Drawing of Charles Darwin made in 1840 by George Richmond,
and discovered in the Cambridge University Botany School in 1932
by his grand-daughter, Lady Barlow, and Prof. Seward.
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NOTICIAS DE GALAPAGOS

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NEWS FROM ACADEMY BAY

ONE HUNDRED AND FIFTY YEARS AGO

In September-October 1835 Charles Darwin spent 32 days in the Galapagos Archipelago. He was 26 years old and had had little formal scientific education. Nevertheless what he saw in the Galapagos, when he had had time to digest it, became one of the principal factors in the development of his theory of evolution, which provoked the greatest intellectual controversy of the century. As Sir Julian Huxley, Founder Member and Honorary President of the Charles Darwin Foundation expressed it so eloquently:

> "It was in the Galapagos in the early autumn of 1835 that Darwin took the first step out of the fairyland of creationism into the coherent and comprehensible world of modern biology."

As articles in this issue explain, Darwin's conversion to evolution did not come about quite so dramatically but without his Galapagos experience it is doubtful whether he would ever have written *The Origin of Species*. Darwin owed much to the Galapagos: the Galapagos owe much to Darwin. Without their association with his great work, the islands might not have been declared a National Park in 1959 nor subsequently given World Heritage status.

THE GREAT FIRE ON ISABELA

The conflagration on the Sierra Negra volcano lasted from February to July 1985. By April the fires were more or less under control and the Ecuadorean armed forces and civil defense firemen were withdrawn, but the National Park wardens remained on guard until after the rains finally began in the last days of June. This disaster attracted more attention from the media than any event in Galapagos history. (If only comparable attention could be paid to the financing of conservation!). The event also generated an unprecedented volume of misinformation even for these islands which have always been a fertile breeding ground of myths. The sealions, marine iguanas, penguins, flightless cormorants, which caused much concern, were never in danger from the fire. As a precautionary measure the National Park Service concentrated a number of the endemic Sierra Negra race of giant tortoise in a corral in case it should be necessary to evacuate them by helicopter but, thanks to the exertions of the local authorities and the National Institute for the Galapagos (INGALA), backed by help from mainland Ecuador, Canada and the USA, the fires were eventually contained.

The true damage may be greater than the false rumours. Some 300-400 square kilometres of wilderness, still barely explored botanically, have been devasted and the vegetation on which all life depends has been largely wiped out. The Darwin Station's acting botanist, Henning Adsersen, supported by forestry students Jorge Escobar and Guillermo Prado, made a preliminary survey along the fire line from 220 metres altitude to the caldera rim (1000m). They established that the fire had burned deep, consuming the organic matter accumulated over the centuries. This may prove the most serious botanical effect of the fire. How revegetation is to come about and what form it will take are questions that will not be answered for years, or decades. No generalization about the various tree species is possible: for instance *Pernettya Lowelli* may grow again from its roots but *Darwiniothamus tenuifolius* will only grow from seed. Some trees will need more than half a century to grow to their full size. And then there are the small animals and organisms that could not escape the flames, about which so little is yet known.

Another source of anxiety is the probable introduction of alien organisms by the gallant firefighters. Scientists working in these ecologically sensitive areas have to disinfect their clothes, equipment and food but such a routine was obviously impossible in these circumstances. A roadway had to be opened from the coast to the rim of the volcano to get water to the fires inside the caldera. The long term consequences of this human invasion are unpredictable. Much monitoring and research will be needed.

The fire was a major ecological disaster. The only possible good that came of it was the worldwide publicity and the implicit recognition of the universal importance of the Galapagos. The fact that the splendid support of the local and national authorities was backed up by generous international aid may, we hope, be a presage for more practical international concern for this World Heritage Site in the future.

Fireline on Sierra Negra Volcano built by the Army of Ecuador
Photo: CDRS

CAMPAIGN FOR A CDF ENDOWMENT FUND

Disasters such as the Isabela fire, again draw attention to the fact that the Charles Darwin Foundation has never been adequately financed. The Research Station's conservation and scientific work continues to be funded annually on a precarious hand-to-mouth basis with no reserves to meet emergencies. Even without such cataclysms, which are to be expected in the wild Galapagos, the Station often finds itself unable to meet basic commitments, such as wages, because the amount and timing of contributions is unpredictable. For lack of cash, programmes have to be interrupted or abandoned. In order to counteract this recurring threat, The Nature Conservancy has agreed to mount a campaign to raise an endowment fund of US.$1,500,000 during 1985-86. A distinguished campaign committee has been formed under the chairmanship of Mr. S. Dillon Ripley, Founder Member of the CDF and Secretary of the Smithsonian Institution, 1964-84. The income from a fund of this size would not nearly meet the Darwin Station's need of half a million dollars a year but it would at least provide a cushion to meet core expenses and avoid wasteful disruption of conservation projects when promised funds do not arrive on time. It is taxing the generosity of CDF supporters to ask them to make a once-only donation to this endowment fund in addition to their annual subscription. The only justification for such a request is to point to the universal significance of Galapagos conservation and to remind our friends of the successful role the Darwin Foundation has played in preserving this unique environment in an era when vast areas of wilderness are destroyed each day.

Contributions, earmarked *"for the Campaign for the Galapagos Islands"*, may be made through national WWF organisations or directly to The Nature Conservancy, International Program, 1785 Massachusetts Avenue NW, Washington D.C. 20036.

THE EXTRAORDINARY CONSEQUENCES OF THE EXTRAORDINARY EL NINO

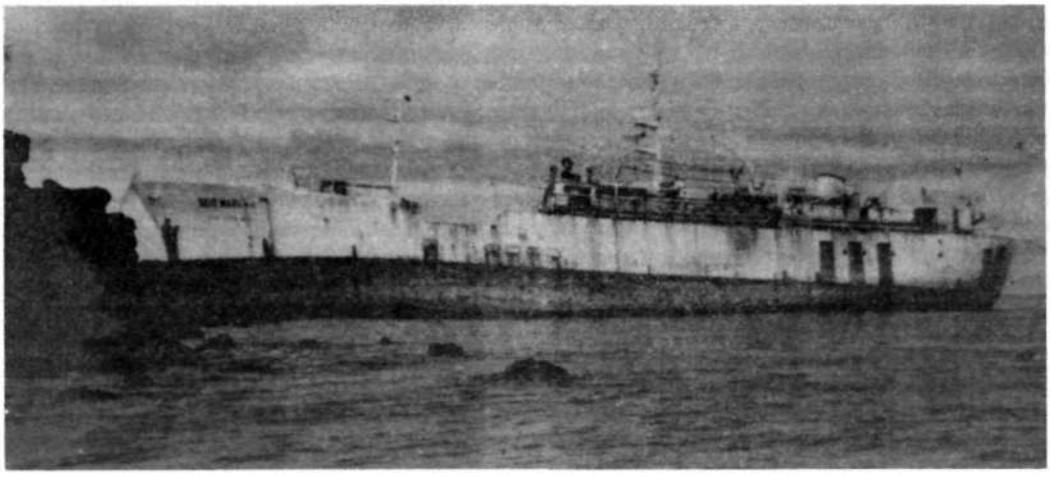
The abnormal *El Niño* event of 1982-83, with high ocean temperatures and tremendous rainfall, did grave damage to virtually all life dependent on the sea. Algae, fish, marine iguanas, fur seals, sealions and seabirds all suffered heavy losses and their numbers were drastically reduced (Noticias 41). However by the middle of 1985 a widespread and often spectacular recovery had taken place. The breeding of the worst affected species was particularly vigorous and in some cases populations had already returned to pre-crisis levels.

In contrast, the event that brought disaster to marine animals produced a veritable population explosion among the landbirds. This situation was violently reversed when a prolonged drought began in 1984 and decimated these swollen populations. (Rainfall measured at the Darwin Station for comparable periods fell from 3,264mm to 151mm). The supply of vegetable and insect food was reduced, many birds did not even try to breed and the struggle for survival was intensified. However distressing, the drastic effects of unprecedented rainfall followed by severe drought have provided a golden opportunity for scientists studying evolution by natural selection. Peter Grant, the leader of a team making a ten year study of Darwin's finches and mockingbirds, considers that this is a chance that will not be repeated in our lifetime and perhaps not during that of the next generation. It makes possible the study of how extreme conditions affect the evolution of species and thus may throw light on some of the factors governing natural selection. There could hardly be a more appropriate research project on this 150th anniversary of Charles Darwin's visit.

A book is in course of preparation, composed of articles by a score of scientists working in the Galapagos, dealing with the effects of this exceptional El Niño event on their specialist fields of study.

ETERNAL VIGILANCE

As though disasters by fire and flood did not create enough problems for the staff of the Darwin Station, a Japanese cargo ship crashed into the cliffs of Pinta and got stuck on the rocks. This remote and rugged island has been the scene of one of the longest and most expensive campaigns to eliminate the thousands of feral goats that were rapidly destroying the vegetation and causing erosion. Just as the goat problem was nearing solution, this wreck posed a new threat: rats might get on shore as easily as the ship-wrecked crew did! However the station sent Lucho Calvopiña and his mammal control team to the island and they were happy to report that, though they had to clear up a lot of the sailors' trash, they could find no trace of rats. Nor was there any serious oil spillage. This time we seem to have been lucky. The preservation of the Galapagos environment depends on constant vigilance.



The Wreck on Pinta Island
Photo by Lucho Calvopina

DARWIN'S "DOGGED" GENIUS: HIS GALAPAGOS VISIT IN RETROSPECT

by

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One hundred and fifty years ago, on 16 September 1835, Charles Darwin landed in the Galapagos Islands and began five weeks of collecting and observing in this famous "laboratory of evolution". While in the Galapagos Darwin visited four of the major islands, and he had a good glimpse, from H.M.S. *Beagle*, of numerous others. Altogether he spent nineteen days, some only in part, on land in the Galapagos — five days on Chatham; four on Charles, where he visited the highlands settlement; one day at Tagus Cove on Albemarle Island; and nine days on James, where he collected extensively and spent three days in the highlands.

By current research standards, Darwin's Galapagos visit was remarkably brief. And yet his encounter with these islands was seemingly decisive for his biological thinking. As he wrote in the second edition of his *Journal of Researches:*

> The archipelago is a little world within itself, or rather a satellite attached to America, whence it has derived a few stray colonists, and has received the general character of its indigenous productions. Considering the small size of these islands, we feel all the more astonished at the number of their aboriginal beings, and at their confined range. Seeing every height crowned with its crater, and the boundaries of most of the lava-streams still distinct, we are led to believe that within a period geologically recent the unbroken ocean was here spread out. Hence both in space and time, we seem to be brought somewhat near to that great fact — that mystery of mysteries — the first appearance of the new beings on this earth. (1845: 377-78).

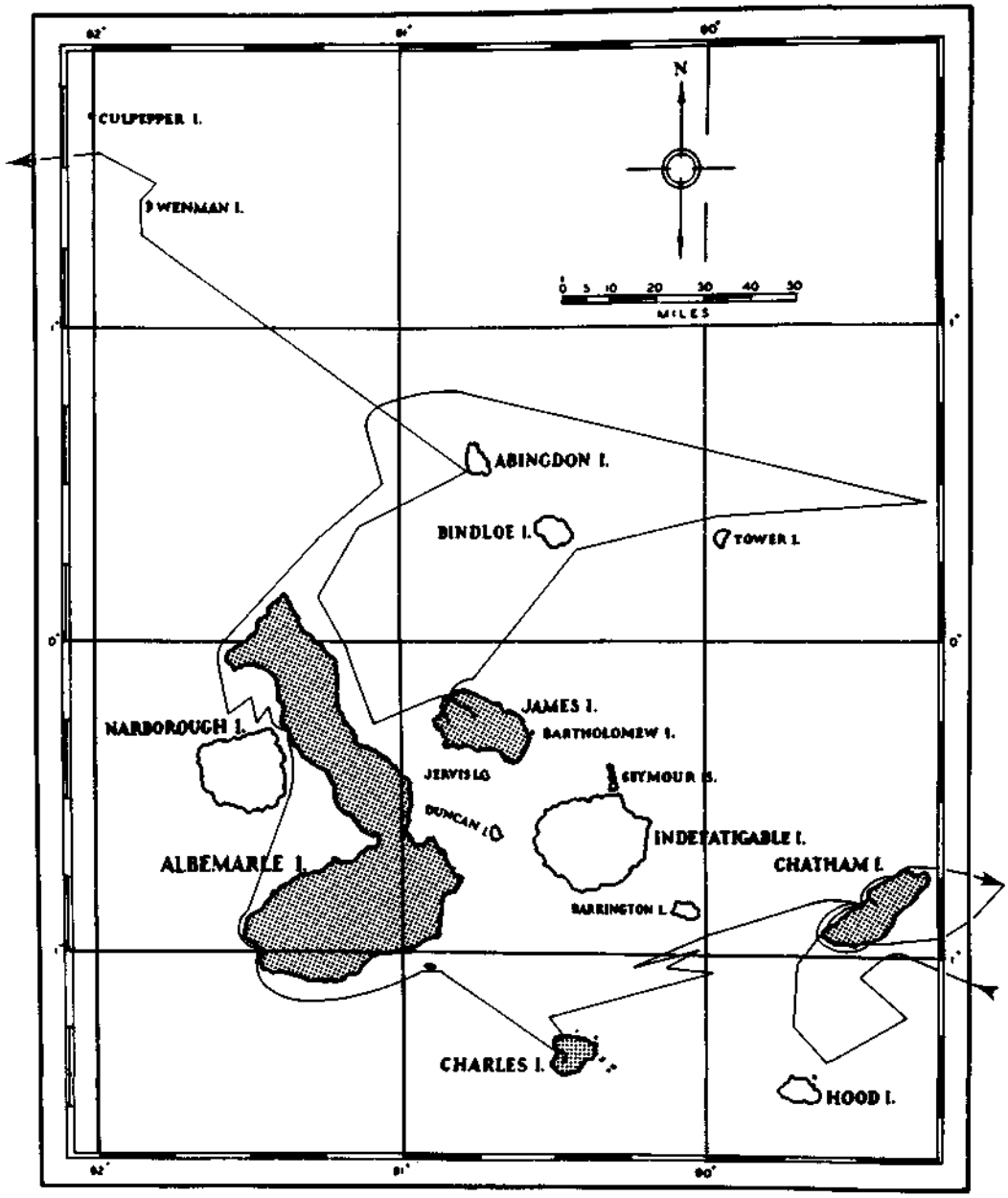
When and how Darwin solved this great "mystery of mysteries", and particularly the role his Galapagos visit played in this regard, have nevertheless become the subject of a considerable legend in the history of science.

Accoding to the legend, Darwin's Galapagos visit first provided him with irrefutable evidence for the mutability of species and converted him, eureka-like, to the theory of evolution. Actually, the impact of the Galapagos was largely retrospective, as I have argued elsewhere (1982a, 1982c, 1984). Thus in order to know precisely what we celebrate in the 150th anniversary year of Darwin's Galapagos visit it is necessary to disentangle myth from historical reality.

Darwin was first alerted to the evolutionary significance of the Galapagos species by the vice-governor, Nicholas Lawson, who informed him that he could tell "with certainty" from which island any tortoise had been brought (1845: 394). Darwin was on Charles Island at the time; and according to David Lack (1947: 23), among other commentators, he was sufficiently impressed to begin separating his collections of finches and other species by island, thus securing the necessary biological evidence to back up the vice-governor's extraordinary claim. What Lack and others did not appreciate, however, was that the bulk of the locality information on Darwin's type specimens and in his postvoyage publications was actually derived, *after* the voyage, from the carefully labelled collections of three other *Beagle* shipmates. Why Darwin initially failed to heed the vice-governor's remarks about the tortoises must be understood in terms of the intimate relationship between a received theory like creationism, no matter how erroneous, and the gathering and perception of scientific evidence.

To begin with, it would never have occurred to a creationist, which Darwin still was in 1835, to label his collections separately by island within a small archipelago. As part of a presumed "center of creation", the Galapagos would have been expected to exhibit a uniform flora and fauna by island, making such detailed locality designations superfluous. In this regard it is noteworthy that those *Beagle* specimens that were carefully labelled by island were collected by the nonscientists on board, who presumably did not realize how unnecessary such information really ought to have been.

We also fail to appreciate how complex and confusing the Galapagos evidence must initially have been, especially to a nonspecialist and nonsystematist like Darwin. It is not just the theory of evolution tha-



Darwin's route through the Galapagos Archipelago in H.M.S. *Beagle*. He visited the four shaded islands and made several inland excursions, also indicated on the map. The occasionally zigzag nature of the *Beagle*'s route reflects the vagaries of winds and currents in the age of sail. (From Sulloway 1984).

The heavily cratered area on Chatham Island, near Stephens Bay, where Darwin made his first extensive geological observations. He explored this region on 21 September 1835 and remarked that the numerous truncated craters "gave the country a *workshop* appearance, which strongly reminded me of those parts of Staffordshire where the great iron-foundaries are most numerous" (1839: 455). Photographed by the author.

introduces unifying order into many of the enigmas of Galapagos biology; creationism also made a certain reasonable, albeit different, sense out of the facts. From his specimen notebooks and manuscript notes it is clear, for example, that Darwin mistook many species of "Darwin's finches" for the forms that they, through adaptive evolutionary radiation, now appear to mimic. Thus he thought the warbler finch was a "Wren"; and he described the large-beaked ground finch as a "Grosbeak" and the cactus finch as an "Icterus" — the genus to which belong the orioles, blackbirds, and certain other forms possessing a long pointed bill. It is perhaps not surprising then that Darwin, having failed to recognise the closely related nature of the Galapagos finches, also failed to suspect that their island distributions might vary within the archipelago.

The evolutionary evidence provided by the famous Galapagos tortoises was also similarly clouded at the time of Darwin's visit. This taxon was then believed by most naturalists to have originated in the islands of the Indian Ocean — hence its erroneous name *Testudo indicus* — and to have been transported to the Galapagos by buccaneers. Thus when Darwin was informed that the tortoises differed by island, he probably initially thought it was a matter of local variations somehow induced by transportal to a new and unnatural environment. Moreover, those tortoises actually seen by Darwin, on Chatham and James, were too similar to be distinguished "with certainty"; so the evidence was not as striking, from Darwin's personal observations, as the vice-governor had claimed. In any event, since tortoises were not supposed to be native to the Galapagos, such differences did not apparently bear directly on the question of what was uniquely "Galapagean", if anything, about the Galapagos. So little value did Darwin place upon the tortoise evidence that he not only failed, at the time of his visit, to collect specimens for scientific purposes, but he apparently co-operated with his *Beagle* shipmates in consuming the last of some thirty large tortoises during the cruise to Tahiti. It was only a decade later that Darwin finally encountered Captain David Porter's (1815) description of the dome-shaped and saddleback forms of tortoise and was able to insert this information into the second edition of his *Journal of Researches* (1845: 394).

The remarkable diversity in the forms of the Galapagos finches is shown here by three species that initially misled Darwin into thinking they were members of separate families or subfamilies: the large-beaked ground finch (*Geospiza magnirostris*), using its powerful jaws to crush a large seed; the cactus finch (*G. scandens*), feeding on the flowers of *Opuntia*; and the diminutive warbler finch (*Certhidea olivacea*) looking for insects in the highland *Scalesia* forests. Photographed by the author on Genovesa (Tower) and Santa Cruz (Indefatigable).

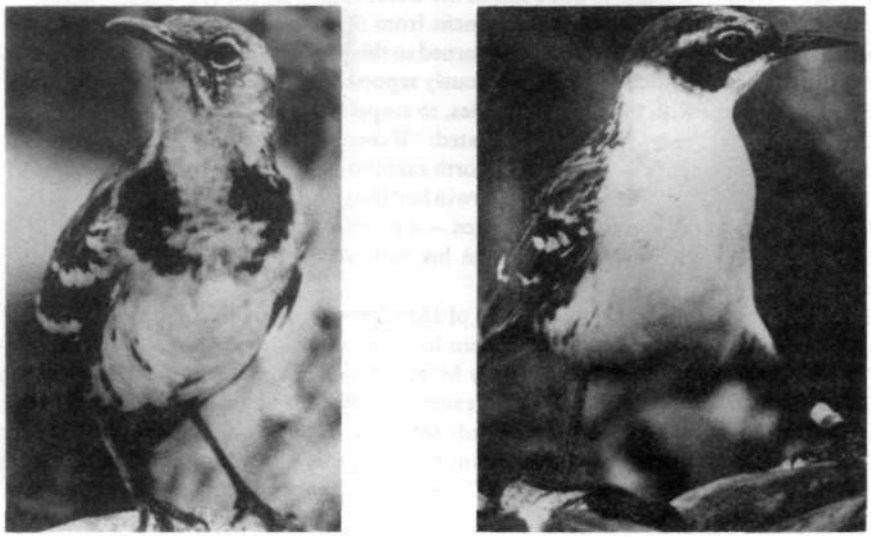
The *Origin of Species* (1859) was never in any real danger, however, of being sacrificed for a bowl of tortoise soup. Darwin *had* noticed, while still in the Galapagos, that the mockingbirds differed by island; and he had taken care to separate these specimens from the four islands he had visited. Approximately eight months after leaving the Galapagos he returned to this problem in his "Ornithology" notes. There he compared this anomalous finding to that previously reported to him about the tortoises. Although he was still inclined, consonant with the fixity of species, to suspect that his mockingbirds were "only varieties" rather than true species, he nevertheless speculated: "If there is the slightest foundation for these remarks the zoology of Archipelagoes — will be well worth examining; for such facts [would *inserted*] undermine the stability of Species" (1963 [1836]: 262). Darwin had thus begun, in a tentative but probing manner, the real process of "discovery" about the Galapagos — a process that lay not so much in his observations or collections during his brief visit but rather in his various reconsiderations of this evidence after his departure.

Following his return to England in the autumn of 1836 Darwin had many opportunities to re-evaluate the Galapagos evidence as expert systematists began to work out his voyage collections and he prepared his *Journal of Researches* for publication. In early March of 1837, he met with the celebrated ornithologist John Gould to discuss the results of Gould's examination of his voyage birds. Gould had immediately appreciated the anomalous but closely related nature of Darwin's Galapagos finches, including the warbler finch, and had named thirteen species in three subgenera. In addition, Gould had pronounced as distinct three of the four island forms of Darwin's Galapagos mockingbirds, thus confirming the suspicions Darwin had previously felt might "undermine the stability of Species". Perhaps just as importantly, Gould convinced Darwin of the highly endemic character of the Galapagos ornithology as a whole, something that Darwin, who had not had access to museum collections during the voyage, had not previously realized. These taxonomic opinions, together with a number of others relating to his collections from the South American continent, finally convinced Darwin that species were indeed mutable and sparked his decision to begin collecting facts that might bear on this question. He subsequently commented in this connection: "In July [1837] opened first notebook on 'Transmutation of Species' — Had been greatly struck from about Month of previous March on character of S. American fossils — and species on Galapagos Archipelago. These facts origin (especially latter) of all my views" (de Beer 1959: 7).

In the wake of his conversion to the theory of evolution, Darwin quickly realized his voyage oversight in failing to label his Galapagos specimens by island. He therefore set out to rectify this problem as best he could by asking other *Beagle* shipmates, including Captain Robert FitzRoy, to supply him with the missing evidence. Unfortunately, later curators at the British Museum failed to appreciate that Darwin's published locality designations in the *Zoology of the Voyage of H.M.S. Beagle* (1841) were not derived from his own collections; and where such information was missing from his own type specimens, they added it to some of the labels, creating a number of erroneous localities. Darwin, moreover, compounded the problem by guessing where eight of his own finch specimens had come from; and in several instances he clearly guessed incorrectly. These various confusions over the type specimen localities created a taxonomic nightmare for subsequent ornithologists, who naturally puzzled over the conflicting and aberrant locality designations on Darwin's specimens and found themselves hard pressed to reconcile this information with present-day distributions of Darwin's finches.

Fortunately, clarification of the retrospective and borrowed nature of the localities on many of Darwin's type specimens has now resolved most of these problems, including the status of several long-debated forms of Darwin's finches (Sulloway 1982b). In particular, *Geospiza magnirostris magnirostris*, an extinct form of the large-beaked ground finch, was collected by FitzRoy and others on Chatham and Charles islands, where David Steadman (1981, 1984) has recently found fossil evidence of this subspecies. Similarly, both Darwin and Fitzroy collected specimens of another extinct subspecies on Charles — a particularly large-billed form of the sharp-beaked ground finch ("*G. nebulosa*" Gould).

Although Darwin (1845: 395) later suggested, based on the joint *Beagle* collections, that the Galapagos finches might have different geographic distributions, he was also aware that the case was a complex one and that his own data on the subject were meagre and probably suspect. Partly for this reason he did not mention his celebrated Galapagos finches in the *Origin of Species* (1859). It is only in this century, after the splendid ornithological studies of Harry Swarth (1931), David Lack (1945, 1947), and many other researchers, that these finches have become such a convincing paradigm of evolution in action. In keeping with the Darwin-Galapagos legend, however, much of this modern evidence is often erroneously attributed to Darwin. For example, he never saw all thirteen species of Galapagos finches (Gould's



Left: the Charles Island mockingbird (*Nesomimus trifasciatus*), showing the distinct breast banding that probably first alerted Darwin to the island differences among these birds; *Right:* the Galapagos mockingbird (*N. parvulus*), which Darwin later collected on James Island. Photographed by the author on Champion (near Charles) and Santa Cruz (Indefatigable).

thirteen "species" encompassed only nine of the presently recognized forms), and he was also unaware that differences in the beaks were correlated with differences in diets.

Even after he had finally become an evolutionist in 1837, Darwin's understanding of the Galapagos Islands continued to undergo a slow evolution of its own. The mockingbirds and tortoises had convinced him of the importance of geographic isolation in the evolution of new species; and in 1838, after reading Malthus's *Essay on the Principle of Population* (1798), he hit on the theory of natural selection. (Even this important insight, however, was not as sudden as Darwin later recalled — see Gruber 1981.) For approximately a decade more he nevertheless failed to understand why evolution should promote widely divergent species on islands, like the Galapagos, that are seemingly identical in climate and general geographic character.

Darwin only solved this vexing problem in the mid-1840s after reading Joseph Hooker's reports on the flora of the Galapagos. Hooker had found that numerous representative species were indeed present on the separate islands, as Darwin had always suspected but had never been able to prove conclusively. In July of 1845 Darwin wrote to his friend: "I cannot tell you how delighted and astonished I am at the results of your examination; how wonderfully they support my assertion on the differences in the animals of the different islands, about which I have always been fearful" (1887, **2**:22).

Darwin was equally impressed with Hooker's (1847) discovery that the different islands possessed plants that were apparently random colonists, present only on one island. In the margin of his copy of Hooker's paper Darwin wrote: "so the flora of different isld[s] must be very different independently of representation". Darwin now began to appreciate that although the various islands in the Galapagos might look superficially similar, they were biotically quite distinct. These biotic differences, moreover, must provide natural selection with a wide scope for expression, thus explaining how representative species had evolved so easily on each island. This basic idea, which Darwin developed in the 1850s into his principle of divergence, altered much of his general thinking about evolution and was given a prominent place in the *Origin of Species* (1859). Thus Darwin required almost two full decades to understand the biological significance of his Galapagos findings and to integrate them into his theory of evolution by natural selection.

CONCLUSION

The Darwin-Galapagos legend, with its portrayal of the sudden and all-encompassing nature of Darwin's Galapagos insights, is largely a twentieth-century development. This legend has been inspired by many factors, including the triumph of Darwinism; the remarkable progress of Galapagos researches, especially on Darwin's finches; the tendency for history to telescope its past in accounting for great events and achievements; and the need for a suitably "empiricist" account of discovery in biology textbooks and in the history of science.

Although Darwin helped to engender this legend in certain of his own empiricist autobiographical accounts of his discoveries, he seems, privately at least, to have recollected matters differently. When writing his *Autobiography*, for example, he initially recounted his major impressions and achievements during the *Beagle* voyage without even mentioning his Galapagos visit. Only as he was revising his first draft, did he insert as an apparent afterthought: "Nor must I pass over the discovery of the singular relations of the animals and plants inhabiting the several islands of the Galapagos archipelago, and of all of them to the inhabitants of South America" (1958 [1876]: 80). In short, Darwin recalled his Galapagos insights as a "postscript" to his other voyage experiences, consistent with the delayed impact his visit to these islands really had upon his biological thinking.

While it perhaps serves to glorify the Galapagos in the annals of science, the Darwin-Galapagos legend nevertheless tends to rob these islands of their real import in the history of Darwin's discoveries. What is perhaps most impressive about Darwin's famous visit is that, having made so little initial impression on him, the Galapagos nevertheless stayed in his thoughts, serving as a powerful source of inspiration to which he returned again and again. The Galapagos experience therefore provided Darwin with a catalyst, not a sudden moment of discovery; they were a problem to be pondered again and again, not an immediate solution to problems. Darwin acknowledged these aspects of his intellectual relationship to the Galapagos when he remarked to Hooker, in 1846: "The Galapagos seems a perennial source of new things." Demystified, Darwin's Galapagos experience is perhaps a better symbol of his achievements than the famous legend, impressive as it may at first seem. For Darwin's genius involved a slow and persistent type of intelligence and a constant reworking of earlier insights and ideas. This aspect of his genius is captured by one of his favourite expressions, "It's dogged as does it" (a line from one of Trollope's novels); and Darwin personally identified his intellectual success more with patience and determination than with quickness or profundity of mind (1958 [1876]: 140, 145).

Finally, the story of Darwin's Galapagos visit illustrates how intimately connected the facts of science sometimes can be with the history of their discovery. Indeed, only through understanding their historical context have certain of Darwin's Galapagos "facts", such as the original localities of his and other *Beagle* type specimens, finally become clarified. It is perhaps a tribute to the enormity of his achievements that it has taken the history of science a century and a half to understand how Darwin reached them. So, in this anniversary year of Darwin's Galapagos visit we celebrate not only Darwin's evolutionary triumph but also our own in finally coming to understand what a difficult, protracted, and complex intellectual process this triumph really was. It is clearly and aptly the triumph of the tortoise rather than the hare, a triumph of Darwin's "dogged" genius in its quintessential form.

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DARWIN IN THE GALAPAGOS

by

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Charles Darwin wrote to his sister Caroline Sarah on 10th March 1835 "I know certainly we are on our road to England, although that road is not quite the shortest. On the 1st of June the *Beagle* sails from Valparaiso ... to the Galapagos". This is the first mention of the islands in his letters home and he goes on to say "I do so long to see you all again. The voyage has been grievously too long; ... But now that I know that I shall see you all again in the glorious month of September, I will care for nothing; the very thoughts of that pleasure shall drive sea-sickness & blue sea evils away". He did not mean the coming September, but that of 1836; indeed it was not until October of that year that he was to see the coast of England.

It was on 16th September 1835 that they made landfall in the Galapagos at Chatham Island and he landed for one hour that evening. He was still homesick and his first impression was not favourable. "Nothing could be less inviting than the first appearance. A broken field of black basaltic lava is everywhere covered by stunted brushwood, which shows little signs of life. The dry and parched surface, having been heated by the noonday sun, gave the air a close and sultry feeling, like that from a stove; we fancied even the bushes smelt unpleasantly". He "obtained 10 different flowers; but such insignificant ugly little flowers, as would better become an Arctic than a Tropical country".

There are three sources for what he felt, recorded and collected at the time. Firstly the little field notebook which Barlow* (1945) says contains disappointingly little of interest; often he gives only the day of the week without date or name of the island. Secondly, there are his ornithological notes (Barlow, 1963); these were mostly written up at the time or shortly afterwards and are much more interesting. Thirdly, there is the first version of the *Journal of Researches;* this he started to write as soon as Captain FitzRoy had decided to write up the whole *Narrative* and asked him to do the third volume. Darwin's part was finished and in print by 1838 although it had to wait until the following year for publication because FitzRoy's parts were not ready.

Once Darwin had got on land all his old energy came back and he started to collect. The plants and insects had to wait for experts at home, but the vertebrates he could observe himself, and his comments on the birds and the reptiles, written when they were fresh in his mind, are the most important. Many later students of evolution have used the second edition of the *Journal of Researches* of 1845, but it must be remembered that by this time the birds and plants had been studied in detail and some work had been done on the insects and the molluscs; the five parts of the *Zoology* of the voyage were out; and, most importantly, Darwin had written out his first evolutionary sketches of 1843 and 1844. His ideas must have shaped the new version.

Darwin only visited four islands, Chatham (San Christóbal), Charles (Floreana), Albermarle (Isabela) and James (Santiago), and his remarks on others are hearsay. The whole visit was of 32 days only and of these there were perhaps seven on which he was not on shore. It is not surprising therefore that he failed to see or collect even some of the most striking animals. He was unlucky not to have seen the flightless cormorant or the penguin when on 3rd October the *Beagle* anchored between Narborough and Albemarle. The following day they sailed round the northern tip of Albemarle, crossing the equator both ways in their journey to James.

He made a lot of observations on the behaviour of the tortoises and the plant-eating iguanas as well as on the tameness of the birds, but those which are best remembered are his three comments on speciation. The Vice-Governor, Mr Lawson, an Englishman, had told him in some detail about the differences in the tortoises, which the resident convicts could all recognize. He himself noticed the differences in the mockingbirds: "the specimens from Chatham and Albemarle Isd. appear to be the same, but the other two [Charles and James] are different. In each Isd. each kind is exclusively found; the habits of all are indistinguishable".

* Darwin's grand-daughter, Lady Barlow

Darwin did not at first notice the differences, in form and habits, of the rather drab little finches which bear his name today. His much quoted observations end sadly: "I was not aware of these facts till my collection was nearly completed: it never occurred to me, that the productions of islands only a few miles apart, and placed under the same physical conditions, would be dissimilar. I therefore did not attempt to make a series of specimens from the separate islands. It is the fate of every voyager, when he has just discovered what object in any place is more particularly worthy of his attention, to be hurried from it".

I may perhaps conclude with a comparison of FitzRoy's final judgement of the animals of these islands with that of Darwin. The former, who, after his return to England, had formed rigid fundamental views, wrote (*Narrative,* II, p.502) "This appears to be one of those admirable provisions of Infinite Wisdom by which each created thing is adapted to the place for which it was intended". Darwin, on the other hand, was sensing something much more important (*Orn. Notes,* p.262) "When I see these Islands in sight of each other, & possessed or but a scanty stock of animals, tenanted by these birds, but slightly differing in structure & filling the same place in nature, I must suspect they are only varieties — If there is the slightest foundation for these remarks the zoology of Archipelagoes — will be well worth examining; for such facts would undermine the stability of Species".

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CAPTAIN FITZROY OF H.M.S. BEAGLE

by

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The importance of Robert FitzRoy's visit to the Galapagos 150 years ago has been completely overshadowed by the fact that he was accompanied by Charles Darwin. Darwin was definitely the junior partner at that time but today FitzRoy is recalled almost solely on account of his denunciation of *The Origin of Species* a quarter of a century later. This cause of dissension did not exist in 1835. FitzRoy was not then a serious student of the Bible and a confirmed fundamentalist, nor had Darwin become convinced of the mutability of species. In spite of profound differences of temperament and political views, these two brilliant young men (FitzRoy was given command of H.M.S. Beagle at the age of 23) were still good friends when they got back to England after sharing a cramped cabin in a tiny ship for five years.

FitzRoy had a life-long interest in science (it was entirely on his own initiative that he invited a naturalist to be his guest on the voyage) and he showed outstanding talent in his own specialist fields. The object of the *Beagle's* voyage was not to revolutionize biological theory nor to provoke the greatest intellectual debate of the century but to chart coasts, chiefly in South America. FitzRoy did this with remarkable skill. The buccaneer, Ambrose Cowley, had made some rough sketches in 1684 and Captain James Colnett of H.M.S. Rattler had improved on them in 1793, but FitzRoy's Galapagos charts are in a different class and are barely distinguishable from those in use today. The captain of the French ship, *La Génie*, who came to survey the islands in 1846, wrote of FitzRoy's achievement:

> "Nothing escaped the perspicacity of this conscientious observer: the smallest details are all indicated with really astonishing precision and following his drawing one can visualize in the most accurate manner the shape of the coast. Coming after him there is not even an opportunity to glean".

J.R. Slevin, the historian of the California Academy of Sciences' great research expedition, wrote in 1959:

> "It is truly amazing that the modern chart of the Galapagos made in 1942 by the *U.S.S. Bowditch* equipped with every modern device should so closely approximate the survey made by Captain FitzRoy over a hundred years before. His little vessel was at the mercy of strong and uncertain currents, together with deadly calms so prevalent in those regions."

When he retired from active service in 1850, Admiral FitzRoy was elected a Fellow of the Royal Society in recognition of his distinction as a scientific navigator and hydrographer: his sponsors included Charles Darwin. Later he began the organization of what became the British Meteorological Office. It is unfortunate that he should be remembered, if at all, for his quarrel with Darwin and his tragic death rather than for his considerable scientific accomplishments. For over a century his meticulously drawn charts served scientists and others navigating in the hazardous waters of the Galapagos. R.D. Keynes* sums up FitzRoy's varied achievement:

> "He deserves to be remembered not just as Darwin's captain on the Beagle, although the importance of the help and encouragement that he gave during the voyage, and his role in stimulating Darwin's ideas, are not to be lightly dismissed. He was also a hydrographer in the front rank, parts of whose charts of South American waters and sailing directions for them are still in use nearly 150 years after the survey was conducted. Above all he was one of the principal founders of the science of meteorology."

* *The Beagle Record*, edited by R.D. Keynes, Cambridge University Press, 1979.

STUDYING SPERM WHALES ON THE GALAPAGOS GROUNDS

by

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The presence of sperm whales *(Physeter macrocephalus)* around the Galapagos Islands was one of the most important factors in the exploitation and degradation of the islands. During the nineteenth century large numbers of whalers from the U.S., Britain, France and other countries hunted the sperms of the Galapagos. During their visits on shore the whalers plundered tortoises and seals. There has been much research and writing about the destructive effects of the whaling industry but the whales themselves have been largely ignored in recent years.

Between mid-February and late April 1985 we made a study of the sperm whales off the Galapagos from the 10 metre sloop, *Elendil.* With a crew of five (Tom Arnbom, Amelia Brooks, Vassili Papastavrou, Linda Weilgart and Hal Whitehead) we located and followed groups of sperm whales using a directional hydrophone to listen for their distinctive clicks. The principal objective of the study was to investigate the effectiveness of the waters around the Galapagos for studying the social behaviour of sperm whales. We were particularly interested in the interactions between the apparently stable groupings of 20-40 female sperm whales, with their young and the large mature males who spend much of the year in polar waters, migrating to the tropics for a few months to mate. We were hoping to gain information on questions such as: for how long does a mature male associate with a group of mature females; and do mature males act in consort or competition with one another? These issues are particularly crucial to current attempts to model sperm whale populations (Anon. 1983).

The research that we were undertaking was a consequence of the 1981-1984 World Wildlife Fund Indian Ocean Sperm Whale Study, which three of us (V. Papastavrou, L. Weilgart, and H. Whitehead), as well as our sloop *Elendil,* had taken part in. During the Indian Ocean Project we had developed methods of finding, tracking and studying sperm whales (summarized by Whitehead and Gordon, in press). When it ended we wondered if there might be a better research area where we could continue our investigations of sperm whale behaviour. Sri Lanka, our major study area in the Indian Ocean, had many advantages, but it was very far from my home in Canada, extremely hot, swept by monsoons which made research almost impossible for half the year, and has recently become embroiled in political turmoil. However, its most significant disadvantage was a lack of the large male sperm whales because during our months in the Indian Ocean we had seen only three large males, and these briefly. At that rate it would take many years to obtain any understanding of the crucial interactions between the large males and the groups of females.

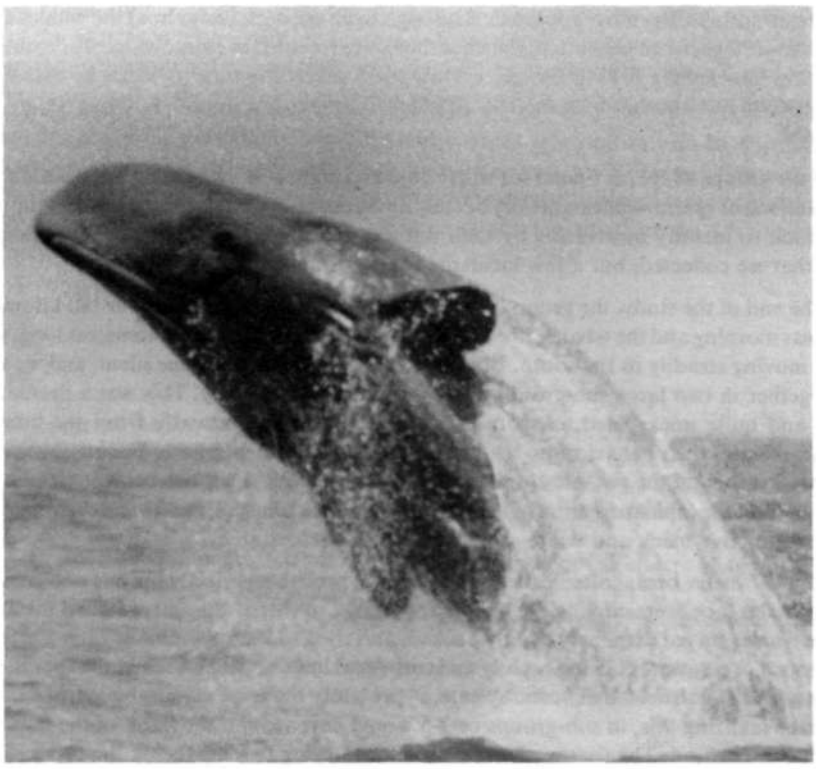
We examined maps of where the 19th century Yankee whalers made their kills (e.g. Townsend 1935), and also charts of ocean weather conditions. The ocean area that the whalers called "The Galapagos Grounds" immediately stood out in terms of the abundance of sperm whales, and the prevalent calm, relatively cool weather. The British had discovered the Galapagos Grounds during their late 18th century round-the-world explorations. Captain James Colnett aboard the ship *Rattler* made *"A Voyage to the South Atlantic and around Cape Horn into the Pacific Ocean, for the purpose of extending the Spermaceti Whale Fisheries, and Other Objects of Commerce".* He visited the Galapagos in 1793 and 1794, writing: *"Everyone was charmed with the place"* (Colnett 1798). They *"saw spermaceti whales in great numbers",* and Captain Colnett recommended the Galapagos Grounds to British whalers. His advice was followed, particularly by the stubby American whaleships sailing from New Bedford, Nantucket, and other New England ports. During the first part of the 19th century, the Galapagos formed one of the Yankees' favourite grounds. At that time the whalers provided much of the western world's oil, and the whales were remorcelessly exploited. After 1850, presumably because the sperm whale populations had been depleted, the whalers found the Galapagos *"dry cruising"* (Shuster 1983) and went there no more.

The Galapagos seems to have mercifully escaped the attention of the ultra-efficient mechanized whalers of the 20th century, and there is little recent information on the Galapagos Grounds. Some competent authorities warned us that we would be wasting our time off the islands, as there were a few whales and those far offshore. Others were more optimistic. The only way to find out was to sail there and see.

We obtained the support of the Green Island Foundation, the Connecticut Cetacean Society and a few private individuals. World Wildlife Fund Netherlands allowed us to continue to use some of the

equipment from the Indian Ocean Study, and so we sailed *Elendil* across the Atlantic Ocean and through the Panama Canal to reach the Galapagos in February 1985. There, with excellent co-operation from the Charles Darwin Research Station, INOCAR, and the Galapagos National Park Service, we found conditions almost ideal for our research. The weather was very calm and often pleasantly cool. The female sperm whales were in large groups that were easy to track acoustically. Most importantly, the large males were often in attendance. Captain Colnett (1798) had advised:

"The situation I recommend to all cruizers, is between the South end of Narborough Island (Fernandina) and the Rock Redondo (Redonda)." This region, where the sub-surface Cromwell Current, running eastwards directly beneath the Equator, is forced upwards by the islands of Isabela and Fernandina, became the core area for our research. The groups of sperms would sometimes stray a hundred kilometres or so to the south or west, but it was between Fernandina and Redonda that they were most numerous. (See map on inside back cover).



Sperm Whale breaching off the Galapagos. 22 March 1985.
Photo by: Vassili Papastavrou

During all the weeks that we have spent with sperm whales, the subjects of our research have shown themselves to be gentle animals. They are often shy, but occasionally curious towards humans and their boats. However, with each other they display a very highly developed sociality. Although adjacent sperms are probably separated by a few hundred metres when feeding at depth, off the Galapagos they often appeared to be co-ordinating by forming a rank several kilometres long, with the whales swimming abreast of one another. These ranks swept through the deep ocean at a steady 2.5-3 knots (4.5-5.3 kilometres per hour), for 24 hours or more. Individuals would come to the surface every forty minutes or so to breathe, but the whole phalanx bore on.

When foraging 400 metres beneath the surface, each individual made the characteristic regular (about once per second) click of the sperm whale, which is presumably a form of echolocation used for locating the large squid that they mainly eat. The jumble of clicks of a group of hunting sperms, which together sound rather like radio static, must foretell approaching death for many squid. But for us on board *Elendil* the clicks were an important key. We listened for them through a directional hydrophone. With this instrument we could detect the bearing of a clicking sperm whale at about 8 kilometres and, by listening regularly and adjusting our course and speed depending on where and how loud we heard the clicks, were able to track groups of sperm whales for periods of days.

Off the Galapagos, between 40 minute feeding bouts, the sperm whales remained at the surface breathing for about 8 minutes. During these periods the whales seemed irresistably drawn to one another; if there was another whale nearby, they would almost surely sidle up together for companionship during their few minutes at the surface. The small calves, who did not dive deeply, were particularly active in joining adults.

But once every day or two the whales ceased their feeding to congregate at the surface in sub-groups of five to forty animals for an hour or more. It was during these "social times" that the significance of their communal relationships was most apparent. Although from the deck of our boat the whales appeared like a raft of inanimate logs, when beneath the surface they were revealed as extraordinarily flexible, tactile and tender animals. Snorkelling behind *Elendil*, we saw them gracefully turn to watch us with deep blinking eyes, gently stroke one another with their small flippers, or nuzzle a smooth bulbous brow against a vast wrinkled flank.

We tracked the groups of sperm whales for thirty days and nights. Much of what has been learnt about the social interactions of sperm whales will only be fully apparent after a complete analysis of the photographs (which we took to identify individuals by their natural markings), recordings of the whales' clicks and other data that we collected; but a few incidents revealed immediate insights.

Very near the end of the study, the group that we were following had strayed over 180 kilometres west of Isabela. It was morning and the whales, lined up in an east-west rank several kilometres long, were clicking noisily and moving steadily to the south. But at 09.45 they suddenly became silent, and we spotted them clumped together in two large sub-groups a few thousand metres away. This was a dramatic change in behaviour, and quite unexpected as sperm whales usually shift gradually from the hunting/spread-out/clicking phase of their behaviour to the social/congregated/silent phase. For an hour or two less and less clicks are heard, and the sub-groups that the whales form at the surface become steadily larger. This sudden silence and the rapid formation of sub-groups was most unusual, but its reason was apparent when we saw the distinctive black and white shapes of orcas (*Orcinus orca*).

The powerful 6-7 metre orcas, often called killer whales, probably the only serious non-human predator that sperm whales face, were circling the huddled sperms. For three hours we watched the attack. The 25 or so sperm whales stayed extremely closely packed, and tried to keep themselves facing directly towards the nearest orcas. They were clicking rapidly and with great intensity. The head of the sperm whale with its powerful jaw and sophisticated acoustic system, is probably the least vulnerable part of the whale. The orcas, perhaps realizing this, in sub-groups or 2-5 would dart around the flank of the massed sperms to attack them from behind. The sperm whales would turn, trying to keep facing the orcas. There was one tiny sperm whale calf. It was kept right in the centre of the concentration, presumably the safest place. In contrast the only large male sperm whale in the group usually hung behind. Was he protecting their vulnerable rear, or just tagging along? The two large male orcas also hung back, taking little part in the action. Most of the close-quarters interactions between the two species took place under water, hidden from us. We did see some fresh open wounds on several sperm whales, but none were particularly deep. It seems unlikely that any of the sperms were badly injured. The whole attack seemed to constitute a skirmish in which the orcas tested the sperms to see if there were any particularly vulnerable animal, which might then be assaulted in force.

The end of the incident was most interesting. The sperms began to turn in tight circles, the whole mass of whales revolving every 2-3 minutes. Perhaps the orcas now realized the futility of their attack for they began to move off to the west. With the orcas 500 metres away the sperm whales made their move. They fell totally silent and started travelling fast eastwards, remaining in their compact sub-group. For six hours they maintained 5.5 knots (9.5 kilometres per hour), and we motored after them. With the exception of the

large male, who fell behind for a while and lost synchrony, the whales remained co-ordinated and tight-packed throughout the entire flight, which was unparalleled in our experience with sperm whales. They were also uncharacteristically silent, again with the exception of the big male, who briefly broke the silence with his very slow distinctive click. When night came, the whales were continuing eastwards, but with no clicks our directional hydrophone was useless, and they were lost to us.

The incident was very instructive in showing how the top natural predator in the ocean attacks what is probably its most formidable prey, but it also contained some important hints about the relationship between the large male sperm whale and the group to which it was attached. The male made considerable effort to stay with the group, although he did not seem to be a fully-integrated member of it, or, in any sense, to be leading it. He also broke the silence of the other sperms, thereby perhaps revealing their presence to the orcas.

On returning from the Galapagos it was particularly interesting to read the accounts and log-books of the whalers who had preceded us. So many of their comments, about the calms, currents, headlands, sperm whale behaviour or other marine life, could have come from our own journals. The most significant variations concerned observations about the density of sperm whales. After a very preliminary examination of the sources, our observations seemed to lie intermediate between those of Captain Colnett and his contemporaries around the year 1800, who found "great plenty of whales", and the frustrated skippers of the second half of the 19th century scanning the horizon without any sign of the sperm whale.

We look forward to analysing the data that we have collected for more indications of the social system of the sperm whale and, above all, to returning to the sperm whales on the Galapagos Grounds in a year or two. But in the meantime we must also worry lest any of the sperms that we grew to know stray northwest to the "Coast of Japan Grounds". There, the Japanese whalers, abetted by the US Government, are defying the International Whaling Commission's ban on sperm whaling.

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EFFECTS OF THE 1982/83 EL NINO ON GALAPAGOS FUR SEALS AND SEA LIONS

by

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The catastrophic 1982/83 El Niño (EN) has left its mark on almost all forms of life on the Galapagos, be it terrestrial or marine. While the event was (almost) paradise for some species of terrestrial animals and plants (Grant and Grant 1984) it proved a serious disaster to marine forms (Laurie 1984, Schreiber and Schreiber 1984). Fur seals and sea lions were hard hit (Limberger et al. 1983) by the dramatic decrease of numbers and the accessibility and quality of their food resources (Barber and Chavez 1983, Santander and Zuzunaga 1984).

The effects are best documented for the Galapagos fur seal (Trillmich and Limberger in press). In late 1982 mothers stayed at sea seeking food for ever-increasing periods and returned to their young only so sporadically that pups and, later on, yearlings and 2-year olds lost weight and eventually died. Apparently mothers found it more and more difficult to find enough food for themselves, let alone for their young, and had to spend very long times at sea to support themselves. We know from dive records (Kooyman and Trillmich in press) and scat analysis that fur seals hunt mostly in the upper 40 metres of the ocean, where they take advantage of the vertical migration of organisms from the deep scattering layer (e.g. lantern fish, small cephalopods) which come close to the surface during the night. Under EN conditions the upper layer of the ocean warmed so much that presumably many of these cold water organisms did not rise so close to the surface. Measurements on Peruvian fishes showed that the nutritive value of the surviving fish decreased by 30-40% (Santander and Zuzunaga 1984). The dependent young fur seals (yearlings and 2-year olds), which are much smaller than their mothers and therefore less efficient divers, were unable to get enough food for themselves by their own foraging. With neither sufficient maternal milk nor enough independent foraging success they died during the latter half of EN.

Even the larger, and mostly weaned, 3-year olds were unable to find enough food for themselves and died to almost 100%. Of the adult females about 30% died and the same proportion of subadult males seems to have succumbed to this climatic disaster. Hardest hit of all age and sex groups were the males which were territorial in the 1982 breeding season (Aug.-Nov.). Of these animals we could not find a single one when we returned in August 1983. Males normally lose about 25% of their body weight as they fast while defending their territory and apparently they were unable to recover from this weight loss under EN conditions.

The EN ended in July 1983. During the immediately following reproductive season from Aug. to Nov. 1983, very few of the surviving females gave birth. Only about 10% of them had carried their foetus to full term under the previous food stress, and even those gave birth to unusually light pups. With the loss of all the very large territorial males from 1982, somewhat smaller males found themselves with huge territories and extremely numerous females which they were unable to defend against small, 4-7 year old, intruding males. Essentially the territorial system broke down and was replaced by one of space-related dominance. The largest surviving males established themselves on areas about 4-5 times the size of a normal territory and chased smaller males away from estrus females when they encountered them, instead of preventing them from intruding altogether.

When I returned in 1984 the situation looked much better for the fur seals. 1984 was an unusually cold year and this apparently provided the fur seals with plenty of food. Females were almost 20% heavier than in previous years, the few pups born in 1983 had grown to large yearlings, about the size of a 2-year old in former years, and the smaller males had grown tremendously during the intervening period. Thus more males held territories in the 1984 breeding season. The most obvious feature of the last season was, however, that despite the reduction in female numbers the colony was full of pups. How did this happen? In normal years only half of the female population produces pups, because females nurse their young for approximately two years. During EN all females had lost their young and were therefore synchronously beginning to reproduce again when they had recovered from the effects of food stress during EN. The age structure of the fur seal population has thus become a very rugged curve: the 1980-1982 classes are entirely missing, the 1983 class is very small and the 1984 class, if not killed by another EN event, will become a steep peak. On the other end of the age distribution, old males are entirely missing.

Galapagos Sea Lions
Photo: Fritz Pölking

We know much less about the effect of EN on the Galapagos sea lions but what little has been documented indicates that they were hit similarly although perhaps less violently: all pups born in 1982 died and pup production in 1983 was about one third of the usual, while in 1984 pups abounded everywhere. The effect of EN on the adults is unknown, but I would expect that older, physically less fit animals and perhaps quite a few territorial males died as well.

It is clear from these observations that recurrent strong EN events must greatly influence the population dynamics of these species by (1) changing the age structure and (2) strongly reducing the average carrying capacity of the environment. It may be that ENs contribute in this way to maintain the population densities of Galapagos fur seals and sea lions at much lower levels than those of more temperate or sub-polar fur seal and sea lion species.

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OBSERVATIONS ON INSECT VISITORS TO FLOWERING PLANTS OF ISLA SANTA CRUZ.

PART I. THE ENDEMIC CARPENTER BEE

by

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Within the Galapagos Islands there are few insect pollinators, which may be the reason that most endemic angiosperm species have small flowers (Stewart, 1911). This paucity of insects is illustrated by the fact that only one species of bee (*Xylocopa darwini*, the endemic carpenter bee) is represented on the islands (Cockerell, 1935; Hurd, 1958). Rick (1963, 1966) studied its role as a pollinator of plants on Isla Santa Cruz and reported that it made visits to *Justicia galapagana* (Acanthaceae), *Scalesia affinis* and *S. helleri* (Asteraceae), *Cordia lutea* (Boraginaceae), *Opuntia echios* (Cactaceae), *Mormordica (charantia)* (Cucurbitaceae), *Piscidia (carthagenensis)* (Fabaceae), *Nolana galapagensis* (recorded as *Periloba galapagensis)* (Nolanaceae), *Cryptocarpus (pyriformis)* (Nyctaginaceae), *Cardiospermum galapageium* (Sapindaceae), *Castela galapageia* (Simaroubaceae), and *Lycopersicon cheesmanii* (recorded as *L. pimpinellifolium)* (Solanaceae).

Linsley et al. (1966) recorded *Xylocopa darwini* as visiting the following additional plants on Santa Cruz between January 20 and February 28, 1964: *Tetramerium nervosum* (recorded as *T. hispidium)* (Acanthaceae), *Vallesia glabra* (Apocynaceae), *Scalesia pedunculata* (Asteraceae), *Bursera graveolens* (Burseraceae), *Canna* sp. (Cannaceae), *Ipomoea pes-caprae* (Convolvulaceae), *Cucurbita pepo* (Cucurbitaceae), *Acacia insulae-iacobi* (recorded as *A. tortuosa), A. macracantha, Cassia occidentalis, Crotalaria incana* (recorded as *C. setifera), Galactea striata* (recorded as *G. jussiana), Inga edulis, Parkinsonia aculeata, Prosopis juliflora* (recorded as *P. dulcis),* and *Rhynchosia minima* (Fabaceae), *Persea americana* (recorded as *P. gratis-sima)* (Lauraceae), *Mentzelia aspera* (Loasaceae), *Abutilon depauperatum, Abelmoschus manihot* (recorded as *Hibiscus manihot), Hibiscus tiliaceus, Malvastrum coromandelianum, Sida acuta* and S. *spinosa* (recorded as *S. angustifolia)* (Malvaceae), *Miconia robinsoniana* (Melastomaceae), *Commicarpus tuberosus* (recorded as *Boerhaavia scandens), Mirabilis jalapa* (Nyctaginaceae), *Passiflora foetida* (Passifloraceae), *Portulaca oleracea* (Portulacaceae), *Chiococca alab, Coffea arabica, Psychotria rufipes* (Rubiaceae), *Physalis pubescens* (Solanaceae), *Waltheria ovata* (recorded as *W. reticulata)* (Sterculiaceae), *Clerodendrum molle, Lantana peduncularis, Stachytarpheta cayannensis* (Verbenaceae), and *Tribulus cistoides* (Zygophyllaceae).
From October 1983 through March 1984 the author performed studies to determine the presence of self-compatibility versus self-incompatibility in selected angiosperms on Santa Cruz. Plants were tested along the southern slope with quadrats established in each of the seven major vegetation zones (Wiggins and Porter, 1971; van der Werff, 1979). A secondary objective of this research was to observe natural pollination agents. The first of these observations (those pertaining to *Xylocopa darwini*) are reported in Table 1, along with information on locations, amount of activity observed, and whether the plants are endemic or non-endemic.

Two of the fourteen species listed by the author are new pollination records for Santa Cruz. These species are *Cordia leucophlyctis* and *Vigna luteola.* Although *Sida rhombifolia* is not mentioned specifically for Santa Cruz in previous studies, Linsley et al. (1966) do include a photograph of *Xylocopa darwini* visiting a flower of this plant near Bella Vista. Therefore, from these studies it appears that the Galapagos carpenter bee, which is polylectic and visits many different plants for pollen and nectar, continues to be a major pollinator on Isla Santa Cruz, especially for non-endemic members of the flora. Part II of this paper will outline observations on other insect visitors to plants on Santa Cruz including butterflies, moths, flies, and ants.

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Table 1. Summary of flower records for *Xylocopa darwini* from October 1983-March 1984.

Family	Species	Location	Activity
Acanthaceae	*Justicia galapagana* (E)	*Scalesia* Zone, near Los Gemelos	low
Asteraceae	*Scalesia pedunculata* var. *parviflora* (E)	*Scalesia* Zone, near Los Gemelos	moderate
Boraginaceae	*Cordia leucophlyctis* (E)	Arid Zone, Darwin Station	high
	Cordia lutea (N)	Arid Zone, Darwin Station	low
Fabaceae	*Cassia occidentalis* (N)	Transition Zone 3.5km n. Puerto Ayora	low
	Parkinsonia aculeata (N)	Arid Zone, Darwin Station	high
	Prosopis juliflora (N)	Littoral Zone, Tortuga Bay	high
	Vigna luteola (N)	Pampa Zone, 3 km. n. Media Luna	low
Malvaceae	*Bastardia viscosa* (N)	Arid Zone, Darwin Station	low
	Sida rhombifolia (I)	*Zanthoxylum* Zone, near Santa Rosa	moderate
Passifloraceae	*Passiflora foetida* var. *galapagensis* (E)	Arid Zone, Darwin Station	moderate
Rubiaceae	*Coffea arabica* (C)	*Scalesia* Zone, near Los Gemelos	low
Verbenaceae	*Clerodendrum molle* var. *molle* (N)	Arid Zone, Darwin Station	low
Zygophyllaceae	*Tribulus cistoides* (I)	Arid Zone, Darwin Station	moderate

(E) endemic (N) native (I) introduced weed (C) cultivated escape

THE ENCHANTED ISLANDS: THE GALAPAGOS DISCOVERED

by John Hickman

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'Take five and twenty heaps of cinders dumped here and there in an outside lot; imagine some of them magnified into mountains and the vacant lot the sea; and you will have a fit idea of the general aspect of the Encantadas.' So wrote Herman Melville in his book *The Encantadas* or *Enchanted Isles.* But Charles Darwin was no more flattering, for his first impression recorded in his diary the day after the *Beagle's* arrival at the Galapagos was as follows: 'These islands at a distance have a sloping uniform outline, excepting where broken by sundry paps and hillocks; the whole black lava, completely covered by small leafless brushwood and low trees. The fragments of lava, where most porous, are reddish like cinders; the stunted trees show little signs of life. The black rocks heated by the rays of the vertical sun, like a stove, give to the air a close and sultry feeling. The plants also smell unpleasantly. The country was comparable to what one might imagine the cultivated parts of the Infernal regions to be.' And FitzRoy thought them 'a fit shore for Pandemonium'.

For most of us today, the enchantment of the Galapagos lies not in the rather forbidding scenery that Darwin and Melville described so vividly, but in their truly fascinating wildlife. No less fascinating, but much less familiar, is the history of their original discovery, and the accounts of them given by their early visitors, as set out by John Hickman in his highly readable book.

That people from the mainland had visited the islands before the Spaniards was proved by Thor Heyerdahl's finding of Chimu pottery on them, and it seems clear that the Incas knew of their existence. However, the first documentary account of the accidental discovery of an island where there were 'such big tortoises that each could carry a man on top of itself, and many iguanas that are like serpents' was that written by Fray Tomás de Berlanga, Bishop of Panama, after he had landed on it on 10 March 1535. His ship had been carried there by the ocean current during a windless spell, when he was bound for Lima at the command of the Emperor Charles V in order to report on the situation in the newly conquered territories in Peru. Fray Tomás claimed no credit for what he had found, but the Flemish cartographer, Abraham Cortelius, read his dispatch and in his *Orbis Terrarum,* published in 1574, showed the islands as 'Isolas de Galapagos'. Ten years later another of the conquistadors, Diego de Rivadeneira, sighted the islands again, but landed only once.

The next recorded visit was by the Dutch explorer, Jacob Herenite, in 1624. But no further interest was taken in the Galapagos until at the end of the century the English buccaneers began to make use of them as a base. Ambrose Cowley, of the *Batchelor's Delight,* made the first chart in 1684, and gave the islands their English names; and among the same group of sailors was William Dampier, who described them vividly in his *New Voyage Round the World,* published in 1697. Dampier was again present when the *Duke* and the *Duchess,* under the command of Captain Woodes Rogers, paid a rather traumatic visit to 'these unfortunate Islands' in May 1709.

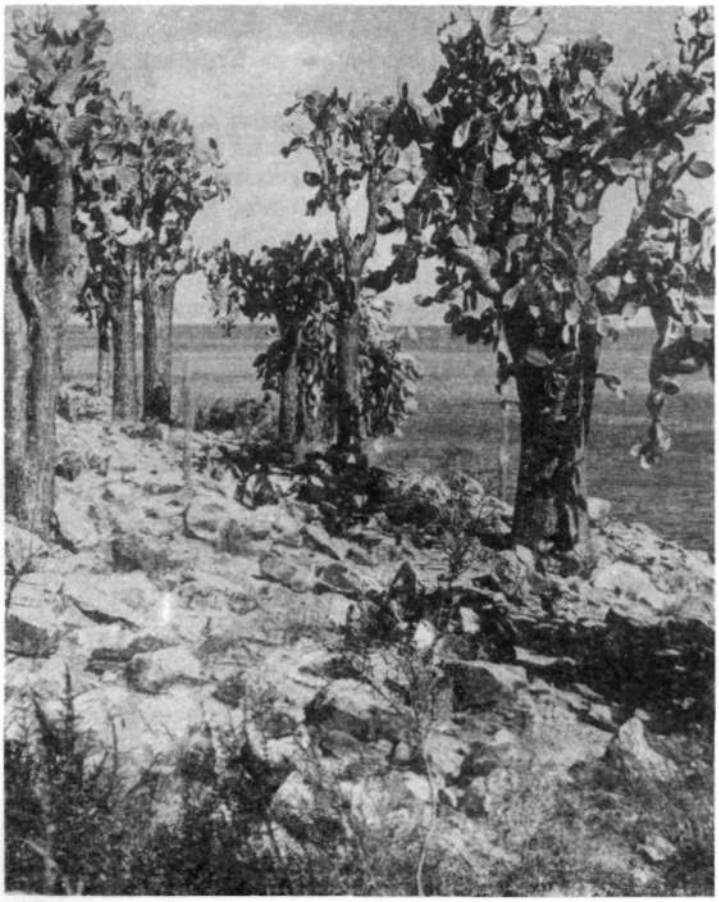
The Galapagos were now firmly on the map, but during the 18th century they were little visited except by occasional smugglers. In 1792 the situation began to change, following a report by Captain James Colnett R.N., commissioned by the leading British whaling company, on the possibilities of exploiting the whale stocks of the Pacific. Colnett wrote a detailed report on the islands, and is said to have instituted the box for the exchange of mail at Post Office Bay. In April 1813, Captain David Porter U.S.N. of USS *Essex* used the post box to inform himself about the British whalers in the vicinity, and in five months of cruising captured a dozen of them. Soon there were great numbers of whalers operating in the Pacific — around 1830 there were at least 700 vessels from America alone — who found in the Galapagos a prolific and seemingly inexhaustible supply of tortoise meat. Even the *Beagle* added to the toll, and departed with 30 tortoises on board destined for culinary rather than scientific purposes. But the whales were slaughtered faster than the tortoises, and by the end of the American Civil War their numbers were so reduced that whaling ceased, and the tortoises were reprieved.

After 1832, the government of Ecuador assumed nominal responsibility for the administration of the Galpagos, though it was some time before any close control was exercised. Various attempts to make use of the meagre natural resources such as the orchilla moss and guano foundered under economic realities and harsh living conditions, though an increasing number of settlers managed to maintain themselves precariously by cultivating crops on the higher moist zone of one or two of the islands. Their possible importance in relation to the Panama Canal, either strategically or as a coaling station, was discussed from time to time, but came to nothing until in 1942 the United States Sixth Air Force constructed a complete air base on South Seymour Island (Baltra). The American base was closed in 1947, but later the runway was resurfaced by the Ecuadorean Air Force, and the Baltra air strip now serves as the main link between the islands and the mainland.

One natural resource, however, the Galapagos had in great abundance, and the material in the final chapters of the book will be familiar to the readers of the *Noticias*. In Darwin's footsteps came a series of scientific expeditions led among others by Rollo Beck, William Beebe, Victor Wolfgang von Hagen and David Lack. In 1959 the Charles Darwin Foundation for the Galapagos Islands was formally constituted under Belgian law, and in 1964 its Research Station on Santa Cruz island was opened. A few years later the Galapagos National Park Service came into operation.

The whole story with its ups and downs, its successes and failures, is told in a masterful manner by John Hickman, combining historical detail with human interest to great effect. I have very greatly enjoyed reading it.

Richard Keynes



Opuntia echios barringtonensis on Santa Fe Island
Photograph by Roger Perry

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