brings home the terribly cramped conditions on the Beagle. And for a voyage lasting four years and nine months! Darwin, who was often seasick and sometimes only ate biscuit and raisins, wrote to his sister: "I loathe, I abhor the sea, and all ships which sail on it."

The Beagle may have been small and cramped, but her impact on history was enormous. The young Charles Darwin’s observations of nature and the conclusions he drew from them caused a huge controversy when they were published. His observations gave concrete shape to an idea that had engaged thinkers from time immemorial: that the earth’s living beings adapt to their environment and change. This theory contradicted the religions of the time, which defined species as unchanging.

The fact that Darwin landed in Galápagos was an important reason to protect the islands. In 1959, they were declared a national park and in 1978 UNESCO recognised them as a World Heritage Site. To this day, the Galápagos Islands are a subject of intense research.

On 16 September 1835, Charles Darwin set foot on the island of San Cristóbal. This was the beginning of his five-week stay in the Galápagos Archipelago, during which he also visited Floreana, Isabela and Santiago. His job was to explore the land, and the "born naturalist" did so with passion and diligence. Darwin perceived the land with all his senses and collected numerous plants and animals such as mockingbirds and Darwin’s finches, which were shipped to England in boxes and later became an important basis for his famous evolutionary theory, which he published in his book On the Origin of Species in 1859.

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Charles Darwin visits four of the Galápagos Islands

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Young people with a big responsibility

When Charles Darwin decided to join the expedition around the world, he was only 22 years old. At 26, Captain FitzRoy was not much older. What a responsibility for such young people! But the Royal Navy trusted them, and they were right to do so. The Beagle, her young captain and the even younger natural scientist wrote world history.

HM is the abbreviation for "His/Her Majesty's Ship" or "His/Her Majesty's Sloop". In the rating system of warships, a "sloop" was an unrated naval ship.

read more about the Origin of Species on page 68

HMS Beagle

The most famous ship that ever lay at anchor in Galápagos was a sailing ship of the Royal Navy: HMS Beagle. Equipped with the very latest in measuring instruments, she sailed the globe for five years (from 1831 to 1836) on behalf of the British Admiralty to survey countries, islands and coastlines and to develop navigation charts. In the autumn of 1835, she anchored off the Galápagos Archipelago. The surveying of the islands took five weeks. Charles Darwin, who considered himself a "born naturalist", though he was still looking for his life’s purpose, was also on board. He was only 22 years old when Captain Robert FitzRoy invited him, a "well-educated and scientific person", to accompany him on his long journey.
Only few can cross the ocean

Animals that manage to colonise the Galápagos Islands from the South American mainland must possess certain abilities. First they have to be able to cross almost 1,000 km of ocean, and once there they have to endure the island climate with periods of extreme drought. Only few animals have these abilities. Among them are reptiles, birds, invertebrates and a few mammals. Amphibians, however, have no chance of surviving the long voyage across the sea. They need fresh water to produce the layer of mucus that coats their delicate skin. Without this protective layer, they would simply dry out.

How do animals get from the mainland to the islands?

By muscle power
Few animals are able to cross great ocean distances under their own power. Migratory birds from North America regularly come to spend the winter on the Galápagos Islands, and some of them stay.

Gone with the Wind
Winds and air currents are a means of transportation for very small organisms such as young spiders and very small insects, but also for insect eggs and larvae. Sometimes, strong winds such as hurricanes also bring larger vagrants from Central and North America to the islands. Wind therefore remains as important a means for island colonisation today as in the time when the first Darwin’s finches, mockingbirds and bats came to the Galápagos.

By rafting on ocean currents
After heavy rains, the swelling rivers in South America can wash uprooted trees and clumps of plants into the ocean. From the West coast, these are transported out into the Pacific Ocean by the Peru Current (Humboldt Current). In this way, a tree trunk from Ecuador can reach Galápagos within two weeks. For the tree trunk, this is no problem, but to the animals riding on it, the voyage is a very risky undertaking, exhausting voyages. They can endure long periods without food or water because they are poikilotherms. Usually, only insects and other invertebrates or reptiles such as iguanas and snakes survive such exhausting voyages. They can endure long periods without food or water because they are poikilotherms. This means that their body temperature is variable: if the outside temperature is low, their metabolism slows down so that they can survive a long time without food or water.

Amphibians, however, would not survive such a voyage even though they are also poikilotherms. The saltwater would dry them out completely. The Snouted Treefrog, which can be found on the islands today, was brought to the islands by human transport. Such an arduous journey is almost impossible for mammals, as well. Mammals are homeothermic and have to keep their body temperature stable, and to do so they need a constant supply of food and fresh water. One of the few mammals that made it to the Galápagos nevertheless is the rice rat.

On other animals
Other animals can also be a means of transport, for example ducks and seagulls. When such birds land or bathe in the water, fish spawn or fry (young fish) can get caught in their feathers and thus be carried to other waters. Only very few fish eggs and fry survive the long flight to Galápagos, so there are only few fresh-water fish species on the islands. However, this means of transport is probably quite successful between the islands themselves. This is how the fish in the crater lake on Fernandina probably got there, transported in the feathers of frigatebirds.

With humans
Humans have also been, and still are, a means of transport. When they colonised Galápagos and settled on the islands, they introduced several species, sometimes with disastrous consequences for the endemic wildlife. Domestic animals such as goats, donkeys, pigs, dogs, cats and chickens were introduced deliberately, while the House Rat, the Brown Rat, and a frog species as well as numerous insects were introduced inadvertently.
Only few species on the islands...

The Galápagos Islands, like all other oceanic islands on earth, are relatively poor in biodiversity, which means that they are not inhabited by a large variety of plant and animal species.

By way of comparison: although both the Galápagos Islands and Yasuni National Park in Eastern Ecuador belong to the tropics, Yasuni National Park is home to 40 times more freshwater fish species, 16 times more mammalian species and more than twice as many reptile species, to give just a few examples. This huge difference can very likely be explained by the fact that only few animals survive the long journey across the sea and are able to cope with the extremely dry climate that prevails on Galápagos once they are there.

A comparison with Switzerland shows that this alpine country, which is located much further north, is inhabited by approximately twice as many mammalian species as Galápagos. However, there are over ten times as many reptiles on Galápagos as in Switzerland. Reptiles adapt themselves perfectly to the extremely arid conditions and have even been able to evolve into numerous species on Galápagos.

... but many in the sea

Oceanic islands are not inhabited by a large number of different plant and animal species as the journey across the ocean is arduous and the land mass is limited. In the sea around the islands, however, the situation is different. There, the ecosystem is very rich in biodiversity, i.e. it is home to countless species since the sea is not isolated.

More than 500 fish species, over 50 shark and ray species, approximately 900 different bivalve and gastropod molluscs, more than 200 sea star, sea urchin and sea cucumber species as well as over 200 crustacean species make the marine life of the Galápagos Archipelago particularly impressive. The most conspicuous marine animals are the sea turtles, the Marine Iguana as well as the Galápagos Fur Seal Arctocephalus galapagoensis and Galápagos Sealion Zalophus wollebaeki, which are both eared seal species.

The high productivity of the sea surrounding Galápagos has a positive impact on the land. Marine animals such as sea lions, Marine Iguanas or sea birds, which spend part of their lives ashore, provide terrestrial plants and animals with nutrients, which they bring from the sea to the land.

Galápagos: The Snouted Treefrog is an introduced species. Yasuni National Park: Species discovered so far. It is very likely that there are many more mammals and fish than stated in the figure.

Although the Galápagos Islands are located in the tropics, there are no palm-lined beaches. The only palm trees on the islands are found in the populated areas, and they have been planted and grown by humans.

Oceanic islands such as the Galápagos Islands, Hawaii, Iceland, the Canary Islands or the Azores have never been connected to the continental mainland, i.e. no land bridge has ever existed. Colonisation of these islands by terrestrial animals has therefore always been difficult. The greater the distance to the closest continent, the more difficult the colonisation of a particular island. Continental islands such as Great Britain, Elba or Sumatra, however, were connected to the mainland a long time ago and could therefore easily be colonised by terrestrial animals from the continent.
Few mammals on land

Only very few terrestrial mammals were able to successfully cross the long distance from the mainland across the open ocean and then colonise the climatically hostile Galápagos Islands.

Among them are two North American bat species: the Hoary Bat *Lasiurus cinereus* and the Eastern Red Bat *Lasiurus borealis*. The Galápagos Bat *Lasiurus borealis brachyotis* is today considered a subspecies of the Eastern Red Bat.

Furthermore, there are four species of rice rats. Their ancestors came across the ocean on pieces of driftwood, and split into several species, four of which still exist today.

Consequently, there are only six terrestrial mammal species on the Galápagos Islands today.

Even rodents are few in number

There are over 2,000 rodent species in the world, which makes them the largest order of mammals. Switzerland is home to around 25 rodent species, while in Germany there are around 28 rodent species. On the Galápagos Islands only rice rats exist, and five of the original nine species are extinct.

Factors threatening rice rats are competition by Black Rats and predation by cats.

Rice rats: nocturnal and adapted to drought

Rice rats have adapted exceptionally well to the dryness of the islands. They eat mainly the fruit and other parts of prickly pears, which provide nutrition as well as water. Rice rats are usually nocturnal, which is why they go largely unnoticed by tourists.

The Galápagos Rice Rat on the island of Santa Fé is a very inquisitive creature: researchers have to leave their tents open in order to keep the rats from gnawing their way through the fabric.

Non-native rodents

Besides rice rats, whose ancestors “rafted” to the islands millions of years ago, four other types of rodents live on the islands, all of which were introduced by humans: the Black Rat *Rattus rattus*, the Brown Rat *Rattus norvegicus*, the House Mouse *Mus musculus* and the Guinea Pig *Cavia porcellus*.

Distribution of rice rats

**Fernandina**

- *Nesoryzomys narboroughi* - Common all over the island thanks to the absence of Black Rats and House Mouse; very inquisitive and not shy.
- *Nesoryzomys fernandinae* - First recorded through bones from owl pellets in 1979 and declared extinct soon thereafter. First living specimens found in 1995 near the volcano summit, where they are threatened by possible volcanic eruptions.

**Santiago**

- *Nesoryzomys swarthi* - First extinction coincides with the introduction of goats in 1971.
- *Nesoryzomys indefessus* - Extinct.
- *Nesoryzomys darwini* - Extinct.

**Santa Cruz**

- *Aegialomys galapagoensis* - First recorded in 1906, described and declared extinct in 1938, rediscovered in 1997. Locally common in the arid zone, where it presumably has an advantage over the otherwise dominant Black Rat because it is adapted to extreme drought.

**San Cristóbal**

- *Nesoryzomys galapagoensis* - Discovered by Charles Darwin in 1835; since then, only documented through prehistoric bones. Presumably extinction caused by introduced animals such as Black and Brown Rats.

**Santa Fé**

- *Aegialomys galapagoensis* - Locally common, especially in the arid zone, as there have never been any Black Rats. Numbers have increased since the extermination of goats in 1971.
History

Discovery and exploration of the islands

The Incas and a Spanish bishop

15th century

The oral traditions of the Incas mention "Islands of fire". It is not clear whether the Galápagos Islands are meant by this, but the Incas were possibly the first visitors to the islands.

1535

This year marks the official discovery of the Galápagos Islands by Fray Tomás de Berlanga, the Bishop of Panama. On his way from Panama to what is now known as Peru, his ship was swept off course by ocean currents. As he was running out of water supplies, he anchored off the uncharted islands. The search for drinking water was arduous: de Berlanga's men were reduced to squeezing water from cactus pads; two men and ten horses died of thirst before water was found. In his report to the King of Spain, de Berlanga provides the very first description of giant tortoises and iguanas. He also highlights, like many travellers after him, how barren the landscape is and how tame the animals are.

Pirates and buccaneers

1593–1710

Pirates and buccaneers, who were supported by their home states, used the uninhabited islands as a hideout and source of food. They took giant tortoises on their ships as a living meat supply, where the animals wasted away until they were eaten. When tortoises became rare, the pirates released goats onto the islands to act as their new meat supply.

Whalers and scientists

1744

The Spanish explored the Galápagos Islands and gave them names.

1789

First scientific expedition under the Spanish flag. Later, smaller expeditions were carried out repeatedly. They were mostly topographic surveys with a view to mapping the islands. In order to do this, scientists and even whalers recorded their field observations.

In the 17th century, the gold on Spanish ships attracted many buccaneers and pirates to the Pacific. Buccaneers were untypical pirates: supported by their home states, they captured enemy ships on the high seas. Some of them trimmed their sails to the wind and were sometimes captains on behalf of their government, sometimes pirates hungry for gold. But the raids were not always successful. In 1684, British buccaneers captured a ship in the hope of finding gold – only to find eight tons of quince jam!

1793–1870

The whalers decimated the whale populations in their quest for whale oil, which was used to light lamps, even street lamps (and which was later replaced by petroleum). The eared seals were hunted almost to extinction for their highly prized fur. The giant tortoises were loaded on ships by the hundreds as food supply. In 1820, a whaling ship carried 360 tortoises on board. In 1823, another ship carried 5,000 seal skins. As many as 200,000 tortoises may have been killed by whalers in the course of the 19th century.

1813

Captain David Porter was sent from the United States to destroy the British whaling fleet. He succeeded by rummaging through the letters he found in the "Post Office Barrel", which supplied him with important information. He operated from the Galápagos Islands for six months and also made field observations. He realised that the islands were changed by volcanic activity and discovered that Fernandina and Isabela were the youngest islands and San Cristóbal and Española the oldest.

1835

Charles Darwin arrived in the Galápagos Archipelago on the British sailing ship HMS Beagle, which sailed around the world to map the coastlines. The observations he made during his five-week stay on four islands set part of the groundwork for his book On the Origin of Species, published in 1859.

1905–1906

The California Academy of Sciences (CAS) conducted the first large research expedition: 8,691 birds and 264 turtles and tortoises were collected from 10 islands, as well as numerous other animals and plants. They formed the basis of the CAS specimen collection. The CAS continues to conduct research projects in Galápagos even today and uses the specimens for research.

1959

The "Charles Darwin Foundation" was established on the island of Santa Cruz, 100 years after On the Origin of Species had been published.

1964

Opening of the "Charles Darwin Research Station" on the island of Santa Cruz.

Since 1959, intensive international research has been conducted on the Galápagos Islands.

Read more about research on page 65
Late human settlement

Settlement attempts and prison colonies

1807
The Irish sailor Patrick Watkins, who was marooned on Floreana was probably the first true settler on the Galápagos Islands. He cultivated vegetables, which he traded with whalers for rum or money. In 1809, he fled to the mainland in a stolen whaling ship and ended up in prison soon thereafter.

1832
Ecuador took possession of the Galápagos Archipelago and called it “Archipiélago del Ecuador”. Soon, a certain number of people settled on the islands, but when political and other prisoners as well as prostitutes were sent to the remote islands, the settlements developed into prison colonies.

1850–1860
The Galápagos Islands were considered to be an “ideal” prison camp. The long distance to the mainland makes it almost impossible to flee, and it was hoped the prisoners would soon die from lack of water and food. Nonetheless, a few prisoners successfully captured a whaling ship and fled. When they arrived in Guayaquil in Ecuador, 28 people were killed. This event marks the end of the prison era on the Galápagos Islands.

1926–1929
A couple of Norwegian whalers who were once stranded on Galápagos managed to fill their fellow countrymen with enthusiasm for the islands. In 1926, many Norwegians came to the Galápagos Islands and established a village on Floreana and another on Santa Cruz. However, the farming conditions proved to be so harsh that most of them soon returned to their homeland.

1929–1934
A German couple settled on Floreana with the absurd idea of living in a kind of Garden of Eden, far away from civilisation. Like-minded people, but also shady characters, followed them. Floreana soon played host to a great deal of cruel intrigues. People disappeared without a trace or died under mysterious circumstances. Finally, only one German family remained.

1946–1959
Once again, Ecuador established a prison colony that soon turned into a sort of concentration camp. In 1950, the police commander forced the prisoners to erect a pointless wall called the “Wall of Tears”. In a revolt in 1958, a prisoner fled to the mainland in a captured yacht. International pressure in the aftermath caused the prison camp to close down.

Late settlement and low population density

In 1860, there were already 300,000 people living on Mauritius, a volcanic island of only 1,865 sq. km. Today, the population is at 1.3 million people. Mauritius is part of the Mascarene Islands located east of Madagascar in the Indian Ocean. Compared to this and other tropical islands, the Galápagos Islands were populated by humans relatively late, and even on Santa Cruz (986 sq. km) the population density is low. Around 15,000 people live on Santa Cruz, that is to say about 60% of the total population of the Galápagos Islands. Accordingly, population density is about 15 people per sq. km.

By way of comparison:

Today’s population density in Austria: approx. 100, in Switzerland: approx. 190, in Germany: approx. 230, and in Great Britain: approx. 280 people per sq. km.

<table>
<thead>
<tr>
<th>Region</th>
<th>Year populated</th>
<th>Area (sq.km)</th>
<th>Population density per sq. km of the most populated island</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galápagos</td>
<td>1832</td>
<td>986</td>
<td>15 (Santa Cruz)</td>
</tr>
<tr>
<td>Hawaii</td>
<td>between 200–800 AD</td>
<td>629</td>
<td>563 (O‘ahu)</td>
</tr>
<tr>
<td>Mascarenes</td>
<td>1638</td>
<td>8,500</td>
<td>629 (Mauritius)</td>
</tr>
</tbody>
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Spared from the fate of classical tropical islands

When the Dutch began to settle on Mauritius Island in the Indian Ocean, they came upon a true tropical paradise: wonderful, endless tropical forests that in their eyes made for excellent sugar cane plantations. Clearing the forests went on and on and on, until 250 years later most of them had been destroyed. By that time, over 50% of the endemic land bird species (i.e. that were unique to the island) had become extinct, notably the flightless Dodo.

The first settlers on the Galápagos Islands had a very different experience. The extremely dry climate and scarce fresh water supplies made it very hard to colonise the islands. This was a disadvantage for human settlement, but a great advantage for nature. Thanks to these conditions, Galápagos was spared the fate of classical tropical islands, and the original flora and fauna largely survived. However, the great number of imported animals and plants as well as a rapid growth of population and tourism is threatening this World Heritage site, which is now in need of massive conservation efforts.

Read more about nature conservation on page 85

History
Until the 1970s, the population on the inhabited islands grew only slowly, but since 1980 the resident population has been rising sharply. This trend correlates closely with the growth of the tourism industry. In search of work in the tourism sector, the people of Ecuador virtually flooded the islands. Between 1990 and 2001, the resident population doubled. Today, the population of the Galápagos Islands numbers about 30,000 residents, of whom 1,800 are temporary and 1,500 are irregular residents. Additionally, there are more than 180,000 tourists per year. Tourism accounts for more than half of the entire regional economy of the Galápagos Islands and makes it the wealthiest region of Ecuador. The growth of the population and the tourism industry, however, present a major challenge to preserving the unique flora and fauna of the Galápagos Archipelago.

In 1939, the Ecuadorian Eliécer Cruz came to the Galápagos Islands for the first time. Born and bred in Ibarra, he had studied at the University of Quito and was now in search of a life in nature and freedom. He married Emma Bedong in 1944 and moved with her to Floreana. On their little farm, a finca called “Las Palmas”, they cultivated coffee and potatoes. Mrs Cruz produced jam from oranges and guava fruit (guayaba). They socialised with the native fisher- men and Eliécer taught them how to read and write. Education was of great importance to him. With the little money they had, he bought books and compiled an impressive library over time. He helped his wife with the birth of all of their 12 children in their house on Floreana. At the time, there were no medical facilities on the islands. Some of their children live on the Galápagos Islands to this very day, where they work to protect the unique biodiversity. One of their sons, Claudio Cruz, still manages his parents’ farm on Floreana.

The Cruz family, successful settlers

Failed industrialisation

1860–1878 Various entrepreneurs unsuccessfully tried harvesting orchilla weeds on a commercial basis for the production of dyes. One of them established plantations on Floreana, where he forced prisoners to work. Eventually, he was killed, and the island became deserted once again. Nobody was willing to return to this “cursed island”.

1879–1940 On San Cristóbal, a businessman built an agricultural centre and called it “El Progreso”. He exported cowhide, turtle oil and fish oil as well as sugar cane to Guayaquil in Ecuador. He established a true terror regime and was eventually killed by his workers.

Military base and ship-based mass tourism

1941–1945 During the Second World War, Ecuador allowed the USA to build a military airbase on Baltra in order to monitor the Panama Canal. After the war, the airbase was handed over to Ecuador.

1959 First commercial flights.

1969 Begin of ship-based mass tourism.

1970 Regular flights to and from Baltra.

2011 185,028 tourists visited the Galápagos Islands within a year.

The island of Baltra received its name from the American military base during the Second World War. The base was called “Base Beta B”. In radio communication, the abbreviation “B-3” was used, which translates to “B-tres” in Spanish. This was transformed into Baltra.

Considerable growth of population and tourism

Until the 1970s, the population on the inhabited islands grew only slowly, but since 1980 the resident population has been rising sharply. This trend correlates closely with the growth of the tourism industry. In search of work in the tourism sector, the people of Ecuador virtually flooded the islands. Between 1990 and 2001, the resident population doubled. Today, the population of the Galápagos Islands numbers about 30,000 residents, of whom 1,800 are temporary and 1,500 are irregular residents. Additionally, there are more than 180,000 tourists per year. Tourism accounts for more than half of the entire regional economy of the Galápagos Islands and makes it the wealthiest region of Ecuador. The growth of the population and the tourism industry, however, present a major challenge to preserving the unique flora and fauna of the Galápagos Archipelago.
Iguanas grazing on the ocean floor, blood-drinking finches, tortoises as heavy as ponies, flightless cormorants, penguins at the equator, daisy trees... the Galápagos Islands abound with species that are to be found nowhere else on earth. Specialists call them endemic species. Darwin perceptively referred to the islands as “a little world within itself”.

The ancestors of these plants and animals came over the ocean from the mainland. They arrived in an environment that was different from their land of origin, with different food, different enemies and a different climate. In order to survive here, they had to adapt and change. This process of change is called evolution. The endemic species of the Galápagos Islands are testimony to evolution. Endemic species are like a history book that traces the course of evolution. If endemic species become extinct, we lose an important part of our earth’s history.
Endemic species – testimony to evolution

The large number of endemic species on the Galápagos Islands can be explained by their location: a group of islands located almost 1,000 km off the mainland. New species evolve particularly fast on isolated groups of islands. On isolated islands, evolution starts with the arrival of a few animals and plants that fly, swim or are carried over the ocean from the mainland. In the case of the Galápagos Islands, they arrived in an environment that was different from their region of origin – different food, different enemies, different possibilities for shelter and a different climate. Only those arrivals that could find everything they needed were able to survive. All the others became extinct. The survivors conquered their new habitat by adapting to the new conditions, and thus by changing. Such changes, of course, did not happen overnight. Hundreds, thousands, sometimes millions of years were required for this process of change, which is called evolution. At some point, the ancestors were so different from the original arrivals that they had developed into new species. And because evolution occurred in isolation, without significant influences from the mainland, many endemic species evolved on oceanic islands, including the Galápagos Islands.

Particularly worth protecting

Endemic species are like a history book that reveals to us the story of evolution. This is why they are of particular interest to biologists, as they help to better understand the process that drives evolution. A prime example of endemic species are the Darwin’s finches found on the Galápagos Islands. In addition, species endemic to oceanic islands are particularly sensitive and it is therefore not surprising that many of them are particularly at risk. It is therefore crucial to protect them.

Unusual by nature

The Galápagos archipelago abounds with extraordinary, even bizarre creatures that can only be found here and are therefore endemic to Galápagos. Why are there so many endemic species? Why are there iguanas that graze on algae on the ocean floor, while the iguanas everywhere else eat plants on land? Or finches that feed by drinking the blood of seabirds, pecking at their skin until blood is drawn? Why are there giant tortoises that are so much larger than continental tortoises, so large that humans can ride on them? And what are penguins doing so far north, at the equator, when their home is mainly in the Antarctic?

Animals and plants are endemic (from Greek, “native”) if they are found exclusively in a certain restricted area. These areas can be large or very small. For example, hummingbirds only live in South and North America (over 300 species), lemurs are only found on Madagascar and the surrounding islands (over 100 species), gorillas only exist in Central Africa, and Trochulus caelatus, a species of air-breathing land snail, only lives on Jurassic rock faces south-west of Basel (Switzerland).
Isolated, large and high: the ideal island for the evolution of endemic species

In order for endemic species to evolve, the arriving animals and plants have to find various new environmental conditions to which they can adapt. Large islands that rise high above the sea level usually provide these conditions. They have more vegetation zones and therefore more varied habitats than flat and small islands. Another important factor is the distance to the mainland. If the islands are located far enough from a continent, new species may evolve and establish themselves without having to compete with others. Thus, isolation is important for the evolution of endemic species. This is shown by the fact that, among the endemic species on the Galápagos Islands, there are many more terrestrial vertebrates (67%) than saltwater fishes (14%). It is difficult for terrestrial vertebrates to cross the 1,000 km between the mainland and the islands – only few of them succeeded –, but they had the time to evolve into numerous new species without being disturbed. On the other hand, it is relatively easy for most saltwater fishes to swim a distance of 1,000 km, so that fish species regularly arrive at the Galápagos archipelago and compete with the previous species or even displace them. Under these circumstances, only few new species can evolve.

Adaptive radiation – diversity by adaptation

Experts speak of “adaptive radiation” (adaptive = based on adaptation; radiation = divergence outward from a central point) when a species adapts to new living conditions and evolves into various new species in a relatively short time. In other words: when diversity is created through adaptation. Adaptive radiation takes place in newly emerged habitats that are still unoccupied and have unique environmental conditions. If individuals of a species occupy these new habitats, they have to adapt to the environmental conditions in order to survive. Their descendants change in the course of time, and new species evolve from the original one. This means that one species splits into multiple new ones – a process that experts call “speciation”. Since this speciation is based on adaptation, scientists refer to it as “adaptive radiation”.

The Galápagos Islands present impressive examples of adaptive radiation. A period of only two to three million years saw the development of 14 Darwin’s finch species, 4 mockingbird species, 15 giant tortoise species, 9 lava lizard species, over 60 Bulimulus snail species, 6 prickly pear species and 15 daisy tree species.

Islands: home to endemic species

Due to their isolation, oceanic islands are generally poor in animal and plant species, but they provide ideal conditions for the evolution of endemic species. Therefore, oceanic islands abound with endemic species, which cannot be found anywhere else in the world. This also applies to the Galápagos Islands, where 80% of all bird species, 56% of insects and 43% of terrestrial plants are endemic. Other oceanic islands, e.g. Hawaii, have even more endemic species, while on the mainland there are much fewer. On the Ecuadorian mainland, for example, less than 1% of all bird species are endemic, even though Ecuador is significantly larger than the Galápagos Islands.

It is exceptional that, among the endemic species on the Galápagos Islands, there are not only typically tropical creatures (e.g. iguanas), but also species that can normally be found only in cold areas. They can live here because the ocean temperatures are surprisingly low in certain areas of the archipelago (e.g. 16–18°C (60–64°F) off the west coast of Fernandina) compared to other areas at the equator, where sea temperatures are mostly above 25°C (77°F). The low ocean temperatures are caused by the cold Peru Current (Humboldt Current) coming from the Antarctic, as well as by deep ocean currents that rise to the surface (e.g. the Equatorial Under-current, Cromwell Current, on the west coast of Fernandina and Isabela). Thanks to these low temperatures, species like the Galápagos Penguin Spheniscus mendiculus and the Galápagos Fur Seal Arctocephalus galapagoensis are able to survive here.

Thanks to these low temperatures, species like the Galápagos Penguin, the Galápagos Fur Seal, the Galápagos Penguin’s relatives and the Galápagos Fur Seal’s relatives change in the course of time, and new species evolve from the original one. This means that one species splits into multiple new ones – a process that experts call “speciation”. Since this speciation is based on adaptation, scientists refer to it as “adaptive radiation”.
The animal and plant species on the Galápagos archipelago are fascinating; not only because most of them are endemic, but also because they are often different from the species living on the continents. In other words: they are exceptional.

This is because oceanic islands like the Galápagos are poor in species. The few species living there are exposed to only a small number of rivals and enemies, freeing them from many of the constraints that they are subject to on the mainland (e.g. having to fight for food with other species). For example, one finch species on the Galápagos specialises in the food that would otherwise be eaten by woodpeckers. The Woodpecker Finch *Camarhynchus pallidus* would have no chance to survive on the mainland, where woodpeckers would compete with it.

In situations with little competition, many species depend on unusual food. On the Galápagos Islands, spectacular examples include the Sharp-beaked Ground-Finch *Geospiza difficilis*, that drinks blood on Wolf Island and therefore is also called "Vampire Finch", or the Marine Iguana *Amblyrhynchus cristatus*, which feeds on algae on the ocean floor instead of terrestrial plants. Islands with little competition are sometimes also a refuge for creatures that have become extinct on the mainland. This is the case for giant tortoises, which all died out on the mainland thousands of years ago.

In addition, oceanic islands are remote, and once the wearisome journey has been made, it is not worthwhile to leave again. For plants, this means it is not worthwhile to produce seeds that are destined to travel long distances. Many island plants therefore produce seeds that are not carried very far by the wind. For birds and insects, this means that their wings are not as important as on the mainland. Moreover, fewer enemies lurk on the islands than on the mainland. Therefore, flightless birds are quite common on oceanic islands, including Galápagos. The Flightless Cormorant *Phalacrocorax harrisi* is probably the most spectacular example.

The Woodpecker Finch *Camarhynchus pallidus* behaves just like the common woodpecker in many respects: it climbs trunks and branches and pecks holes in them in order to reach the hidden insects. Surprisingly enough, it uses tools (small twigs or cactus spines) to extract them from the holes, unlike the common woodpecker, which uses its tongue.

On Wolf Island in the very north of the archipelago, the Sharp-beaked Ground-Finch *Geospiza difficilis*, also known as the Vampire Finch, has quite an unusual diet: it feeds by drinking the blood of other birds, the Nazca and Blue-footed Boobies, pecking at their skin with its sharp beak until blood is drawn. The finches also feed on eggs, pushing them over the edge of a rock in order to break them. Occasionally, mockingbirds also break eggs and drink blood.

The daisy trees *Scalesia* have been called the Darwin's finches of the plant world on Galápagos. The 15 species differ from each other in the way they adapted to their habitats. As in the case of Darwin's finches, the differences are enormous. Some species of *Scalesia* grow as small shrubs, while others are tall trees, making impressive forests. The different shapes and sizes of their leaves are just as impressive. Like many plants on the Galápagos Islands, most *Scalesia* species developed seeds that are not transported very far by wind. This is an adaptation to life on islands, where the wind would most probably blow the seeds out in the ocean.
Prickly Pears

Prickly pears and other cactuses are an important feature of the dry zone on the Galápagos Islands. Scientists quickly become aware of this once they hit their heads on a Galápagos prickly pear or sit on a prickly pear pad that has fallen off. It is not without reason that a pair of tweezers should be part of every scientist’s equipment on the Galápagos! Apart from the ‘daisy trees’, the six endemic prickly pear species are the best-known result of adaptive radiation among the plants on Galápagos. Prickly pears are primarily adapted to large herbivores and to competing shrubs. In places where giant tortoises and land iguanas graze and where dense bushes grow, prickly pears grow like trees (up to 12 m) and are armed with hard spines. It is the only way that they can find enough light to grow and escape the herbivores wanting to eat their succulent pads. By contrast, on islands like Genovesa, where there are no large herbivores and fewer competing shrubs, prickly pears are as small as bushes and have soft spines.

There are relatively few insect species on the Galápagos Islands that pollinate flowers (there is, for example, only a single bee species, whereas there are hundreds on the continent). Prickly pears are therefore also pollinated by birds: mockingbirds, Galápagos Doves and a few Darwin’s finch species do this while eating the prickly pears’ pollen and nectar, an important food for the birds, especially in the dry season. In the course of evolution, some Darwin’s finches have adapted their beaks so that they are able to most efficiently extract pollen and nectar from the prickly pear blossoms: two species have long, thin beaks that enable them to reach the bottom of the prickly pear blossoms.

Don’t researchers know how to count?

When studying the scientific literature on endemic plant species of the Galápagos Islands, readers will be surprised to find that the percentage of endemic species varies between 18% and 43% and that, according to one source, their number has almost been halved since the 1970s. How is this possible? Don’t researchers know how to count?

Usually, they do. The problem is not the counting but the question of what to count. If you add up all endemic and non-endemic species and equate the sum with 100%, you will be able to calculate the percentage of endemic species. It’s as simple as that. Why, then, do the results in the literature differ so much? To answer the riddle, we need to ask “what is to be included in ‘all non-endemic species’?” If the definition includes all plant species existing on Galápagos, including those introduced by humans, then the percentage of endemic species is indeed small in relation to the various other species. Since the number of introduced plant species has been increasing greatly since the 1970s, the percentage of endemic plants has almost been halved, i.e. it has decreased from 30% to 18%. But if you calculate the number of plant species that existed on the islands before human settlement, your result will be 43% in the 1970s and now.

The seeds of the endemic Galápagos tomatoes only properly germinate after they have been eaten, digested and excreted by animals. It can take one to three weeks for the seeds to make their way through a giant tortoise’s intestinal system. After this, the tomatoes germinate very well.
**Prickly Pear Forest**

**Land Iguanas**

**Galápagos land iguanas Conolophus**

**Preferably prickly**

Land iguanas’ favourite food is the prickly pear cactus. To get rid of the large spines, land iguanas roll the piece of cactus on the hard ground with their forefeet. They do not mind the smaller spines, and they swallow prickly pear fruits after only a few bites. Apart from providing solid food, the prickly pear also contains enough water to keep the iguanas hydrated during dry seasons.

The land iguanas of Fernandina travel surprisingly long distances. In the lowlands, where their favourite food, the prickly pear, grows, the lava soil is so hard that the land iguanas are not able to dig hollows in which to lay their eggs. Consequently, thousands of females climb up the volcano where they find appropriate spots to lay their eggs in the crater. On this journey, female Galápagos land iguanas cover distances of more than 10 km, climb 1,500 metres and descend another 900 metres into the crater, which makes them record holders among all iguanas. It takes the 3-kg animals about 30 days to travel this considerable distance and dig hollows for their eggs.

**The arduous journey**

Wolf Volcano, which is located on Isabela, is home to land iguanas with a strikingly pink-coloured body, black stripes and a fleshy crest with hardly any spines. The Galápagos Pink Land Iguana Conolophus marthae was first described by Gabriele Gentile and Howard Snell in 2009, which shows that new discoveries are possible even on the well-explored territory of the Galápagos Islands.

**Discovered only recently**

Small Ground-Finches Geospiza fuliginosa feed on ectoparasites such as ticks from the skin of the land iguanas. When a finch turns up, the iguanas sometime assume a “cleaning position”: they raise their bodies off the ground extending their legs and bend up their tails in order to enable the finches to reach every part of their bodies.

**Finch cleaning service for iguanas**

The population size of the Galápagos Pink Land Iguana is only about 200, which means it is an endangered species. On Santiago and Rábida, the Galápagos Land Iguana is already extinct and only intense conservation programmes have ensured their survival elsewhere.

**Today, 40 reptile species live on the Galápagos Islands, 33 of which are endemic. This means that they exist nowhere else in the world. These 33 endemic species include 10 giant tortoise species, 19 lizard and iguana species, and 4 snake species.**

**Read more about the protection of the land iguanas on page 91 and page 93**
Giant Tortoises

Galápagos giant tortoises Chelonoidis

Giant tortoises with saddleback shells live on the smaller and flatter islands with extensive arid zones and sparse ground vegetation. By arching of the front edge of their shell upwards, they can easily rise up on their legs and stretch their necks to reach leaves on trees and parts of treelike cacti. Genetic tests in recent years have shown that there are giant tortoises living on Wolf Volcano (the northernmost volcano on Isabela) that are hybrids between the giant tortoises on Isabela, Española, Pinta and Floreana. The animals must have been moved between the islands when pirates, buccaneers and whalers took thousands of tortoises on their ships. By doing this, they unintentionally ensured the survival of their genes. The two species that lived on Pinta and Floreana have become extinct by now, but their genes have been preserved thanks to the animals on Isabela.

Crossbreeds due to pirates, buccaneers and whalers

No animal can possibly afford a more [...] luscious and delicate food than they do“, the American captain Porter wrote in 1813 about the giant tortoises of the Galápagos Islands. Their flesh contains a large amount of fat, which when burned up by the body, creates water. That is why giant tortoises can do without water over an extended period of time and even survive long journeys over the ocean.

Naming the “islands of the tortoises”
The Galápagos Islands owe their name to the giant tortoises. On the map by Gerardus Mercator from 1569, the islands are recorded as “Insulae de los Galopegos”, i.e. “islands of the tortoises”. “Galápago” is also the word for a Spanish riding saddle that recalls the saddle-shaped shell of the giant tortoises.

With time, the shell grows along with the tortoise. This is evident from studying the annual growth bands of the horny carapace (the top part of the shell), where the skin underneath gradually produces larger and larger plates (scutes). On the basis of the topmost plate, one can imagine how small the tortoise must once have been.

Male or female?
Galápagos giant tortoises weigh up to 250 kg and reach lengths of up to 130 cm. They only reach sexual maturity at around 20 to 30 years, but they may attain an age of over 175 years. Males have a concave undershell (curved inward) and are larger than females of the same age.

Saddleback shells in dry habitats
Giant tortoises with saddleback shells live on the smaller and flatter islands with extensive arid zones and sparse ground vegetation. By arching of the front edge of their shell upwards, they can easily rise up on their legs and stretch their necks to reach leaves on trees and parts of treelike cacti.

Giant tortoises with domed shells live on the larger islands with abundant vegetation at high elevations. They “graze” on the lush grass, herbs and lichens that are conveniently available on the ground.

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Distribution of tortoises

Pinta
- Pinta Galápagos Tortoise Chelonoidis abingdoni, represented only by "Lonesome George". He lived at the "Charles Darwin Research Station" on Santa Cruz until he died in 2012. With his death, this species is considered to be extinct, although part of the species' genes survives in crossbreeds on Isabela.

Fernandina
- Fernandina Galápagos Tortoise Chelonoidis phantastica, extinct, a dead male specimen found in 1906 was the only one ever recorded; it may have been released by humans.

Isabela
- Isabela Volcán Wolf Galápagos Tortoise Chelonoidis becki and crossbreeds
- Isabela Volcán Darwin Galápagos Tortoise Chelonoidis microphyes
- Isabela Alcedo Galápagos Tortoise Chelonoidis vandenburghi

Rábida
- Rábida Galápagos Tortoise Chelonoidis wallacei, extinct. Genetic tests have shown that it was most likely not a separate species at all, but that the extant evidence is actually the remains of tortoises brought from Isabela by humans.

Santiago
- Santiago Galápagos Tortoise Chelonoidis darwini, reintroduction

Santa Cruz
- Santa Cruz Galápagos Tortoise Chelonoidis porteri

Pinzón
- Pinzón Galápagos Tortoise Chelonoidis ephippium, reintroduction

Santa Fé
- Santa Fé Galápagos Tortoise Chelonoidis sp., extinct, known from only one skeleton discovery.

Española
- Española Galápagos Tortoise Chelonoidis hoodemnis, reintroduction

Floreana
- Floreana Galápagos Tortoise Chelonoidis elephantopus, extinct since 1846, but part of the species' genes survives in crossbreeds on Isabela, and 9 animals in the breeding station of the "Charles Darwin Research Station" genetically belong mostly to C. elephantopus.

Isabela
- Isabela Sierra Negra Galápagos Tortoise Chelonoidis guntheri, reintroduction

Floreana
- Floreana Galápagos Tortoise Chelonoidis elephantopus, extinct since 1846, but part of the species' genes survives in crossbreeds on Isabela, and 9 animals in the breeding station of the "Charles Darwin Research Station" genetically belong mostly to C. elephantopus.

Marine Turtles
- Apart from the Galápagos giant tortoises, four species of marine turtles can be found in the Galápagos archipelago: Pacific Green Turtle Chelonia mydas, Hawksbill Turtle Eretmochelys imbricata, Olive Ridley Turtle Lepidochelys olivacea and Leatherback Turtle Dermochelys coriacea.
Endemic Plants
From the Deep-Sea Floor to the Atmosphere

The manned research submersible JAGO explores the ocean up to a depth of 4000 metres.

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All Galápagos visitors are impressed by the tameness of the islands’ animals. The obvious question is: are these animals even able to flee? The answer is yes, they are, and they actually do. They flee from familiar predators such as Galápagos Hawks or Galápagos snakes. So why do they not flee from human beings, or from introduced dogs and cats? Because for millions of years there were no human beings, dogs, cats, or any other terrestrial predators on the Galápagos Islands. As a result, flight behaviour got lost in the course of evolution. This proved to be the undoing of some species: when humans introduced terrestrial predators, the island animals became easy prey.

Today’s research indicates, however, that the animals are stressed, even if they do not run away from humans and terrestrial predators. And the Galápagos animals are slowly starting to recognise their forgotten and new enemies. Some of them even flee.
Running or flying away from enemies takes time and energy. Settling in an area where many natural enemies are absent means less fleeing and more time to eat. On most oceanic islands, mammals are inexistent or very rare because they can only reach them with great difficulty. As a result, animals that have managed to settle on such islands have lost their fear of predatory mammals in the course of evolution. Thus, Galápagos animals are tame because they no longer recognise the natural enemies of their ancestors from the mainland as such. And, at the time of their ancestors, there were no human beings living on the South American mainland at all. The tameness of the animals on Galápagos and the other oceanic islands is one of the reasons for the extinction of a particularly large number of animal species living on islands in recent centuries. The predatory mammals that were introduced by humans found easy prey in the tame island animals.

When a Marine Iguana is attacked by a Galápagos Hawk, it flees; in doing so, it releases stress hormones and its heart beats faster. The release of stress hormones, an increased heart rate and taking flight are thus a Marine Iguana’s three normal responses to the approach of a familiar enemy. However, when a human being approaches, Marine Iguanas neither move nor respond. Only when they are intensively and repeatedly disturbed by humans over a long period of time does their body respond with an increased release of stress hormones and sometimes by taking flight. It appears that Marine Iguanas can learn through experience to recognise a human being as an enemy. Of the three reactions to familiar enemies, only two occur; their heart rate remains unchanged. So we might say that Marine Iguanas have only a limited ability to recognise new enemies. However, perhaps the sight of a human being will cause their heart rate to increase as well some time in the future.

Are the animals on the Galápagos Islands “so silly that they do not know how to flee”, as Fray Tomás de Berlanga, who discovered Galápagos in 1535, wrote in his report to the King of Spain? Or was Darwin, 300 years later, closer to the mark when he wrote that they have “not [...] yet learnt that man is a more dangerous animal than the tortoise or the amblyrhyncus [Marine Iguana]? If so, then the animals on Galápagos are far from being “islands without fear”.

Forgotten enemies

In Galápagos, you can hardly believe your eyes sometimes... Is this really a bird sitting on my colleague’s head? Is this sea lion actually making itself comfortable at our feet? Is this Marine Iguana truly climbing up my arm? At home, you would never witness a thing like that. No wonder the very first Galápagos visitors were entranced by the tameness of the island animals. Even today this fascinates everyone who comes to visit.

Some people draw the conclusion that Galápagos is a paradise where animals are free from enemies and fear. This is a misconception. The animals do know fear, because they have always had and always will have enemies both in the air and in the sea. Marine Iguanas, for example, run when they are hunted by Galápagos Hawks. In the sea, sea lions and fur seals flee from sharks. Finches and mockingbirds “mock” their enemies (owls and Galápagos Hawks), i.e. they fly mock or real attacks just like our birds. Evidently, the Galápagos Islands are far from being “islands without fear”.

Some island animals have already been exterminated: for instance, the endemic cormorant Phalacrocorax harrisi has lost its ability to fly because it has no more enemies to fear on land.
Calm on the outside, stressed on the inside

The release of stress hormones, an elevated heart rate and fleeing are the reactions that a bird might have to the approach of an enemy. These reactions are related but do not necessarily occur together. Therefore, when a relatively unfamiliar enemy approaches, a bird may seem fearless on the outside, but its body may show stress reactions such as an elevated heart rate.

This is precisely what researchers have observed in incubating frigate-birds, albatrosses, blue-footed boobies and swallow-tailed gulls on Galápagos. When an incubating frigatebird sitting in its nest is approached by a human, its heart rate rises as soon as the human comes closer than 10 m (about 18 m for albatrosses). The normal heart rate of a frigatebird is about 65 beats per minute; if a human is just 5 m away, the bird’s heart beats 200 times per minute. However, the bird still shows no visible signs of stress. If the human comes even closer, the bird’s heart rate can reach up to 1,000 beats per minute before the bird eventually flies away.

Used to disturbances…

to some extent

If disturbances are repeated, frigate-birds and other birds become accustomed to them to some extent, and they no longer experience a rapid increase in their heart rate. Birds that breed in the vicinity of visitor trails are therefore less sensitive; however, they still respond with a significant increase in their heart rate. As a result, even birds that are used to the proximity of humans suffer from stress when a human comes too close.

Does this stress have negative effects on the animals? Unfortunately, no conclusive study has yet been conducted on this topic. Despite all the research that has been done on Galápagos, we know that boobies change their behaviour when tourists pass by, e.g. by moving away from them. However, in order to determine the effect this stress has on the birds’ survival or their reproductive success, further research is required.

How can the heartbeat of an incubating bird be measured?

In order to measure the heartbeat without getting too close to the bird (which would cause a change in its heart rate), body-sound microphones that transfer the incubating bird’s heart sounds via radio are attached to the eggs. In this way, the researcher can record the heart rate on tape at a distance of about 100 m without disturbing the incubating bird.

Paradise for researchers

The fact that animals on the Galápagos Islands are “strangers to man”, as Darwin wrote, makes Galápagos a paradise for researchers: they can observe animals at close range and record observations that would not be possible with animals that are shy of humans.
Recent arrivals with unusual breeding behaviour

The Galápagos Hawk’s ancestors came to Galápagos about 130,000 years ago and therefore are among the most recent immigrants. Today, this hawk species can be found on many islands: there are about 300 adult birds in total. They are reluctant to fly long distances over water, which is why an exchange between the islands is rare. It is no wonder that they are among the bird species with the highest natural rates of inbreeding. Their mating habits are quite unusual among birds: one female will mate with several males, who all help rear the young. Like vultures, they keep watch over large areas from the air and show each other where to find food. This is the case, for example, on Santiago, whereas on Española each female mates with only one male.

Lost colours

On islands, flight reactions may be “forgotten” in the course of evolution. Warning colouration can disappear as well.

The Crimson-speckled Flunkey Utetheisa pulchella is a moth that can be found in Europe and is active during the day, or diurnal. In order to protect itself from natural enemies, its caterpillar eats plants that enable it to produce toxins. These toxins are later contained in the moth, making it toxic for birds and other natural enemies. The moth’s striking colours ensure that its toxicity is noticed from afar.

On the Galápagos Islands, the five species that are related to our Crimson-speckled Flunkey have a dull brown colour. This is because they are nocturnal: at night, colours are not visible, so it would be no use to signal toxicity with striking warning colours. Their lack of warning colouration is actually of advantage to them: while they sleep during the day, they are hidden from natural enemies like the lava lizard thanks to their brown hue.

Only the sixth Utetheisa species living on Galápagos has kept its multi-coloured appearance. It can also be found in North and South America and is, also active during the daytime, just like the Crimson-speckled Flunkey. This probably explains why it has kept its warning colouration.

Galápagos Hawk

The Galápagos Hawk Buteo galapagoensis is the natural enemy of the following animals: Marine Iguanas, lava lizards, native and introduced rats, smaller birds such as Darwin’s finches, Galápagos Doves and mockingbirds.

It is the only diurnal bird of prey on Galápagos and so tame that it does not even flee from humans. When it captures a young chick, the hawk does not fly away with it, but sits in front of the house eating it. It even stays there when the chick’s angry owner appears and threatens to beat the hawk to death.

Woe betide anyone who threatens its offspring

However, as soon as someone threatens its offspring, the tame hawk turns into a savage beast. It dives down, claws extended, to attack any human who threatens to harm its young.

As soon as the offspring of the Flightless Cormorant Phalacrocorax harrisi leave the nest, the male takes over the feeding entirely. The female leaves to find a new partner for the second round of breeding in the same year.
Lizards grazing on the ocean floor

Marine Iguanas are the only lizards that find their predominantly vegetarian food exclusively in the ocean. Some of them graze for 2 to 45 minutes, in depths of one to five metres. The largest animals dive as deep as 30 metres. Most Marine Iguanas look for algae at low tide so they do not have to dive deep.

Marine Iguanas are reptiles and therefore poikilothermic. Their body temperature depends largely on the ambient temperature, and their activity decreases as temperatures decline. Larger animals do not lose their body heat as fast because, compared with smaller animals, their body surface is small in comparison with their body volume. This is why only larger Marine Iguanas are able to dive down to 30 meters, where temperatures are easily as low as 13°C (55°F).

The Marine Iguanas’ unusual lifestyle also led to evolutionary changes in their bones. Jasmina Hugi and Marcelo Sánchez from the University of Zurich were able to show that their bone structure is much denser than that of other iguanas. The higher the density, the heavier the bones, the better the iguanas can dive at greater depths (because buoyancy is lower). Moreover, the seasonal climate of the Galápagos Islands is reflected in the bones in the form of growth rings.

Marine Iguanas differ in size according to the island they live on. Males on Genovesa weigh less than 1 kg, while those on Isabela easily weigh 11 kg and more. On all the islands, females are smaller than males.

Marine Iguanas usually have a blackish colouration, which helps them warm up fast in the sun after grazing in the cold water. In males, this colouration changes to bright colours during mating season (from December/January). Depending on the island, they turn either brick red or greenish, which is presumably because the algae they feed on contain different pigments. Martin Wikelski (Max Planck Institute for Ornithology in Radolfzell, Germany) found out that the females are not impressed by this colouration. Instead they always prefer the largest males, be they the largest among the small iguanas on Genovesa or the largest among the large ones on Isabela.

Sneezing lizards

Lying on coastal rocks, Marine Iguanas bask in the sun. They feel most comfortable with a body temperature of 36–38°C (96–100°F). Their intestinal bacteria also need warmth in order to digest the vegetarian food.

Strange noises can be heard from afar: Marine Iguanas sneeze forcefully and often. The white mucus they expel from their nostrils (sometimes it lands on their heads) comes from their salt glands and is very salty. This is how they get rid of the excess salt that they ingest with their oceanic food.
“We’re carefully making our way up to the crater rim of the small island of Gardner-por-Floreana. The climb is extremely steep, and I’m worried that one of our team members might fall. Suddenly I hear someone yell behind me. Fearing the worst, I turn around. My colleague is pointing excitedly towards a rock ledge, where a snake has caught a lava lizard. The lava lizard is holding onto a rock with all its might, which makes it impossible for the snake to wind itself around it and strangle it. The snake is fighting wildly for its meal, the lava lizard for survival. The spectacle attracts a mockingbird, which begins to peck at the snake. The snake tries to escape the mockingbird’s attack without letting go of its prey. After a few minutes, the battle on two fronts – the lava lizard in front, the mockingbird behind – has become too much. The snake loses its grip, and the lava lizard slips away immediately.”

Recounted by Paquita Hoeck, who did field studies on Galápagos while a student at the University of Zurich and went to work as a researcher at the San Diego Zoo in California after finishing her Ph.D. in 2010.
The Galápagos Islands are among the most thoroughly studied archipelagos on earth. It all started with Charles Darwin, who visited the islands in 1835 and was fascinated by their unique flora and fauna. He saw that animal species lived there that were closely related but whose various populations differed slightly from island to island. These observations later contributed to his conviction that species can change through “natural selection” as he called it. This was a revolutionary idea: the theory of evolution. More than a century later, researchers found out, again on Galápagos, how this process works in nature. Teams of researchers in biology and geology are still working on the Galápagos Islands to this day, but this unique natural environment is still far from being exhaustively researched; new species are still being discovered. Islands are a mecca for researchers because they show complex interactions in simplified terms, just like test tubes in a lab.
Islands (or, better yet, archipelagos) are ideal sites for biologists to investigate the phenomenon of evolution. Indeed, every island is like a test tube in the laboratory of evolution, and correspondingly, archipelagos are like whole arrays of test tubes.

What do we mean by this? A test tube shows complicated things in a simple way. The same holds true for islands: they show the complicated life on the mainland in simplified terms. On the mainland, the coexistence of innumerable plant and animal species is extremely complex, whereas on islands it is downright simple since there are relatively few plant and animal species. Hence, islands are particularly suitable for investigating the phenomenon of evolution. Furthermore, volcanic islands that rise from the sea, such as the Galápagos Islands, are initially uninhabited. Thus, the first arrivals can undergo largescale evolutionary changes. On islands, the course of evolution is much more obvious than on the mainland, where only smaller evolutionary adaptations can be observed. Finally, the tameness of island animals is an undeniable advantage: researchers can observe them at close range.

Heavenly research in hellish conditions

Charles Darwin’s Galápagos expedition in 1835 aroused widespread interest in these islands. This is all the more astonishing as he and subsequent researchers were, according to their travel accounts, anything but enthusiastic about the working conditions. Nevertheless, dozens of researchers followed their example with the aim of exploring this pristine patch of Earth as quickly as possible. They feared that the unique flora and fauna could be displaced by introduced species and eventually die out. Most of all, however, they wanted to investigate the phenomenon of evolution. The Galápagos Islands still remain an important research centre, especially for evolutionary research.
What Darwin saw

In his pioneering book *On the Origin of Species*, Charles Darwin mentions the Galápagos Islands several times. What did he see there in 1835? Why was he still so impressed some twenty years later? Well, he had observed that many animals and plants on Galápagos were unique and that they could only be found on these islands. At the same time, they seemed to be related to each other and resembled the flora and fauna on the South American mainland. From this, he concluded that South American species coming from the mainland had landed on Galápagos and colonised the islands. Over time, they evolved and new species were born.

No moment of epiphany

Darwin's observations were not followed by a sudden insight. It was not until many years later, after reviewing his observations and connecting the dots, that it dawned on him that all species evolved from one common ancestor and that new species arise through evolution. With his discoveries, Darwin's theory was in stark contradiction to the prevailing belief that every species was created by God alone.

Charles Darwin (1809–1882)

From a beetle-collecting boy to a scientific thinker

Charles Darwin was born in Shrewsbury, England, in 1809 to a wealthy family with a strong intellectual background. It was here that the boy with a passion for collecting beetles and shooting birds turned into a thinker. His grandfathers (a physician and an industrialist) had controversial views on religion, free-thinking, evolution, the origin of life, the laws of nature, slavery, etc. His father was a physician and interested in the science of the time. His pious mother kept pigeons and grew exotic plants. She died when Charles was 8 years old, and he was raised by his sisters. In order to make an impression, Charles invented stories and collected anything he could find. He took solitary strolls, read *Wonders of the World*, and dreamt of long journeys, tropical islands and South American landscapes. “What wouldn’t I give to be a natural scientist”, he confessed to Price, his school friend. In a letter to his cousin Fox, he wrote “It is quite absurd how interested I am getting about the science.”

During his studies in the cosmopolitan city of Edinburgh, Charles Darwin met the geologist Robert Jameson, who taught him to observe minute details and to recognise connections. From Robert Grant, a physician and natural scientist, he learned to ask the right questions. He read Humboldt’s book *From the Orinoco to the Amazon*, annoyed fellow students with his enthusiasm for tropical landscapes. “What wouldn’t I give to be a natural scientist”, he confessed to Price, his school friend. In a letter to his cousin Fox, he wrote “It is quite absurd how interested I am getting about the science.”

Darwin at the age of 7

Charles Darwin (1809–1882)

Two researchers, one discovery

Darwin was not the only researcher who was credited with the discovery of the theory of evolution by natural selection. After spending eight years exploring the islands of Indonesia, Alfred Russel Wallace (1823–1913), a trained surveyor, had the same idea. Darwin’s and Wallace’s discoveries were presented to the public at a symposium of the Linnean Society in London… on exactly the same day. However, in the course of the 20th century, Wallace’s contribution sank into oblivion.

Charles Darwin and the mockingbirds

Contrary to common belief, it was not the Darwin’s finches but the mockingbirds that impressed Charles Darwin the most on Galápagos. In fact, it is the mockingbirds that appear in his book *On the Origin of Species*. Originally known as Galápagos finches, the present name of Darwin’s finches was given 50 years after Darwin’s death.
Evolution by natural selection

Darwin's realisation that living creatures are formed by evolution was unprecedented in its clarity and therefore quite provocative. However, it was not fundamentally new. Scientists and intellectuals had already expressed similar ideas before him; among them Darwin's grandfather Erasmus Darwin, a physician and free-thinker. However, nobody knew how evolution worked. This discovery was Darwin's pioneering achievement.

Evolution by natural selection works like this:

All living creatures produce an excess of offspring, more than is actually necessary. Why is this? The reason is that not all of the offspring survive. Some die of hunger, others are eaten or become diseased, while some may fail to reproduce because they lack a partner.

"Tough luck", you might say, but it's not so simple. The point is that some characteristics (e.g. body size, beak form, leg length, health, behaviour) are not fitted well enough in some individuals to ensure survival. Those who cannot run fast enough are eaten. Those who cannot find enough food starve to death. Those who cannot withstand diseases die. Those who cannot find a partner will not reproduce and leave no descendants. In this way, only individuals with well-fitted characteristics survive. Some of these characteristics are rooted in the genetic make-up and passed on to the offspring. Darwin called this process "natural selection".

If the environment changes, for instance if new natural enemies appear or the climate changes, different characteristics are needed for survival. Then, only those individuals with these different, adapted characteristics will survive. When they reproduce, they pass on these characteristics to their offspring. In the course of time, a whole population develops with these different characteristics. This is evolution.

In this way, animals may change so fundamentally over long periods of time that new species develop. This is how evolution brings forth new species.

Example: Darwin's finches

Darwin could not observe evolution by natural selection on the Galápagos Islands. However, 140 years later, scientists Peter and Rosemary Grant from Princeton University succeeded in doing so. For 40 years, they regularly visited the small island of Daphne Major in order to conduct field research on Darwin's finches and thereby document evolution by natural selection. Here is a summary of their findings:

In 1977, the Galápagos Islands were affected by severe drought. On the island of Daphne Major, the Medium Ground-Finch Geospiza fortis, one of the species of Darwin's finches endemic to the islands, was forced to feed on seeds from the last rainy season which it found on the ground. At that time, the finch population included more small birds with small beaks than large birds with large beaks. The small birds with small beaks eat small, soft seeds, and these were soon eaten. What was left were some larger and harder seeds that could only be cracked by large finches with large beaks. Many Medium Ground-Finches starved to death, especially the small finches with small beaks, while some larger birds survived. The larger finches with large beaks passed their body and beak size on to their offspring, just like the smaller finches passed on their corresponding characteristics. But since only few small finches were left, the larger birds predominated and subsequent finch populations numbered more large birds with large beaks than before the drought.

In 1978, the average finch was 10% larger than in 1976. Natural selection led to a change in their body and beak size: the bird species evolved. Peter and Rosemary Grant's observations validated Darwin's theory.

It may not have led to the creation of a new bird species, but evolution did occur. Evolution does not necessarily
bring forth new species. It can lead to changes in certain characteristics, such as, in this case, the birds’ body and beak sizes. When the characteristics change to a great degree, for example because the environment changes and the birds have to adapt repeatedly, new species can evolve.

Drought periods are not uncommon on the Galápagos Islands. The question is: will the Medium Ground-Finches keep increasing in size because larger birds have a better chance of survival in periods of drought? Will we find gigantic Medium Ground-Finches on Daphne Major Island some centuries from now? The answer is no, because a small body size with a small beak has advantages as well. A small fledgling needs less energy than a large fledgling, giving it a slightly better chance to survive. Small finches feed on small-seed plants, which grow so profusely during El Niño years with extreme amounts of rainfall that they overrun plants with large and hard seeds. In years like this, there are hardly any large seeds and therefore more large finches die than small ones. As we can see, evolution can go in various directions.

A future of giant finches?

Drought periods are not uncommon on the Galápagos Islands. The question is: will the Medium Ground-Finches keep increasing in size because larger birds have a better chance of survival in periods of drought? Will we find gigantic Medium Ground-Finches on Daphne Major Island some centuries from now? The answer is no, because a small body size with a small beak has advantages as well. A small fledgling needs less energy than a large fledgling, giving it a slightly better chance to survive. Small finches feed on small-seed plants, which grow so profusely during El Niño years with extreme amounts of rainfall that they overrun plants with large and hard seeds. In years like this, there are hardly any large seeds and therefore more large finches die than small ones. As we can see, evolution can go in various directions.

Plant seeds are an important source of nutrition for finches.

Daphne Major: a small island with extensive research

The small Daphne Major Island is located just north of Santa Cruz Island. It is barely 40 ha in size and therefore an ideal place for field research, since practically all the finches on this small island can be caught and ringed (in order to distinguish them), which facilitates the examination of their survival and reproductive success. The research is important in order for natural selection to be measured and must be conducted over many years. Scientists Peter and Rosemary Grant from Princeton University, USA, and their colleagues did exactly this: Forty years of field research on Daphne Major in great heat and on sharp-edged lava rock. Only few scientists have this kind of endurance.

A homemade seedcracker

Is it possible to buy instruments to measure the hardness of the seeds that are cracked by birds? No. Therefore, they have to be invented and specially produced. This is what Peter and Rosemary Grant did: together with engineers from McGill University in Montreal, Canada, they developed a pair of pliers that measures the force (in kg) that is needed to crack a seed.
A revolutionary discovery triggered by mockingbirds

While visiting the island of Floreana, Darwin was surprised to find a mockingbird *Mimus trifasciatus* drinking from a cup in his hand. Later, he wrote that these mockingbirds had looked slightly different from those he had seen and collected on San Cristóbal. The differences were not very conspicuous, but they were clearly visible: the birds had different beak lengths and colouring of eyes and feathers. Before the *Beagle* returned to England, Darwin wrote down his thoughts on these differences (he had seen three of the four existing mockingbird species): “...such facts would undermine the stability of species.” The scientific community of the time was convinced of the stability, or immutability, of the species created by God. The doubts that Darwin expressed in this comment show that the mockingbirds helped him eventually arrive at the conclusion that all species descend from common ancestors and change through evolution.

Darwin’s “muse” disappears

The Floreana Mockingbird *Mimus trifasciatus* was an inspiration to Darwin: one could even call it his “muse”. About 50 years after his visit, it died out on Floreana. No one noticed the mockingbirds were going extinct until after they disappeared, which is why no one really knows the cause of their extinction. It is assumed that the introduced rats, cats and goats were responsible. Today the Floreana Mockingbird only lives on two islets off the coast of Floreana: Champion and Gardner-by-Floreana. The populations of the three islands (Floreana, Champion, and Gardner-by-Floreana) are therefore closely related and birds from both islets would be necessary for the reintroduction of the Floreana Mockingbird. When there were still mockingbirds on Floreana, the populations of Champion and Gardner-by-Floreana indirectly exchanged their genes, as there was an exchange between the populations of both islets with the population on Floreana. The extinction of mockingbirds on Floreana meant that the indirect genetic exchange between the two islets was halted. The tiny population on Champion has had a high degree of inbreeding, which is why today its genes differ greatly from those of the population on Gardner-by-Floreana. This was not always the case. In the course of the past 100 years, inbreeding increased strongly, and the population lost almost 40% of its genetic diversity. We know this because Paquita Hoeck and Lukas Keller also examined the genes of animal skins which were collected in 1906. The extinction of the Floreana population thus indirectly brought about a change in the genetic composition of the Champion population.

Reintroduction of the Floreana Mockingbird?

The Galápagos National Park, supported by the Charles Darwin Foundation, is planning to reintroduce the Floreana Mockingbird *Mimus trifasciatus* on the island of Floreana. The University of Zurich is contributing to this project with research, supported by the Swiss Association of Friends of the Galápagos Islands. Since 2006, Paquita Hoeck, Lukas Keller and their co-workers have been studying the mockingbirds. They have discovered that the mockingbirds on the islets of Champion and Gardner-by-Floreana exhibit significant genetic differences. The question is: could it be that the populations on the two islets are not, after all, as closely related to the extinct Floreana Mockingbirds as has been assumed due to the islets’ proximity to Floreana?

Old birds provide new insights

How can this question be answered? Being extinct, no living Floreana Mockingbirds can be examined. However, there are still the two Floreana Mockingbirds that Darwin and Captain FitzRoy collected in 1835 and whose skins are now kept at the Natural History Museum in London. These over 170-year-old birds are the key to the answer, as they are so well preserved that their DNA can be extracted and their genetic material deciphered. This is exactly what Paquita Hoeck has achieved thanks to a tiny shred of skin from each bird’s foot. In this way, old animal skins kept in museums can provide new insights even after a very long time.

Genes tell stories

The decoding of the genetic material has shown that the gene variants of the two Floreana Mockingbirds at the museum can now be found partly only on Champion and partly only on Gardner-by-Floreana. The populations of the three islands (Floreana, Champion, and Gardner-by-Floreana) are therefore closely related and birds from both islets would be necessary for the reintroduction of the Floreana Mockingbird. When there were still mockingbirds on Floreana, the populations of Champion and Gardner-by-Floreana indirectly exchanged their genes, as there was an exchange between the populations of both islets with the population on Floreana. The extinction of mockingbirds on Floreana meant that the indirect genetic exchange between the two islets was halted.

The two Floreana Mockingbird specimens from 1835 are today in the Natural History Museum in London.
Mockingbirds are sedentary: only rarely do they fly long distances. This is why the populations on the individual islands do not mix. Nor do they mix genetically. Even the mockingbirds’ parasites, feather lice and feather mites, exhibit considerable differences between their genes. This was shown by Jan Štefka (formerly at the Natural History Museum in London, now at the University of South Bohemia in the Czech Republic) and his co-workers. In addition, as the mockingbirds hardly travel between islands, their parasites are likewise hardly transported between islands. This resulted in the evolutionary family trees of the mockingbirds being almost identical to those of their respective feather lice and feather mites. In the case of the birds as well as their parasites, the oldest populations and species are on the oldest islands in the south-east, while the youngest are found on the youngest islands in the west.

Closely related mockingbirds (green evolutionary trees) harbour closely related feather mites Analges sp. (red evolutionary trees).

The Galápagos Islands are the best-explored archipelago on earth. Up to now, they have been the subject of over 7,500 scientific publications.
A life dedicated to the females

Adult male Galápagos Fur Seals *Arctocephalus galapagoensis* have their territories along the coast, preferably a stretch of shoreline where females are numerous. They defend these territories against rival males with all their might so they are the only ones who can mate with the females. On the one hand, this requires a lot of energy, and on the other hand, it means not much time to eat. Therefore, male fur seals lose a lot of weight during this time. After a few weeks, they have to give up and accumulate fat reserves before they can try to get hold of another territory.

On land, Galápagos Fur Seals are most likely to be observed at full moon. This is because, by bright moonlight, their prey stays on the ocean floor. As soon as the nights get darker, the prey rises to the surface, where fur seals can easily catch it.

**Fighting Galápagos Fur Seal males**

On the other side of the island, Martin Wikelski and his team from the Max Planck Institute for Ornithology in Radolfzell (Germany) have been studying the Marine Iguanas on several islands for years. They have observed not only that many Marine Iguanas die in El Niño years, but also that the animals shrink by up to 20%. (Imagine how small we would be if we shrank by 20%!) The more the Marine Iguanas shrink, the longer they live, because they need less energy. They grow again in La Niña years.

El Niño and fishery: a deadly duo

El Niño events can even lead to the extinction of species. The endemic Galápagos Damselfish *Azurina eupalma*, which used to live in the waters of almost all the big islands, became extinct during the extremely intense El Niño event of 1982/1983. Graham Edgar from the University of Tasmania in Australia and his team were able to show that the combination of El Niño and fishery can have especially serious consequences: fishermen catch predatory fish and lobsters, which keep the algae- and coral-eating sea urchin populations in check. As a consequence, there are too many sea urchins, so algae and corals have no chance to grow back after El Niño events. One algae species has already disappeared from Galápagos in this way.

Shrinking Marine Iguanas

Fritz Trillmich from Bielefeld University in Germany and his research team were able to show that Galápagos Fur Seals die in El Niño years because they cannot make up for the loss of weight. In the El Niño year of 1983, all the big fur seal males in Fritz Trillmich’s research area on the island of Fernandina died.

The number of registered fishermen on Galápagos has grown considerably: between 1971 and 2001, it increased tenfold.
Species older than the islands: how can that be?

The Galápagos Islands are young; most of them are not older than three million years, some considerably younger. Yet there are species that are older than the oldest island: the marine and land iguanas, ten *Galapagomus* weevil species and perhaps the giant tortoises, lizards and geckos. How can that be? The answer to this puzzle is that, in the course of Earth’s history, islands have come and gone in Galápagos. There are several 5- to 14-million-year-old islands lying at a depth of 300 to 2,500 m beneath the ocean surface. Before these islands disappeared, they were in all likelihood inhabited by creatures that colonised the newly emerging islands. It therefore comes as no surprise that the age of the ten endemic *Galapagomus* weevil species is estimated at over seven million years and that of marine and land iguanas even at ten million years.

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After all these years of intensive research, it might seem that there is nothing left to explore on the Galápagos. Yet appearances are deceptive: a great number of questions still remain unanswered. Many species have not even been recorded yet. Indeed, the Galápagos Pink Land Iguana was discovered only in 2009. Two years later, Bernard Landry of the Natural History Museum of Geneva discovered a new butterfly species: *Cheverella galapagensis* is a beautifully spotted butterfly that lives on several islands. The Galápagos Islands will undoubtedly reveal many more fascinating research results. In fact, research is often the basis for nature conservation, which in turn is a precondition for the preservation of Galápagos as a UNESCO World Natural Heritage site and the “cradle of evolutionary biology”.

In 1978 and 1979, John Treherne and his colleague William Foster spent several weeks on the Galápagos. Treherne (1929–1989) was a physiologist, director of the Department of Zoology at the University of Cambridge, editor of the *Journal of Experimental Biology* and president of Downing College in Cambridge.

He and Foster studied the behaviour and ecology of the marine insect *Halobates robustus*. Insects have colonised every habitat around the globe, except the open ocean. The only ones that live on the ocean are the *Halobates*, a genus with 46 species. The sea skater *Halobates robustus* can only be found in the Galápagos archipelago, mainly on the mangrove coasts.

What makes the *Halobates* unique is that they benefit from the pollution of the oceans. The increasing amount of plastic particles in the Pacific provides them with a new surface to lay their eggs on. Thus, the population of *Halobates* has grown significantly.

John Treherne not only wrote scientific articles on sea skaters, but also published a book on the turbulent history of the early European settlers on Floreana: *Galápagos Affair* (1983). Furthermore, he initiated the book series *Key Environments*, dedicating its first volume to the Galápagos Islands.
The Galápagos archipelago has a natural environment that is unique on earth, and as the "cradle of evolutionary biology", it is vitally important. Both of these facts led to the archipelago being declared a national park of Ecuador and the first UNESCO World Natural Heritage Site. This status is in danger, however, because the archipelago has lost its isolation. The uniqueness of the natural environment has long been threatened by introduced animals and plants. Some original species have already become extinct. Nature conservation and research are countering this threat with large-scale projects: extermination of introduced animals coupled with breeding and reintroduction of endemic species, which has already succeeded on some islands. However, an end to the problems, reaching from the tiniest parasite to the growth of population and tourism, is not in sight. This is why, in the future, nature conservation will still play a leading role in preserving the World Natural Heritage Site of Galápagos.
Goat Island

Lost isolation
The few animal and plant species that accidentally reached and colonised the Galápagos Islands were able to evolve into new species, far away from the mainland and completely undisturbed. This unique natural environment, this natural paradise, developed thanks to isolation. This isolation was lost, however, when humans both intentionally and inadvertently started to bring non-native animals and plants to the islands on ships and planes. Many of these proliferated, and still do, taking food and living space away from the native species. This leads to disease and death. The exploding population and mass tourism are also contributing to endangering the World Natural Heritage Site of Galápagos. Whether it will remain a natural paradise depends on the success of conservation efforts.

Goats may be cute, but they are a threat
Most people would probably agree that goats are cute and friendly animals. This is why many do not understand that the goats on Galápagos have to be exterminated.

Goat invasion
Pirates and whalers released domestic goats on the islands to act as another meat supply in addition to tortoises. The settlers brought domestic goats, which proliferated profusely. On Pinta, for example, there were about 667 goats per square kilometre before they were exterminated.

Survival experts
Goats can live anywhere. Their ruminant stomach can digest almost any plant, and they obtain water from their food. In addition, thanks to their hooves, they can climb the jagged volcanic cliffs without difficulty. With these gifts, they are perfectly equipped for the bare and dry Galápagos Islands.

Landscape destroyers
The goats’ effects on the flora of the Galápagos Islands are devastating: they eat even the smallest plants that grow on the volcanic rock, and the thin layer of earth underneath, which took hundreds of years to be created, is washed away by the rain. Many plants are threatened by extinction and with them, many animals.

Competitors for food
If you know goats, then you know that they eat more or less anything that comes their way. This leads to enormous problems on Galápagos, especially for giant tortoises and land iguanas, because the goats eat away their food. In extreme cases, the goats leave nothing whatsoever behind – not even seeds for the birds or blossoms for the insects.

Introduced species as the main problem
In the course of time, humans have introduced about 750 plant species and about 500 insect species to Galápagos. Thirty species of vertebrates: fish, amphibians, reptiles, birds and mammals have established themselves, and they cause great problems.

Black and Brown Rats eat the eggs of tortoises and iguanas as well as the eggs and chicks of birds. They also carry parasites and pathogens.

Dogs hunt land and marine iguanas and penguins. Cats hunt birds and young iguanas.

Domestic pigs plunder the nests of iguanas and giant tortoises.

Donkeys have an impact on the flora that is similar to that of goats.

Tiny animals that pose a great threat
More than a quarter of all insect species on Galápagos are introduced (invasive), which means that more than 500 species are actually non-native. Most of them have been introduced in the last few decades, especially through vegetable, fruit and wood imports, which have increased tremendously with the growth of population and tourism. Once they are established on the islands, the insects, attracted by the lights on tourist boats, spread across the whole archipelago.

Many of the introduced insect species are competitors of the native species, or even eat them. Some are also harmful to reptiles and birds. Among these, there is Philornis downsi, a parasitic fly that was first recorded in 1964. It lays its eggs in birds’ nests, where its hatched larvae feed upon the blood of the young birds. Sometimes they bore deep into the nestlings’ bodies, causing many to die. The endangered Mangrove Finch Camarhynchus heliobates is particularly at risk from this parasite. Using insecticides to fight this plague is problematic, as the unique native insects of Galápagos would be harmed in the process.
Islanders are more at risk than mainlanders

Animal and plant species on islands have a more restricted geographic range than the species living on the mainland. In the case of Galápagos, many of them cannot be found on every island and a few even exist only on a single island. A small geographic range implies unfavourable conditions for combating disturbances (such as introduced species, environmental changes, tourism and population growth). This is why nature conservation efforts are so important for preserving the unique fauna and flora of the Galápagos Islands.

Exemplary projects for nature conservation

Eradication of goats on ten Galápagos islands

The feral goats on ten Galápagos islands were successfully eradicated thanks to international collaboration. By combining knowledge and experience from New Zealand (helicopter hunting, use of dogs) with new methods (“Judas” goats), the project succeeded in eradicating goats. Over a period of about 50 years, 268,000 goats were killed on ten islands. Felipe Cruz was the leader of this important project.

Island | Island area in km² | Number of goats killed | Year of eradication
--- | --- | --- | ---
Plazas Sur | 0.13 | 5 | 1961
Santa Fe | 24 | 3,005 | 1971
Rábida | 5 | 14 | 1975
Española | 61 | 3,344 | 1978
Marchena | 130 | 484 | 1983 and 2002
Pinta | 60 | ca. 40,000 | 2003
Santiago | 577 | ca. 85,000 | 2005
North Isabela | 2,400 | ca. 135,000 | 2006
Baltra | 25 | 35 | 2008
Floreana | 172 | 1,334 | 2008

Massive killing for nature conservation – eradicating goats on Isabela

1995 Attention was directed to the goat problem and its dramatic consequences for the giant tortoises on North Isabela.
1997 An international workshop integrated the project for the eradication of pigs that was already running on Santiago Island, and it was decided to eradicate both goats and pigs.
1999 Eradication methods were tested on the small island of Pinta.
2000 A six-year-programme focusing on Isabela was set up.
2001 Various eradication methods were tested on Santiago, an island that is considerably larger than Pinta. 1) Hunters on horseback drove the goats into fenced areas and killed them. 2) Hunters tracked them down with hunting dogs. 3) Groups of hunters systematically paced off individual areas and scared up the goats.
2004 In addition, goats were hunted by helicopter on Santiago, Isabela and Floreana. After that, sterilised “Judas” goats were released (over 200 on Santiago, 770 on Isabela).
2005 The last goat on North Isabela was killed. 266 “Judas” goats are kept on the island for monitoring purposes.
Sixty years ago, the number of giant tortoises was alarmingly low on many islands. First, pirates and whalers captured the animals and stored them alive on board their ships as food supplies. Later, the tortoises had to compete with feral goats for their food. The only solution was often to capture all the tortoises of an island, to breed them at a breeding station and to release the captive-bred tortoises into the wild. At the station, researchers had to ensure that the tortoises from the various islands would not crossbreed. Of course, the goats had to be eradicated before the tortoises could be released. If not for these intensive conservation programmes, the tortoises would be extinct today on many islands.

**Exemplary projects for nature conservation**

**Intensive conservation programmes for giant tortoises**

Sixty years ago, the number of giant tortoises was alarmingly low on many islands. First, pirates and whalers captured the animals and stored them alive on board their ships as food supplies. Later, the tortoises had to compete with feral goats for their food. The only solution was often to capture all the tortoises of an island, to breed them at a breeding station and to release the captive-bred tortoises into the wild. At the station, researchers had to ensure that the tortoises from the various islands would not crossbreed. Of course, the goats had to be eradicated before the tortoises could be released. If not for these intensive conservation programmes, the tortoises would be extinct today on many islands.

**Galápagos giant tortoises living in captivity can reach an age of up to 177 years.**

**Giant tortoises for Española**

1963–1974 All 14 giant tortoises (2 male and 12 female) were captured and brought to the “Charles Darwin Research Station” on Santa Cruz, where the breeding programme for giant tortoises was initiated. The first incubators for tortoise eggs were simple constructions without insulation: the temperature in the incubators alternated between warm and cold – fortunately! It was not until later that researchers discovered that the breeding temperature determines the sex of the tortoise.

1968 A programme to eradicate feral domestic goats on Española was launched.

1970 First successful nesting grounds were installed at the Station after numerous failures. Eventually, the tortoises laid eggs.

1971 The first tortoise hatched at the Station.

1975 The first 17 baby tortoises were repatriated on Española.

1977 Diego, a male tortoise that had been living in the San Diego Zoo since the 1930s, arrived at the Station. Despite being over 100 years of age, he continued to help rebuild his island’s population.

1978 The eradication of the feral domestic goats on Española was completed (3,344 goats within 10 years).

1990 The first nesting grounds of repatriated tortoises were discovered on Española as well as the carcasses of two tortoise hatchlings that had been killed by hawks.

1991 The first living, newly hatched tortoises were discovered on Española.

1994 At least half of all tortoises repatriated nearly 20 years earlier were still alive.

2000 The 1,000th tortoise was released on Española.

2007 After a total of 1,482 released tortoises, the successful repatriation programme was completed.

2011 Emma, a tortoise equipped with GPS, provided interesting data about activities of giant tortoises.

**Rescue of land iguanas on Santa Cruz and Isabela**

In 1959, there were still a large number of land iguanas living on both islands, but in 1975, wild dogs wiped out most of the existing colonies. In order to rescue them, the remaining population was captured. However, the hastily built breeding and care centre soon ran out of space. Therefore, 38 land iguanas were released on the small island of Venecia, where they were kept in “semi-captivity”. As the ground on the island was inadequate for the iguanas to deposit their eggs, 100 cu. m of soil were transferred from Santa Cruz. When the wild dogs on South Isabela and North-West Santa Cruz had been eradicated, the land iguanas were successfully reintroduced.
Exemplary projects for nature conservation

**Rat control to protect the Galápagos petrels**

The Galápagos Petrel *Pterodroma phaeopygia* is one of six endemic seabirds. This long-lived bird nests in the highlands of Santa Cruz, Santiago, Floreana, San Cristóbal and Isabela. The populations of these five islands vary in their body features (e.g. feathering), but also in the size of their eggs and their calls. Also, they breed at different times of the year. The petrel nests in burrows where its eggs and chicks are preyed upon by introduced cats, pigs and rats in particular, which is why the Galápagos petrel is threatened with extinction. Since 1981, poisoned baits have been used to reduce the rat populations during the bird’s breeding season. This successful programme has led to an increase in the petrel population in recent years.

**The Galápagos Petrel is a long-haul traveller**

The Galápagos Petrel’s habitat during the non-breeding season (i.e. most of the year) was unknown until recently. Thanks to a project conducted by Carolina B. Proaño (Max Planck Institute for Ornithology, Radolfzell), in which ten birds were equipped with GPS transmitters, the migration routes have now been discovered. Within only 17 days, the birds travelled up to 5,281 km, which means that they fly far beyond the marine reserve limits in their search for food. While the birds on Santa Cruz mainly fly east, to the coast of South America, the birds on Floreana set out southwest, far into the Pacific Ocean.

**How land iguanas got from Baltra to Seymour – and back**

“Why are there land iguanas living on Baltra, but not on the similar island of Seymour nearby?” an American expedition team wondered in 1932. On the spur of the moment, the researchers captured several dozen land iguanas on Baltra and released them on Seymour. Sixteen years later, the land iguanas were still abundant on Baltra, but another six years later, all the iguanas were gone. Their extinction was attributable to the consequences of the American military air base that was built on Baltra during World War II. Direct habitat destruction, heavy traffic and introduced domestic dogs, cats, rats and goats aggravated the problem.

It was therefore only natural to fall back on the offspring of the Baltra iguanas, which had been released on Seymour in 1932, and to reintroduce them on Baltra. In the breeding station, young Seymour land iguanas were raised and then returned to the wild. Since 2008, a viable population of land iguanas has been living on Baltra again.

**Biological control**

The Cottony Cushion Scale *Icerya purchasi* was reported in Galápagos for the first time in 1982 and has, since then, colonised 15 islands. It has infested at least 62 native or endemic plant species, 16 of which are listed as threatened in the Red List published by the IUCN (International Union for the Conservation of Nature). This scale insect damages the plants, stunting their growth.

In a programme launched in 2002, Australian Ladybirds *Rodolia cardinalis* are being successfully used to control the scale insect. However, before the ladybirds were released on the Galápagos Islands, they had to pass numerous tests. Scientists had to be sure that the ladybirds would really just eat the scale insect and not native insects, and that their eating habits did not have any negative effects on the native birds. The ladybirds passed all the tests with flying colours. In 2002, they were released on ten islands. Meanwhile, they have been established successfully on other islands and are reducing the Cottony Cushion Scales on native plants (including the white mangrove, acacia species and scalesia). The reason why certain plant species are still infested by Cottony Cushion Scales is the subject of further research.

This successful programme, launched by Mark and Christina Hoddle (University of California) and Roy Van Driesche (University of Massachusetts), together with Charlotte Causton (Charles Darwin Foundation), was supported financially in 2002 by the “Swiss Association of Friends of the Galápagos Islands”. For further information on this programme visit:

http://www.biocontrol.ucr.edu/rodolia/rodolia_icerya_biocontrol_Galápagos.html
In January 2001, the tanker “Jessica” ran aground off the San Cristóbal coast. Around 600 tons of crude oil spilled into the ocean. Winds and currents soon pushed the oil slick far away from the islands into the open sea. Only few animals died as a direct result of the oil spill. Since oil pollution on the islands’ beaches was low, the authorities gave the all-clear.

Serious population losses are no exception
Changes in ocean current conditions, known as El Niño, regularly warm up the ocean to such an extent that most algae die off. As Marine Iguanas feed exclusively on marine algae, up to 90% of the entire population on certain islands died of starvation after the 1997 El Niño. Researchers also recorded serious population losses due to the same cause in 1983, 1988 and 1992. Otherwise, adult Marine Iguanas mostly die of old age, because they have virtually no enemies.

The search for the cause of death
Before and after the tanker accident, there were no El Niño episodes. Thus, the widespread deaths on Santa Fé must have had another cause. The iguanas could not have been directly poisoned by the oil spill, since they died a full year after the accident. The algae pastures on which the iguanas feed were also intact, and as the iguanas kept on eating the same amount of algae as before, a change in the taste of the algae could not be the cause either. The research teams ultimately found that the oil had damaged the iguanas’ gut flora. Their malfunctioning digestion led to severe stress and eventually caused their death.

Long-term research reveals the cause
The tanker accident, although classified as low impact, had serious long-term consequences for the Marine Iguanas. Without the many years of prior study of the Marine Iguanas on the two islands, this correlation could never have been discovered. This is also one of the few examples where the creeping consequences of “low-risk” environmental pollution have been examined at all.

One year after the tanker accident, Martin Wikelski, biologist at the German Max Planck Institute for Ornithology, and his team found a great number of Marine Iguana skeletons on Santa Fé. They estimated the loss at around 15,000 iguanas, which corresponds to 62% of the island’s entire population. No skeletons were found on Genovesa Island, located considerably further away from the tanker accident site. It therefore seemed likely that there was a connection between the oil pollution and the death of the iguanas on Santa Fé. In order to prove this, researchers pored over the data on the Marine Iguana populations on both islands that had been gathered over 20 years.

Marine Iguana skeletons: an unpleasant surprise
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Read more about Marine Iguanas on page 60

The Mangrove Finch of Galápagos is among the rarest bird species and is critically endangered. It has already disappeared from Fernandina and can now only be found in a small number of mangrove forests on Isabela. Most of the Mangrove Finch population, which numbers around 100 birds, is located in two large mangrove forests, the only places where they still breed. Thanks to a broad-based monitoring and research programme, it has become clear that the main reason for the decline in their population is their low breeding success. The main reasons for this are parasites and predation by rats. The birds’ breeding success has been improved by exterminating the introduced fly species Philornis downsi, whose parasitic larvae infest the nestlings and cause their death. It is not possible to simply use insecticides, as this would also destroy the native insects. Therefore, the nestlings must be treated directly with insecticides, but the nests are often located so high up in the trees that it is difficult to reach them. Tests are now being conducted to see whether it is possible to trap the flies by attracting them with pheromones.

A far-reaching education programme was implemented in the inhabited south of Isabela in order to teach the resident population about the importance of the Mangrove Finches and the mangrove forests for the ecosystem – even if scarcely anybody ever catches sight of one of these rare finches.

Mangrove Finches can only survive in the long term if their distribution is extended to more mangrove forests. New populations must therefore be established by reintroducing the birds to deserted mangrove forests. This is being done by transferring finches from the existing populations. The first transfers have already been carried out in suitable mangrove forests.

Exemplary projects for nature conservation
Endangered bird species – the Mangrove Finch Camarhynchus heliobates
Ninety-five per cent of the Galápagos Islands form the Galápagos National Park, which is governed by Ecuador. Two institutions look after the park: The "Galápagos National Park Service" on the one hand and the "Charles Darwin Foundation", which operates a care and breeding centre for giant tortoises and iguanas, on the other. The Park Service employs rangers and guides and supervises tourism, while the foundation runs research and nature conservation programmes. Together, they have the primary responsibility for nature conservation and for ensuring sustainable development on the islands.

www.darwinfoundation.org
www.galapagospark.org

1959 The "Charles Darwin Foundation" was established with the support of the IUCN (International Union for the Conservation of Nature) and UNESCO. Ecuador founded the Galápagos National Park.

1960 As the first director of the research station, Raymond Lévêque from Switzerland decided to build the station on Santa Cruz, thus turning the island into the archipelago’s primary research and travel destination.

1964 Opening of the "Charles Darwin Research Station", including a herbarium (accommodating today’s largest plant collection on the Galápagos Islands), in Puerto Ayora.

1965 Start of the giant tortoise reintroduction programme.

1968 The National Park started its operations.

1971 Lonesome George, the last remaining Pinta Galápagos Tortoise, was discovered. From 1972, he lived at the "Charles Darwin Research Station", where he died in 2012.

1972 Scholarships and voluntary programmes for Ecuadorian students.

1976 Start of the land iguana reintroduction programme.

1978 UNESCO recognised the islands as a World Heritage Site.

1984 UNESCO recognised the national park as a Biosphere Reserve.

1998 Establishment of the Galápagos Marine Reserve. Start of "Project Isabela" (largest goat eradication and ecosystem restoration programme worldwide). Opening of the environmental education centres on Santa Cruz, San Cristóbal and Isabela to the public.

2000 UNESCO extended the World Heritage Site to include the marine reserve. The IUCN included all endemic plants of Galápagos in their Red List of Threatened Species. Accident of the oil tanker "Jessica".

2003 Ecuador enacted the law for total control of introduced species in Galápagos.

2007 The Ecuadorian president declared that the protection of Galápagos was a matter of vital national importance. UNESCO put the Galápagos Islands on its List of World Heritage in Danger.

Today Apart from the introduced animals and plants, tourism and the resulting population growth pose the primary challenges for nature conservation. Tourism on Galápagos generates a great deal of money, but not all of it is used for nature conservation projects.

Fishing in the Galápagos Marine Reserve is regulated. Indigenous fishermen are allowed to fish under certain conditions. Fishermen from the continent are not allowed to fish at all. However, illegal fishing is thriving, and this is a big problem for nature conservation, affecting especially sharks, tuna and sea cucumbers. In order to find the criminal fishermen, the reserve is monitored by ships and planes under the management of the Galápagos National Park Service (GNPS). Since the implementation of a Satellite Vessel Monitoring System, the number of illegal fishing vessels captured has increased significantly.
Sustainable commitment to Galápagos

Since 1994, the Swiss Association of Friends of the Galápagos Islands has been committed to protect and preserve the unique biodiversity of the Galápagos Islands. One of the association's core missions consists in ensuring the training and education of local experts. Thanks to our 1,500 members, 30 projects involving approx. CHF 1.5 million have been funded.

For additional information: www.galapagos-ch.org
Tourist checklist

Both on board and on the islands, casual and sporty clothing is in order (luggage: max. 20 kg)

- T-shirts or blouses/shirts with long or short sleeves
- warm sweater
- shorts and trousers
- underwear, socks
- waterproof/windproof clothing
- hiking boots
- sturdy hiking sandals that are all right to get wet
- sunscreen (min. SPF 15 needed!)
- After Sun lotion
- sunglasses
- broad-brimmed hat
- swimming costume
- two towels
- snorkelling gear
- wetsuit
- insect repellent
- toiletries, personal medication
- medication against seasickness
- water bottle
- passport
- enough US dollars, small notes (USD has been the official currency in Ecuador/Galápagos since 2000)
- backpack in waterproof kit bag for field trips
- camera including rolls of film (Galápagos 100 ASA) or memory cards, batteries or charging device
- UV filter for camera lens (recommended)
- waterproof camera case for wet landings
- travel alarm clock
- binoculars
- torch
- pocket knife
- writing utensils
- guide book
- dictionary (Spanish-English)
- games
- sundowner ingredients

Researcher checklist

Field work in Galápagos with mockingbirds

About 140 kg sent as cargo (camping and field work equipment e.g. for bird catching and banding, liquid nitrogen tank, etc.) plus 20 kg of check-in luggage per person (clothes, waterproof bags, books, etc.)

- old T-shirts with short and long sleeves
- sweater
- old shorts and trousers
- underwear, socks
- good waterproof clothing
- sturdy hiking boots, spare shoelaces
- sturdy hiking sandals
- sunscreen
- After Sun lotion
- sunglasses
- broad-brimmed hat, bandana
- swimming costume, towels
- snorkelling gear
- face flannel, clothes pegs
- tents, sun canopy, poles and ropes
- tent repair kit, tent seam sealing tape
- sleeping bag, mat
- cooker, pots, cooking spoon
- gas cartridge, spare gas cartridge
- lighters, spare lighter, 5 matchboxes
- cutlery, crockery, chopping board, bowl, sharp knives
- rubbish sacks
- plastic bucket
- water bottles
- field chairs
- hammock
- toilettes, personal medication, hand mirror, insect repellent, tweezers
- first-aid kit (antibiotics, antihistamines, painkillers, sticking plasters, blister plasters, bandage, splint, disinfectant, etc.)
- book “Where there is no doctor”
- satellite telephone, radio devices
- passport
- organise crossings to the lonely islands (dates, important phone numbers of the people involved)
- dictionary (Spanish-English)
- book “Birds of Galápagos”
- book “Flowering Plants of Galápagos”
- book “Reef Fish”
- permits for the Galápagos National Park, Ecuador
- customs declaration (ATA Carnet): import and export of expensive devices
- permits for the importation of samples into Switzerland from the Federal Veterinary Office
- organise transport of research material CH-Guayaquil-Galápagos (especially of frozen samples in the liquid nitrogen tank)
- 2 binoculars (min. 8 or 10x42)
- good head torch, 2 spare batteries, 2 shake torches
- alarm clock
- good pocket knife, Leatherman/Victorinox Multitool
- duct tape
- repair kit containing wire, string, cable ties, pliers, screwdriver, screws, glue, duct tape, etc.
- folding shovel
- tarpaulin
- shock-resistant cases for the research material, aluminium boxes, padlocks
- plastic and aluminium rings, pliers, stopwatch, needles, 1-20 µl pipette, wing measuring ruler, Cryomarkers, PVC glue, tweezers, nail scissors, ballpoint pens, bird banding journals, Pesola spring scales (50 kg, 100g, 300g), 1,000 Eppendorf tubes, 27 bird bags
- storage boxes, calliper, bird traps, bananas for baits, needles, disinfecting wipes, liquid nitrogen tank, capillaries, several waterproof markers, liquid CO2 in a tank, scissors, blood stopper, beaker, GPS devices, 2 small memo notepads, 2 compasses, 2 thermometers, handkerchiefs, leather gloves, disposable gloves, distilled water, liquids for the storage of samples, alcohol swabs, syringe box, laboratory labels (prepared in advance), notebook
- booklet with waterproof paper, waterproof pens
- computer (will only be used in the village, not in the field) and replacement battery
- solar panels with battery and replacement battery
- nets for catching birds
- net repair kit
- bird traps
- US dollars in cash, small notes (USD is the official currency in Ecuador since 2000), credit card
- backpack and waterproof kit bag
- camera including memory cards and batteries or charging device in weatherproof cases
- UV filter for camera lens
Welcome to the Galápagos Islands!

As a visitor to this National Park and World Heritage site, please do your part to promote their conservation.

- Visitors to any protected areas in the National Park have to be accompanied by a licenced Galápagos National Park Guide.
- If you want your trip to Galápagos to be an enjoyable one, please use the service of authorized tour operators and / or tour boats.
- For your own safety and to help protect the plants and animals, please stay within the marked trails.
- Please keep your distance from the wildlife. A distance of two metres (6 ft) is required. Do not touch plants or animals or allow them to touch you.
- To help protect the balance of nature, do not feed the wildlife.
- Do not use flash when photographing the wildlife; it can alter their natural behaviour. Professional photographers and filmmakers must have National Park authorization.
- To use the authorized camping sites, you must obtain authorization from the National Park office.

Please fully cooperate with the environmental inspection and quarantine services during your visit. Introduced plants, animals and certain types of food which are not native to the islands are a very serious threat to the Galápagos ecosystems.

- Do not remove anything from the islands.
- Do not buy any souvenirs made from black coral, shells, volcanic rock or any animal or plant parts.
- It is illegal to catch and eat certain marine animals outside the fishing season. Please report any such activity to the authorities.
- Leave the surroundings intact. Do not inscribe or disfigure rocks, trees or walls in any way.
- Take all types of rubbish back with you to the populated areas and dispose of them in the appropriate recycling containers.

The following activities are strictly prohibited:

- smoking and making camp fires
- motorized aquatic sports
- using mini-submarines
- air sports
- any type of fishing activity, including from tour boats
When carrying out field research in the Galápagos National Park (GNP), the following rules must be observed (an extract from the rules set down by the GNP):

**Before field work:**
- Submit the project proposal to the GNP for approval at least 6 months before the start of the field work.
- General collecting of samples for museums or similar institutions is strictly prohibited.
- The GNP does not allow collecting of endemic animals or animal parts. Exceptions can be made if the research is extremely important for the survival of the species.
- Field work in tourist areas is strictly prohibited.
- The field work may not cause any damage (or only minimal damage).
- Putting marks on animals and plants as well as placing landmarks is only permissible if absolutely necessary. Remove completely after use.
- The field work area may only accommodate 2 to max. 5 people at the same time.
- The training of Ecuadorian staff is very important to the GNP. For this reason, 50% of the field assistants must be citizens of Ecuador.
- Equipment should be kept in aluminium boxes or airtight plastic containers.

**During field work:**
- On arrival in Santa Cruz, you must report immediately to the Director of the GNP in Puerto Ayora with the letter of approval for your project. Here, you will receive definite permission to carry out the project.
- You will first be held in quarantine for at least 3 days.
- All clothes, shoes and equipment will be inspected and then cleaned in order to avoid the introduction and distribution of non-native seeds and organisms.
- 72 hours before leaving for the field, you may not eat anything containing seeds (e.g. tomatoes, passion fruits, guavas, raspberries) because seeds are not digested and could end up in places where they do not belong.
- You may only bring food products that do not contain any seeds, e.g. yucca roots, potatoes, carrots, beet roots, radishes, garlic, onions, bananas, breakfast cereals.
- If several islands have to be visited, you must go back into quarantine on Santa Cruz before each trip to another island in order to avoid accidental distribution of non-native organisms between the islands.
- Before returning home, researchers should be prepared to spend 3 more days in quarantine, especially if they want to take back samples.

**After field work:**
- Before leaving the Galápagos Islands, a two-page research report must be handed in to the GNP.
- Within a year after their trip, researchers must submit a final report in Spanish to the GNP. It must state, among other things, in what way the research results may help with the protection of the Galápagos Islands.
Invertebrates

Silver Argiope
*Argiope argentata*

Sally Lightfoot Crab
*Grapus grapsus*

Painted Locust
*Schistocerca melanocera*

Genus Bulimulus 162 species

Nerite Snail
*Nerita scabricosta*

Fish

White-Tipped Reef Shark
*Trienodon obesus*

Juvenile Salema of the genus *Xenichthys* or *Xenocys*

Reptiles 1

Pinzón Galápagos Tortoise
*Chelonoidis ephippium*

Española Galápagos Tortoise
*Chelonoidis hoodensis*

Santa Cruz Galápagos Tortoise
*Chelonoidis porteri*
This roughly 50-year old Galápagos giant tortoise *Chelonoidis* sp., a female named Cazuela, was caught in the wild and brought to Wilhelma Zoo in Stuttgart in 1966. From 2002 to 2010 she lived at Zurich Zoo, the only zoo in Europe which successfully breeds Galápagos giant tortoises.
Wildlife Guide to the Exhibition

**Birds 1**

Galápagos Penguin  
*Spheniscus mendiculus*

Waved Albatross  
*Phoebastria irrorata*

Red-billed Tropicbird  
*Phaethon aethereus*

Brown Pelican  
*Pelecanus occidentalis*

Nazca Booby  
*Sula granti*

Blue-footed Booby  
*Sula nebouxii*

Flightless Cormorant  
*Phalacrocorax harrisi*

Great Frigatebird  
*Fregata minor*

Striated Heron  
*Butorides striata*

Greater Flamingo  
*Phoenicopterus ruber*

Galápagos Hawk  
*Buteo galapagoensis*

Swallow-tailed Gull  
*Creagrus furcatus*
Wildlife Guide to the Exhibition

Birds 2

- Brown Noddy
  - *Anous stolidus*
- Galápagos Dove
  - *Zenaida galapagoensis*
- Short-eared Owl
  - *Asio flammeus*

- Large-billed Flycatcher
  - *Myiarchus magnirostris*
- San Cristóbal Mockingbird
  - *Mimus melanotis*
- Galápagos Mockingbird
  - *Mimus parvulus*

- Floreana Mockingbird
  - *Mimus trifasciatus*
- Large Ground-Finch
  - *Geospiza magnirostris*
- Common Cactus-Finch
  - *Geospiza scandens*

- Small Tree-Finch
  - *Camarhynchus parvulus*
Wildlife Guide to the Exhibition

Mammals

Galápagos Rice Rat
Aegialomys galapagoensis

House Rat
Rattus rattus

Domestic Dog
Canis lupus familiaris

Galápagos Sea Lion
Zalophus wollebaeki

Galápagos Fur Seal
Arctocephalus galapagoensis

Domestic Goat
Capra hircus
# Reptiles of the Galápagos archipelago

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- **Origin**: endemic, native, introduced
- **IUCN red list**: Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Not Threatened
- **Distribution**: Inhabited island, Uninhabited islands, Unassigned records

---

*Note: The table above lists bird species found in the Galápagos archipelago, including their scientific names, origin, IUCN red list status, and distribution.*
# Birds 2

## Bird species of the Galápagos archipelago

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## Mammals

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<tr>
<td>European Rabbit</td>
<td>Oryctolagus cuniculus</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Domestic Sheep</td>
<td>Ovis aries</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Brown Rat</td>
<td>Rattus norvegicus</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>House Rat, Black Rat</td>
<td>Rattus rattus</td>
<td>x</td>
<td>x x x</td>
</tr>
<tr>
<td>Cotton-top Tamarin</td>
<td>Saguinus oedipus</td>
<td>x</td>
<td>x x</td>
</tr>
<tr>
<td>Domestic Pig</td>
<td>Sus scrofa domesticus</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Galápagos Sea Lion</td>
<td>Zalophus wollebaeki</td>
<td>x x x</td>
<td>x x x x</td>
</tr>
</tbody>
</table>

## Amphibians

### Amphibian species of the Galápagos archipelago

<table>
<thead>
<tr>
<th>Species (<em>official English name inexistent</em>)</th>
<th>Scientific name</th>
<th>IUCN red list</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Origin</strong></td>
<td><strong>Extinct</strong></td>
<td><strong>Critically Endangered</strong></td>
<td><strong>Endangered</strong></td>
</tr>
<tr>
<td>Snouted treefrog *</td>
<td>Scinax quinquefasciatus</td>
<td>x</td>
<td>x x x</td>
</tr>
</tbody>
</table>

*Species of the Galápagos archipelago have specific endemic and introduced statuses.*
Ein Vergleich mit der Schweiz, die viel nördlicher liegt als Galápagos, zeigt, dass das Alpenland rund doppelt so viele Arten Säugetiere hat wie Galápagos. Die Schweiz war die Heimat vieler der Tiere, die auf Galápagos lebten, darunter die Conolophus. Die Schweiz ist auch bekannt für ihre vielen Arten von Pflanzen und Tieren, die auf den Inseln von Galápagos auch zu finden sind.

Wenige Arten auf den Inseln ... sind an die extreme Trockenheit bestens angepasst. Sie konnten sich auf Galápagos sogar in zahlreiche Arten aufspalten.

Das zeigt ein Vergleich mit dem Yasuní Nationalpark im Osten Ecuador, wo es beispielsweise 40 mal mehr Süßwasserfischarten, 16 mal mehr Walrossarten, 30 mal mehr Funkelschnäpfen, 40 mal mehr Schlangenarten, 30 mal mehr Vogelarten, 15 mal mehr Bienenarten, 60 mal mehr Käferarten und 10 mal mehr Fledermausarten gibt als in Galápagos.

Inseln, Hawaii, Island, Kanarische Inseln oder die Azoren standen nie in Verbindung mit dem kontinentalen Festland. Es war sehr schwierig, Tiere von Inseln auf Inseln zu bringen, da sie oft nicht über die weite Strecke übers Meer schaffen. Ein Beispiel für diesen Prozess ist der Vulkan Wolf auf Isabela, der einzigartig in Galápagos ist. Er hat eine Wanderleistung von über 10 km, was ihn zu einem Rekordhalter unter den Echsen macht. So legt ein Weibchen aus der Küstenregion über 10 km zurück, wobei es mit den Vorderfüßen das Kaktusstück auf dem harten Boden herumrollt. Kleinere Stacheln werden mitge-
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<thead>
<tr>
<th>Page</th>
<th>Image nr. and credit</th>
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<td>83–85</td>
<td>ZMUZH</td>
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<td>1 Greg Estes / Thalia Grant, 2 Hendrik N. Hoeck</td>
</tr>
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<td>1 ZMUZH, 2,3 Raymond Léveque</td>
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<td>1, 2 Hendrik N. Hoeck, 3 Galápagos National Park</td>
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<td>1, 2, 4 Greg Estes / Thalia Grant, 3, 5 ZMUZH</td>
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<td>107</td>
<td>1–3, 5 ZMUZH, 4 Christine Parent</td>
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<td>1 Greg Estes / Thalia Grant, 2–6 ZMUZH</td>
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