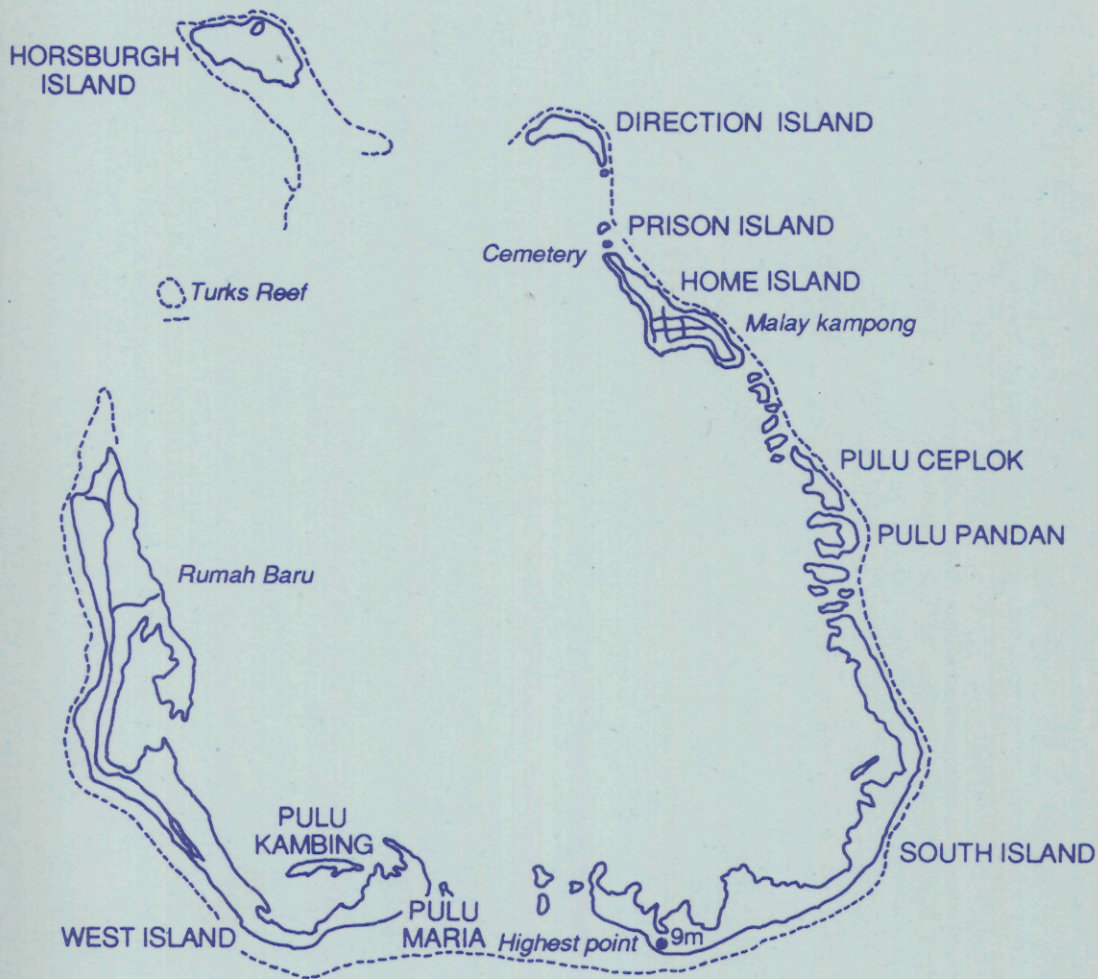


Under the Blue Vault of Heaven:

A Study of Charles Darwin's Sojourn in the Cocos (Keeling) Islands

by
Patrick Armstrong



Indian Ocean Centre for Peace Studies
and
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A Study of Charles Darwin's Sojourn in the Cocos (Keeling) Islands

Patrick Armstrong

Foreword by Carolyn Stuart, sometime Administrator of the Territory
of the Cocos (Keeling) Islands



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Indian Ocean Centre for Peace Studies, Nedlands, Western Australia, 6009

ISBN 0 86422 121 5

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Preliminary Note

This project was commenced in 1987, with the support and encouragement of the Centre for Indian Ocean Regional Studies (as it then was) at Curtin University of Technology. Subsequently Curtin University has joined with the University of Western Australia to transform the Centre into a joint Indian Ocean Centre for Peace Studies.

Despite this work on Darwin having been largely completed before the new alignment of the Centre was considered, the new focus is not inappropriate. The Cocos (Keeling) Islands, tiny in area and population though they may be, encapsulate on a micro-scale a host of the problems of the modern world, and of the Indian Ocean Region in particular.

Thus the islands have been important strategically since World War II, and the airfield retains considerable military significance. The juxta-position of the Cocos Malay people and a group of "expatriate" mainland Australians poses problems in community relations. The build-up of the Malay population on the tiny atoll earlier this century resulted in the archipelago becoming something of a demographic laboratory. The recent economic collapse of the coconut industry illustrates the single-crop dependence of a number of island micro-states and territories. The 160 years of settlement have resulted in substantial human impacts of the environment (for example the introduction of cats and rats, intermittent falls in the water table, and the disappearance or reduction of certain plant and animal species).

The atoll environment that we see at Cocos today, and the problems it poses, are the results of a long-continued dialogue between a human community (both European and Malay) and biophysical resource base. Charles Robert Darwin, who visited the group of islands in 1836 was able to record, in striking detail, the nature of this relationship very soon after the first human settlement. An attempt to reconstruct this environment, and the network of linkages within it, is perhaps therefore, a not entirely inappropriate study for a publication in the Indian Ocean Centre for Peace Studies occasional paper series.



Acknowledgments

I thank, as so often before, Peter Gautrey and his staff at the Department of Manuscripts at Cambridge University Library; Peter's knowledge of the Darwin Archive held there is unrivalled. I also thank the Master and Fellows of Darwin College, Cambridge who provided me with an superb base for Darwin studies during the first half of 1989, not to mention access to an Apple Mac.

Staff of many other libraries and museums in both England and Australia, have helped with access to particular sources (books, manuscripts or specimens); these include: the Mitchell Library, New South Wales; the Reid Library, University of Western Australia; the Zoology Department Library, the Botany School Herbarium, and the Zoological Museum, all of University of Cambridge; the Public Record Office at Kew; the Archives Section of the Ministry of Defence Hydrographic Survey Office at Taunton; the British Museum (Natural History), London. The Australian National Library also provided access to microfilm of archives of documents held in the British Library.

For assistance on the Cocos Islands I am deeply indebted to Carolyn Stuart, former administrator of the Territory, and Dr David Williams whose knowledge of the natural history of the island was invaluable. I also thank Carolyn for so kindly agreeing to write the Foreword. Pauline Bunce's knowledge of the the history of the islands, and deep affection for the Malay people, was of enormous benefit to me, both on Cocos, and subsequently. All these persons, my wife Moyra, and my colleague Viv Forbes, read an early draft of parts of the text, to its considerable benefit. Guy Foster drew the diagrams.

Australian Airlines made the journey from Western Australia to Cocos rather more comfortable and speedy that that endured by Charles Darwin in HMS *Beagle* in 1836.

I am also pleased to acknowledge the financial support of the Indian Ocean Regional Studies Centre (as it was formerly known) of the Curtin University of Technology, and my own employer, the University of Western Australia, for fieldwork on the islands. Ken McPherson, Director of the Centre at Curtin, has displayed a level of interest in the project that has been a constant encouragement.

My wife Moyra has long tolerated Charles Darwin's presence at the breakfast table, as well as her husband's absence from it during his occasional disappearances to remote islands. Bless her.

Finally I acknowledge my debt to my late father, Edward Armstrong, to whom I am indebted for a delight in the living world, a sense of the past, and an interest in the natural history of islands.

Foreword

"The sea is blue", wrote Paul Colinveaux¹. "This is a very odd thing because the sea is also wet and spread out under the sun". To explain this oddity, we must ask the right question - the Darwinian question. When we see a coral atoll in the middle of this sea, what better way to approach this oddity than through Darwin's mind?

Patrick Armstrong takes us into the mind of the great scientist on his visit to the Cocos (Keeling) Island. We are with him as his ship "swept in" to the Cocos lagoon on Saturday 2 April 1836, as he moves around the islands during the following days, and in his later deliberations on the questions aroused by his visit. By means of careful historical research Dr Armstrong draws together from many disparate sources everything Darwin wrote about his visit and about coral atolls. We know how Darwin organised his research writings, what he saw, what he jotted down in his notebooks, what he collected, his method of collection, and even what the weather was like. Most important, perhaps, we know how he approached the question of atoll formation.

By April 12, on leaving Cocos, Darwin was able to form the question: "In time the central land would sink beneath the level of the sea and disappear, but the coral would have completed its circular wall. Should we not then have a Lagoon Island?" His later papers extend the theory: "...we may feel sure that the movement has been slow as to have allowed corals to grow up to the surface, and so widely extended as to have buried over the broad face of the ocean every one of these mountains, above which the atolls now stand as monuments, marking the place of their burial." As so, reading this book, we are in a sense present, able to observe the process by which one of the great wonders on this earth - these great monuments" - may be explained.

Patrick Armstrong's researches into the Darwin papers, the additional information he is able to provide as a result of his expertise and his visit to the islands, and references to other scientific writings ensures that this book will be of great interest to scientists, historians, and those interested in atoll islands. But it will also be fascinating to those who have been privileged to know and love Cocos. Patrick Armstrong himself is one of the small number of scientists who have visited Cocos, and writings about Cocos, because of their remoteness and unique history, have been difficult to obtain.

This account of Darwin's visit is important from another point of view. It reveals the ecological changes that have taken place in the island since their first occupation. Almost none of the hardwood trees remain

on the South Keeling atoll, having been cut down for housing and boat-building. The vegetation consists mainly of coconut trees. The birds have also all but gone from South Keeling (though they are still numerous on the tiny, remote North Keeling atoll), as have the giant robber crabs, the turtles and the giant clams. If Darwin's observations are not brought to general attention it is all too easy to believe that these precious flora and fauna were never present in any great number, and therefore to argue that no action need be taken to preserve and protect the few which remain.

Despite the changes the lagoon still dazzles the eye with its magnificent sweeps of iridescent blue, turquoise and green, causing us to wonder, as did Darwin, what processes brought it into being in this vast sea - this monument "under the blue vault of heaven". This book gives us a rare insight and a fitting record of Darwin's progress toward an answer.

Carolyn Stuart

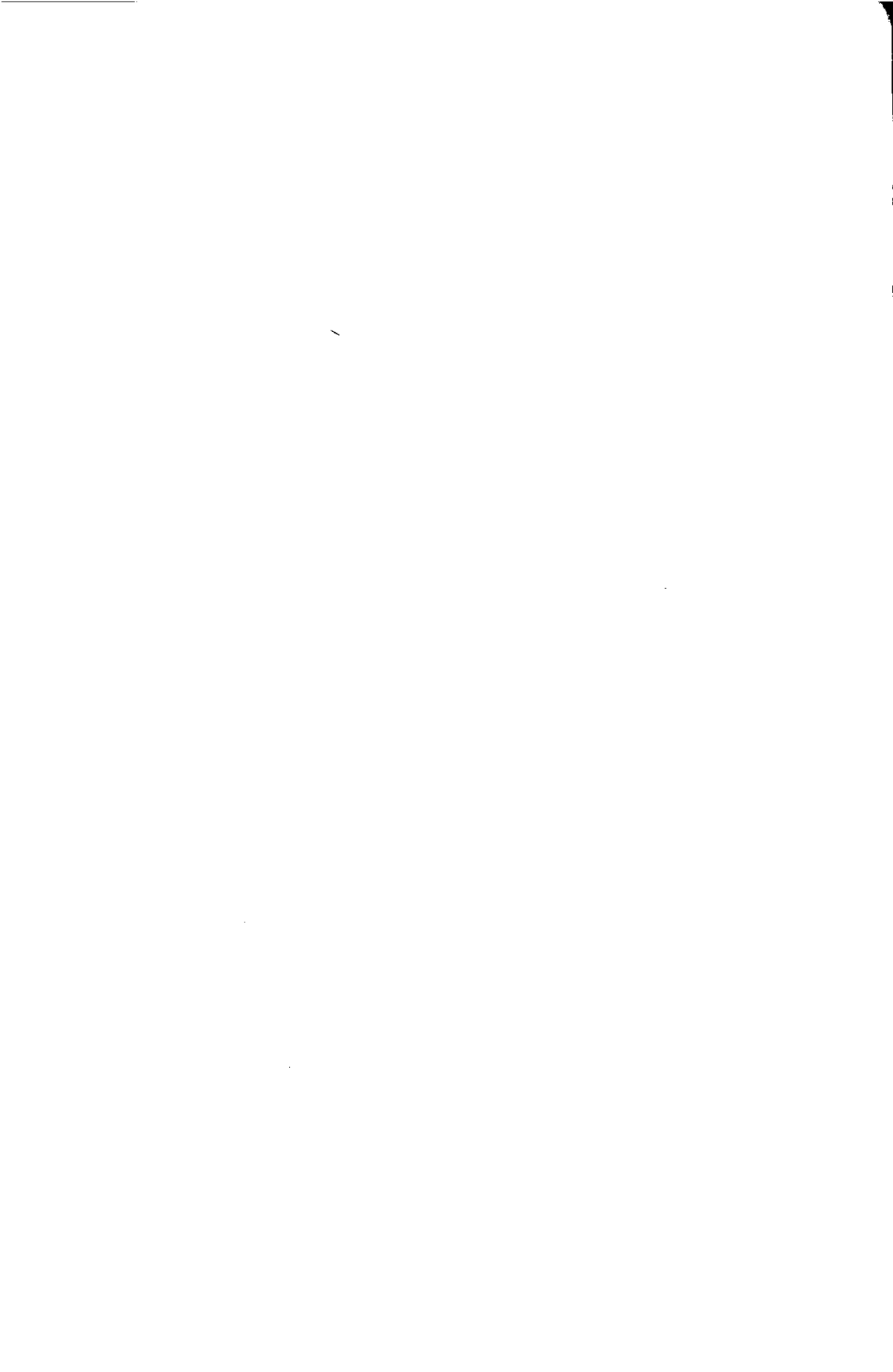
Canberra, ACT
December 1989

Administrator of the Cocos
(Keeling) Islands (1985-1987)

¹ *Why big fierce animals are rare*, Penguin Books, 1980.

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Photographs, except where stated, are by the author

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Introduction

In many ways Darwin's brief stopover in the Cocos Islands was a high point in his voyage. He had left Australia "without sorrow or regret": although he found the plant and animal life of the the Great South Land fascinating, he thought the landscape, particularly that around King George's Sound, in Western Australia, "uninviting". And although he felt that Australia would some day reign as "a great princess in the south", there were many aspects of Australian life that he deplored - the convict system, the grasping outlook of some of the British colonists, the isolation. The exquisite beauty of an unspoilt tropical island with its coral lagoon, the green palm trees silhouetted against the "blue vault of heaven" (as he put it in one of his more lyrical moments), the brilliance of the light, the almost unimaginable beauty of some of the corals and other creatures of reef and lagoon must have formed a striking contrast with the subdued green-greys of the Australian bush.

Moreover, the *Beagle* was well and truly homeward bound after more than four years of voyaging, exploring, collecting, observation and recording. In his letters to his sisters, Charles Darwin had written more than once of his dislike of ships and the sea, and a few days respite from the dreadful weather that the Indian Ocean had thrown at the little ship as it struggled northwards from Cape Leeuwin must have been welcome. Every league of the voyage from here on would bring him closer to England, and his beloved family waiting anxiously in Shrewsbury.

He knew he had done well. Thousands of specimens were aboard the *Beagle* on their way to enrich the scientific collections of London and Cambridge; thousands more had already been dispatched to his friend and mentor, the Reverend Professor John Stevens Henslow¹: all the feedback had been good. The first draft of his coral atoll theory was already down on paper, partly based on observations in the Pacific. It fitted in well with other ideas he was pulling together concerning sea-level change along the coast of South America. Frank Sulloway², in a study published in 1985, on the basis of a careful quantitative analysis of the words used in some of Darwin's personal letters, suggested that the young naturalist's morale and self-confidence were higher during this segment of the voyage than at any other time during the *Beagle's* circumnavigation.

Charles Robert Darwin came from a reasonably prosperous, somewhat intellectual, upper-middle class family. He had been brought up in the Church of England and was, at least at the start of the voyage, when he was but 22 years of age, considering entering Holy Orders. (We may

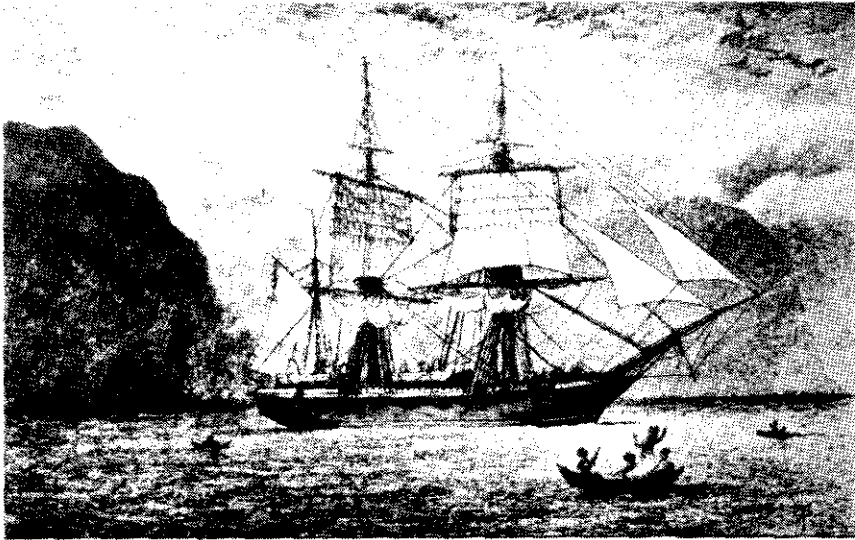
note that divine service was conducted aboard HMS *Beagle* while she lay at anchor in the lagoon near Direction Island, on Sunday 3 April 1836. Darwin attended.) His family adhered to the Whig political tradition. He had been to Shrewsbury School, although he left it very willingly at the age of sixteen to spend two years, also somewhat unhappily, at Edinburgh Medical School. He then took a degree in Arts from Cambridge, although a good deal of the time he spent in residence at Christ's College was spent "shooting and ratcatching" to the chagrin of his doctor father. He had had since early boyhood, an interest in natural history, particularly the collection of beetles, and the years in Cambridge also gave the young Charles Darwin the opportunity of extending this interest. He became acquainted with the Professor Henslow mentioned above, Professor of Botany in the University of Cambridge, and Curate of the Cambridge church Little St Mary's. Darwin used frequently to go for natural history walks with Henslow into the Cambridgeshire countryside, and attended some of his lectures: Henslow seems to have been an excellent teacher. It was Henslow who was partly responsible for Darwin's invitation to sail on HMS *Beagle* - indeed the position was offered to Darwin only after Henslow had turned it down. The other friendship that Darwin made while he was in Cambridge was the Reverend Professor Adam Sedgwick, the distinguished geologist, who gave Darwin most of the geological training he ever had on a three-week excursion to North Wales in the summer before the *Beagle* sailed.

The voyage was supported by their Lordships of the Admiralty for the purposes of hydrographic survey, and the fixing of "a chain of meridians around the world". Natural history was very much an addendum, and Darwin always a supernumerary.

From Portsmouth, from whence HMS *Beagle* departed on 27 December 1831, the ship proceeded via the Cape Verde Islands and St Paul's Rocks to the coast of Brazil (landfall 29 February 1832) and the *Beagle* remained in South American waters for the next three-and-a-half years (see Figure 1). The expedition then left the west coast of South America for the Galapagos Islands (September-October 1835), Tahiti (November 1835), New Zealand (Christmas 1835) and Australia (January-March 1836). The visit to Cocos (or the Keeling Islands, as they were generally known in Darwin's day) took place three weeks after the little ship "stood out" from King George Sound, Western Australia (see Figure 2 - inset).

The aim of this work is to reconstruct Darwin's days on the remote Indian Ocean atoll, as far as is possible from the documents, and also to consider how Darwin's character and background, lifestyle and

previous experiences influenced the manner in which he perceived and recorded the islands. Further, an attempt will be made to place the Cocos sojourn in perspective against the broad sweep of the Victorian Naturalist's life and work through a discussion of the way in which some aspects of the later development of Darwin's ideas were influenced by the interlude he spent on the idyllic islets, or at least reflect concepts that were already partly formed during his stay.



H.M.S. "Beagle" in the Straits of Magellan

Fig 1

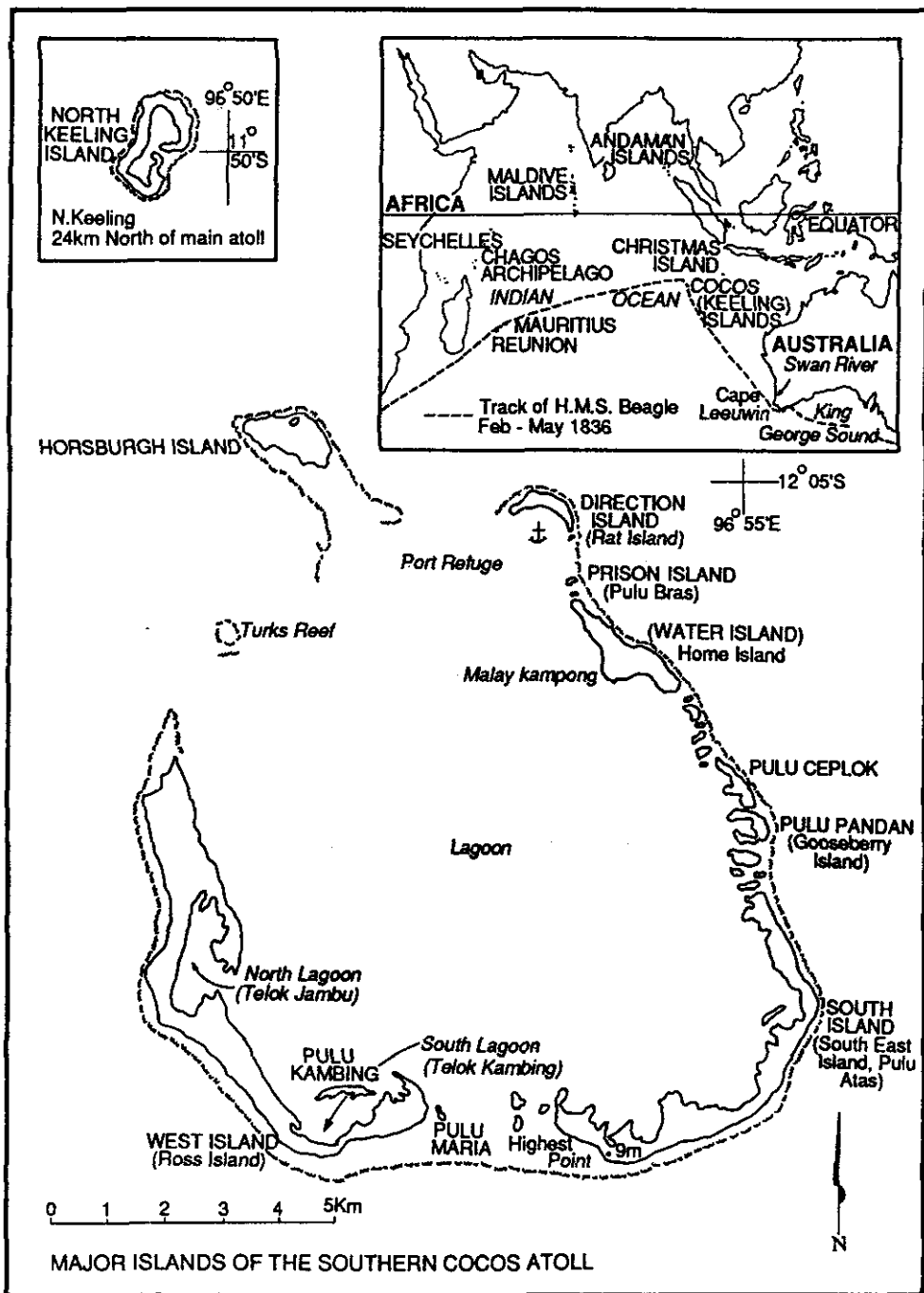


Figure 2. Map of the Cocos (Keeling) Islands showing places mentioned in the text. Inset: Track of HMS *Beagle* in the Indian Ocean.

Chapter 1

The Sources, and the Relationships amongst them

Charles Darwin, throughout his life, was a prodigious note-taker and letter writer. This was especially the case during the *Beagle* period; there are thousands of pages of notes from this stage in his life, and the young naturalist must have spent many of his hours on board ship in writing them up. Moreover, he, and his family, kept almost everything he wrote, and in the Darwin Archive in Cambridge many of these papers are preserved, so that it is often possible for the modern enquirer to trace the development of his ideas with some precision, and also, very often, to say exactly what Darwin was doing at any given time.

Another prime source is Darwin's personal diary, which he maintained from his arrival at Devonport on 24 October 1831 until the *Beagle* docked in Falmouth on 2 October 1836. He did not write it up on a daily basis - sometimes days or even weeks at a time went by without an entry. Probably it was often written up retrospectively, while the *Beagle* was sailing between ports. Darwin wrote several times to his father and sisters how much he enjoyed writing his journal¹; it often gives the impression of being written with great spontaneity and at high speed. In another letter he wrote: "I have taken too little pains with it. My Geological notes and descriptions I treat with far more attention."² Nevertheless from time to time he spent portions of his diary home for his father and sisters to read, so it cannot be said he was writing just for himself.

On his return from the sea Darwin edited and polished the journal considerably for its inclusion as Part III of Captain FitzRoy's official *Narrative of the Voyages of the Adventure and Beagle*, published in 1839. Darwin's manuscript had in fact been ready for the presses in 1837, but there had been a delay through the *Beagle's* Captain's ill-health. Considerable material was incorporated from other sources - for example an account of the robber crab on the Cocos Islands was brought in, based on detailed notes on the species in the *Zoological Diary* (see below), and a comment on the arrival of species on the islands by long distance dispersal, taken from Holman's *Travels*, was added to his own notes, and those of Henslow, on the plants.

A second edition appeared in 1845. Darwin found revision a quite onerous task; it took him four months - 25 April - 25 August 1845, and he noted that he "rested idle for a fortnight" in order to recover. By then Darwin had adopted an evolutionary outlook, although of course he was not to publish anything explicitly on his ideas on the "transmutability of species" for many years. Gruber³, however has shown that the revisions in the 1845 edition gave the work a subtly more evolutionary timbre.

Later editions were without significant alterations, although the book came to be known as *The Voyage of the Beagle*. The original diary was edited by Charles' granddaughter, Nora Barlow, and published in 1933.⁴ A completely new edition has recently appeared.

A useful source for the student of much of Darwin's journeyings is that preserved in his letters to his family and friends, most of which have been preserved, and indeed published⁵. However, no letter actually written from the Cocos is known, and as letters were usually written in port when there was a ship close by that was about to sail for England, and as there were no other ships at Cocos while the HMS *Beagle* was there, it is likely that none was written. A letter to his sister Caroline, from Port Louis in Mauritius on 29 April 1836, does however, record, something of his researches on the atoll, and is in fact quite important.

But it is the piles of scientific notes that provide particular insight to the way in which Darwin worked. Most of Darwin's observations about animals - fish, reptiles, crabs, sea anemones and so on - were set down in his *Zoological Diary*. These notes are full of interest and exemplify the young scientist's careful observation and attention to detail.

Charles also usually recorded his geological observations with similar precision in a set of manuscripts known as the *Geological Diary*. There are no entries in the main batch of geological notes between the descriptions of the rocks around King George's Sound, Western Australia, made in March 1836 and his observations on the coral reefs of Mauritius made between 29 April and 9 May 1836⁶. However, a manuscript exists, partly in ink, partly in pencil, partly in more-or-less continuous prose, and partly in note-form, that records much of Darwin's geological work at Cocos. In a few places there are headings - *Monday, Wednesday, etc* - that allow stages in the progress of the work to be dated. The writing shows many later insertions, and in places is struck through in pencil: this last was Darwin's custom when he had made use of material in a publication. These notes have every appearance of being written immediately on return from fieldwork, or possibly in some cases actually in the field. They do not bear a title, but will be referred to here as the *Cocos Coral Manuscript*; they are held in the Darwin Archive at the Cambridge University Library at DAR 41 - they were kept separate from the *Geological Diary*. As will be shown, Darwin constantly reworked his notes, adding comments and cross-references, and geological notes from several localities have annotations concerning the Cocos on the reverse. These brief scribbles too, can sometimes provide an indication in the way in which he was thinking.

It should be noted that the first draft of the "Coral atoll theory" was prepared a little earlier (probably in December 1835, or early January 1836)⁷.

Some parts of the *Zoological and Geological Diaries* were written up when Darwin had a little leisure, possibly during the voyages from port to port, from hurriedly scribbled jottings in what he called his "little notebooks" - small leather-covered brown or red notebooks used in the field for recording observations. The book, sometimes referred to as Number 1.6, includes some soundings from the Cocos; and a brief comparison of some of the living corals of Cocos with those in Mauritius appears in 1.5⁸.

Throughout the voyage Darwin collected many thousands of specimens; the period in the Cocos was no exception; while on the atoll he accumulated hundreds of specimens - corals, shells, rocks, plants, fish, insects and crabs. These were taken back to England, but are now dispersed: it was Darwin's custom to give away groups of specimens to those known to be interested in a particular biological group, or other class of material. Professor Henslow examined the Cocos plants, and thus most of the specimens that Darwin collected there are now in the Botany School Herbarium in Cambridge; they are described in Porter's paper on Darwin's plant specimens in the *Linnean Society Journal* that appeared in 1986⁹. The rocks eventually found their way into the Earth Sciences Collection at the same University. A number of Darwin's zoological specimens (e.g. the fish) are now in the British Museum (Natural History) in London. The notes relating to these various groups of specimens often survive, or in a few cases can be reconstructed, having been copied by someone else. Darwin wrote comments on his Cocos plants on small labels, for example, which were of value to Henslow, and indeed some are included in Henslow's *Annals of Natural History*¹⁰ article on the Cocos plants published in 1838.

Darwin marked his geological specimens with numbered labels, listing and describing them briefly in red, cloth-bound note-books that he kept for the purpose (also now held in the Cambridge Darwin Archive). A number of Cocos specimens of coral rock were recorded in this way.

Darwin's *Insect Notes* are preserved in the Entomology Library of the British Museum (Natural History) under the title *Copy of Darwin's notes in reference to Insects collected by him* written on the cover in Darwin's own hand; they were published (edited by K G Smith) in September 1987¹¹. It should be noted, however, that F Sulloway, in his important 1982 paper, expressed the view that the *Insect Notes* were written in August 1836.

Although he collected many of his specimens himself, he employed his servant, Syms Covington, to assist him, and some of the notes about specimens appear to be in Syms' handwriting. A list headed "Mr Darwin's shells", including many from "Keeling" may well have been compiled by Covington¹². On a few occasions Darwin included specimens in his collection that were given to him by others.

Besides *The Voyage of the Beagle*, there were two other major publications with which Darwin was associated that stemmed from the voyage. *The Zoology of the Voyage* was given his general oversight, with the different volumes being written by specialists.¹³ The volume on mammals (Part II), published in 1839, was by George Waterhouse, and contains a brief description of the "Keeling rat". That on fish (part IV) was written by Leonard Jenyns (Henslow's brother-in-law), and published in 1842 with descriptions of several fish collected at Cocos.

Jenyns' own note-book containing the descriptions of the fish, including those from Cocos, is stored in the Zoology Museum in Cambridge.¹⁴

Perhaps even more important is the *Geology of the Voyage*. This was published in three volumes, Part I being entitled *The Structure and Distribution of Coral Reefs*¹⁵. This contains a detailed description of the Cocos (Keeling) Islands as a case-study in chapter 1, and a good deal of the material in this, and other chapters of the book, can be traced to notes made on the atoll or shortly after the visit, particularly the *Cocos Coral Manuscript* mentioned above.

It seems that from about the time of Darwin's sojourn in Australia onwards he appreciated that the time for observation and collection was almost complete, and the time for reflection, collation and evaluation was at hand. For it was at about this time that he opened his *Red Note Book* (RN), a note book into which he wrote references and ideas - and indeed the location of the first known unambiguous Darwinian writings on the "transmutability of species", a jotting on the rheas (ostrich-like flightless birds) of South America made some months after his return to England. RN (the initials appear in Darwin's hand on the cover of the book) contains few direct references to the Cocos Islands ("Keeling" as Darwin usually called the atoll), but a scanning of the entries that were written during the crossing of the Indian Ocean can provide an indication of what Darwin was reading and what ideas were in his mind.¹⁶

There were others on HMS *Beagle* that were keeping journals and records while Charles Darwin was aboard, and it is frequently instructive to compare their observations with those of the ship's naturalist.

The brilliant, charismatic, aristocratic but often rather difficult Commander of the ship, Captain Robert FitzRoy, RN, wrote the official *Narrative of the Voyage*, the second part of the volume in which Darwin's *Voyage* first appeared¹⁷. Often the accounts of the two overlap, and we know that they showed each other their writings, and indeed the odd notation apparently in FitzRoy's hand can be detected in Darwin's journal; both include a cameo account of the catching of turtle in the lagoon at Cocos by the Malay islanders (see page 56). But sometimes an anecdote or observation was noted only by one of the two. Such is FitzRoy's note on the "fish-catching dog" (page 57). On the other hand there is no equivalent in the Commander's account of what appears to be a funereal ceremony, described in some detail in the Darwin diary, and in very slightly more polished prose in the *Voyage of the Beagle* (see pages 59-60). FitzRoy is always stronger, as one would expect, on matters such as hydrographic survey, meteorological observations and descriptions of the state of the sea. An Appendix to FitzRoy's *Narrative* includes details of meteorological observations (and also some geomagnetic observations that were made throughout the voyage), and thus one can say with some certainty what the weather was like for each day that Darwin was aboard the ship, or working nearby. Other sources that reflect FitzRoy's view of the voyage include the log of the *Beagle* (held in the Public Record Office at Kew under Reference ADM 51/3055). This source may sometimes give valuable clues as to timings, positions, weather conditions, stores taken aboard and such practical matters. Occasionally the log (usually written in a hand other than that of FitzRoy, but countersigned by him) gives some detail not mentioned elsewhere, but it is frequently somewhat pedestrian in character, having little of the colour and diversity of the diary and letter sources described above. Marginally more interesting are FitzRoy's letters to the Admiralty (Reference PRO/ADM 1) summarising the ship's progress and outlining immediate plans. That written from Hobart informs the Admiralty that as late as February 1836, Captain FitzRoy was intending "probably" to visit the Swan River Colony (which was in fact omitted from the itinerary) and only "possibly" the Keelings.

Mention has already been made of Darwin's servant, Syms Covington, who also kept a journal (now in the Mitchell Library in Sydney, New South Wales),¹⁸ that contains observations on the Cocos. Charles' relationship with Covington is interesting. Syms was engaged on the ship as "fiddler and boy to poop cabin" and was appointed Darwin's assistant and secretary in about May 1833. In a letter to Caroline Darwin¹⁹ dated July 1834 Charles wrote of his servant as "an odd sort of person"; he went on: "I do not much like him; but he is perhaps from his very oddity very well adapted to all my purposes" and indeed at one

stage Darwin described Syms as "invaluable"²⁰, for he left a lot of the shooting and skinning of bird specimens, and other collecting work to his assistant in the later stages of the voyage. To judge by comparisons between their two diaries, Syms Covington often accompanied Charles on his excursions, although he is only seldom mentioned in the naturalist's letters or diary. The relationship appears to have been a distant one, and confined to business matters. Probably the social gulf between the well-to-do young Cambridge man and the "boy to poop cabin" was too great for the relationship to have ever been close.

Although in most particulars Covington's journal echoes that of Darwin, it contains occasional fragments not recorded in either the Darwin or FitzRoy journals. Darwin, for example, writes of the Malay kampong on Home Island:

The whole place bore a rather desolate air, because there were no gardens to show signs of care & cultivation.

FitzRoy, however, commented that when they left the islands they had with them supplies of coconuts, poultry, pumpkins and turtle and that "Maize and sugar-cane might have been had if wanted". Covington observantly noted that the poultry were of the Chinese breed, and that bananas, and tobacco were also grown, the latter producing well. He also mentions the growing of coffee, although he carefully states that he "never saw it". He also noted that the Java sparrow had been introduced to the islands, a fact which, rather surprisingly, Darwin does not seem to record.

Although most of Covington's diary is in rather attenuated style, and is anything but a literary work, there occur some quite evocative snatches of description:

The water always being clear the beautiful branches of coral can be seen from the ships side, the fish passing & repassing amongst the coral, has (*sic*) a most beautiful effect...

... in the small lagoons or pools on reefs are immense numbers of small fish of difference (*sic*) species & the most brilliant colours I ever saw, or fancy could paint...

Yet Syms Covington's observations must be treated with a measure of caution; he is not infrequently in error. Sometimes he is essentially accurate, but gives the wrong impression. For example he asserts that "about 50 or 70 Malays from the Cape of Good Hope live on the Islands".

Most of the Malays in fact came originally mainly from south-east Asia, although to be fair, Hare had resided in Cape Colony with his entourage after being required to leave Borneo, and indeed there does seem to have been a small amount of African blood.

The main objective of the circumnavigation, from the point of view of the Admiralty, was the compilation of hydrographic charts, a task at which FitzRoy was first rate. Early in the voyage Captain (later Admiral) Beaufort, to whom FitzRoy reported in the hydrographic department of the Admiralty, wrote to the *Beagle's* Captain:

Were my letters to lie in any degree proportionate to the deep interest I take in your voyage or to the extent of the materials you send me home, I should have time for nothing else. (5 September 1832)

It is particularly agreeable to me to hear such strong language about your survey ... All agreeing that none worked so hard, so well and so pleasingly as you - Long may you enjoy the delightful pleasure of just praise. (5 June 1833).²¹

The originals of these letters are also preserved in the Mitchell Library, Sydney, New South Wales.

Amongst the charts that were produced following the voyage was one of the Cocos (Keeling) archipelago, published in 1845, which in the distribution of the soundings and certain other information it contains, provides evidence of where members of the ship's company went during their few days in the islands. The original manuscript charts are still in existence in the Ministry of Defence Hydrographic Office's Archives at Taunton, Somerset. They bear the stamp: *Hydrog Office 10 My 37*. Even a cursory inspection of these charts shows that Captain Beaufort's remarks were fully justified.²²

Sometimes a source entirely independent of the *Beagle* can throw light on a particular incident or stage of the voyage, perhaps only to corroborate the writings of Darwin, Covington or FitzRoy, but occasionally to bring some quite different aspect into view. In New South Wales, Darwin stayed with the King family, and certain items in the archives of this family, now in the Mitchell Library, Sydney can throw light on incidents in Darwin's sojourn in the Colony; at King George's Sound, Darwin and FitzRoy called on Sir Richard Spencer, and reference to the visit can be found in a report written by Sir Richard, now in the Battye Library, Perth. There is one document that is in some respects comparable with these sources for the Cocos visit, but, for

reasons that will become clear, it was not used as extensively in compiling this account as it could have been. Nevertheless, the circumstances of its creation are so strikingly interesting, that despite questions about its reliability, some notice of it is given here.

When HMS *Beagle* came to anchor at Cocos in 1836, Captain John Clunies Ross, proprietor and self-styled ruler of the island group, was away, and so never got to meet Darwin, FitzRoy and the crew of the little ship. Both the ship's naturalist and the Captain obtained a good deal of information about the archipelago from Mr Liesk, Ross's assistant, a fact that Ross bitterly resented, partly no doubt because he (justifiably) considered him unreliable, and partly because he came to regard him as a "treacherous plotter". Because of Liesk's information, and what they they saw, the accounts of the remote settlement written by both Darwin and FitzRoy were less than complimentary. Ross also disputed Darwin's theory of origin of coral reefs. The result of all this was that Ross developed a blazing hatred of both Darwin and FitzRoy, and for the rest of his life wished to discredit them: possibly living for long periods in isolation influenced his sense of proportion. Clunies Ross prepared an account that he entitled: *Voyage of the Adventure and the Beagle: Supplement to the 2nd and 3rd Appendix Volumes of the First Edition*. On the title page of the document he appended "written for and in the name of Author of these volumes by J.C. Ross, sometime master of a merchant ship".

This account, well over a hundred pages in length, although prepared as though written by FitzRoy, is in fact a vicious attack on both FitzRoy and Darwin.

It is couched in terms of vitriolic sarcasm, and in places it is intemperate to say the least. It is so libellous that no publisher would ever accept it. Although obviously the work of someone of considerable ability and education, and not devoid of insight, in a few places it lapses almost to incoherence, as though written by a person utterly consumed with rage. It seems to have been written in the late 1840s, some ten years after the *Beagle's* visit to the remote Indian Ocean group, and in relation to Darwin and FitzRoy's activities on the islands, describes (probably largely on the basis of the account of Mrs Ross who remained at Cocos during her husband's voyage) incidents that he did not personally experience. It is frequently in conflict with other writings. In view of all these factors it cannot be regarded as a very reliable source.

An extract from an early part of this extraordinary diatribe will indicate its rich flavour. Remember that although written by Clunies Ross, it effects to be FitzRoy speaking:

I naturally wished to have a savant at my elbow in the position of a humble toadyish follower - who would do the Natural History department - on my account - but not being able to obtain such a one I was (in a mariner) compelled to take Mr Darwin on a far too independent footing. - He was indeed, perhaps he still is "very fond of Natural History" - but by way of ascertaining that fondness involves fitness - Mr Ross has promised ... he shall ... exhibit evidence to [show this] ... in Mr Darwin's instance, especially in respect to the super sublimity and deeply diving profundity of his "Theory of Origin of the low and lagoon encircling Islands of the Coral formation".-

(*Clunies Ross Papers*, British Museum Additional MSS No 37631)

The document purports to demonstrate a large number of errors in published FitzRoy's accounts, and maintains in thinly veiled fashion that he (FitzRoy) is guilty of plagiarism, for example, in that the charts prepared by FitzRoy and his officers were based on surveys previous conducted by Ross.

But Ross's sarcastic venom is sprayed alike onto hydrographic surveyor and the naturalist:

... Mr Darwin is exceeding "fond" of dry bones - and charmed into raptures by the discovery of a Skeleton.

Although this material must obviously be used with the very greatest caution, in a few instances its record can, however, perhaps be usefully placed alongside others.

Another source of material available to the enquirer attempting to reconstruct what Charles Darwin did and thought about during the voyage should be mentioned: the books that Darwin read. Darwin's little cabin (about 3m x 3.5m) also served as the ship's library, and the shelves adjoining the "great table" on which he spread his notes and specimens contained hundreds of books²³ to which he frequently made reference in writing his notes. For example in his description of the giant robber crabs of Cocos Darwin noted that:

In the 'Voyage par un Officier du Roi' to the Isle de France there is an account of a crab which lives on Cocoa Nuts in a small island North of Madagascar: probably it is the same animal. (DAR 31.2/361, Reverse)

Darwin seems to have made good use of this source²⁴ throughout the Indian Ocean sector of the voyage, for he also quotes the Officier in his geological notes on Mauritius, particularly with regard to coral reefs now raised above the level of the sea. Other "Voyagers' accounts" to which Darwin frequently made reference were those of Freycinet²⁵, Dampier²⁶ Beechey²⁷ and Flinders²⁸.

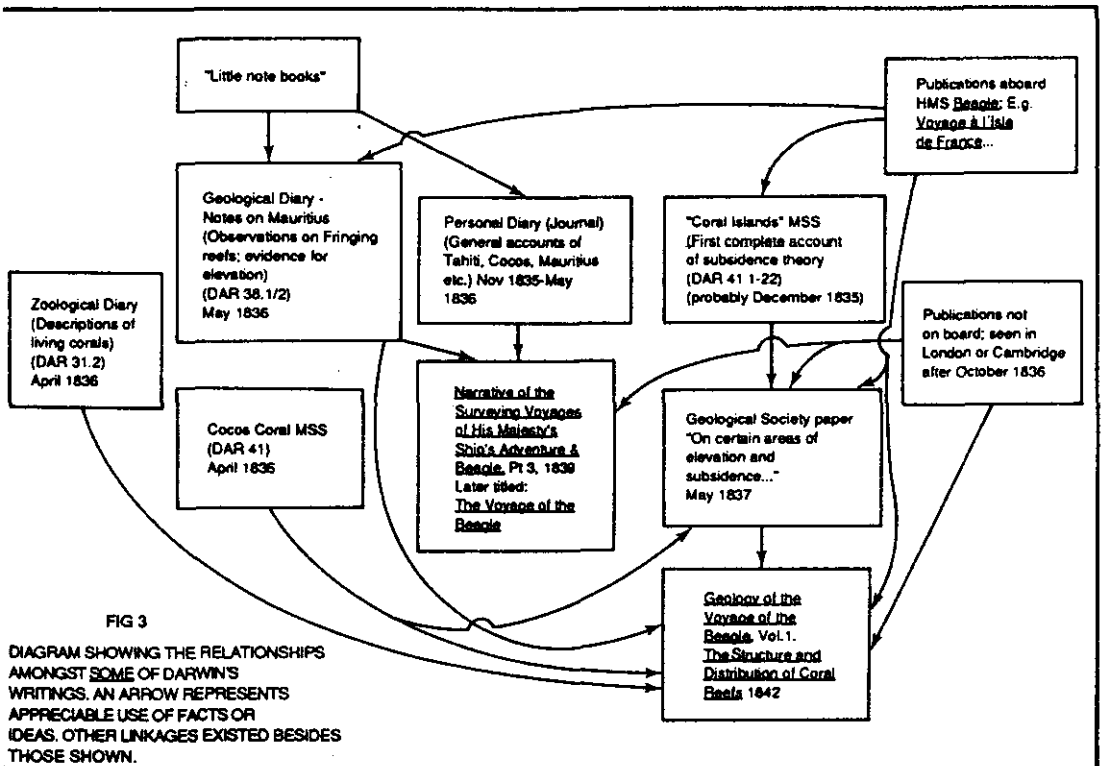
But probably the work that was most frequently open upon the "great table" was Charles Lyell's *Principles of Geology*,²⁹ which had a profound influence on the way in which Darwin perceived the world around him throughout the voyage, and was of particular significance during the stay at Cocos, because Darwin's "coral island theory" amounted to a disproof of the notion, espoused by Lyell, that atolls formed as the result of the growth of coral upwards from the lip of a submarine volcanic crater. The Red Note Book (RN) contains many references to Lyell.

By comparing these printed sources with Darwin's notes it is possible to reconstruct something of the way in which the young Darwin absorbed the ideas of others during the voyage. By a cross-comparison of the different manuscript materials, and by comparing the *Beagle* notes with later published writings by Darwin it is possible to see how his own notions developed over time. The "flow" of ideas can be followed - from printed page to note book, from note book to rewritten manuscript, later to be reworked yet again and combined with material from some other part of the voyage, and finally to some writings of Darwin's later life. Some of these relationships are shown in Figure 3.

And then there are the islands themselves. I was fortunate in September of 1987 to be able to spend a week on Cocos, staying on West Island, but visiting several of the other islands visited by Darwin just over 151 years previously. Certainly much has changed: West Island now supports an airstrip of major strategic importance, and the islands provide air-traffic control for a substantial part of the Indian Ocean region. There is a wind generator on Home Island, and a large satellite dish on West Island. The scientist visiting the atoll today (it is now an overseas territory of the Commonwealth of Australia) can stay in an air-conditioned chalet, and have meals prepared for him in a modern mess - a far cry from the poop cabin of the *Beagle*! Yet most of the atoll would be recognisable to members of the crew of the ten-gun brig. Today's visitor can marvel at the brilliant blue of the lagoon, and the contrast between the green palms and the white sand, just as did the nineteenth century voyagers. In walking along the coral reefs, thrashing through the dense thickets of coconut palms, and watching the fish amongst the coral of the lagoon with photocopies of Darwin's

notes in hand the modern enquirer can probably get as close to Charles Robert Darwin as he can anywhere, with the possible exception of the Old Study at Down House, in Kent. In seeing the plants collected by Darwin in their natural habitat, and examining the coralline rock platforms that he described, I felt that I understood the man that little bit more clearly.

Finally, it must be stressed that it is the *totality* of the rich, but scattered treasury of Darwin materials that allows the modern student to attempt a reconstruction of the young Victorian naturalist's doings and thoughts during those important few days in April 1836 when Darwin's ideas on the nature of coral atolls seemed to be gaining confirmation, and perhaps, just perhaps, vague ideas on the nature of life in islands were forming in his mind. By comparing the accounts of the different actors in the drama, different insights on the nature and importance of incidents during HMS *Beagle's* visit can be gleaned. By examining Darwin's writings on particular subjects before, during and after the Keeling experience the development of his ideas can be traced. By examining the islands themselves, alongside the printed sources available to Darwin aboard the *Beagle*, one can to some extent reconstruct the array of stimuli to which he was exposed. The whole really is greater than the sum of the parts!



Chapter 2 Island Days

Captain Robert FitzRoy's Instructions, issued by their Lordships of the Admiralty at the start of His Majesty's Surveying Sloop *Beagle's* historic voyage, included the suggestion that the ship might call at the Keeling Islands and "accurately fix their position", providing that the northern or Torres Strait route from the Pacific to the Indian Ocean was followed. In the event the *Beagle* arrived at Port Jackson (Sydney) on 12 January 1836, at the height of the southern hemisphere summer, and thus it was possible for the Captain to take his ship by the southern route via Hobart Town and King George's Sound, and around Cape Leeuwin into the southern Indian Ocean. Captain FitzRoy's letter to the Admiralty written from Port Jackson on 29 January 1836 reads:

The *Beagle* ... will sail tomorrow for Van Diemen's Land. Thence she will proceed towards England, touching at King George's Sound, the Mauritius, Cape of Good Hope and St. Helena...¹

It was also planned to visit the Swan River Colony. But instead of calling at Swan River, and making a direct traverse thence across the Indian Ocean, the *Beagle* deflected northwards to Cocos.

There is thus every indication that the decision to visit Cocos was taken very late in the day.

The voyage around Cape Leeuwin, and northwards parallel to the coast of Western Australia, was a difficult and stormy one, and thus although the *Beagle* "stood out of the Sound of King George" on 14 March, it was not until 8.45am on the 1 April 1836 that the ship came within sight of the Cocos Islands. Darwin's diary describes the Voyage:

Our passage would have been a very good one, if during the last five days when close to our journey's end, the weather had not become thick & tempestuous. Much rain fell, & the heat & damp together were very oppressive: in the Poop cabin the thermometer, however, only stood at 81° or 82°.

The night before the Cocos landfall, the Captain and officers of the *Beagle* had not been entirely sure in which direction lay the islands - unsurprising in view of the stormy weather experienced during the last few days of the passage, and the fact that one of the tasks of the expedition was to fix their position, and FitzRoy recorded:

[We] were in much doubt whether they lay eastward or westward of us. There was reason to induce me to steer eastward - indeed I was about to give orders to that effect just as the sun was setting, (no land being seen from the masthead, though the horizon was clear) - when a number of gannets² flew past the ship towards the west. We steered directly after them, and the next morning (after making but little headway during a fine night) saw the Keelings right ahead, about sixteen miles distant. (Narrative)

FitzRoy's account goes on to describe the first sight of the archipelago:

A long but broken line of cocoa-palm trees, and a heavy surf breaking on a low white beach, nowhere rising many feet above the foaming water, was all we could discern till within five miles of the larger Keeling, (there are two distinct groups) and then we made out a number of low islets, nowhere more than thirty feet above the sea, covered with palm-trees, and encircling a large shallow lagoon. (See Figures 4 and 5.)

Although the weather was fine that April morning - the log shows the symbol "b" or "bc" for "blue sky" or "blue sky with passing clouds" - the winds were light and variable in direction (force 1 or 2) and progress was slow. At 10.30am the ship "altered course to WNW and trimmed" her sails. An hour later all scuddy sails were taken in, and sails were again trimmed. At noon the position was noted as 12^o15" S, 96^o58"E by dead reckoning, and 12^o8"S, 97^o01"E from instrumental observations, and the nearest point of the islands was to the west-north-west at a distance of about six-and-a-half or seven miles. At 2.00pm signal guns were fired for a pilot and at 3.00 the ship's boat was sent ahead. An hour later the log records that the "Pilot came on board". The "pilot" was Mr Liesk (Darwin wrote in his diary that "Mr Liesk, an English resident, came off in his boat")³, and he assisted in bringing the ship into "Port Harrison" just outside Direction Island, and the vessel was anchored in 4 3/4 fathoms at 5.20pm. Boats were then put out.

The following morning (Saturday 2 April 1836), at 10.00 am, the log records that the anchor was weighed and the ship "swept in" to the lagoon on the powerful current that exists between Direction Island and Horsburgh Island. The anchor was then cast in "Port Refuge", the part of the lagoon with a sandy bottom 3 to 5 fathoms (5.5m to 9m) in depth inside Direction Island. Frequently today a number of ocean-going yachts are to be seen at anchor in precisely this location, and it is not hard to imagine the *Beagle* on the brilliant blue-green lagoon, a couple of hundred metres out from that island. As Darwin noted that it was

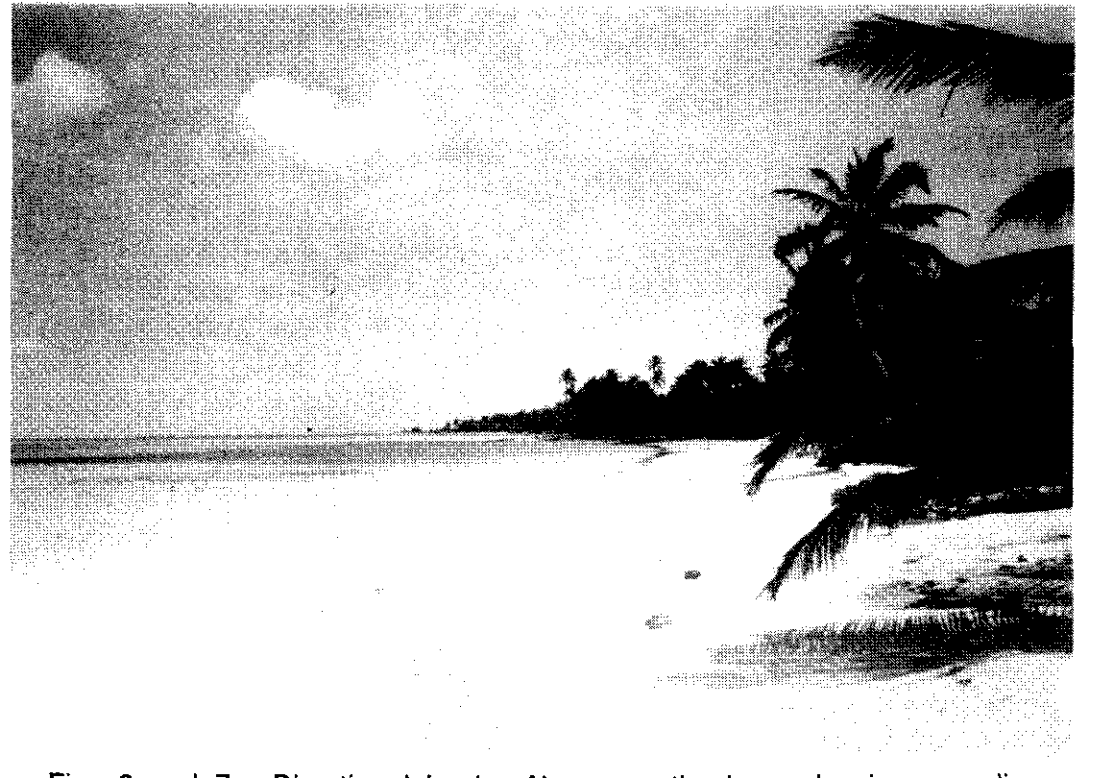
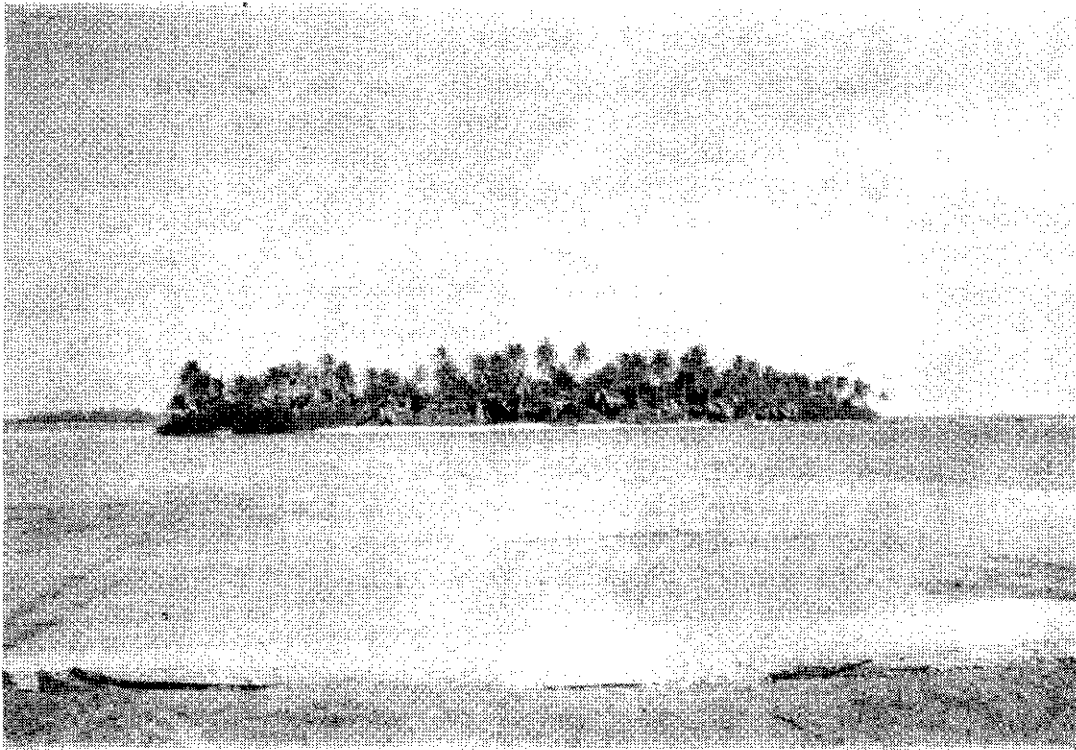


Fig 4 (above). "Low islets ... covered with palm-trees ... encircling a large shallow lagoons." Pulu Maria, from West Island. 5 (below). Coconut palms and *Scaevola scrub*, West Island.

Figs 6 and 7. Direction Island. Above: north shore showing pounding surf: "On the outer coast, a broad flat of coral rock serves to break the violence of the sea." Below: inner shore: "On the lagoon side is a white calcareous beach."

"still morning" when he "went on shore on Direction Island" (see Figures 6 and 7, he obviously wasted very little time; from the character of his descriptions he seems to have walked around a good deal of the shore of the islet, and botanising and collecting probably occupied much of the rest of the day.

The next day (3 April) was Sunday, and the Captain's log records:

11 - Mustered by Divisions, & performed Divine Service.

The young naturalist, once destined for the Church of England priesthood, attended. His record goes on:

After Service I accompanied Captain FitzRoy to the settlement, situated at a distance of some miles, on the point of an islet thickly covered with tall cocoa-nut trees. (*Voyage*)

The Captain and his young scientific colleague seem to have spent the better part of the afternoon and evening on Water or Home Island (the site of the settlement - see Figures 8 and 9) for he describes in detail the Malay kampong, its inhabitants, and the wells from which water was obtained. The meal, that evening seems to have been taken with Mr Liesk's family, and perhaps Mrs Ross, for the Ship's Naturalist notes: "After dinner we stayed to see a curious half superstitious scene acted out by the Malay women ... The dance did not commence until the moon had risen" (see page 59).

Evidently the visitors remained quite late (there is a hint in the Clunies Ross account, see page 11, that they stayed the night) and they must have enjoyed themselves, for Charles writes quite lyrically of the scene. Probably the conversation spread over the natural history of the islands, their formation and the settlement, for Charles Darwin quotes Liesk quite frequently in his notes in all these subjects.

Of the next day (Monday 4 April) Darwin recorded "I employed myself in examining the very interesting yet simple structure and origin of these islands". The weather was mainly fine; the "occasional squall" or passing shower that occurred that day would not have deterred the enthusiastic young scientist. It seems, from his descriptions that he visited West Island, for he describes an inlet surrounded by trees, which may have been North Lagoon (Telok Jambu) and Darwin's descriptions of coral reefs seem to be at least partly based on the outer coast of West Island. Thus we may picture the by now sun-bronzed young Englishman collecting and observing, at times wading out into the breakers to examine corals, at times thrashing his way through coconut thickets seeking plant specimens.



Figs 8 and 9. Home (Water) Island. Above: "The settlement ... situated on the point of an islet thickly covered with tall Cocoa-nut trees. Below: the kampong, September 1987.

For much of HMS *Beagle's* sojourn in the islands the log gives rather little information, although we know from it that on 4 April some of the crew were "employed watering" - carrying water from the wells on Water Island (Home Island) to the ship. Watering continued on 5 and 6 April. For the most part, however, for several days of the *Beagle's* stay in Cocos, the log says only that the crew were "Employed variously on ship's duties" or something similar. But Captain FitzRoy, Midshipman Stokes (Assistant Surveyor) and several of the other officers and members of the crew must have been busy with hydrographic survey. The manuscript maps show a dense pattern of soundings in the northern half of the lagoon - the area adjoining Home, Direction, Horsburgh Islands and northern West Island - implying a whole series of traverses back and forth across that part of the lagoon. Detailed navigational measurements were also made (to "accurately fix the position of the islands"), probably under the supervision of Lieut Sullivan, from an "observatory" on the westernmost point of Direction Island.

On Wednesday 6 April Charles accompanied the Captain on an expedition in one of the ship's boats to the extreme south of the lagoon. He wrote in his diary: "The channel was exceedingly intricate, winding through fields of delicately branching corals". They saw several turtle, and Malays hunting them. Detailed observations were made on the corals, fish, molluscs and the other varied and beautiful creatures in the calm, shallow water. Notes in Darwin's *Cocos Coral Manuscript* give some detail:

The upper parts of the Lagoon are much filled up with Coral. Extensive flats are nearly awash at low water, and only here & there a circular hole of 12 fathoms deep is left, & these are clearly being filled up. The more common depth is about 6 fathoms, so that this is a shallow lagoon. ... The commonest species are the (*Seriatopora*, crown coral, a yellow sort) ... *Fungia*, *Escara*, *Chama*, *Meadrina* in great loose balls.- *Astrea* (the bulwark species) infrequent, as are the two other kinds which are found outside ... These Corals are brittle & soft, & on standing on them a person breaks through to some depth.

(DAR 41/9)

The boat eventually reached the southern part of South-East Island (Pulu Atas). The position of the soundings recorded on the manuscript maps in Taunton, as well as aspects of Darwin's description, such as the mention of expanses of turtle grass, and "hillocks of blown sand about 14 ft" confirm this.

When we reached the head of the lagoon, we crossed a narrow islet, and I found a great surf breaking on the windward coast.

The contrast between the quiet waters of the lagoon, and the pounding Indian Ocean surf of the outer reef - just a short walk through the coconut thicket and scrub apart - obviously impressed Darwin.

I cannot explain the reason, but there is to my mind much grandeur in the view of the outer shores of the lagoon island. There is a simplicity in the barrier, the margin of green bushes and tall cocoa-nuts, the solid flat of dead coral-rock, strewn here and there with great loose fragments, and the line of furious breakers, all rounding away on either hand.

(*Voyage of the Beagle*)

The intrinsic beauty of the scene, Darwin's appreciation of the exotic, and the elegance of the coral atoll theory, already partly-formed in his mind, were probably sufficient reason for him to pause awhile on this lonely tropical beach after he had worked his way through the tangled palm groves and *Scaevola* scrub that afternoon, before he returned through the thickets to where the boat was drawn up on the inner shore of the narrow islet.

Even when Darwin and FitzRoy, and their accompanying crew members, had returned to the boat and cast off again into the lagoon, they did not hurry back to where the *Beagle* lay at anchor near Direction Island. Darwin recalls:

We did not return on board till late in the evening, for we staid a long time in the lagoon, examining fields of coral and the gigantic shells of Chama, into which if a man were to put his hand, he would not, as long as the animal lived, be able to withdraw it. (Voyage)

Few of the very large clams (*Tridacna gigas*) are to be found in the lagoon today, but smaller individuals abound, and a number of shells of the larger species (up to 1m in length) can be seen in the settlement on Home island - quite sufficient to give a vivid impression of the organisms that so impressed Darwin.⁴ He was also much interested in the fields of dead coral that the boat encountered on its return trip to the ship. These are discussed on page 97.

From 7 April (Thursday) onwards, as far as the fragmentary annotations in the log enable one to judge, the crew of the *Beagle* were preparing to sail on the next leg of the voyage. On the morning of 7th, many of the

crew were "Employed cleaning lower decks", and it is also recorded that the ship "Received Wood per boat" - this may well have been firewood for cooking. On the 8th the Armourer was at work at the forge, and carpenters were working on the spithead yard. The 11th saw the sailmakers repairing the topsail. Food supplies - turtle, poultry, vegetables and coconuts - were taken aboard.

There are clues in Darwin's diary that some of this activity was "filling in time", for he writes of the latter part of the stay:

April 7th-11th. During these days nearly every one was employed in parts of the examination of the Island: but the winds being very strong rendered the most important part, the deep sea sounding, scarcely practicable. I visited Horsburgh & West Isd. ...

An examination of the meteorological record confirms that high winds - force 6 and 7 - were experienced on the 6, 7 and 8 April. At 6 am on 7 April the wind reached force 8 ("fresh gale"); clearly the exacting work of measuring the depths of water close to a coral reef would be virtually impossible, and certainly extremely dangerous, under such conditions.

FitzRoy's account suggests that *some* survey work, mainly in the lagoon, continued until 12 April.

In the evenings, and whenever they were not otherwise required for ship's duties, the seamen probably spent their time relaxing in the sun, fishing or swimming (see note from Covington's diary, page 31). One day FitzRoy seems to have baptised some of the European children in the settlement. He recorded:

As no Christian minister had ever visited the place, and there was no immediate prospect of one coming there, I was asked to baptize the children of Mrs Leisk. So unusual a demand occasioned some scruples on my part, but at last I complied, and performed the appointed service in Mr. Ross's house; where six children of various ages were christened in succession.

(In the Church of England, as in many other denominations, any baptised Christian is entitled, when the occasion demands it, to baptise, but it was no doubt thought that the Captain of one of His Majesty's naval vessels would add a certain dignity to the occasion. The Ross papers have it that only three children were baptised.)

In fact FitzRoy must have quite a lot of contact with the Liesk family, probably drawing on Mr Liesk considerably for his information on the islands. Despite the intemperance that characterises any of Clunies Ross's remarks about either FitzRoy or Liesk, there is a description of one incident in the Ross manuscripts (see page 12) that has something of a ring of truth to it. Here, again, is Ross writing as though he were FitzRoy:

Knowing as I think I did, that some of the Malays could speak - and nearly all understand English, and of whom some were within earshot - I therefore hesitated not to utter my thoughts to Mr Leisk - whilst walking to and fro with him in the shade of the coco-nut trees. A peripatetic academical mode which I preferred to any other - 1st as being classical - and 2nd that altho' near the house - the walk was far enough distant for our not being overheard by Mrs Ross - who however (with true woman's tact) guessed by our gesticulations and squinting alternately towards the Malay bystanders and towards the house - that our confabulations were not of any very fair - above board or honourable nature - and expressed her suspicions thereof to Mr Ross, when he returned.

(*Clunies Ross Papers*, BM Add Mss 37631, *Adventure and Beagle Document*, page 110)

FitzRoy was always a slave to *what he considered to be* his duty, and would never be a party to anything *that he thought* to be dishonourable. (His particular perspective, however, got him into trouble several times in his career.) Yet the picture of the aristocratic FitzRoy, walking up and down in the shade of the coconut palms "in classical mode", in enthusiastic converse with Liesk about the status of the Cocos Malays has every appearance of being accurately drawn.

Darwin meanwhile probably continued his collecting of plants, insects, fishes, rocks, corals and other marine invertebrates, and his careful observation of the island environment. No doubt he would sometimes have been ferried by one of the ship's boats to an islet in the morning, and collected later in the day. It is likely also that he was at least sometimes accompanied by his servant Covington (the pronoun "We" is occasionally used, and FitzRoy generally prohibited members of the crew of the *Beagle* from wandering off on their own). But it is not easy to date precisely Darwin's activities during the latter part of the stay. However, in the *Cocos Coral Manuscript* a section headed "Horsburgh Isd" follows the account of the southern part of the lagoon and South-east Island. On the other hand this section precedes some notes headed "Monday" (ie 11 April). The notes made on the basis of work on Wednesday 6 April are

very detailed, and will have taken some time to write up; as the 6th was a very full day's outing, the notes are not likely to have been completed that evening, so possibly part of Thursday 7 April was devoted to this task. This would suggest that Friday 8th, or Saturday 9 April was the date of the Horsburgh Island excursion. Sunday 10 April is less likely, but not impossible.

On Horsburgh Island Darwin noted that a small area on the lagoon side had been accidentally cleared by fire; this seems to have facilitated some of his geological observations. He comments on the sand heaped up on the lagoon side, and the breccia deposit close to the beach.

Confirmation of the date of the Horsburgh Island visit is found on page 15 of the *Cocos Coral Manuscript*; clearly the visit to West Island took place after that to Horsburgh:

Monday [11 April]

Crossed over to West Isd.- Found one part of Beach exposed beds of Calc Sandstone precisely resembling those of Horsburgh Isd. Here then the lagoon eats out its own formation. In several other places old trees have been undermined & fallen.

In another part a large lagoon covered with the finest white sand is only covered at Spring Tides. It is formed ... of bits of branched coral thrown up by gales of wind... On the outer coast, which is the leeward Coast, the reef is very broad. ... There is however, in parts, a little way inland, a high beach and some sand hillocks...

Much of this description of West Island (now the site of the runway, and the home of the Australian "expatriate" community) is still appropriate. The sandy hillocks are not far from the settlement. The inlet is clearly North Lagoon (Telok Jambu) - in his diary Charles mentioned the way in which "smaller creeks penetrate the surrounding woods". And clearly this inspection of West Island (the name Ross Island appears on some of the manuscript charts at Taunton) must have been after the visit to Horsburgh.

Darwin also reports of West Island:

... the vegetation is perhaps more luxuriant than in any other part. Generally the Cocoa trees grow separate, but here the young ones flourished beneath their tall parents & formed with their long & curved fronds, the most shady arbors.

(See Figure 10.)

He also describes what it was like to be seated in such a shady place, and there drinking the "cool pleasant fluid" of the coconuts. Once again our young scientist friend is impressed by the picturesqueness of the scene:

...thus to see a field of glittering sand ... around the border of which the Cocoa nut trees extend their tall waiving fronds, formed a singular & very pretty view.

(*Diary*, April 7th - 11th, 1836)



Figure 10. West Island: "Generally the ... trees grow separate, but here the young ones flourished beneath their tall parents & formed with their long & curved fronds, the most shady arbors."

The fine detail of some of the hydrographic notes in the *Cocos Manuscript* (depths of water, character of sea bottom) suggests that Darwin may have been present when hydrographic work was being conducted during the last day or two of the stay. On the other hand it is quite possible that some of these particulars could have been obtained from FitzRoy, Sullivan or Stokes; in some cases, the pencil notes include a day of the week by way of heading upon which Darwin was occupied ashore.

In the evenings, after fieldwork, and sometimes after dining with FitzRoy, Darwin would write up his notes, and sort his specimens in the poop cabin of the *Beagle* - rocks, plant specimens, instruments, notes and reference books spread out in the dim light of a lantern on the table, while the gentle waters of the lagoon lapped against the ship's hull. Sometimes he probably sat on deck, chatting idly to friends among the ship's company, beneath the rising moon, with a gentle tropical breeze in the rigging and amongst the canopies of the palm trees on the island a short distance away, before he turned in to his hammock.

But Charles Darwin, and probably everyone else on board the *Beagle*, would have been up early on 12 April. The day was fine, with some clouds amidst the light blue of the early morning tropical sky; there was a light haze. The wind was quite strong (force 5), although it weakened somewhat later in the day, and the swell seems to have been less than for some days. Once or twice in the course of the morning there were squally, passing showers, and indeed occasionally in the course of the day the sky was described as "gloomy or threatening".

At 6.00am the ship's boats were taken aboard, and the ship was "unmoored". Top gallant yards were set at 10.00, but it was not until 11.30 that the anchor was weighed and the crew "made sail to top gallant sails". The ship briefly hove to just off Port Refuge, close to the tip of Direction Island, around noon. Just after midday Royals and starboard topmast scuddy sails were set, although it was necessary to take in some sails at 12.30pm. 1.30 saw the HMS *Beagle* making "all sail" to the nor' nor' west.

Some soundings appear to have been taken as the ship set off, and this may account for the slight delays - FitzRoy seems to have been awaiting exactly the right conditions for this work (see page 24). Darwin recorded in his Diary:

April 12th.- In the morning we stood out of the lagoon on our passage to the Isle of France [Mauritius] ... Captain FitzRoy found no bottom with a line at 7,200 feet in length at a distance of only 2,200 yards from the shore; hence this island

forms a lofty submarine mountain, with sides steeper even than the most abrupt volcanic cone.

This last observation must have been gratifying to Darwin, providing as it did support for the notion that coral atolls formed atop a subsiding volcanic cone.

Under full sail, and with a good wind it would not have taken more than an hour or so before the ship was within sight of the tiny atoll of North Keeling, about 24km (15 miles) north of the main group. No one from the *Beagle* landed, although a few soundings were taken as the little brig rounded the islet in a counter-clockwise direction, just a few hundred metres away at the closest point. The form of the atoll was sketched, probably partly from the masthead, as the inner lagoon of the little atoll was recorded approximately correctly. Despite the apparent superficiality of this inspection of North Keeling, the survey stood the test of time, for on hydrographic charts of the Cocos Keeling group, there appeared, until 1986, an inset of the northern islet partly attributed to "Captain R FitzRoy, RN, 1836". Darwin was no doubt watching very carefully; he was deeply interested in the northern islet, as a representative of a particular category of islands - the nearly circular, virtually closed atoll. He had earlier discussed the form of North Keeling with Mr Liesk, and scribbled a few notes about it on the back of his *Cocos Island Manuscript*.

At 4.43pm, the crew of the *Beagle* had their last glimpse of Cocos. At that time the north-west tip of North Keeling Island lay N 27° E, and Direction Island S 29°E. The afternoon sun may have lit up the distant palm trees, and there must have been a touch of sadness in the hearts of some of those aboard who had enjoyed this place of beauty and tranquillity. Neither Darwin, nor FitzRoy, nor indeed, as far as we know, any of the crew, ever returned.

Chapter 3 The Naturalist at Work

Let us now examine some aspects of the way in which the Ship's Naturalist of the *Beagle* worked during the ten days that he sojourned at the remote Indian Ocean archipelago. His studies of the topography and the origin of the islands are described elsewhere in this publication, and will not be discussed in detail here. Attention will be concentrated upon the manner in which he set about making his natural history collections, and the way in which he perceived and evaluated this extraordinary environment.

Collecting

Charles Darwin was a copious but careful collector. In advising those about to depart upon voyages similar to his own he was later to write that for a few types of specimens the student "can hardly collect too copiously".¹ He lived and worked in the great age of natural history collections. But he also cautioned:

In the present state of science it may be doubted whether the mere collection of fragments of rock, without some detailed observations on the district whence they are brought, is worthy of the time consumed and the carriage of the specimens ... A mere fragment, with no other information than the name of the place where found, tells little ...

In the few days that HMS *Beagle* lay at the Cocos or Keeling Islands Darwin (with his servant Covington) collected about nine species of fish, one mammal, one bird, several species of corals and sea anemones, a specimen of the vast robber crab (now rare on the southern atoll) and thirteen insects, as well as at least nineteen species of flowering plants, a moss, a fungus, several dozen shells and about seventeen rock specimens. The methods used for collection we can infer from his notes, and the comments that are attributed to him in some of the published descriptions of specimens. In a few cases, where we do not have a great deal of information on collecting techniques actually used at Keeling, we must generalise from other locations, for collection methods are likely to have been fairly standard.

Fish were sometimes caught by means of a seine net, but the lagoon and reefs around Keeling hold fish in such abundance that, as sailors habitually do, probably some members of the *Beagle's* crew fished with a line, giving or selling to "the philosopher" anything that they caught which was of special interest. Sometimes Darwin records the eating

qualities of fish in his scientific notes, so some collecting was done with more than one purpose in view! An interesting, and very human sidelight on the fishing (and other) activities pursued the crew of the *Beagle* while the ship lay at anchor off Direction Island is provided by the following extract from Syms Covington's journal:

On Sunday the 3 of April caught a shark 8 feet long which put a stop to our bathing which before was [for done *del*] at every evening by moonlight.²

Fish, along with other organisms with soft parts, were often preserved in spirits. A few other specimens were dried. Darwin was careful always to take note of their colours when fresh, for both preservation in spirit and the drying of skins caused some colours to be lost, others to change. He described, for example, a specimen identified by Jenyns in the Fish volume of the *Zoology of the Voyage* as *Diacope marginata*, in the following terms:

Upper part pale lead colour: pectorals yellow; ventrals and anal orange, sides very pale yellow.

But Jenyns commented: "In spirits, the colour appears almost uniform greyish-white".³ Darwin's co-workers had cause to be grateful for his perceptive, vivid, descriptions of the colours of fresh specimens.

Insects were probably collected mainly by sweep netting - Darwin used a sweep net extensively in Australia and South America, and one of the entries in Darwin's book of "Insect Notes" (3593) reads: "Insects sweeping: the small ant swarms in countless numbers Keeling Island".⁴ It is likely that the "Keeling rat" was caught in a trap baited with cheese; Darwin noted that he caught rodents at several localities using this method. The bird, a specimen of what was later identified as *Rallus philippensis* (the banded land-rail; the Cocos form is an endemic sub-species), was presumably shot. Fragments of coral rock, and perhaps living coral, were probably broken off with the help of his geological hammer: we know that he found some coral rock particularly hard to break, and had to use a chisel. However FitzRoy mentions unsuccessful attempts to obtain samples of coral from below five fathoms, just offshore; small anchors, hooks, grappling irons and chains were all employed, and all were broken as soon as the strain was taken up. Soft sediments were sometimes taken from the sea bottom from the side of the *Beagle* using a dredge or by a tallow-loaded sounding lead. Shells, including many specimens of species noted by Darwin, are

abundant on the outer coasts of the atoll, and he, or perhaps Syms Covington, would have to do nothing more than to stroll along a short stretch of beach to pick up several dozens. Among those that Darwin collected, that are still to be found along the coasts of the atoll are *Trochus maculatus*, *Turbo argyrostomus*, *Nerita albicilla*, and species from the genera *Spondylus*, *Purpura* and *Perna*. Shells of the giant clam (*Tridacna gigas*) were collected from the lagoon.

It seems that Darwin had a good deal of assistance with collecting from local residents, both European and Malay, for Henslow, presumably on the basis of conversations with Darwin, recorded in his 1838 article⁵: "*Florula Keelingensis* . An account of the native plants of the Keeling Islands", as follows:

Thrown as these men are so completely upon their own resources, they have accurately investigated the natural productions of the islands, and readily pointed out to Mr. Darwin the different species of plants, and assured him that he had seen them all except one.

They were wrong in this last point: there are a number of species thought to be indigenous which he does not appear to have noticed. Or else Darwin misunderstood his informants.

Throughout his travels Darwin from time to time took specimens given to him by others. He always records their provenance. At Cocos he was given at least two rock specimens: "fragment of coral, picked up by C. Ross, I know not where", and a specimen of greenstone from North Keeling "in the possession of Capt. Ross.-" As Captain John Clunies Ross was away from the islands at the time of the visit, Darwin must have been given the specimens by Mr C Liesk, Captain Ross's deputy, or a member of Ross's household.

The specimens were usually numbered, and in this way linked to detailed descriptions and notes elsewhere. In the case of the rock specimens, short notes were kept in a red cloth-covered notebook; descriptions a couple of lines in length, each accompanied by a four-digit number identifying the specimen, follow one another in exactly the same form, from Hobart Town, King George's Sound, Keeling, Mauritius, and so on. Typical such notes for two of the Keeling specimens run:

3598 White petrified hard coral from the solid floor at
 foot of the beach. [Compare Figure 11.]

....

3617 Excessively fine white sand or mud from 8 fathom
water at anchorage at Keeling Isds.

In all this Darwin was practising what he was later to preach, for in his contribution to the *Admiralty's Manual of Scientific Enquiry*⁶ he was to write:

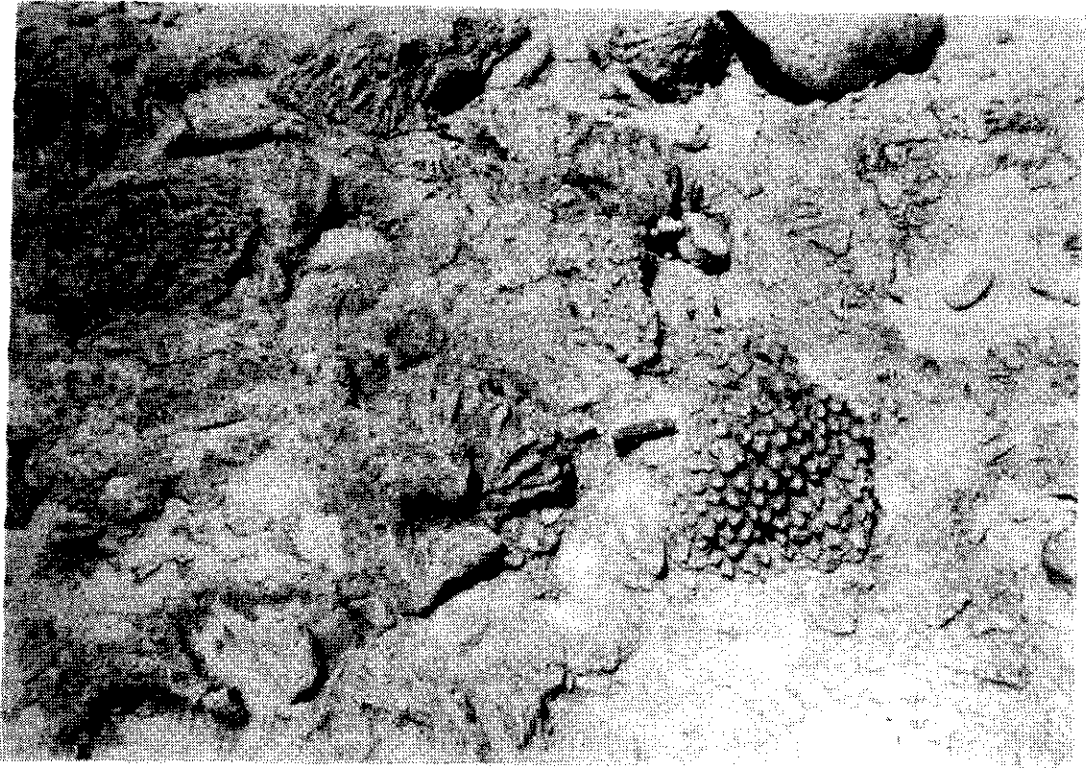


Figure 11. Coral rock with "petrified" corals, on outer beach, West Island.



Figure 12 (above). *Pandanus* roots. Darwin thought it possible that robber crabs might be able to ascend the mass of branching aerial roots. 13 (below) *Ochrosia parviflora* (modern scientific name *Neiosperma oppositifolia*) "Forms handsome trees ... the fruit is bright green, like that of a walnut."

Every single specimen ought to be numbered with a printed number and a book kept exclusively for their entry. As the value of many specimens depends on the stratum or locality whence they were procured being known, it is highly necessary that every specimen should be ticketed the same day when collected.

Frequently a specimen number appears in the margin of the more detailed descriptions to be found in the notes of the *Zoological* and *Geological Diaries*. With the plants, labelled tags with numbers were attached to each specimen. These were later removed by Henslow. With his flowering plants Darwin was careful to record entbotanical or ecological details when he thought these of interest. The following examples are typical:

Partitium tiliaceum (now known as *Hibiscus tiliaceus*)

Common on one of the islands. It is exceedingly useful throughout the Pacific; and in Otaheite particularly, the bark is employed in the manufacture of cordage, whilst the light wood is used by fishermen for floats. The natives readily procure fire from the wood by friction.

Pemphis acidula

No sooner has a new reef become sufficiently elevated by the accumulation of sand upon its surface, but this plant is sure to be the first which takes possession of the soil.

On the whole Darwin was systematic in his collection, preservation, labelling and note-taking, although there were, during the voyage, occasional lapses. (The most notable of these was at the Galapagos Islands, where Darwin "intermingled" bird specimens from the different islets.) It was probably thus in the grim light of experience that Darwin later wrote that if specimens were not carefully ticketed the day they were collected "in after years the collector will never feel an absolute certainty that his tickets and and references are correct".

There are some obvious omissions. Although Darwin was told of a Cocos species of tree "bearing a large square, and very hard nut" he was not able to see it (it was probably *Barringtonia asiatica*, Box fruit or *kayu besagi* which is quite rare on the islands today). There was another species of tree which was not in flower but which attained a trunk diameter of about five or six feet, and has a "particularly soft wood" which he saw but did not collect. This may well have been *Pisonia grandis* or *ampol*. This species grows to a height of 9m (30 feet) and is

not now common on the main island group, although it occurs on North Keeling. Nor did he take any specimens of the coconut (*Cocos nucifera*), although he refers to it extensively: he probably thought it was too familiar to be of interest, and a specimen would in any case be very bulky for the confined space he had available. He mentions in the *Voyage of the Beagle* account, sugar cane, several types of vegetables and some introduced grasses growing close to the settlement, but did not concern himself with them either. A more odd omission is the pandan or screw pine (*Pandanus tectorius*), which although far from abundant, is not unusual on the islands today, and indeed grows on Home Island close to the settlement (see Figure 12). This is referred to obliquely by way of comparison in the *Voyage*, in a reference to the giant Robber crabs:

It has been said by some authors that the Birgos crawls up the cocoa-nut trees for the purpose of stealing the nuts: I very much doubt the possibility of this; but with the Pandanus the task would be very much easier.⁷

But the *Voyage* was written after the return to England, and although based on Darwin's diary, quite a lot of material from publications not available on the *Beagle* was incorporated. Probably the plant was already familiar to Darwin from elsewhere and for this reason he did not think it worth collecting.

Darwin, although his collections of flowering plants, shells and insects were fairly thorough, *could*, I suppose, have taken more specimens of invertebrates, of fish, birds or some other groups. But possibly he had, at this late stage in the voyage, to be selective: his cases must have been very full. His interests were at that time particularly focussed on the coral island problem, and perhaps also to a lesser extent on that of the origins of island biotas, and his collecting may have reflected these preoccupations to some degree. Considering the short time he had available, and the many dozens of specimens he was able to collect, he did not do badly!

The eye for detail

Darwin had extremely good powers of observation. Whether he was writing of the mineralogical composition of a rock, the arrangement of petals in a flower, or a ceremony of some native people, his descriptions were excellent. In later life he wrote exhaustive monographs on subjects as diverse as the barnacles (Cirripedia), the reproductive strategies of orchids, the movements of climbing plants, and a pioneer

work on animal behaviour; all were models of detailed description and analysis. But even during the days aboard the *Beagle* his accounts were extraordinarily perceptive. To assist him in his descriptions of organisms he had a microscope and hand lens, as well as dissecting instruments. The account given below of a species of coral from Cocos is typical:

1836 April

Keeling Is

Madepora 3560 This stony branching elegant coral is very abundant in the shallow still waters of the lagoon: it lives in the shoalest parts which are always covered by water to a depth of 15 ft & perhaps more. Its color [sic] is nearly white or pale brown. The orifice of the cells is either nearly simple or protected by a strong hood; the polypus is similar in both. The upper extremity or mouth of the polypus is closely attached to the edge of the orifice: it cannot be drawn back out of sight; it consists of a narrow fleshy lip which is divided into 12 tentacula or subdivisions of the lip. These tentacula are very short & minute & are flattened vertically; are brown colored, tipped with white. The animal possesses very little irritability on being pricked, the mouth is folded into an elongated figure & partially drawn back. The body of the polypus fills up the cell & is so excessively delicate, transparent & adhesive, that I in vain tried to examine its structure. I could see a sort of abdominal sack & attached to the side of this there were intestinal folds of a whitish color. These when separated from the body possessed a sort of peristaltic motion. I examined the *Madrepora* (3584) also common in the lagoon & found the same sort of polypus & from a shorter examination I believe such will be likewise found in kinds (3612)(3586). (DAR 31.2 354-355)

Darwin was no artist but simple sketches in the margin illustrate points of the structure of the creature.

There are several aspects of this extract that are worthy of note - the attention to detail with sections on macroscopic and microscopic observation; the comparative approach; the notes on habitat and behaviour (or at least irritability), as well as morphology and appearance. There is also the hint of scientific caution so often found in Darwin's writing: he describes his difficulties in working, and notes when his examination was superficial. When he was not certain he said so.

His descriptions of plants are usually more brief than those of animals, but show a similar concern that no particle of detail should be missed. Notes on the plants' ecology or distribution are frequently included along with other details that would not be apparent from herbarium specimens.

Cordia orientalis (the Keeling-teak, now called *Cordia subcordata*) he described as "A large tree abounding in some of the islands, very leafy, with scarlet flowers; but only a few blossoms were expanded at the time and they easily fell off". *Ochrosia parviflora* (now known by the scientific name of *Neisosperma oppositifolia*) he described as forming "straight handsome trees, with smooth bark which are commonly dispersed two or three together. The fruit is bright green like that of a walnut". He commented on these fruits in his notes: "... milky green, grows in pairs or threes" (see Figure 13).

He used all his senses. Two species of coral were recorded as possessing "a strong & disagreeable smell" while the flowers of *Guettardia speciosa* Darwin described as possessing "a delightful perfume". The sugar cane that had run wild on some of the islands⁸ was said to have lost much of its flavour and the flesh of the large land crabs constituted "very good food". The milk of the coconut was "pleasant and cool". Some corals were described as "slimy", others as "stony" or "pulpy". Darwin had a musical ear and noticed the singing of the Cocos Malay women and the chatter of the children. For other localities visited he commented on the sounds of birds and other creatures.

The integrated view

Yet despite this passion for detail, this feeling that sometimes almost amounted to an obsession that no fragment of information should be lost, Darwin was also able to see the big picture, and the way in which the varied components of an environment related to each other. There was a beauty in the way in which the vegetation of an area reflected the climate, and the landforms were a function of the geology. This approach, which he had probably to some extent assimilated from his reading of the works of Alexander von Humboldt, is admirably summarised in the final few pages of the *Voyage of the Beagle*:

...there is a growing pleasure in comparing the character of the scenery of different countries, which to a certain degree is distinct from merely admiring its beauty. It depends chiefly on an acquaintance with the individual parts of each view: I am strongly induced to believe that, as in music, the person who understands every note will, if he also possesses

a proper taste, more thoroughly enjoy the whole, so he who examines each part of a fine view, may also thoroughly comprehend the full and combined effect.

Darwin was also able to convey in a few words a remarkably accurate impression of what an environment was like. Who can fail to be transported by a near-rhapsodic description such as the following?

On entering [the lagoon] the scene was very curious and rather pretty; its beauty, however, entirely depended on the brilliancy of the surrounding colours. The shallow, clear, and still water of the lagoon, resting in its greater part on white sand, is, when illuminated by a vertical sun, of the most vivid green. This brilliant expanse, several miles in width, is on all sides divided, either by a line of snow-white breakers from the dark heaving waters of the ocean, or from the blue vault of heaven by the strips of land, crowned by the level tops of the cocoa-nut trees. As a white cloud here and there affords a pleasing contrast with the azure sky, so in the lagoon, bands of living coral darken the emerald green water.

.....

On some of the smaller islets, nothing could be more elegant than the manner in which the young and full-grown cocoa-nut trees, without destroying each other's symmetry, were mingled into one wood. A beach of glittering white sand formed a border to these fairy spots.

(*Voyage of the Beagle*, 1845, chapter 20)

Yet perhaps Charles Darwin the scientist was just a little self-conscious of his own lapses into lyricism, for in his Diary entry for 4 April 1836 he wrote:

I was employed all day in examining the very interesting yet simple structure & origin of these islands. The water being unusually smooth, I waded in as far as the living mounds of coral on which the swell of the open sea breaks. In some of the gullies & hollows, there were beautiful green & other colored fishes, & the forms & tints of many of the Zoophytes were admirable. It is excusable to grow enthusiastic over the infinite numbers of organic beings with which the sea of the tropics, so prodigal of life, teems; yet I must confess I think those Naturalists who have described in well known words the submarine grottoes, decked with a thousand beauties, have indulged in rather extravagant language.

(The balance between the objective scientist and the romantic in Darwin is discussed a little further below, on page 44-48.)

It was not, of course, just the painting of the picture that was important. In his diary, and in the *Voyage of the Beagle* account that was derived from it, he was often able, in a few succinct sentences to indicate how a landscape *worked* - to indicate the network of relationships that existed within it. In the few pages that encompass Darwin's description of the Cocos archipelago he refers to the coral rock and the soil that developed from it, the plants and the animals, the human community - the appearance of its members, their customs and from whence they came, as well as how they interacted with their environment. The nature of the surrounding sea, its depths and the creatures that lived within it, the weather and climate - these too are mentioned, however briefly. The Ship's Naturalist of the *Beagle* was, however, much more than a cataloguer and a collector, he was in many cases able to see with remarkable perspicacity, the linkages within the system that were significant. The extract below, from the diary entry of 3 April 1836 shows an advanced understanding of the relationships amongst the several elements of the island: - the nature and porosity of the substratum, the tidal range in the surrounding ocean, underground hydrology and water supply. Darwin is referring to Home Island (he uses the name Water Island):

On this island the wells occur from which ships obtain water; at first sight it appears not a little remarkable that the fresh water ebbs & flows with the usual tide. We must believe that the compressed sand & porous Coral rock act like a sponge, & that the rain water which falls on the ground, being specifically lighter than the salt, merely floats on its surface and is subject to the same movements. There can be no actual attraction between salt & fresh water, & the spongy texture must tend to prevent all mixture from slight movements; on the other hand, where the land consists of loose fragments, a well being dug, salt or brackish water enters, of which facts we saw an instance.

"The habit of comparison"

In the final few pages of the *Voyage of the Beagle*, Darwin, in a short retrospection, lists for his readers "the advantages and disadvantages, the pains and the pleasures" of a long voyage. He deals at some length with the excitement of novelty that may stimulate the traveller to increased activity. He admits that there are dangers in being continually

on the move so that

...descriptions must generally consist of mere sketches, instead of detailed observations. Hence arises, as I have found to my cost, a constant tendency to fill up wide gaps of knowledge, by inaccurate and superficial hypotheses.

Useful advice although this may be to the young enquirer, Darwin was not altogether being fair to himself. He had been profoundly influenced, in his undergraduate career by J F W Herschel's *Preliminary Discourse on the Study of Natural Philosophy*,⁹ and Herschel set high standards for the adequacy of a scientific explanation, the search for order and pattern in nature. He resisted *ad hoc* explanations, emphasising the search for *verae causae*, the ultimate causes of phenomena, laws which had a measure of universality in their power of explanation. One of the routes to this goal, besides accuracy, precision and detailed observation, was the technique of comparison. Almost Darwin's final words in the *Voyage* were:

..as a number of isolated facts soon becomes uninteresting, ... the habit of comparison leads to generalisation.

Comparison allowed amorphous collections of facts to lead to generalisations, and generalisation led onward in the search for "laws" or ultimate causes. Comparison also allows new facts or observations to be put onto an existing framework of ideas, it permits the unfamiliar or the disturbing to be reconciled to some extent with the familiar. Even in collection Darwin advocated the comparative method:

A collection of shells (both those living on the coast and those to be procured by the dredge off it) from the same country or island at which a collection of ... fossil shells is made, is generally of very great service...¹⁰

We may also note that when Darwin was writing for other men of science, he occasionally found it useful, in the days before the widespread availability of photographs, and with the expense and difficulty of including woodcuts in publications, to compare unfamiliar organisms from distant places with those of Britain.

In this entry in Darwin's personal diary, from his first day at Cocos, the slightly homesick traveller is comparing the raucous clamour of the island sea-bird colony with the springtime gatherings in the canopies of woodlands in England, perhaps those close to his home in Shrewsbury, or

in the villages of Cambridgeshire where he used to walk with Henslow:

Overhead, the trees are occupied by numbers of gannets, frigate birds & terns; from the many nests & smell of the air, this might be called a sea rookery; but how great the contrast with a rookery in the fresh budding wood of England! The gannets, sitting on their rude nests, look at an intruder with a stupid yet angry air. The noddies, as the name expresses are silly little creatures...

Behind some of his comparisons, therefore, dwelt a homesickness, and a longing for the familiar scenes of youth.

Darwin not only compared his observations made in a locality with those he had made elsewhere, he also made comparisons between his own annotations and those of others. His geological and zoological notes frequently contain marginal notes, often added later, linking one description or suggestion with another. For example, Darwin's notes on the calcareous deposits of King George's Sound, Western Australia, which was visited in March 1836, have a comment in the margin:

The sand on the shores of the Lagoon Island of Keeling is entirely calcareous.- I could not discover in the sand a particle otherwise constituted.

The remark is dated April 1836, and was clearly written after the Cocos visit. Charles Darwin was obviously re-reading his notes of a few weeks earlier and saw comparisons both in the nature of the sediments and in evidence of changes in sea level, for elsewhere amongst his Australian geological notes are the following hurried scribbings: "recent elevation on SW & W extremity of New Holland. - Put in Coral Paper ... The Monument of Lagoon Is? ... Quote extent of formation & rise in land..." He often seemed to have reviewed his notes from earlier parts of the voyage, adding notes on anything that occurred to him as being relevant from his later experiences.

Similarly on the reverse of Darwin's pages of notes on one of the Cocos "Millepora" corals (3583) is a note comparing it with specimens of the same form that he collected on the island of Mauritius:

I saw this coral at the Isle of France forming great bushes 2 ft high.- Not infrequently it coats any foreign body in place of forming distinct branches - of which specimen (3634) is an instance.

Darwin's most frequent method of working was to write up detailed notes, perhaps some little time after field observations were made, from fragmentary notes made at the time or immediately afterwards, amplifying them with detailed descriptions of specimens, and material obtained from books in the extensive library aboard the *Beagle*. Many dozens of accounts of the voyages of previous mariners and explorers, and important scientific texts, were but an arm's length away from the "great table" at which he worked.¹¹ While the sails of the ship were billowing before the Trade Winds as she traversed the Indian Ocean, along with specimens on the poop cabin table was the *Voyage a l'Isle de France ... par un officier du Roi*, by Jacques Henri Bernardin de Saint Pierre, published in 1773, for his notes contain several references to this source: describing the giant crabs he encountered on Cocos Darwin noted:

They are exceedingly strong.- The back is colored [sic] dull brick red; the under side of the body & legs is blue, but the upper side of the legs clouded with dull red. In the 'Voyage par un Officier du Roi' to the Isle of France there is an account of a crab which lives on Cocoa Nuts on a small island North of Madagascar: probably it is the same animal, but the account is very imperfect.

Darwin here typically shows his fine eye for detail, taking the utmost care over describing the colours of organisms, adopts a comparative approach, as well as assuming appropriate scientific caution when giving an opinion. He also included in his notes the observations of those who he met, although he is careful to distinguish information gleaned from others from his personal observations. His principal informant while he was actually on the Cocos Islands was Mr Liesk.

Darwin's account of the giant robber crab ends:

Mr Liesk informs me that the crabs with swimming plates toposterior claw employ this tool in excavating burrows in the fine sand and mud & that he has repeatedly watched the process.

It goes almost without saying that this comparative method in which Darwin trained himself from the very early days of his scientific career was of the greatest use to him later when evolutionary ideas were beginning to develop in his mind. It might even be that it was a factor that predisposed him towards an evolutionary outlook.

The eye of the beholder

The remarkable powers of observation and deduction possessed by Darwin, and manifest in his writings are no doubt partly explained by his intellect and intelligence. But any observer sees the world through the lens imposed by his background, upbringing and education. Let us now consider the extent to which Darwin's early life and training may have influenced the way in which he perceived the Cocos Islands, and the manner in which he interpreted and recorded his observations.

His reading at Cambridge, probably more than any lectures he attended, influenced his perception of the world, "its varied productions" and its peoples. His reading of Alexander von Humboldt's writings not only gave him a profound desire to see something of the world, but contributed to his remarkably integrated view of it. His debt to Herschel, particularly in his use of the comparative method, has been described above.

Darwin's eye for detail perhaps was a function of experience - he had been finding, collecting and identifying beetles since he was a teenager. He had been known as the one "who walks with Henslow" while at Cambridge, and the country rambles along the River Cam valley no doubt helped him to notice, and also to know what was worthy of notice, amongst the objects of the living world. Three weeks of fieldwork in North Wales the summer before the commencement of the voyage in the company of Sedgwick, were all the formal geological training Darwin ever had, but this proved sufficient to assist the young naturalist in the identification of rocks and minerals, and to train him in the rudiments of stratigraphy. By the time the *Beagle* had reached Cocos these skills would have been honed by over four years of experience in the field.

It is possible that the miserable time at Medical School in Edinburgh also paid dividends in strengthening Darwin's powers of observation, and indeed there are times when evidence of the medical training shines rather strongly from the naturalist's note-book; he was not averse to performing simple experiments on himself. Of a pair of species of "Millepora" corals he wrote:

They ... agree in the very remarkable property, hitherto unnoticed in such productions, of producing on contact a stinging sensation. Mr Liesk first observed this fact by accident in the plate kind, & I find it as strong in the branched sort.- The power appears to be very generally speaking, on pressing or rubbing a fragment on tender skin of the face or arm, a pricking sensation will be felt after an interval of a

second, & which lasts for a very short time. But on rapidly touching with the specimen (3609) of the branching kind the side of the face the pain was instantaneous, but increased as usual after a very short interval; the sensation continued strong for a few minutes but was perceptible half an hour afterwards. The sensation was as bad as that of a sting of a *Physa*¹².- On touching the tender skin of the arm, red spots were produced, & which had the appearance, if the stimulation had been a little stronger of producing watery pustules.

Here again is a strong comparative treatment, as well as fine level of detail. But the experimental approach, the use of terms such as "pustules" (small abscesses on the surface of the skin) and the detailed notes on the sensations and their longevity, probably reflect the days of medical training in Edinburgh, or assisting his father, Dr Robert Darwin, with patients.

At the time HMS *Beagle* was engaged in her hydrographic survey, Britain's naval power was at a high point, and the empire was expanding apace. As an educated young Englishman, particularly perhaps after spending several years in the company of naval officers of the cut of the patrician Captain FitzRoy, Darwin would naturally believe in the advantages of European civilisation, and the appropriateness of the British imperial role. Just a few weeks before the visit to Cocos he had written to Henslow describing the colony of New South Wales as "a wonderful place. Ancient Rome might have boasted of such a Colony." He went on to comment that the prosperity, expanding trade, and rapid rate of development of the colony bespoke the "Giant force of the parent country". It is therefore unsurprising that he compared the ways of life of native peoples that he encountered somewhat unfavourably with his own culture.

The Malays of the Cocos, he felt, were "discontented", their kampong "had a desolate air" because there were not any gardens "to show the signs of care and cultivation", and "they appeared poor & their houses were destitute of furniture". The rituals conducted as part of a funeral ceremony he describes as "foolish" and "half superstitious". Darwin is clearly commenting on the way of life of the Cocos Malay families from the point of view of his own value system - one which emphasised order, hard work, the significance of possessions, and the Protestant Christian tradition.

Yet, reared in Whig liberalism as he was, the young Darwin was anything but an ignorant bigot, and reserved his most trenchant scorn for those of

his own countrymen who mistreated those (particularly of other races) who were in their care. For example, he castigated the English and Scots settlers in New Zealand who exploited the Maoris shamefully. He thus similarly expressed his disapproval for the way in which the Malays of Cocos had been treated. He wrote that they were, at the time of his visit "nominally in a state of freedom, & certainly so, as far as respects their personal treatment; but in most other points they are considered as slaves." He added that it might well be because of the repeated removals from island to island that followed quarrels between a "very worthless" Mr Hare (who had subsequently left, see chapter 4) and Captain Ross's party, in the early years of the settlement, and perhaps also "from a little mismanagement", that things were "not very prosperous".

And Darwin strove to be fair to the Malay people; he wrote in his Diary that he "liked both their general expression and the sound of their voices". Despite their appearance of poverty the children appeared plump and well-fed.

Thus Darwin was certainly not always the detached, cold, scientific observer and collector. There was something of the romantic in him: like others of his nation and class before and since he had a penchant for the exotic, the weird and the unusual. "[M]asses of naked rock" grouped "in the wildest forms ... afford a sublime spectacle", and when painted "with bright and varied colours, as in Northern Chile, they will become fantastic", he enthused at one stage. The "power of life" and the "grandeur" of the Tropics particularly appealed to him. "[T]he scenery", he wrote, "of the intertropical zones", was in "a class by itself".

The strange rituals of "primitive" people also had a fascination for the young Englishman. He wrote in detail in his diary of the nose-rubbing greeting of the Maoris in a village close to the Bay of Islands, and of an Aboriginal coroboree at King George's Sound, Western Australia. No bizarre detail escaped his notice.

Witnessing the curious ceremony that was accompanied by the songs of the Malay women, while a full moon shone through the gently waving palm trees on his third evening at Cocos had a powerful effect on Darwin. The scene had all the ingredients a seeker of the exotic could wish for. He described the occasion in his diary:

These scenes of the Tropics are in themselves so delicious, that they almost equal those dearer ones to which we are bound by each best feeling of the mind.

A little cryptic, this, but I take it that Darwin is expressing such delight at the strange beauty of the occasion, that it almost overcame the homesickness brought on by the familiar scenes of youth and home, seen in the mind's eye of a young man after nearly four and a half years at sea.

Darwin's description of what is obviously the white tern (*Gygis alba*) also hints that inside the observant naturalist lay something just a little poetic:

... there is one charming bird, it is a small & snow white tern, which smoothly hovers at a distance of an arm's length from one's head, its large black eye scanning with quiet curiosity your expression. Little imagination is required to fancy that so light & delicate a body must be tenanted by some wandering fairy spirit.

Certainly he expressed a liking for this isolated palm-clad atoll, surrounding its brilliant lagoon. In his diary he wrote "I am glad we have visited these Islands" and just over a fortnight later in a letter to his sister Caroline he wrote of Cocos: "I am very glad we called there". In each case he makes it clear that the principal reason for his dissatisfaction was the opportunity the stay presented for the testing of his coral reef hypothesis. But as lyrical extracts quoted above (and pages 38 and 39) suggest, it was perhaps not entirely so.

Despite the shortness of his sojourn at the Cocos-Keeling islands, and his preoccupation with his coral atoll theory whilst he was there, Darwin was very thorough in his evaluation of almost all aspects of the geography of the island group. His collections were extensive. Necessarily he was to some extent constrained in his perception and evaluation by his upbringing and the ideals that imbued his social class and his generation, yet he was usually capable of making a balanced, objective statement. Through his writings he comes across as a most precise and accurate observer, anxious to preserve the most minute detail, yet able to take an overview of the *workings* of an environment, and describe the *processes* operating within it. Yet there was the touch of the romantic in him; he took an enthusiastic delight in the beautiful living world about him, and had a lively curiosity concerning people and places. A particular characteristic of almost all the work that he did was that it was dominated by a distinctive comparative approach. He was sufficient of a polymath to be able to record with perception almost every aspect of the living and non-living environment, including the human community. Further details of his investigations of this

human component of the microcosm that was the atoll of South Keeling in April 1836 will be given in the next chapter.

COCOAS OR KEELING'S ISLANDS,
IN THE SOUTHERN INDIAN OCEAN.

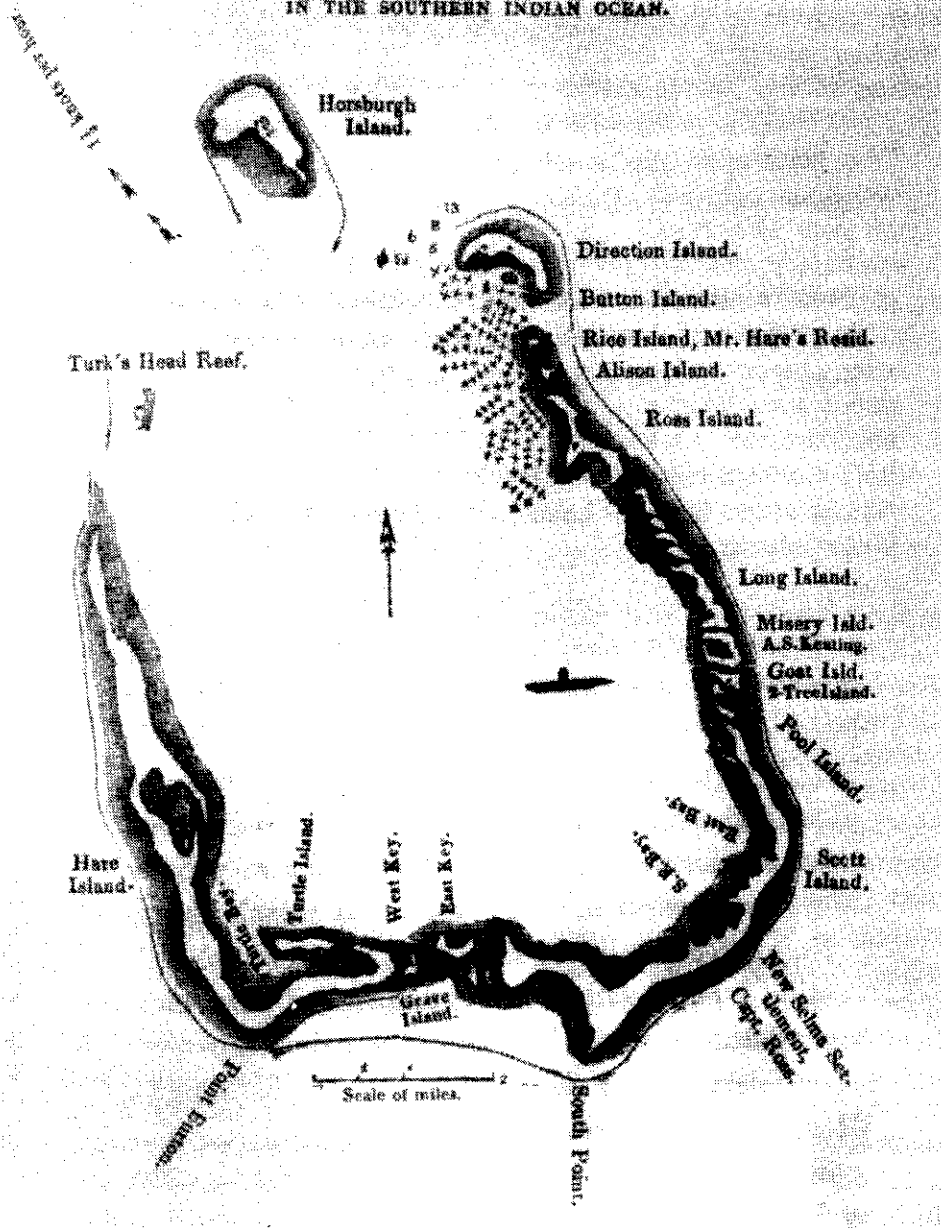


Figure 14. Map of the Cocos (Keeling) Islands in about 1829. Captain Clunies Ross is shown living at New Selma, at the southern end of the lagoon, and both Hare and Keating are still in residence.

Chapter 4 A Human Community

The origins of the settlement

In 1836, probably about a hundred and thirty souls¹ made up the the human population of the Cocos (Keeling) Islands, a human community which had existed for about ten years. Darwin in his diary described the founding of the settlement in a straightforward economical way:

The history of the inhabitants of this place, is, in as few words as possible as follows:- About nine years ago a Mr Hare, a very worthless character, brought from the E Indian Archipelago a number of Malay slaves which now, including children, amount to more than a hundred. Shortly afterwards, Capt. Ross who had before visited these Isls in his merchant ship, arrived from England bringing with him his family & goods for settlement: along with him came Mr Liesk, who had been a Mate in the same ship. The Malay slaves soon ran away from the Isd on which Mr Hare was settled & joined Capt. Ross's party; Mr Hare upon this was ultimately obliged to leave these Islands.

For some reason the next sentence is deleted:

Capt. Ross then occupied a more convenient place which is now called Water Island, where all the inhabitants are now collected.

The facts seem to be that in February 1827, following an earlier reconnaissance visit in 1825, Ross's party settled first on Gooseberry Island (Pulu Pandan, sometimes known as Goose Island), and then, partly because of tension with Hare who had established his own settlement nearby on Home Island (Water Island), they moved to South Island (see Figure 14). The final move, to Home Island, after Hare's departure, had only taken place a short perod before the *Beagle's* arrival. William C Liesk is described in some sources as one of the ten "apprentices" that Captain John Clunies Ross had brought with him, intending as he did to establish a ship-repair and provisioning business. John Clunies Ross in his account denied that Liesk (he uses the spelling Leisk) ever had the status of "Mate". By April 1836 all the other apprentices had left on passing ships. One reason that Liesk stayed may be that he had married Mrs Ross's maid.

Captain FitzRoy's account differs in a few details from that of Darwin:

These lonely islands (also called Cocos) were discovered in 1608-9 by Captain William Keeling, who was in the East India Company's service, and held a commission from King James I. Little or no notice was taken of them from that time till 1823, when one Alexander Hare, a British subject, established himself and a small party of Malays, upon the Southern Keeling Island, which he thought a favourable place for commerce, and for maintaining a seraglio of Malay women, whom he confined to one island, - almost to one house.

In 1826, or within a year of that time, Mr J C Ross, some time master of a merchant ship, took up his abode on the south-eastern island of the group; and in a very short time Hare's Malay slaves, aggrieved at his harsh treatment of them, especially by his taking away the women, and shutting them up on an island which the Malay men might not approach, deserted as a body, and claimed protection from Mr Ross. Hare then left the Keelings, and about a year afterwards was arrested in his lawless career by death, while establishing another harem at Batavia.

FitzRoy will not countenance, it seems, giving John Clunies Ross the dignity of "Captain"! FitzRoy was Royal Navy, Clunies Ross merely a merchantman! There is also some difference as to the date: FitzRoy stating Hare's arrival was 1823, Darwin suggesting that it was "about" 1827. In actuality it seems to have been in May 1826, but many details of the Alexander Hare incident are impossible to establish with any certainty. Both Darwin and FitzRoy will have obtained their stories from Liesk, Ross's assistant, who though he seems to have been a reliable informant on some matters, was anything but infallible: he is reputed to have been "plotting" against Ross at the time and may have had his own reasons for giving a less than entirely balanced account. Hare dying so soon after the events (some say in Singapore, not Batavia, and the Ross papers say "Belcoolen" or Benkulu, in Sumatra), we cannot compare his interpretation with that of Ross or Liesk. Liesk himself does not seem to have stayed very long in the islands after the *Beagle's* visit; it is clear that he too eventually found it impossible to live on the same islet with Ross, leaving in about December 1837.²

Alexander Hare apparently held a government post in South Borneo during the period of British administration, and tried, according to some accounts to "assume the status of an independent ruler"³ which on the reestablishment of Dutch authority he could not maintain. He resided for several years in South Africa, then retiring to the Cocos with a "large

harem of various nationalities and numerous slaves". He seems to have been a man of considerable fortune. All the accounts agree, however, that he treated his entourage with great harshness, and that there was a good deal of tension between the Hare and Ross camps, Hare surreptitiously but unsuccessfully attempting to engineer a Dutch take-over of the islands.

F Wood-Jones wrote some account of the incidents in *Coral and Atolls*, published in 1910. Some of his informants may well have been children of Malays who have been Hare's slaves - Nek Basir and his wife Daphne - the former only dying in 1893, at the age of 88 years. His account may well be quite reliable. He writes of Hare's strange establishment on the Cocos islands, and its eventual demise:

His attempt to realise his ideal - to be the monarch of a slavish Eastern court amidst the luxurious setting of a tropical coral island - had proved a failure. His band of musicians, his slaves, his courtiers, his harem, and his splendid sovereignty had slowly but surely slipped from his grasp, and the more stubborn, more practical rule of Ross Primus had ruined his Utopia.⁴

The Cocos Malays

Darwin describes the ethnic origin of the Cocos Malay people in some detail:

The natives come from different islands of the east Indian Archipelago, but all speak the same language; we saw the inhabitants of Borneo, Celebes, Java & Sumatra. In color of the skin they resemble the Tahitians, nor widely differ from them in form of features; some of the women, however, showed a good deal of Chinese character. (Diary)

The *Beagle's* Captain echoes some of this, but the emphasis in his account is a little different; FitzRoy commented:

No material difference was detected by me between the Malays on these islands, and the natives of Oetaheite [Tahiti] or New Zealand ... I merely say there was not one individual among the ... Malays whom I could have distinguished from a Polynesian Islander, had I seen him in the Pacific. (Narrative)

Although the term "Malays", or more recently "Malay people" or "Cocos Malays" has consistently been used for the Cocos islanders, from before the time of the visit of H M S *Beagle*, the ethnic origins of the original settlers were, as Darwin's account suggests, quite complex. The community was formed as the result of the melding of the fugitives from Hare's despotic regime, together with those that arrived with Ross, who, apart from the members his own and Liesk's family and the apprentices, seem to have included a Portuguese and a couple of Javanese.⁵

Darwin, although he emphasises the East Indian component in the population, and hints at a Chinese element (sources vary on the importance of the latter), does not mention either the Papuan or the African negro component, but these were certainly of some importance: the term "Sudanese" has been used for some of the population. Covington's diary, and certain other early accounts confirm that some of the "Malays" came from the Cape of Good Hope, taken there by Hare after his ousting from Borneo. Other sources suggest that a small number of "Zulus" from the Cape were included in the original party.⁶ There was also some intermingling with European blood. FitzRoy wrote in his *Narrative*:

Two boys attracted my notice particularly, because their colour was of a brighter red than that of any South American or Polynesian whom I had seen, and upon enquiry I found that these two boys were sons of Alexander Hare and a Malay woman.

He adds a note: "Brighter by comparison; their colour was that of copper in its very reddest state - without any tinge of yellow." The Clunies Ross Papers maintain that the children in question were a boy and a girl, not two boys, and that while one was the offspring of a union between Hare (said to have been a "fair-haired man") and a dark-skinned Malay woman, the other was the child of Mr Ogilvie (Mr Hare's overseer), and a "pale-coloured Dyak" woman.

There is some difference in the accounts with regard to the number of Cocos Malays at the time of the *Beagle's* visit. FitzRoy refers to "two hundred Malays", a total that is not inconsistent with John Clunies Ross's claim. Darwin refers to "a number of Malay slaves which now including children amount to more than a hundred"; Syms Covington's diary mentions "about 60 or 70 Malays". Covington is frequently inaccurate (for example he refers to Ross as the Governor, whereas he had not any such official status), but he may have been including only adults. A total number of a little over one hundred Malay people is probably not far from the truth.

Charles Darwin refers in his diary to the Malays as

now nominally in a state of freedom, & certainly so as respects their personal treatment; but in most other points they are considered as slaves.

His Captain explains a little further:

By some strange misconception, not intentional act of injustice, Mr Ross had refused to give Hare's slaves their freedom for fear that the executors of that man should demand their value from him; but he paid them two rupees, in goods (at his own valuation), provided that they worked for him, both men and women, as he thought proper. Mr Leisk told me this, and said that many of the Malays were discontented, and wanted to leave the island. "No wonder," thought I, "for they are still slaves, and only less ill used than they were by the man who purchased them."

A surprisingly enlightened view for FitzRoy, who had defended slavery in conversations with Darwin in South America: perhaps nearly five years of discussions with the more liberal young Darwin had mellowed him. At any event we see here the birth of the system, variously called exploitation or paternalism, whereby the Cocos Malay folk were employed by five generations of the Clunies Ross family to work on their estate for minimal wages, or for tokens (latterly "plastic rupees") redeemable in the estate-owned shop. The system was only brought to an end following the take-over of the islands by the Government of the Commonwealth of Australia in 1978.

FitzRoy records that in 1836 the Malay women were required to "husk" a hundred nuts a day, collected for them by the men.

It is perhaps only fair to say that Clunies Ross stoutly defended the arrangements existing in 1836 in his "reply" to the FitzRoy and Darwin accounts (see page 12), written in the late 1840s, giving many pages of complex legal and theological argument on the subject. He also took FitzRoy to task for saying that the Cocos Malay women were expected to husk a hundred nuts a day, arguing that they were quite capable of dealing with a thousand! It is in fact possible that FitzRoy misinterpreted some of the things that were told him by Ross's employee, Mr Liesk, and it is more than likely that to some extent Liesk deliberately distorted certain aspects for his own purposes.

Daily life in the Malay kampong

The visitor going ashore on Home island today for the first time finds a good deal that echoes the accounts of Darwin and FitzRoy. The Naturalist recorded:

We found on a point thickly scattered over with nut trees, the town ... the houses of the Malays are arranged along the shore of the lagoon.

Thick tangles of coconut palms still grow in places along the shore of Home Island, and although the "town" is now more extensive than in Darwin's day, many of the houses still have a view of the lagoon. Captain Ross and his family, and Mr William C Liesk with his, are said to have lived "in a large barn-like house open at both ends & lined with woven bark", so it may be assumed that the houses of the Malays were smaller, similar structures, probably roofed with palm-leaves. Fibre from the bark of *Hibiscus tiliaceus* was used for the manufacture of cordage - and it still is. Most of the materials for the construction of simple dwellings would thus have been conveniently to hand. Darwin also records that fibre from robber crab burrows (the husks of coconuts removed by the crabs) was also collected by the Malays. There are several mentions of boats and canoes (almost certainly the latter were Malay "dugout" canoes or *koleks*) in the accounts of both Darwin and FitzRoy, and along the lagoon a line of locally built wooden open boats still lie just above the level of the water. Alas, many of them now contain a scattering of fragments of palm-leaves, drifted there on the breeze, for few are now in use. Aluminium "runabouts" with powerful Johnson outboards have little of the grace of the traditionally built local Cocos craft but are preferred for their speed, lightness and ease of maintainance. The timber traditionally used most for boat-building on the island is *Cordia subcordata*, referred to by Henslow as *Cordia orientalis*. Darwin's notes, repeated by Henslow, report:

The settlers have named this Keeling-teak, because it furnishes them with excellent timber. They have built themselves a vessel with it. A large tree, abounding on some islands, very leafy, with scarlet flowers; but only a few blossoms were expanded at the time and they easily fell off.⁷

The flowers are convolvulus-like, hence the name "sea trumpet". Another name used is "ironwood" and this timber was and is that used most extensively for carving. Elsewhere Darwin mentions "a small schooner" built on the island - this must be the "vessel" mentioned above. She was named the *Harriet*, and was built in 1835.

Syms Covington's diary noted that the islands were "a very short distance" apart. He reported, in his somewhat confused rustic manner, that it was possible to "walk from one to another when the tide is low to nearly all except the entrance to Basin"! This is still the case, although the wade from the most southerly point of West Island across the two-and-a-half kilometres of coral reef via the islets of Pulu Maria, Pulu Blan Madar and Pulu Klapa Satu to the most southerly point of South Island was one of the more adventurous tasks undertaken during the field-work for this book. In many places I was in quite turbulent water up to my waist, jagged coral underfoot, curious reef sharks a metre or so in length coming to inspect my legs every few minutes!

Clearly boats would be virtually essential, and were frequently used in Darwin's day, for hunting, fishing and for visiting the more remote islands of the archipelago for food collecting.

At the time of the *Beagle's* visit, turtle seem to have been very common. Those seen in the lagoon were probably green turtle (*Chelonia mydas*), although hawksbills (*Eretmochelys imbricata*) are very occasionally sighted off Direction Island. Darwin's diary account records that on 6 April 1836 he and FitzRoy ventured in a ship's boat to the southern end of the lagoon:

We saw several turtle & two boats were employed in catching them. The method is rather curious: the water is so clear and shallow that although at first the turtle dives away with much rapidity, yet a canoe or a boat under sail, will after no very long chase overtake it; a man standing ready in the bows at this moment dashes through the water upon its back. Then clinging with both hands by the shell of the neck, he is carried away until the turtle becomes exhausted & is secured. It was quite an interesting chase to see the two boats doubling about, & the men dashing into the water till at last the prey was seized.

Captain FitzRoy's description of the chase is almost identical, he merely adding that the turtle was "secured" by turning it on its back.

Such has been the pressure on the turtles, and also their eggs, that few turtles are today seen in the southern part of the lagoon. They used to feed on turtle grass close to West Island, however, and for a while an attempt was made to "farm" them on Home Island. The remnants of the enclosure close to the jetty near the settlement can still be made out. The size and number of the turtles that swam in the lagoon in 1836 can

however be imagined by Covington's note that the *Beagle* was supplied with two turtles per day during her stay at Cocos, each of them "about 150lb weight" (approximately 70kg).

Darwin says little about the methods used in fishing by the Cocos people, apart from the annotation amongst his Plant Notes that the light wood of the Hibiscus (*Particum tiliaceus*) was "used by the fishermen for floats". All contemporary accounts suggest that fish were very abundant in the lagoon - as they are today - that they must have formed an important part of the Cocos Malays' diet. Fish traps may have been used at the time of Darwin's visit, as well as nets and lines. Captain FitzRoy, however records:

Mr Stokes [Mate and Assistant Surveyor] saw a dog, (bred on the island), catch three ... fish in the course of a few hours by chasing them in shallow water, springing after them, almost as a kangaroo springs on land. Sometimes one would take shelter under a rock, when the dog would drive it out with his paw, and seize it with his mouth as it bolted. (Narrative)

The vast clams (Darwin says chama, Covington mentions "clamp" shells, FitzRoy the old scientific name *Chama gigantea*) appear to have been numerous, and they along with some of the other 500 species of mollusc recorded from the atoll would have been eaten.

Crabs were also consumed. Land crabs of a number of species are abundant throughout the island group, but the large robber crab (*Birgus lato*) was particularly esteemed. Darwin's *Zoological Diary* records:

Their flesh is very good food: in the tail is a large lump of fat which when melted down gives a bottle full of oil.

(DAR 31.2/362)

The robber or coconut crab has been virtually exterminated on the main atoll, so eagerly is it sought after. It is believed by some peoples of the Indo-Pacific region that the flesh has aphrodisiac properties! It survives on North Keeling and is locally quite abundant on Christmas Island (about 900 km east of Cocos).

The birds of Cocos, like the robber crabs and the turtle have declined in numbers since the *Beagle* visited the archipelago. Darwin's wistful account, comparing the bustle of the sea-bird breeding colony with that of the rookeries of the fresh-budding woodlands of the English spring (see page 42) implies that many islands of the group were alive with boobies, noddies and terns. Covington commented that the seabirds were

"very tame, as to let you come quite close to them or within a yard". The land rail (*Rallus philippensis*), Covington noted, was "common". The visitor to West Island or Home Island today will see few birds apart from the occasional fishing egret or a flock of turnstone. Conservation measures are in hand but a century and a half of slaughter (simply by grabbing the tame birds as they sat on their nests, by using firearms and with a type of whip or flail-like contraption called a *cambuk* in Malay) has taken its toll.⁸ It is reasonable to assume that birds were taken freely in substantial numbers at the time of Darwin's visit.

Darwin asserts firmly that domestic animals included only the pig, which he said grew very fat on a diet of coconuts! But there seem to have been some thoughts of introducing goats. In Henslow's article on the plants of the island group (written after lengthy discussions with Darwin) it is written:

Three species of grass had been introduced ... from Java under an impression that goats would not eat the rank herbage of the island; but the settlers were surprised to find that one of these animals left on the islands by Capt. Fitzroy preferred the native to the introduced species.

The *Beagle*, like many other ships, had goats on board for fresh milk, and it looks as though one of them was tethered on one of the islands for a while to feed it up. Covington's diary says that there were "plenty of poultry (Chinese breed)", and both Darwin and FitzRoy mention ducks.

Plant foods were also available in extreme abundance. Quite apart from the coconuts⁹ which covered, and still cover, almost every islet, Covington mentions "2 sorts of indigenous fruits". One of these may have been the cheesefruit, *mengkudu*, or *Morinda citrifolia*. This shrub, up to about three metres high was not included in Darwin's collection although it is today quite common several of the islands. It bears a fleshy fruit shaped a little like a pine-cone about seven centimetres in length, which although not attractive to European taste is cut into slices by the Malays and eaten (see Figure 15).¹⁰

Darwin in his diary entry for 3 April states that he saw "no gardens"; this was written early during the course of his stay for he must have told Henslow of the sugar cane, tobacco and maize mentioned in the *Annals of Natural History* article. From the writings of FitzRoy and Covington we may add the following crops: water melon, bananas, pumpkins and possibly coffee.

"A strange half superstitious scene"

After having dinner with Mr Liesk on Home island on the evening of 3 April, Darwin and FitzRoy remained for a while ashore to watch what Darwin described as:

a strange half superstitious scene, acted by the Malay women. They dress a large wooden spoon in garments - carry it to the grave of a dead man - & then at the full of the moon they pretend it becomes inspired & will dance & jump about. After the proper preparations the spoon held by two women became convulsed & danced in good time to the song of the surrounding children and women. It was a most foolish spectacle, but Mr Liesk maintained that many of the Malays believed in its spiritual movements. The dance did not begin till the moon had risen & it was well worth remaining to behold her bright globe so quietly shining through the long arms of the Cocoa nuts as they waved in the evening breeze.

The ceremony was almost certainly a funereal ritual, and according to Ms Pauline Bunce, a longtime resident of the Cocos islands, several of the elements described in Darwin's account are recognisable in the death rituals that were still being practised by the Malay people of Home Island in the late 1980s. The "spoon" mentioned in the diary entry is probably a *mesan*, the wooden spade-like head-piece, pairs of which are placed on male graves - note that that the object is described above as being carried "to the grave of a dead man". (Female graves have distinctively different thistle-flower-shaped head-pieces). They are typically a little less than a metre in length, and do indeed rather resemble spoons. Darwin mentioned the "spoon" being dressed in garments: today, during the mourning rituals these objects are, according to informants in the Malay community, wrapped in white cloth. The cloth was described as being tied "like a tie" around the *mesan*. Singing, particularly by older women, was said to be repeated during the seven days of the mourning period. The rising full moon in Darwin's description may also have been significant: there is said to still be a strong lunar element in the Cocos Malays' pattern of activities.

Captain FitzRoy noted that the Malay people were "Mahometans". He continues, however by saying that although one of their number "officiated as priest" [imam], "exclusive of an extreme dislike to pigs, they showed little outward attention to his injunctions." But perhaps his impression was just one gained from a short stay, without a great deal of close contact with the Malay people.



Figure 15. *Morina citrifolia* : cheese fruit or *menkudu*

The Cocos Malays remain a predominantly Islamic community: today (1987) there are three mosques conspicuously displaying the Islamic crescent on their roofs, and three imams on Home Island. The imams, who apparently learn their duties locally, have an important social role.¹¹ Arabic inscriptions are painted on the side of the mosques, although few people on the island understand enough of the language to be able to translate it into Malay. Despite, however, the strength of the Islamic faith in the Home Island community, elements of an older animist or spiritualist tradition remain. The spirits of the departed are said to make their presence felt on the living in certain ways. Although the material is fragmentary, this is at least compatible with Darwin's report that the "spoon" became "inspired" and the assertion by Liesk that "many of the Malays believed in its spiritual movements".

The grave-yard at the time of Darwin's visit was quite close to the village, and indeed a regularly tended grave, said to be that of the first imam (presumably the one mentioned by FitzRoy, see above), lies at the foot of a large coconut palm, fifty metres north-east of the Primary School on Home island (see Figure 16). But relatively early in the history of the settlement a cemetery was established away from the kampong on the island of Pulu Gangsa, although this islet has now been joined to



Figure 16. Grave on Home Island, said to be that of the first imam; note the spoon-shaped mesan or headboard.

Home Island.¹² The graveyard is regularly tended each year at *Hari Raya* (the first day of the month after Ramadan). Objects are frequently left on graves, and the grave yard is said to be particularly the haunt of spirits: a Malay man describing an early morning boat-trip along the shore of Pulu Gangsa, was heard to comment, not entirely jokingly, that no-one was yet up and about!

A number of the people show a fear of the island of North Keeling, believing that it is the particularly the haunt of evil spirits: young women especially will not land there, some saying that children born to them will be deformed.

Much of this suggests that the belief in the widespread presence and influence of spirits, hinted at very obliquely in the Darwin narrative, remained part of the Cocos Malay way of life in the 1980s.

"A favourable place for commerce"

Captain Ross's aims in colonising the islands were intensely practical. His plan, after inspecting the islands during his trading voyages around the Far East, and bringing out his wife and family of several children, was to establish a fitting and provisioning centre for ships sailing to the Far East and Australia, and to grow coconuts for sale. When he arrived in 1827 he brought a number of English apprentices, but most of these left fairly early, partly because the estate was not able to develop as rapidly and profitably as had been hoped on account of the long-running dispute with Hare. Mr W C Liesk was the only one of these apprentices who remained by 1836; by then he had been married (apparently quite legally by a visiting Royal Navy Captain) to Mrs Ross's maid, who had born him several children (see account of baptism, page 24). There do not seem to have been any Europeans resident on the islands at the time of the *Beagle's* visit apart from the Ross and Liesk families, and, apparently, an American seaman, a deserter from a ship called the *Trusty*, one Joseph Raymond by name. He is not mentioned in the accounts of Darwin, FitzRoy or Covington: perhaps he adopted a low profile - he has been said to have been plotting with Liesk against Ross at this time.¹³

The settlement was at one stage established in the southern part of the archipelago, on South Island (sometimes called South-east Island, Pulu Atas). This was not very satisfactory, because the shallowness of the lagoon made it impossible to bring any but the smallest craft close in. The settlement, with both its European and Malay communities, had moved to Home Island (known as Water Island at the time of the *Beagle's* visit) not long before the time of which Darwin writes, a point that he acknowledges in his somewhat unflattering account. The principal advantage of the new location was its adjacency to Port Refuge (the name is used by Darwin, and appears on modern hydrographic charts), a sheltered anchorage between Horsburgh and Direction Islands, with a depth of about 5 fathoms (about 9 metres).

The Clunies Ross family were later to build a succession of imposing residences on Home Island - the last was Oceania House, built around the turn of the century - but at the time the two European families lived in something rather more humble. Captain FitzRoy recalls "the whole party residing in a large house of Malay build - just such a structure as one sees represented in old japanned work." Darwin adds, that the house was "barn-like", open at both ends and lined with mats of woven bark.

We should perhaps at this point glance at what Clunies Ross himself had to say about his house, once again purporting to write from FitzRoy's point of view, but as usual with lashings of sarcasm:

My mention of the "house in which the whole party were residing together" would certainly not be worth noticing here - otherwise than as an instance of my indefatigable attention and ready ingenuity in noticing and turning to account every particular that appeared at all susceptible of being so turned.- Accordingly although I saw in reality two houses - but for convenience in describing these so as best to serve my main purpose, I made one out of two - and then had no difficulty in making that one considerably unlike either.

That one (in which the whole party were residing) constructed for Mr Leisk's habitation - and certainly has nothing very *large* in its aspect or dimensions - being about ten feet from the ground to the eaves of the roof. The other was Mr Ross's - standing then on the S.Eⁿ islet at the time awaiting his convenience for removing it to the Island on which he had recently placed (as he had always intended to place) the Settlement. It's [sic] floors and partitions had been put together so as to be removable in compartments, floated down to the Settlement and there again set up.

Mr Darwin and myself having visited and slept the night.- I can therefore speak as I do from personal observation. The beams were of Norway deals brought out from England by Mr Ross. The floors and partitions of Singapore boards - and the pillars of the Island timber. Two Englishmen (Thomas Dealey and George Bailey) of the party brought out with him.- the one a carpenter and the other a joiner prepared and assisted in putting it together and setting it up, and except in putting the thatch on the roof, no Malays were employed in it's [sic] construction.- But even these were not Malays but Javanese that Mr Ross brought to the Isles. The form was, and is, a square of forty eight feet on the ground and twenty feet

thence to the eaves of the house. The resemblance of the entire fabric to such a structure as one sees on old japanned work was no doubt exact - providing that the said representation corresponds to the foregoing - but if not - why then - not.-

(*Clunies Ross Papers* BM Add Ms No 37631, *Adventure and Beagle*, account, page 99)

There is no evidence whatever that Darwin and FitzRoy visited any house of the Ross family on South Island, the point where they landed on that islet seems to have been to the south of "New Selma" the site of the original Ross settlement. Neither of them mentions any signs of construction or of former indications of habitation at the point where they landed: the whole community seems to have been completely relocated on Home Island shortly before their visit. It is just possible that the building they mention was the comparatively slight structure of the Liesks, but I believe it to have been the Ross home. Although Ross may be entirely accurate in saying that it was originally erected on South Island, and pre-fabricated in such a way as to allow its later removal and re-erection, I think the Clunies Ross account is inaccurate in saying it was still awaiting removal to Home Island. Bearing in mind that Ross was away at the time, and that his account was written years later, it is possible that he was confused about the exact date the structure was transported. And it must be admitted that he seems determined to show Darwin and FitzRoy to be in error at every possible turn, so it is just possible that the inaccuracy was deliberate. In any event as regards the actual form of the building, the *Beagle* accounts do not seem to be entirely incompatible with Ross's own description.

FitzRoy has some interesting details about the trading activities of the young enterprise, which also provide an insight into the character of its somewhat despotic proprietor in relation to his "employees":

These Malays were allowed to rear poultry, which they sometimes sold to shipping. They were also allowed to have the produce of a certain number of cocoa-nut trees, and might catch fish and turtle for their own use: but the sale of turtle to shipping, when they touched there, and the immense crops of cocoa-nuts which are produced annually on all the islets of the group were monopolised by Mr Ross for his sole advantage.

Oil was extracted from the nuts by the Malay men, after husking by the women - a gallon from every ten - and this was also traded, along with

turtle, and their shells (tortoise shell). Vegetables and pigs were also sold to passing ships. Both Covington and FitzRoy mention trade in beche-de-mer (bicho do mar, Opisthobranchia); Covington describes "Beech de la mar like large black English slug only about 10 times the size".

Captain Ross sold the coconuts, oil and other products of the islands in Singapore (this is where he was at the time the *Beagle* visited the island group), and also traded with the Cape of Good Hope, Mauritius, Madras and Batavia and other ports of the East Indian Archipelago. From these centres, according to Darwin, he brought back "rice & goods for the Malays". Although the Cocos Islands did not, in April 1836, represent the important trading and profitable copra production enterprise of later years, it certainly already had the makings, as seafarer FitzRoy put it, of "a favourable place for commerce".

"A Sketch of the Natural History of these Islands"

Although human communities had a fascination for Darwin, to the extent that throughout his voyage he took careful note of the physical appearances, customs, dwellings and activities of the varied peoples with whom he came into contact, it was nevertheless natural history that had been his first love since he collected beetles in the Shropshire countryside and "walked with Henslow" in the woods and meadows around Cambridge. Charles Darwin's powers of observation and eye for detail have already been commented upon (Chapter 3). Here emphasis will be placed on a search for evidence that the young naturalist was beginning to arrange the observations that he made on the plants and animals of the islands upon the distinctive conceptual frameworks that so characterise much of his later work. The task is not easy, but there are, I believe some fragmentary writings from the Cocos-Keeling interlude that give a hint that ideas which came to be of fundamental importance in later life were already being used as an aid to the understanding of the complex living community of organisms of which the atoll comprised. In this chapter I try also to indicate briefly the way in which ideas that were triggered by observations and specimens from Cocos were later developed.

"Exquisite adaptation"

A theme that characterises a good deal of Darwin's later work is that of the adaptation of plants and animals to their environment and way of life. Phrases such as "perfectly adapted" and "exquisite adaptation" litter, for example, the *Sketch of 1842*, the *Essay of 1844*¹ and *On the Origin of Species*. Although the notion that organisms are adapted to their surroundings forms an important component of the theory of natural selection, it was not, of course, in any sense a Darwinian innovation: it forms an important component of the doctrine of natural theology - the idea that the existence and character of God can be deduced by observation of the natural world and through reason. Writers such as Paley (whom Darwin had read while at Cambridge) argued that the perfect way in which each creature fitted into its position in the scheme of things was evidence for the existence of a divine Creator. Darwin actually quoted Paley in Chapter 6 of *On the Origin*: "No organ will be formed, as Paley has remarked, for the purpose of causing pain or for doing an injury to its possessor". And indeed there is a body of opinion that Darwin's best-known publication should be considered as the last of the great works of natural theology rather than the first of a new generation of volumes on evolutionary biology. The idea that each organ had a particular purpose that reflected the creature's way of life, and that each plant or animal had a particular part to play within the whole

pattern, was therefore, an old one, and one with which Charles was quite familiar when he went on shore on Direction Island on 2 April 1836. Nevertheless the concept had such a powerful part to play in the development of his evolutionary ideas, that it is worth noticing that it was in use in his diary description, written on that day, of the hermit crabs:

The large claw or pincers of some of them are most beautifully adapted when drawn back, to form an operculum to the shell, which is as perfect as the proper one which the living molluscous animal formerly possessed. I was assured, & as far as my observation went it was confirmed, that there are certain kinds of these hermits which always use certain kinds of old shells.

The commonest red hermit crab on the islands is *Coenobita perlata*, which very often inhabits the shells of the mollusc *Turbo argyrostomus*. Modern observations confirm that hermit crabs tend to restrict themselves to particular species of shell. It may, however, be noted that there exist fewer alternatives for older, larger crabs.

Here is the phrase "beautifully adapted", the idea of an individual organ being structured for a particular task, and less obviously, that of different organisms fitting into a wider network of relationships.

Darwin seems to have been particularly pre-occupied with the idea of adaptation in relation to different types of crabs. He appreciated that behavioral characteristics could represent adaptations, as well as morphological ones. After describing the alleged ability of robber crabs to open coconuts and extract the food he wrote that this was "as curious a piece of adaptation" as he had ever seen. (Further comments on Darwin's interest in animal behaviour are offered below.)

Darwin was of course particularly interested in the coral formations of the Cocos-Keeling Islands and spent a good deal of time collecting specimens of the many species of coral, examining and dissecting them. He appreciated the way in which the different species were adapted to the subtly different environments posed by the complexity of the reef structure - robust, compact forms from the breaker zone (he waded out to collect them), and slender, filamentous, branching corals in the lagoon. For example:

The second species of *Millepora* grows in strong vertical plates, which frequently intersect each other & so form a coarse honeycombed mass. In such masses the outer parts

alone of the plates are alive. This coral flourishes in the outer part of the reef where the sea violently breaks.²

With plants Darwin was less explicit, although his notes on the plant specimens are replete with mentions of associations with particular habitats. The notion of adaptation is at least hinted at by such statements as that *Lepturus repens* "occurs in salt places in the interior of the islands".

Struggle and interaction

The idea of the existence of a continuing "struggle" within the natural world was of course fundamental to the Darwinian idea of natural selection, and it is interesting to notice a use of this type of metaphor in Darwin's diary entry for his first day ashore:

The aspect and constitution of these Islands at once calls up the idea that the land & the ocean are here struggling for the mastery: although terra firma has obtained a footing, the denizens of the other think their claim at least equal. In every part one meets Hermit-Crabs of more than one species.

A few lines later he refers to the terrestrial hermit crabs "carrying on their backs the houses they have stolen from the neighbouring beach".

The figurative use of the words and phrases "struggling for mastery", "obtained a footing" and "stolen" gives the passage a distinctly pugilistic flavour, and although the struggle to which Darwin refers is between land and ocean, organisms as well as the inanimate forces of nature are involved.

The metaphor of conflict between the ocean and the apparently fragile coral island's structure is even more clearly demonstrated in the diary entry made a few days later (6 April):

The ocean throwing its waters over the broad reef appears an invincible all-powerful enemy, yet we see it resisted & even conquered by means which would have been judged most weak & inefficient.

The struggle between land and ocean will be discussed further in Chapter 6.

Although the establishment of the science of ecology lay many decades in the future, Darwin's notes from the *Beagle* period are full of

observations of the relationships between organisms, and between organisms and their surroundings. These vary from simple descriptive comments about the habitat of a plant or animal, to analyses of more sophisticated ecological linkages. The Darwinian use of the notion of organisms being adapted to their surroundings has already been discussed. Less obvious is the idea that plants and animals actually contribute to a two-way "dialogue" with their environments.

Once again this was not a particularly novel idea. It is stressed in Charles Lyell's *Principles of Geology*³, a copy of each of the three volumes of which Darwin had with him in the poop cabin of HMS *Beagle*. (Ironically one of these was gifted and signed by FitzRoy, who in later years was to make himself appear ridiculous by adhering to fundamentalist and extreme creationist views long after they had largely been discarded by others.) A little surprisingly Lyell writes particularly fluently about the relationship that exists between living things and their physical environment on remote islands, although he had no personal experience of such places. In the second volume of the *Principles* is written: "The cocoa, pandanus and mangrove take root upon the coral reef before it has fairly risen above the waves" (p158). It is not difficult to imagine that these words, or something like them, were at the back of Darwin's mind when he wrote the note on his specimen of *Pemphis acidula*: "No sooner has a new reef become sufficiently elevated by the accumulation of sand upon its surface, but that this plant is sure to be the first that takes possession of the soil". Note again the metaphor with the slight military allusion.

Darwin also appreciated the way in which organisms might affect the physical environment. He was particularly impressed by the fish of the genus *Scarus* that consumed the stony corals on Cocos (see Figure 17), and the way in which sea-cucumbers or holothurians (of which several species are abundant in the lagoon and on the shallower reefs) affected the material of the sea bed. He wrote later:

Two species of fish, of the genus *Scarus*, which are common here, exclusively feed on coral: both are coloured of a splendid bluish-green, one living invariably in the lagoon, and the other amongst the outer breakers. Mr Liesk assured us, that he had repeatedly seen whole shoals grazing with their strong bony jaws on the tops of the coral branches: I opened the intestines of several, and found them distended with yellow calcareous sandy mud. The slimy disgusting Holothuriae (allied to our star-fish), which the Chinese gourmands are so fond of, also feed largely, as I am informed by Dr Allan, on corals; and the bony apparatus within their bodies seems well adapted to this

end. These holothuriae, the fish, the numerous burrowing shells, and the nereidous worms, which perforate every block of dead coral, must be very efficient agents in producing the fine white mud which lies at the bottom and on the shores of the lagoon.

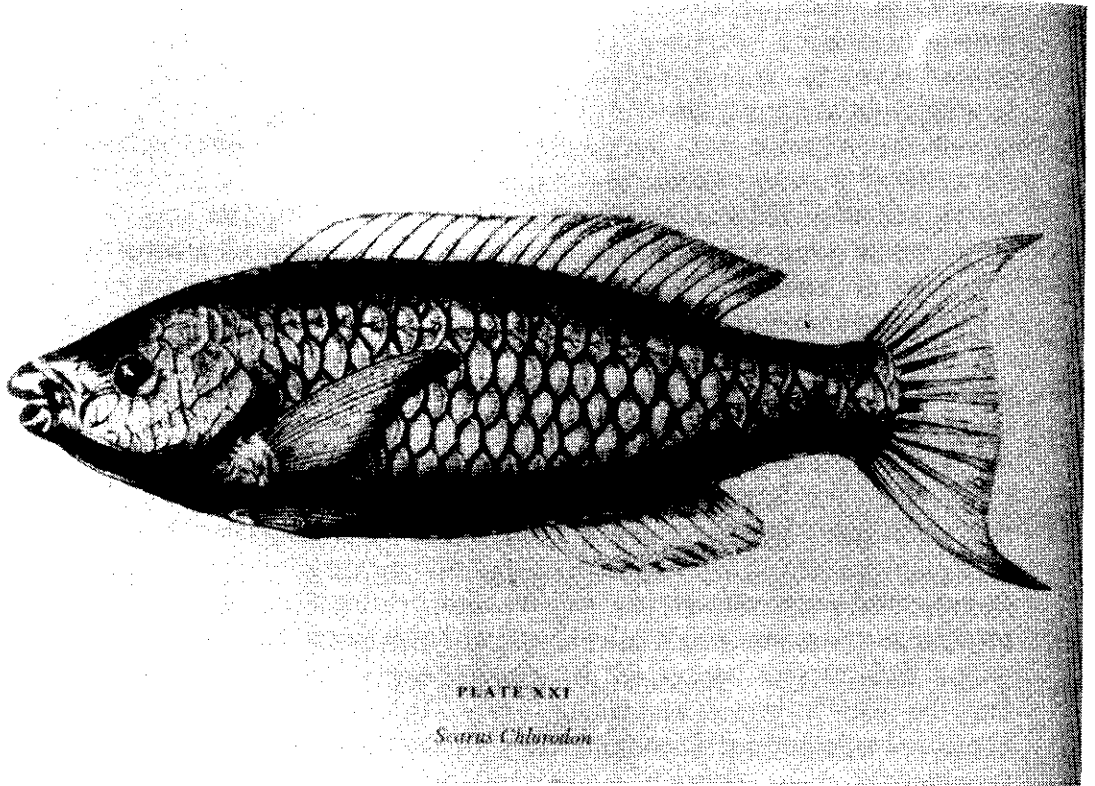


Figure 17. A species of *Scarus* collected by Charles Darwin in the Cocos Islands, as illustrated in *The Zoology of the Voyage of the Beagle Part IV, Fish*, by Leonard Jenyns.

This passage, from the *Voyage of the Beagle*, chapter 20, was put together after Darwin's return from the sea, but was based on material he collected at Cocos: specimens of both species of fish were taken, and are described, partly on the basis of Darwin's notes, by Leonard Jenyns in Volume IV of the *Zoology of the Voyage of the Beagle* (see Figure 17). Indeed, the strange green species seems to have attracted a good deal of interest on board; FitzRoy mentions them and even Covington, who does not often display great interest in natural history in his diary, mentions the "green fish or coral eater". A specimen of the fine mud was also collected (specimen No 3617) and briefly described in the red geological specimen book. The paragraph displays many Darwin characteristics - the comparative approach, the careful separation of his observations from those of others, the detailed descriptions, the "ecological" emphasis.

Many examples of descriptions of subtle relationships between the species of organisms found at Cocos could be mentioned. In dissecting a coral he found delicate branching filaments, which he thought might be "a minute microscopical parasitical plant or animal". He also noticed, like many subsequent naturalists, the interesting tripartite relationship between hermit crab, mollusc shell and sea anemone:

Actinia The specimen which I found was adhering to old shells, (1415) which were inhabited by hermit crabs; they lay beneath the large stones on the outer reef....

(*Zoological Diary* : DAR 31.2/361)

As he wandered along the palm-backed beaches and through the coastal thickets, splashed across the reefs and around the edges of the lagoon, and while he carefully examined and described his specimens at the table in his tiny cabin, Darwin was frequently conscious of the complexity of nature and the subtlety of the network of relationships within it. These ideas, while not so well developed as during the drafting of the first essays on natural selection and in later work, nevertheless to a remarkable extent influenced the way in which he collected material, and organised it in his mind. Moreover, he quite frequently attempted a crude analysis of situations in terms of the metaphors of struggle and warfare that were later to dominate his thinking on evolution. It must also be stressed here, that in these early stages of the journey, as later on the trek that led to *On the Origin of Species*, Charles Lyell was his constant companion. Aboard HMS *Beagle* the association was through the *Principles of Geology*; later they became close personal friends.

"A refuge for the destitute"

It may be said that the concept of long-distance dispersal is the natural companion of the theory of evolution. If all living plants and animals are derived from a few simple forms instead of being independently created, living things must have dispersed throughout the world. The plants and animals now found upon remote islands must at some time have made the journey thither. In his later years Charles Darwin spent a great deal of time and energy investigating the means by which this transference of living beings might have occurred. He tested the floating capacities of seeds and whether seeds would survive passage through the gut of a bird. He wanted to know whether seeds would germinate from mud washed from a bird's foot. He corresponded widely on these matters, and paid the children of the village of Downe in Kent small sums to collect specimens for him to experiment upon.

It is quite clear that while on the Cocos-Keeling atoll the poverty of the floras and faunas of remote islands was in the upper part of his mind. It should be remembered that the Cocos visit came about six months after the sojourn on the Galapagos, and that HMS *Beagle* had called at several other oceanic islands and island groups, including Cape Verde, St Paul's Rocks, the Falklands (twice) and Tahiti: Darwin by now knew what he was looking for.

While he was on the islands Darwin was impressed by the apparent lushness of the vegetation, despite the poor soil:

In such a loose, dry, stony soil, nothing but the climate of the intertropical regions could produce such a vigorous vegetation. ... Yet the woods, from the dead branches of the trees, & the arms of the Cocoa nuts, is as thick as a jungle.

But the observant young naturalist was not deceived:

Besides the Cocoa nut which is so numerous as to first appear the only tree, there are five or six other kinds. One called the Cabbage tree, grows to a great bulk in proportion to its height, & has an irregular figure; its wood is very soft. Besides these trees the number of native plants is exceedingly limited; I suppose it does not exceed a dozen.

(Diary: 2 April 1836)

The Cabbage tree was *Scaevola sericea* (*Scaevola Koenigii* in Henslow's account of Darwin's plants of the Cocos), and it is indeed one of the most conspicuous plants of the islands, often forming a near-continuous but



Figure 18 (Above) *Scaevola sericea* (*S. Koenigii*) growing on West Island.
Figure 19 (Below) "Refuge for the destitute." Seedlings of coconuts and other plant species germinating close to the top of a Cocos beach.

rather loose bright green shubby barrier along the top of a beach (see Figure 18). Darwin's estimate of the flora was something of an underestimate; a recently compiled list of the plants of the archipelago⁴ included about 70 native species, (plus a number of that have been introduced since Darwin collected). But he clearly understood the nature of the poverty of island biotas in general. His diary continues:

There are no true land birds a snipe & land-rail are the only two "waders", the rest are all birds of the sea. Insects are very few in number: I must except some spiders & a small ant, which swarms in countless numbers at every spot and place.

The "snipe" was probably in fact a turnstone, *Arenaria interpres*. The land rail was mentioned earlier (page 31). Darwin wrote in the *Voyage* that he "was at pains to collect every kind" of insect. There is, among Darwin's zoological notes from the Cocos, a fragment of paper that bears a careful list of the insects he collected there (DAR 29.3/35):

One minute elater
Blatta
Chrysopa (Hemisbius)
Moth Diopea
_____ & one with fissile wings
2 Flies
2 Ants
2 Homopterus 2
1 Hemipterous insect
12 specimens

The note appears very little altered, but with one or two further identifications, as a footnote to the *Voyage*. Again it is quite clear that he was impressed with the poverty of the terrestrial fauna and flora.

Throughout his writings on the land plants and animals of the islands words such as "poorer", "poverty", "paucity", "few" and "only" abound. The contrast between the paucity of the land forms and the richness of the surrounding seas could not escape the naturalist with such a penchant for the comparative approach: "Although the productions of the land are thus scanty", he was later to write, "if we look at the surrounding sea, the number of organic beings is indeed infinite."

There is not much evidence that Darwin gave a great deal of thought to the *mechanisms* of dispersal *while he was actually on the islands*. However his careful distinction between the richness of the sea-bird colonies in comparison with the poverty of the terrestrial bird fauna,

and his distinguishing in collecting plant specimens between those species that naturally occurred in the islands and those he felt had been introduced suggests that he might have given the matter *some* consideration. Darwin also seems to have made a study of the plant material washed up on the strand line (probably of Direction, Horsburgh and Home Islands, all of which he visited), for Henslow in his paper on Darwin's plants from the archipelago comments:

Mr Darwin heard of the trunks of trees, of many seeds, and of old cocoa-nuts being washed on the shore from time to time.

(See Figure 19.)

Although there are vague hints of a changing outlook in the later stages of the voyage (particularly from Australia onwards) he is thought not have fully adopted a truly evolutionary position until March 1837⁵, six months after his return to England. Once he had assumed that position, the matter of the colonisation of remote islands became increasingly important.

In modifying his diary for publication as the *Voyage of the Beagle*, originally *A Naturalist's Voyage*, Darwin noted that the Florula (list of the flora) of the islands had "quite the character of a refuge for the destitute". This statement implies not only of the poverty of the flora, but the idea of a long and difficult journey for those that eventually became successfully established. Elsewhere in the same passage Darwin wrote:

As the islands consist entirely of coral, and must at one time have existed as mere water-washed reefs, all their productions must have been transported here by the waves of the sea.

And of a solitary tree growing near a beach he commented "without doubt the one seed was thrown up by the waves".

Clearly in the months and years following his return to England in late 1836 Darwin followed up the related problems of the poverty of island biota (particularly those of the Galapagos and the Cocos-Keeling Islands) with some vigour. He badly wanted to know how many species there were amongst the Cocos specimens he collected, which he regarded (mistakenly) as comprising "a nearly complete flora". On 28 March 1837, a few days, according to Frank Sulloway, after Darwin's "conversion" to an evolutionary outlook (see note 5), the naturalist wrote to his friend and former teacher Henslow:

At some future time I shall want to know number [sic] of species of plants at Galapagos and Keeling, and at the latter whether seeds could probably endure floating on salt water. I suppose, after a little more examination you would be able to say, what was the general character of the vegetation of the Galapagos.-?

Darwin was at the time working very hard on preparing his diary for publication, and in increasing desperation he wrote again to Henslow on either the 12 or 13 of July 1837:

I am now hard at work, cramming up learning to ornament my journal with, you may guess the object of this letter is to beg, a few hard names, respecting my plants. - I believe I shall really begin printing in beginning of August, so there is no time to lose. - Will you look over the list of questions, & try to answer some of them. - For instance it will not take you long just to count the number of species in my collection from the Keeling Is^{ls}:- You can tell me something about the Galapagos plants, without further examination...

In fact the publication of the account of the voyage was delayed because of FitzRoy's illness, but Henslow did get on with examining the plants from the Cocos Islands, for an account of them appeared in the *Annals of Natural History* exactly a year later.

Darwin's desperate desire for information on the number of species in the "Keeling Florula", linked with a similar request for information about the Galapagos flora, plus the clear evidence of interest in the possibility of Keeling seeds floating in salt water, so soon after the probable date that Darwin adopted an evolutionary outlook is hardly likely to be coincidental. Darwin was in fact thinking a good deal about the Galapagos at the time; there exist several letters from him written in May, June and July of 1837, to naturalists about the peculiarities of the plants and animals of that archipelago, which assumed such importance in the development of his evolutionary ideas.

Further evidence of the reading and thinking that Darwin did in the years following his return, on the subject of the poverty of the Cocos Islands' biota and the mechanism of its dispersal, can be gained by setting the diary account of his visit beside that in the *Voyage on the Beagle*, particularly later editions. Such a comparison shows that one result of Darwin's "cramming up" was the inclusion of a number of other examples from the literature. For instance he quotes the following from Holman's *Travels* vol 1, page 378, an account based on information from a Mr A F

Keating⁶ who lived for about a year in the islands:

Seeds and plants from Sumatra and Java have been driven up by the surf on the windward side of the islands. Among them have been found the Kimiri, native of Sumatra, and the peninsula of Malacca; the cocoa-nut of Balci, known by its shape and size; the Dadass, which is planted with the Malays with the pepper-vine, the latter intertwining round its trunk, and supporting itself by the prickles on its stem; the soap-tree; the castor-oil plant; trunks of the sago palm; and various kinds of seeds unknown to the Malays who settled on the islands. These are all supposed to have been driven by the NW monsoon to the coast of New Holland, and thence to the islands by the SE trade-wind. Large masses of Java teak and Yellow wood have also been found, besides immense trees of red and white cedar, and the blue gum-wood of New Holland, in a perfectly sound condition. All the hardy seeds, such as creepers, retain their germinating power, but the softer kinds, among which is the mangostin, are destroyed in the passage. Fishing canoes, apparently from Java, have at times been washed on shore.

This is an excellent account, that must have fitted with Darwin's developing views on the importance of long distance dispersal perfectly. Seeds and fruits are to this day to be found in large numbers on the outer shores of Direction and Home Islands, and some of the plants mentioned (for example the castor oil plant, *Ricinus communis*) are to be found growing on the islands today. Darwin added to the *Voyage* text a comment from Henslow that many of the plant species found on Cocos were littoral species from the East Indies.

Typically Darwin's comparative approach helps him to bring his own observations and those of others into a comprehensible framework. He quotes Chamisso's remarks on the Radack Archipelago (now often known as the Ratak Chain in the Marshall Islands) of the western Pacific:

...the sea brings to these islands the seeds and fruits of many trees, most of which have not yet grown here. The greater part of the seeds appear to have not yet lost the capability of growing.

Darwin goes on:

It cannot be doubted that if there were land birds to pick up the seeds when first cast on the shore, and a soil better adapted for growth than loose blocks of coral, that the most isolated of

the lagoon islands would in time possess a far more abundant Flora than they have now. (Voyage, chapter 20.)

Out of a comparison of his own observations on the Cocos Islands with those of other authorities Darwin has pulled a generalisation about the colonisation of remote islands by sea-born plant invaders.

In the next paragraph of the *Voyage* Darwin uses exactly the same technique - comparing his own observation on Cocos with those of others elsewhere, adding some of his observations made under different circumstances - in an attempt to provide a more general statement on the avifauna of remote islands. After mentioning the occurrence of a rail on Cocos (see page 31), he continues:

Birds of this order are said to occur on a number of the small low islands in the Pacific. At Ascension, where there is no land bird, a rail (*Porphyrio simplex*) was shot near the summit of the mountain, and it was evidently a solitary straggler. At Tristan d'Acunha, where according to Carmichael there are only two land birds, there is a coot. From these facts I believe that the waders, after the innumerable web-footed species, are generally the first colonists of small isolated islands. I may add, that whenever I noticed birds, not of oceanic species, very far out to sea, they always belonged to this order; and hence they would naturally become the earliest colonists of any remote point of land.

Darwin also uses Chamisso's account of the Radack Archipelago for a succinct comparison of the entire biota:

... it is remarkable how closely its inhabitants, in number and in kind, resemble those of Keeling Island. There is one lizard and two waders, namely a snipe and a curlew. Of plants there are nineteen species, including a fern; and though some of these are the same as those growing here, though on a spot so immensely remote and in a different ocean.

Darwin was thus able to go on, after comparing his observations on the plants and animals of the Cocos group, with the observations of other naturalists, and his own observations made at other places and times, to adduce certain generalisations about island biota: they were depauperate in animal and plant species; many of the species occurring on islands reached them "by the action of the waves", or by some such mechanism of long distance dispersal; some types of organisms had a particular

propensity to be dispersed to islands.

Darwin also of course, appreciated the possibility that some of the plants and animals on Cocos had been introduced, accidentally or deliberately, by human action. He saw that sugar cane had "in some parts run wild"; FitzRoy mentioned the presence of both rats and mice, and Darwin described a rat specimen from the Cocos in the following terms:

This rat is exceedingly numerous on some of the low coral islets forming the margin of the Lagoon of Keeling Island, in the Indian Ocean. The Climate is dry and hot. The rats are known to have come in a vessel from Mauritius, which was wrecked on one of the islets, which is known as Rat Island [Direction Island]. They appeared stunted in their growth, and many of them were mangy. They are supposed to live chiefly on cocoa-nuts, and any animal matter the sea may chance to throw up. They have not any fresh-water; but the milk of the cocoa-nut would supply its place.

(*Zoology of the Beagle*, vol II, page 32.)

Amongst Darwin's Zoological notes is also the following fragment:

Keeling Rat (3591)

Differs from common rat in being smaller & brighter colour, rather yellower, no other difference, perhaps tail rather longer.

It would be interesting if this had been written by Darwin during the visit to the islands, as it would suggest that at this early time he appreciated the uniqueness of some island creatures, but it is possible that it was written after he had discussed the specimen with Waterhouse. The note is included in the archives with papers recording discussions with Waterhouse on the subject of rodents from Australia. Waterhouse describes the Keeling specimen in the *Zoology of the Voyage* (Volume II, page 32) as follows:

The general hue of the Keeling Island specimen, is deep brown, the longer hares of the upper parts of the body being, as usual, black: but the shorter hares, instead of having the pale yellow tint which we observe in the European (or, rather British), specimens of *Mus Decumanus*, are of a deep rusty yellow. The most remarkable difference, however, consists in the colouring of the under parts being a yellowish tint, and, towards the root of the tail, of a very distinct buff yellow; the feet are brownish.

A table immediately beneath Waterhouse's description of the Keeling Rat shows that the tail is indeed slightly longer than other specimens Darwin collected on the voyage (from South America and the Falklands). My guess is that the note was written after Darwin had had a talk with Waterhouse about the specimen, but before Waterhouse had completed his detailed comparison of the several rat (now known as *Rattus norvegicus*) specimens that Darwin had obtained.

As well as the notes on the "vegetable and animal" productions of the islands, Darwin also seems to have made a couple of observations on some "mineral" material which appears to impinge on the matter of long distance dispersal. In the *Cocos Coral Manuscript* appear the words: "small pumice pebbles on beach from Sumatra, like the seeds". Fragments of bubble-filled volcanic material, sometimes 15-20 cm in diameter are still frequently washed up on the shores of Cocos. I picked up several on Home Island in 1987. And in the little red note book used for recording the numbers of his geological specimens from Cocos we see the following:

3581 A piece of a well rounded boulder of compact greenstone found in the coral breccia of the Northern Isd: in possession of Capt. Ross.-

The "Northern Island" must presumably be North Keeling, not visited by Darwin.⁷

The diary is silent on this strange lump of greenstone (basic igneous rock) although the *Voyage* adds that it was "rather larger than a man's head"; Darwin in the latter work ventures the opinion, once again on the basis of comparison with Chamisso's comments, on the finding of similar stones amongst the roots of trees cast on the beach in the Marshall Islands, that it must have arrived in similar fashion. Darwin suggests that stone may often be thus carried, the tree-trunks often being unnoticed, as they drift below the surface of the ocean. Darwin as though to convince the reader, and himself, perhaps, of the importance of this particular form of long distance dispersal, remarks: "The island has scarcely ever been visited, nor is it probable that a ship had been wrecked there." In this last Darwin was probably mistaken, for Captain FitzRoy (who would have known about such matters) says the following about North Keeling:

... two English vessels have been lost since 1825, and probably other ships met a similar fate there in earlier years, when its existence was hardly known.

Despite this, it seems that the Cocos Islands played a significant role in providing evidence for natural long distance dispersal, as well as the poverty of island floras and faunas: ideas that were later built into his evolutionary schema.

The beginnings of the behavioural approach

It is not always widely appreciated that Darwin was one of the pioneer students of animal behaviour. He wrote extensively in later life on psychology, including the comparative psychology of humans and other animals. Such works included the *The Expression of Emotions in Man and Animals* (1872), and, what has been called "a deeply psychological work" *The Descent of Man* (1871). His *Diary of an Infant*, compiled from observations on the psychological development of his son William (compiled 1839-1842) was the basis of an article in *Mind* (1877), and represented one strand in Darwin's psychological interest; his last major work *The Formation of Vegetable Mould, through the Action of Worms, with Observations on their Habits* shows his concern for invertebrate as well as vertebrate behaviour.

Naturalists of the early and mid nineteenth century were not very greatly concerned with the behaviour of organisms: the science of ethology lay far in the future. The typical zoological work of Darwin's generation emphasised the morphology and classification of the animals. It is therefore all the more remarkable that the young naturalist aboard the *Beagle* so frequently included notes on the behaviour of the creatures he encountered.

He undertook experiments with even the simplest animals he encountered, testing their "behaviour" or at least irritability. Here is a description of a "purplish red" sea anemone (*Actinia*, specimen No 1415) found at Cocos:

The animal has the remarkable power when irritated of emitting from its mouth & 24 glands or pore bunches of viscous threads. These threads are colored [sic] "Peach & Aurora Red", they can be drawn out when in contact with any object to the length of some inches, & are emitted with considerable force.- They are not at all strong. The pores near the part most irritated only at any time ejected this substance. The animal having been kept for a day still retained this power. Within the body in the basal parts, large numbers of these red threads are laid. I know not their nature or use.⁸

They were in fact the *cnidoblasts*, the stinging cells, containing poison-bearing threads, used for defence and the capture of food by animals of this sort. The threads spring out of their capsules when a bristle-like trigger or *cnidril* is touched; hence their release following irritation noticed by Darwin.

Darwin was throughout his scientific work interested in instinctive behaviour in animals. Chapter seven of *On the Origin* is devoted to a discussion of the phenomenon of instinct in a variety of animals, from ants to ostriches! His use of the term in connection with the behaviour of the robber crab of the Cocos Islands is therefore of particular interest. The account of the behaviour of this creature is remarkably detailed. Some aspects of the description were referred to on page 67 (see also Figure 20); some slight repetition occurs here:

These monstrous crabs inhabit in numbers the low strips of dry coral land; they live entirely on the fruit of the cocoa nut tree. Mr Liesk informs me he has often seen them tearing, fibre by fibre, with their strong forceps the husk of the nut. This process they always perform at the extremity, where their three eyes are situated. By constant hammering the shell in that soft part is broken & then with the aid of pincers the food is extracted. I think this is as curious a piece of adaptation and instinct as I ever heard of. The crabs are diurnal in their habits: they live in burrows which frequently lie at the foot of the trees. Within the cavity they collect a pile, sometimes as much as a large bag full of the picked fibre and husks & on this they rest. At night they travel to the sea: there also the young are hatched & during the early part of their life they remain & probably feed on the beach.⁹

The above represents a remarkably comprehensive account of the behaviour of the creature, even if it has been compiled partly from the account of someone else. Some authorities have disputed whether this species does in fact open coconuts in the way described; but they may well be able to open a nut that is already damaged. Be that as it may, the account clearly implies, in the phrase "adaptation and instinct" an appreciation of the innate nature of certain behaviour patterns, ideas so important in Darwin's later writing.

One of the ways in which Darwin's accounts are so stimulating and refreshing, compared with that of other nineteenth century naturalists, is that the creatures he describes are *alive*. Animals and birds are more than just specimens; Darwin describes the way in which terns hover at arm's length from the visitor; fish graze off the ends of the branches of

coral; hermit crabs retreat into their stolen shells blocking the opening with their claw. Not only do we share in the beginnings of Darwin's innovative behavioural studies, it is as though we are with him as he walks along the coral beaches and through the coconut thickets, noticing every aspect of his surroundings on this remote atoll.

1835 April Keating Is. 362
 Crab These numerous crabs inhabit the steps of
 1928 by land & they have entered on the front of
 the coral not once. The crabs inform
 me he has often seen them tearing fibres of
 fibre with their strong fingers the back of
 the web. This process they always perform &
 the explanation when the three eyes are struck
 by constantly hammering the ~~of~~ shell in the
 soft part is broken in & the ~~of~~ the end
 of these narrow posterior pieces the front
 is stretched. I think this is a curious &
 piece of adaptation & instinct and some benefit
 for these crabs are descended in their habits
 they live in burrows which frequently lead
 the front of these within the cavity they
 collect a pile sometimes of sand in a large
 bag filled with the pushed fibres of the back
 & on this they rest & sit. At night they
 sand out travel to the sea. They also their
 young are ~~and~~ hatched & during the early
 part of their life they remain a probably feed
 on the beach. These crabs in very good food
 in the end of a large one there is a large

Figure 20. A page from Darwin's notes on the Robber crab (Photo: Cambridge University Library Syndicate).

It cannot be said that Charles Darwin's evolutionary ideas were well formed by April 1836; but, with careful scrutiny some fragmentary evidence may be found that the young naturalist was beginning to look at the world in ways that were later to assist him with his evolutionary insights. While Darwin was on the remote Indian Ocean atoll he clearly appreciated that organisms were adapted to their environment; he also seems to have analysed parts of the natural world in terms of competition and struggle, as well as appreciating the complexity of relationships between organisms. He certainly was starting to realise the paucity of island floras and faunas and the great importance and nature of long distance dispersal. He displayed a real interest in the behaviour of animals, and placed emphasis on instinct. When, on 12 April 1836 HMS *Beagle* "stood out of the lagoon" Darwin was not an evolutionist, but there were in his mind certain ideas that put him part way along the road to becoming one. The material he collected was probably not so important as the specimens he collected in the Galapagos six months earlier, but he seems to some extent to have bracketed the two island experiences together. Where the Cocos experience was unique was that while he was working hard on the natural history of the islands, he was also putting the finishing touches on another of the ideas, for which he will be remembered, the Theory of Coral Reefs. To this we will now turn.

Chapter 6

The Theory of Coral Reefs

Introduction

Besides his extensive collecting programme, his careful descriptions of the plants and animals of the atoll, and his perceptive annotations on the human community, while he was at Cocos, Darwin was at work in developing one of his best-remembered theoretical constructs: the theory of the origin of coral reefs and atolls. It is possible that Darwin's enthusiastic interest in coral atolls was one of the factors that influenced Captain FitzRoy's decision to include Cocos (Keeling) in the *Beagle's* itinerary. The instructions from their Lordships of the Admiralty directed FitzRoy to take the route north from Sydney, through the Torres Strait, and thence to the Keeling Islands, should HMS *Beagle* reach Australia during the winter months. In the event of the ship arriving in Australia in the southern summer, the southern route, via Tasmania and King George's Sound was to be taken. After rounding Cape Leeuwin, and calling at the Swan River, Captain FitzRoy was to sail directly across the southern Indian Ocean to Mauritius. The compromise route that was in fact taken, quite correctly as the *Beagle* had arrived in Sydney in January, at the height of the southern summer, took the expedition to Hobart Town, across the Great Australian Bight to King George's Sound. But instead of diverting to the Swan River Colony, the little ship struggled on northwards to the Cocos Islands before crossing to Mauritius. Certainly this may have allowed FitzRoy to make better use of the prevailing winds, but it is also certain that Darwin and FitzRoy discussed the germinating ideas on coral islands from time to time, and the Captain could hardly fail to have been impressed by his colleague's enthusiasm.

The origins of the theory

We have already noted that one of the most important influences on Darwin during the *Beagle* period was Lyell's *Principles of Geology*. In this work Lyell expressed the view that the low circular or horseshoe-shaped islands and groups of islands in the Pacific and Indian Oceans were formed by the growth of coral upwards from a circular volcanic crater. The idea did not appeal to Darwin; he wrote to his sister Caroline:

The notion of a lagoon island, 30 miles in diameter being based on a submarine crater of equal dimensions, has always seemed a monstrous hypothesis.¹

Charles Darwin saw "the three great classes of coral reefs" - fringing reefs, barrier reefs and atolls - as members of a single sequence. Coral

grew upwards on an oceanic island as the island sank, and in this way a fringing reef was first converted to a barrier reef, and finally, as the last vestiges of the original island disappeared, into an atoll, Figure 21. Darwin assumed that there were some areas of the world where the land was rising, some where subsidence was taking place, and others where land and sea were approximately in balance.

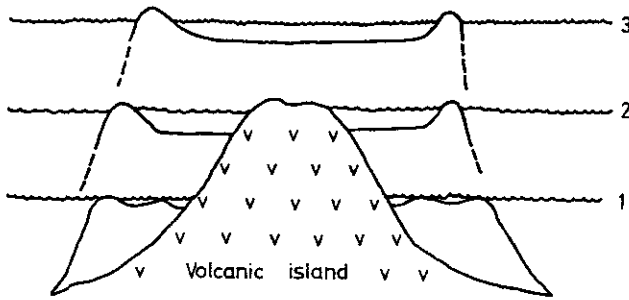


Fig 21 Charles Darwin's subsidence theory for the origin of coral reefs

He had been first drawn to this view on the west coast of South America, where he had observed the existence of beach deposits and marine shells far above the present shore-line, and regarded this as clear evidence of a rise in the level of the land relative to the sea. There is fragmentary evidence in some of Darwin's note-books and letters that he was thinking, in April 1835², in terms of a compensating movement somewhere in the Pacific. Darwin first viewed coral atolls from the masthead of the *Beagle* on 13 November 1835, as the ship billowed its way through the "Low or Dangerous Archipelago" (Tuamotu).³ He then spent several days at Tahiti investigating the barrier reefs there and climbed a high mountain; his diary account reads as follows:

From this point there was a good view of the distant island of Eimeo ... On the lofty & broken pinnacles white massive clouds were piled, which formed an island in the blue sky as Eimeo itself in the blue ocean. The island is completely encircled by a reef, with the exception of one small gateway. At this distance a narrow but well defined line of brilliant white, where the waves first encountered the wall of coral, was alone visible. Within this line was included the smooth glassy water of the lagoon, out of which the mountains rose abruptly. The effect was very pleasing & might be compared to a

framed engraving, where the frame represents the breakers, the marginal paper the lagoon, & the drawing the island itself.

Darwin's first draft of his coral atoll theory was probably written a few weeks later, while the *Beagle* was en route from Tahiti to the Bay of Islands in New Zealand. A 23 page, hastily-written manuscript in Darwin's hand, headed "*Coral Islands*"⁴ includes almost every detail of the final theory that emerged in Volume I of *The Geology of the Voyage : The Structure and Distribution of Coral Reefs*. Darwin, in the manuscript, distinguishes the different types of coral reef, expressing the notion that the one might transform itself into another through subsidence. He repeats his description of Eimeo (today known as Moorea):

The mountains rise out of a glassy lake which is separated on all sides by a narrow defined line of breakers, from the open sea.- Remove the central group of mountains, & there remains a Lagoon Isd.- I ground this opinion from the following facts.- There is a general similarity in the two cases in the form & size of the reefs; their structure appears identical, we have scarcely fathomable water in each case, at a very short distance from the outer margin; within is a shallow basin more or less filled up by knolls of growing Corall [sic] or converted to dry land.- In the Lagoon Isds. there are some, which do not deserve this title, for they consist solely of a circular reef, of which scarcely a point projects above the water; while others have a more or less complete, but narrow ring of dry land...

Darwin is perceptive in his description and in accounting for the smaller scale variations in the form of coral reefs. Elsewhere in the manuscript he describes, on the basis of his fieldwork in Tahiti, the way in which an outer "mound" or "breakwater" is built up, the coral dipping gently inwards towards the smooth water of the lagoon.

The sea, breaking violently on the outer margin, continuously pumps over in sheets the water of its waves. - hence the surface is worn smooth & gently declines towards the lagoon...

Darwin noted that coral growth was most rapid on the outer fringes of the reef, suggesting that this might be due to "the motion of the fluid, or the quantity of insolved air".

He summarises:

... in certain parts of the Pacific, a series of subsidences have taken place; of which no one exceeded in depth, the number of ft at which saxicolous polypi will flourish. The intervals ... [between the subsidences] were sufficiently long to allow their growth [and that of] ... those species of Lithophytes, which build the outer solid wall where the sea violently breaks.

In short, Darwin in the "Coral Islands" draft analyses the form of coral reefs in fine detail, on the basis of his fieldwork in Tahiti, his view of Eimeo (Moorea) from afar, and his masthead views of atolls. He associates the variety of coral reef forms, of varying scales, to a series of processes including wave action, coral growth and the subsidence of oceanic islands. The subsidence he saw as a compensation for the elevation of land which he noticed elsewhere, particularly in South America. This last idea probably received confirmation during the Australian sojourn, for his geological notes on Australia, particularly those made after fieldwork at Hobart Town and King George's Sound contain many references to changes in sea level.

The significance of the Cocos experience

Darwin thus arrived at Cocos with a clear hypothesis on the origin of atolls in his mind. This was despite the fact that although he had seen barrier reefs close at hand, he had only seen atolls from several miles distant. Nor had he had any substantial experience of the third form of reef in his sequence, fringing reefs.

When he left the Cocos archipelago some ten days later he must have felt extremely satisfied. He had seen nothing to contradict his theory, substantially erected on theoretical grounds, and a good deal that he felt confirmed it. In both his diary, and in a letter written a little over a fortnight later to one of his his sisters, he wrote enthusiastically about the stay at the Cocos-Keeling Islands.

In his diary entry for 12 April 1836, after the *Beagle* had "stood out of the Lagoon" Darwin wrote:

I am glad we have visited these Islands; such formations surely rank high amongst the wonderful objects of the world. It is not a wonder which at first strikes the eye of the body, but rather after reflection, the eye of reason. We feel surprised when travellers relate accounts of the vast piles & extent of some ancient ruins; but how insignificant are the

greatest of these, when compared to the matter here accumulated by various small animals.

And part of his letter, dated 29 April 1836, to Caroline reads:

We ... proceeded to the Keeling Is^{ds}.- These are low lagoon Is^{ds}. about 500 miles from the coast of Sumatra.- I am very glad we called there, as it has been our only opportunity of seeing one of these wonderful productions of the Coral polypi.- The subject of Coral formation has for the last half year been of particular interest to me. I hope to be able to put some of the facts in a more simple & connected point of view, than that in which they have hitherto been considered.

(DAR 223)

The Keeling Atoll case study

The untitled account of Darwin's observations on the structure of the Cocos archipelago, referred to here as the *Cocos Coral Manuscript* (also in the Archive at DAR 41) provides the main basis for our knowledge of Darwin's developing ideas on coral reefs and atolls during his stay. This set of notes commences with a neat cross-section (cross-sections and the transect technique were widely used by Darwin in his geological investigations in many parts of the world) but the connected prose of the first few pages degenerates to a series of pencil jottings, including a series of hydrographic notes. It was probably commenced after the first few days of the stay at Cocos, but added to, modified, and scribbled upon later in the sojourn, and afterwards. Despite the names of days of the week that appear at the head of certain sections, it is difficult sometimes, to say whether a particular comment or observation dates from the days on the archipelago, or much later. It did, however, clearly form the basis for the very polished case study of the Keeling Islands, as Darwin often called them, published in chapter one of *The Structure and Distribution of Coral-Reefs*: a similar elegant sketch-section appears early in the chapter (see Figure 22). But other sources were used too: detailed descriptions of some of the corals are almost word for word from the *Zoological Notes*; snatches of descriptions of rock types echo the brief descriptions in the red geological specimen book; a few phrases used are the same as those used in the "first draft" - the "*Coral Islands*" manuscript. There is also a certain amount of hydrographic material, information on the depths of water offshore, that Darwin may obtained either directly from Captain FitzRoy, or Lieut Sullivan, or from reports and accounts prepared by them. Some of the notes appear to be actually in Sullivan's hand.

Sufficient material is available from the *Cocos Coral Manuscript*, the "first draft" of the Coral atoll theory written at sea late in 1835, letters, the Keeling chapter in the *Coral Reefs* volume and other sources to trace the broad sweep of the development of Darwin's ideas on the subject from South America onwards.

The Keeling Atoll account in the first chapter of *Coral Reefs* is remarkably well integrated, showing the relationships that existed amongst coral growth, physical environment and the micro-topography of the reefs. Its author also provides a careful link between the physical

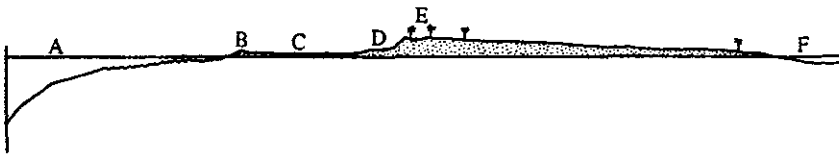


Figure 22. Idealised cross-section of a coral islet, after the sketch in chapter 1 of *The Structure and Distribution of Coral Reefs*. Darwin's caption reads as follows:

A.- Level of the sea at low water: where the letter A is placed, the depth is twenty-five fathoms, and the distance rather more than one hundred and fifty yards from the edge of the reef.

B.- Outer edge of the flat part of the reef, which dries at low water; the edge either consists of a convex mound, as represented, or of ragged points like those a little farther seaward, beneath the water.

C.- A flat of coral-rock, covered at high water.

D.- A low projecting ledge of brecciated coral-rock washed by the waves at high water.

E.- A slope of loose fragments, reached by the sea only during gales: the upper part, which is from six to twelve feet high, is clothed with vegetation. The surface of the islet gently slopes to the lagoon.

F.- Level of the lagoon at low water.

The reader might care to compare the above sketch with the photograph in Figure 23.



Figure 23. The outer windward edge of West Island, close to the modern settlement. Note shelving beach of coral rock, littered with fragments of coral. The top of the beach is marked by *Scaevola* scrub and coconut palms.

and biological nature of the reefs, and the processes involved in their development. (It will be referred to extensively here, but material from other sources will be introduced as appropriate.)

Darwin, for example, starts this account with a careful description of the zonation in coral types from the outer barrier, where the waves break, inwards towards the shore and in the lagoon. He describes the type of environment associated with each coral (or community of corals), and the form of the reef in which their growth results. To put it in modern terms it shows a clear awareness of ecological principles. A few quotations from the early part of the essay illustrate its general temper:

... the reef-building polypifers, not being tidal animals, require to be constantly submerged or washed by the breakers ... an exposure to the rays of the sun for a very short time invariably causes their destruction. Hence it is only possible under the most favourable circumstances, afforded by an unusually low tide and smooth water, to reach the outer margin, where the coral is alive. I succeeded only twice in gaining this part, and found it almost entirely composed of a living *Porites*, which forms great irregularly rounded masses ... from four to eight feet broad, and little less in thickness. These mounds are separated from each other by narrow channels, about six feet deep, most of which intersect the line of the reef at right angles. On the furthest mound, which I was able to reach with the aid of a leaping-pole, and over which the sea broke with some violence ... the polypifers in the uppermost cells were all dead, but between three and four inches lower down on its side they were living, and formed a projecting border round the upper and dead surface. The coral being thus checked in its upward growth, extends laterally, and hence most of the masses, especially those a little further inwards, had broad, flat, dead summits. On the other hand I could see, during the recoil of the breakers, that a few yards further seaward, the whole convex surface of the *Porites* was alive ...

On the margin of the reef, close within the line where the upper surface of the *Porites* ... is dead, three species of *Nullipora* flourish. One grows in thin sheets like the lichen on old trees; the second in stony knobs, as thick as a man's finger, radiating from a common centre; and the third, which is less common, in a moss-like reticulation of thin, but perfectly rigid branches. The three species although able to exist above the level of true corals, seem to require to be bathed by breaking water, for they are not found ... in the protected hollows in the back part of the reef ... It is remarkable that organic productions of such extreme simplicity ... should be limited to a zone so peculiarly circumstanced.

The lagoon is inhabited by a quite distinct set of corals, generally brittle and thinly branched; but a *Porites*, apparently of the same species with that on the outside, is found there, although it does not seem to thrive, and certainly does not attain the thousandth part in bulk of the masses opposed to the breakers.

Almost all the facts and ideas in this extract can be traced to the *Cocos Coral Manuscript*, written while Charles was actually on the islands, although the style has been much improved.⁵ The whole of the passage is a most careful analysis, far ahead of its time in many respects, of the ecology of the coral reef. Not only is the concept of zonation fully understood, but the account shows an understanding of the relationships amongst life-form, microtopography and environmental conditions.

Darwin is equally at home describing the broader scale geomorphology of the atoll:

It is [the] reef which essentially forms the atoll. In Keeling atoll the ring encloses the lagoon on all sides except at the northern end, where there are two open spaces, through one of which ships can enter. The reef varies in width from 250 to 500 yards; its surface is level, or very slightly inclined inwards towards the lagoon, and at high tide the sea breaks entirely over it: the water at low tide thrown by breakers on the reef, is carried by the many narrow and shoal gullies on its surface into the lagoon: a return stream sets out of the lagoon through the main entrance. The most frequent coral in the hollows on the reef is *Pocillopora verrucosa*, which grows in short sinuous plates, or branches, and when alive is of a beautiful pale lake-red ... As soon as an islet is formed, and the waves are prevented from breaking entirely over the reef, the channels and hollows become filled up with fragments cemented together by calcareous matter; and the surface ... is converted to a smooth hard floor, like an artificial one of freestone. [Compare Figure 11, page 33] The flat surface varies in width from 100 to 200, or even 300 yards, and is strewn with a few fragments of coral torn up during gales ... Nothing can be more singular than the appearance at low tide of this 'flat' of naked stone ...

The islets on the reef are first formed between 200 and 300 yards from its outer edge, through the accumulation of a pile of fragments, thrown together by some unusually strong gale. Their ordinary width is under a quarter of a mile, and their length varies from a few yards to several miles. Those on the S.E. and windward side of the atoll, increase solely by the addition of fragments on their outer side; hence the loose blocks of coral, of which their surface is composed, as well as the shells mingled with them, almost exclusively consist of those kinds which live on the outer coast. The highest part of the islets (excepting hillocks of blown sand, some of which

are 30 feet high), is close to the outer beach and averages from six to ten feet above ordinary high-water mark. From the outer beach the surface slopes gently to the shores of the lagoon [see Figure 22]; and this slope no doubt is due to the breakers, the further they have rolled over the reef, having less power to throw up fragments. The little waves of the lagoon heap up sand and fragments of thinly branched corals on the inner side of the atoll; and these islets are broader than those to the windward, some being 800 yards in width ...

The lagoon alone remains to be described; it is much shallower than most atolls of considerable size. The southern part is almost filled up with banks of mud and fields of coral, both dead and alive; but there are considerable spaces, from three to four fathoms, and smaller basins from eight to ten fathoms deep. Probably about half its area consists of sediment, and half coral-reefs.

But Darwin was geologist first and foremost, and was at least as interested in the rocks to which the growth and eventual death of the corals gave rise as in the corals themselves. The following is an extract from his notes made at the time:

Beneath this beach ... is a breccia, the rock is very solid, white coloured and sonorous beneath the hammer; this breccia consists of calcareous sand, cemented & the fragments blending into one another, generally it is composed of [any *deleted*] fragments of all sizes of [the *del*] coral, which are nearly perfectly petrified: there are large masses in which hardly any trace of any organic structure can be discovered: the rock would be as a yellow or white calcareous rock with an almost crystalline fracture: containing a few minute cavities. The horizontal extent of this varies much; in thickness it can hardly exceed 3 ft.- it is a very curious and interesting rock ... the mass is irregularly stratified.

(*Cocos Coral MS*: DAR41/3; compare Figure 11, page 33)

Darwin also described the offshore part of the atoll:

At a distance of 2,200 yards from the breakers, Captain FitzRoy found no bottom with a line 7,200 feet in length; hence the submarine slope of this coral formation is steeper than that of any volcanic cone. Off the mouth of the lagoon, and likewise off the northern point of the atoll, where the currents act violently, the inclination, owing to the

accumulation of sediment is less. As the arming of the lead from all greater depths showed a smooth sandy bottom, I at first concluded that the whole consisted of a vast conical pile of calcareous sand, but the sudden increase of depth at some points, and the fact of the line having been cut, when between 500 and 600 fathoms were out, indicates the probable existence of submarine cliffs.

In these passages, again, together with a most careful description of the *form* of the atoll, we have an attempt at an analysis of the *processes* that gave rise to it. It is only, however, towards the end of the Keeling Atoll case study of Chapter 1 of the *Coral Reefs* volume that Darwin hints at the conceptual framework that provides the *raison d'être* for the whole work, the notion that atolls are formed through the submergence of a volcanic island surrounded by reefs, and thus that an atoll is the end-member of a series: fringing reef - barrier reef - atoll. Even there he does so obliquely.

Struggle, depression and transformation

The way in which the metaphor of "struggle" or "contest" influenced Darwin's natural history writing has already briefly been noticed. It can hardly be too strongly emphasised that Darwin saw the development of the atoll in terms of a struggle between those processes that tended to build up the land, and "increase ... the diameter of the atoll" and "those having an opposite tendency". It is against the background of this notion of a form of combat between land and ocean that Darwin's work on his coral atoll hypothesis must be seen. Certainly he felt at the end of his ten-day stay that his submergence theory was correct. But he acknowledged that other processes - wave erosion, deposition, dune building by the wind - were also at work, some of these having effects contrary to that of submergence: the network of relationships was a complex one.

Darwin described most perceptively, after only a few days on the island, the processes leading to the infilling of the lagoon, appreciating that they were to some extent self-limiting:

The shores at the head of the lagoon have a different character from any other part, here there is an extensive bed of mud, which reaches far into the bay at a very small angle - Here flourishes the Turtle grass - This mud is entirely calcareous.- I can only account for its presence by the Trade Wind drifting across the finer particles of sand which is accumulating on the Weather coast. If we imagine the future state of the lagoon,

we see a perfect ring of land [formed, & with a new tidal opening *del*], complete excepting by one orifice.- The corals will have grown up over the whole extent, to their highest limits, that is to the lowest low water ... their comminuted fragments will form a fine band in which turtle grass will grow. ... It is difficult to imagine how it would ever entirely be silted up.- We must not allow false appearances to misguide & compare a lagoon with a lake surrounded by higher land, from which detritus may be carried.- These facts may account for infrequency of Lagoons, being converted into absolutely dry land.- Moreover, when the lagoon was nearly filled up the impurity of the water might add much to the slow growth of the corals-

(*Cocos Coral Manuscript* DAR 41/11-12)

On the other hand he wrote of Horsburgh Island a day or two later:

Certainly taking the whole lsd together, the Breccia is wearing away in a large proportion.

(*Cocos Coral Manuscript* DAR 41/13)

Darwin mentions an old chart described to him by Mr Liesk "in which the recent long island on the SE side was divided by several channels into as many islets".⁶ Darwin notes how on a few islets only young coconut trees grew at the extremities and "older and taller trees grew in regular succession behind them". There are places today where on South Island the trees appear lower. Charles also described in some detail a field of largely dead coral in the southern part of the lagoon:

... I was much surprised by finding an irregular field of at least a mile square of branching corals, still upright, but entirely dead... they were of a brown colour, and so rotten, that in trying to stand on them I sank half way up the leg, as if through decayed brushwood. The tops of the branches were barely covered by water at the time of lowest tide.

(*Coral Reefs* , Chapter 1, page 21.)

At first Darwin felt that the death of the coral was the result of the elevation of the atoll, but after some thought decided that there was insufficient evidence for this.

Upon reflection ... it appeared to me that the closing up of the above mentioned channels would be a sufficient cause; for before this, a strong breeze by forcing water through them into the head of the lagoon, would tend to raise its level. But now

this cannot happen, and the inhabitants observe that the tide rises to a less height, during a high S.E. wind at the head than at the mouth of the lagoon. The corals which under the former condition of things, had attained the utmost possible limit of upward growth, would occasionally be exposed for a short time to the sun and be killed. (Coral Reefs, page 22.)

The existence of the field of dead coral, along with the existence of isolated areas of accretion was thus seen as evidence for a local tendency for an increase in the area of the atoll. There is however another interpretation. Occasionally in recent years serious fish kills have occurred in the Cocos lagoon - for example in 1962 and 1983. Dr David Williams, a biological scientist resident on the island in 1987, informed me that these kills may have their origin in occasional changes in the intensity of the South Equatorial Current, coupled perhaps with the flushing effect of rain brought by a tropical cyclone (typhoon); algal blooms have in a few instances been noticed to coincide with the fish kills. It might be therefore that the *Beagle's* visit closely followed a particular combination of climatic phenomena that resulted in the destruction of much of the life of the southern lagoon.

On the tendency for the lagoon to subside, and thus the area of land to be reduced, Darwin is more definite, although the modern sceptic might not be entirely convinced:

On the western side ... of the atoll, where I have described a bed of sand and fragments with trees growing out of it, in front of an old beach, it struck both Lieut Sullivan and myself, from the manner in which the trees were being washed down, that the surf had lately recommenced an attack on this line of coast. Appearances indicating a slight encroachment of water on the land are plainer within the lagoon: I noticed in several places, both on its windward and leeward shores, old cocoa-nut trees falling with their roots undermined, and the rotten stumps of others on the beach [see Figure 24], where the inhabitants assured us the cocoa-nut could not grow. Capt. FitzRoy pointed out to me, near the settlement, the foundation posts of a shed, now washed by every tide, but which the inhabitants stated, had seven years before stood above high water-mark. ... From these considerations I inferred, that probably the atoll had lately subsided a small amount; and this inference was strengthened by the circumstance, that in 1834, two years before our visit, the island had been shaken by a severe earthquake, and by two slighter ones during the ten previous years.⁷

But while actually on the island Darwin seems to have been rather less than certain in his own mind; in his rough notes we find the jotting:

Perhaps the island ought to be considered as at rest after changes consequent on some change in level.= It is scarcely possible to follow out all the consequences in slow or sudden depressions: & outward growth, too many uncertain elements.

(*Cocos Coral MS DAR41/13*)

But a line or so later the idea of combat emerges again:

When land & water are opposed such equal & antagonist powers, a depression of an inch or two would turn the balance of of [sic] degradation. The depression must have been trifling from fields of dead coral.



Fig 24. "[W]ithin the lagoon I noticed in several places ... old cocoa-nut trees falling with their roots undermined, and the rotten stumps of others on the beach.

Close to the conclusion of Darwin's essay on Keeling in the *Coral Reefs* volume there appear the words:

Whether this view be correct or not, the above facts are worthy of attention, as showing how severe a struggle is in progress on these low coral-formations between the two nicely balanced powers of land and water.

The notion of "struggle", hinted at in some of the diary entries, the *Cocos Coral Manuscript*, and other writings actually made on the islands (see chapter 1) is here expanded to an important sub-theme. Not perhaps raised to the importance the idea held in *On the Origin of Species*, but nevertheless, serving to link Darwin's fragmentary observations on the remote Indian Ocean atoll with one of the main thrusts of his later work.

When the *Beagle* stood out of the lagoon at Cocos on the morning of 12 April 1836 Darwin had, through several days of careful observation, confirmed the essential validity of his hypothesis - that fringing reefs, barrier reefs and atolls were members of a series, and that submergence resulted in one form being converted into another. He accepted, after his observations at Cocos that there were complicating factors, but by and large he was convinced that the core of his subsidence model was valid.

The idea had germinated while he was in South America; he had seen his first atolls from the *Beagle* on 13 November 1836, immediately before extensive work on barrier reefs in Tahiti (see page 86). The first draft of the theory had been written, probably at sea between Tahiti and the Bay of Islands, New Zealand. Darwin's understanding of the importance of sea-level changes, firmly established during the years in South America, probably received confirmation during his brief visits to Australia, for his geological notes on both Hobart Town and King George's Sound contain many references (not all of them correct) to changes in the relative levels of land and sea. Darwin also believed that as some areas were uplifted, others subsided. A note on the reverse of page 6 of the *Cocos Coral Manuscript* expresses the idea succinctly: "Cocos lsd connected with volcanic force of Sumatra, that rises, this falls".

Darwin concludes his Diary entry for 12 April 1836 with the following passage:

Throughout the whole group of Islands, every single atom, even from the most minute particle to large fragments of rocks, bear the stamp of once having been subjected to the power of organic arrangement. Capt. FitzRoy at the distance of but little more than a mile from the shore sounded with a line 7200 feet long, & found no bottom. Hence we must conclude the Isd as the summit of a lofty mountain; to how great a depth or thickness the work of the Coral animal extends is quite uncertain. If the opinion that the rock-making Polypi continue to build upwards as the foundations of the Isd from volcanic agency, after intervals, gradually subsides, is granted to be true; then probably the Coral limestone must be of great thickness. We see certain Isds in the Pacifick, such as Tahiti & Eimeo, mentioned in this journal, which are encircled by a coral reef separated from the shore by channels & basins of still water. Various causes tend to check the growth of the most efficient kinds of Coral in these situations. Hence if we imagine such an Island, after long successive intervals to subside a few feet, in a manner similar, but with a movement opposite to the continent of S. America; the coral could be continued upwards, rising from the foundation of the encircling reef. In time the central land would sink beneath the level of the sea & disappear, but the coral would have completed its circular wall. Should we not then have a Lagoon Island? - Under this view, we must look at a Lagoon Isd as a monument raised by myriads of tiny architects, to mark the spot where a former land lies buried in the depths of the ocean.

Mauritius - the missing link

Yet despite the satisfaction that Charles expressed both in his diary on 12 April, and when he wrote to Caroline about his theory a fortnight later (see page 6), there remained a significant gap. Darwin had not yet seen a fringing reef. By good fortune the next port of call on the voyage of the *Beagle* was St Louis, Mauritius. Between 29 April and 9 May 1836 Darwin was able to walk or ride around a good deal of the coast of the northern part of the island; he recorded his observations in 20 pages of notes in the *Geological Diary*, and a good deal of this was ultimately to see the light of day in Chapter 3 of the *Structure and Distribution of Coral Reefs*, that entitled "Fringing or Shore Reefs". Here were the missing pieces of the jig-saw; not only was Darwin able to see over coral reefs attached, or nearly attached, to what was essentially a volcanic island, but he was able to find evidence of the *elevation* of reefs. This was important, as Darwin was to emphasise later that while barrier reefs and atolls were usually associated with

submergence, fringing reefs might be associated with either elevation or still-stand. A single quotation is sufficient to demonstrate the importance of the Mauritius visit:

On the NW, W & SW of the island, coral rock such as now forming the reefs is commonly found in masses elevated considerably above the reach of any but the highest tides. I will describe in detail some of these cases.

To the northward of Port Louis the surface of the country to a height of 30 or 40 ft, & to a considerable distance inland is created by a bed of partially cemented fragments of stony branching corals. Some of the layers are hard & compact and contained feruginous matter. The rock is composed of precisely the same materials such as are now lying on the beach: comminuted fragments of the ... more delicate stony corals, which flourish on the quiet side of the island are mingled with calcareous sand.⁸

A theory completed

Table I illustrates how the whole integrated coral reef theory was built up. Its elevation can be compared to the construction of a large modern building: the skeleton or framework is first erected - the initial theory - and this is then clad with solid material until the whole edifice appears complete - the slotting in of ideas and evidence gained from fieldwork in South America, the Pacific, Tahiti, Australia, Cocos and Mauritius. The theory was first formally presented to the scientific community in a paper given to the Geological Society of London of 31 May 1837, just eight months after Charles Darwin's return from the sea, and incidentally just a matter after weeks of Darwin's "conversion" to the evolutionary view, if Sulloway's date of mid-March 1837 is accepted (see page 75). It seems appropriate that Darwin's close friend and companion on many a geological walk, Lieut Sullivan, was in the audience.

It is worth mentioning that two other ideas appeared quite inconspicuously in the 1837 paper. The first was the suggestion that remote islands might have a part to play in the development of new species:

... certain coral formations acting as monuments over subsided land, the geographical distribution of organic beings (as consequent on the geological changes as laid down by Mr Lyell) is elucidated, by the discovery of former centres whence the

germs could be disseminated ... and some degree of light might be thrown on the question, whether certain groups of living beings peculiar to small spots are the remnants of a former larger population, or a *new one springing into existence*.⁹

(Emphasis not in original.)

Second, Darwin ended his paper putting forward the idea of an area passing through a *cycle of change*. He seems to have been thinking of a broader scale than that of the individual island passing from fringing reef, through barrier reef to atoll, emphasising that on a broad oceanic or continental scale there were regions of uplift and others of submergence.

Lastly, when beholding more than one hemisphere, divided into symmetrical areas, which within a limited period of time have undergone certain known movements, we obtain some insight into the system by which the crust of the earth is modified during an endless cycle of change.¹⁰

Both were ideas that were ultimately to prove of some consequence.

The book on the *Structure and Distribution of Coral Reefs*, Part 1 of *The Geology of the Voyage of the Beagle* gave the polished, complete version of the theory when it appeared in 1842. That volume concludes as follows:

Finally, when the two great types of structure, namely barrier-reefs and atolls on the one hand, and fringing-reefs on the other, are laid down on the map, they offer a grand and harmonious picture of the movements which the crust of the earth has undergone within a late period. We there see vast areas rising, with volcanic matter every now and again bursting forth. We see other areas sinking without any volcanic outbursts; and we may feel sure that the movement has been slow as to have allowed corals to grow up to the surface, and so widely extended as to have buried over the broad face of the ocean every one of those mountains, above which the atolls now stand like monuments, marking the place of their burial.

The final sentence in the above is remarkably similar to the sentence with which Darwin closed the brief entry in his diary describing the theory when he left the Cocos Group on 12 April 1836 (page 100). He liked the idea of atolls as "monuments"!

TABLE 1. TIME CHART SHOWING THE DEVELOPMENT OF THE CORAL ATOLL THEORY

DATE	PLACE	COMPONENT	DOCUMENTS
Pre - April 1835	South America	Evidence for change in levels of land and sea accumulated	Misc. notes and letters
April 1835	South America	First glimmerings of coral island theory	Entries in "little note-books"
13 November 1835	Low Archipelago	First glimpse of atoll (probably from masthead)	Diary entry
15 - 26 November 1835	Tahiti	Observations on barrier reefs	Diary entries Geological Notes
December 1835 (possibly early January 1836)	On board HMS <u>Beagle</u>	First written draft of theory	"Coral Islands" DAR 41:1-22
5 - 17 February 1836	Hobart Town	Observations on sea level change	Geological Diary DAR 38.1
6 - 14 March 1836	King George's Sound	Observations on sea level change	Geological Diary DAR 38.1
1 - 12 April	Cocos Islands	Only visit to atoll Detailed observations on living coral and Cocos coral reefs	Diary entries Zoological Diary DAR 31.2 Cocos Coral MSS DAR 41
29 April 1836	Mauritius	Satisfaction with theory expressed	Letter to Caroline DAR 223
29 April - 9 May 1836	Mauritius	Observations on Fringing Reefs Evidence of elevation	Entry in "little note book" Geological Diary DAR 38.1/2
31 May 1837	Geological Society of London	First formal presentation of theory	Paper: "On certain areas of elevation and subsidence..." <u>Proceedings 2,</u> (1838) 552 - 554
1842	London	Publication of full statement	<u>The Structure and distribution of Coral Reefs</u>

It is not for nothing that the coral atoll theory has been described as showing the young Darwin as a "theoretician upward and outward bound". In the theory, and within its development, we can detect almost every component that made Darwin so successful in his later scientific work. In its emphasis on gradual change, and in its appreciation of changes in sea level, it can be seen as a quest for a *vera causa*, or as Darwin put it so elegantly in the paragraph quoted above "a grand and harmonious picture". Here we see also the notion of "struggle" that characterised Darwin's work on natural selection. Here too is the idea of plants and animals being "exquisitely adapted" to their surroundings, as well as the subtlety of the dialogue between organisms and their environment.

Chapter 7 Concluding summary

It has often been emphasised that there were significant connections between Darwin's various intellectual enterprises. It is perhaps just coincidence that *The Structure and Distribution of Coral Reefs* appeared in the same year that Darwin's first essay on evolution, the *Sketch of 1842*.¹ Yet there are important links: - the experience on the Cocos (Keeling) Islands provided vital components for Darwin's first flirtation with the thought-form of gradualism; it provided also an early if not the first use of the model of "struggle" or "conflict"; it was partly on the basis of Cocos material that long distance dispersal became an important theme in Darwin's work; the coral reef ecosystem provided many instances of organisms' adaptations to their environment, and of that environment becoming modified by the activities of organisms; we can also see some early indications of the interest in behaviour and instinct that later formed important components of both his evolutionary and psychological work.

The Cocos (Keeling) interlude provides us with a glimpse of the young naturalist at work - collecting, observing and recording, certainly - but also beginning to build theoretical systems. At the same time he was wrestling with the complexity of reality. Time and again in Darwin's notes or letters from those island days, or from immediately afterwards we can perceive, maybe a little crudely, ideas that were to reappear again and again in the years and decades that followed. Darwin's Cocos experience thus had a significant influence on the development of his philosophy - not perhaps as a locale in which significant ideas *originated* but certainly a place where ideas already in his mind were strengthened and developed. Were it not for those 12 days in April 1836, Darwin's later scientific output might have been rather different.

The documents relating to the sojourn in the Cocos islands also provide us with evidence, in a particularly vivid way, of the manner in which the young Darwin worked. An insight is to be gained from a letter to his sister just a couple of weeks after leaving Cocos, from Port Louis, Mauritius (the *Beagle* had just arrived and Darwin had presumably not seen the name written; he heads his letter "Port Lewis"; later he spells the place-name correctly):

Whilst we are at sea, & the weather is fine, my time passes smoothly, because I am very busy. My occupation consists in rearranging old geological notes: the rearrangement consists generally in totally rewriting them.

(Charles Darwin to Caroline Darwin, 29 April 1836; DAR 223)

The archives completely support this assertion; Darwin in the weeks and months following his visit to the Indian Ocean archipelago was constantly reworking his material, transplanting notes from one set to another, combining his own observations with material from the reference books that he had available. The student can trace a group of facts from, say, the *Cocos Coral Manuscript*, written on the islands, and its combination with an idea from the first draft of the theory of formation of atolls, written at sea between Tahiti and New Zealand - "*Coral Islands*" - to his Geological Society paper of 1837, and ultimately his *Coral Reefs* book published in 1842. In the book also appear extracts from his *Zoological Notes*, usually with just a minimum of rewriting. Material from both the *Zoological* and other sources written aboard the *Beagle*, along with some of Henslow's comments on the plants enlivened Darwin's diary entries, to make what eventually became the immortal *Voyage of the Beagle*. Figure 3 shows some of these relationships. Sometimes, during this "rearrangement" new relationships became clear: notes written on the reverse of pages of geological notes show where, perhaps as the ship billowed southwards towards the Cape of Good Hope, or perhaps much later in his rooms in London or Cambridge, or even in the Old Study at Down, Darwin added an annotation of comparison with some exposure in a distant part of the globe, or from something he had read. He compared the reefs at Cocos with those at Tahiti, he saw similarities between the sediments in the lagoon with some at King George's Sound. The "habit of comparison" was at the heart of Darwin's approach, and it perhaps one of the keys to his genius. It was in part the technique that enabled him to build sophisticated conceptual systems.

Darwin's Cocos writings also enable us to see something of The Man. His eye for detail, his past experience, his feeling for the exotic, his determination to get to the root of a problem despite the complexity of a situation - and his occasional errors - all shine through.

It is perhaps worth mentioning that the last paragraph in Darwin's last scientific work of consequence: *The Formation of Vegetable Mould Through the Action of Worms* ² provides a surprising link with his coral island work. After describing the way in which earthworms contributed to the denudation of the land, and were responsible for gradual changes that occurred in the soil and the landscape, Darwin concluded:

... long before he [Man] existed the land was in fact regularly ploughed and still continues to be thus ploughed by earth-worms. It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organised creatures. Some other animals, however, still more lowly organised,

namely corals, have done far more conspicuous work in having constructed innumerable reefs and islands in the great oceans; but these are almost confined to the tropical zones.

The *Vegetable Mould and Earthworms* volume, could be described as the end-point in Darwin's development of the notion of gradualism. The whole work is not only thoroughly evolutionary in character (witness the phrases "history of the world", "lowly creatures" and "before man existed" in the above quotation), but is imbued with the idea that "tiny effects over long periods of time can wreak great changes". Darwin's gradualist adventure began on the coral reefs and atolls of the South Seas and Indian Ocean. It continued in his geological, biological and psychological works over nearly five decades. There is a fitting symmetry in the fact that the final remarks in his last substantial, and in some ways most extreme work with a gradualist theme, published in the final few months of his life, included a return to the tropical coral islets "under the blue vault of heaven" experienced in his early manhood.

Epilogue

It was explained in Chapter 2 that Captain John Clunies Ross, proprietor and self-proclaimed ruler of the Cocos Islands was absent on a trading voyage when HMS *Beagle* called in April 1836, his wife being left in charge, with Mr Liesk to assist. Captain Ross was disappointed not to meet the members of the crew of one of His Majesty's ships, and felt strongly that Liesk had not conveyed a favourable enough impression of the little isolated community. Moreover, he seems to have been enraged by some of the things that Darwin and FitzRoy wrote about the settlement - it will be remembered that some of the observations in both the *Narrative* and the *Voyage* were not particularly favourable. Clunies Ross probably seethed over these matters for years, and wrote a lengthy, vitriolic diatribe against Darwin and FitzRoy some time in the 1840s, some fragments of which have been quoted in this book. This attack, preserved in the Clunies Ross papers in the British Library, does not seem to have been published at the time.

His opportunity for another attempt at revenge came in 1855, when he published a scornful attack on Darwin's *Structure and Distribution of Coral Reefs* in a somewhat obscure Dutch journal, published in Batavia (now Jakarta), *Natuurkundig Tijdschrift voor Nederlandsch Indie* (Deel viii,1-43). Perhaps it was simply because Batavia was the nearest centre to Cocos that had a suitable scientific journal that he selected this periodical, but maybe he suspected that an British journal would be reluctant to publish quite such an outspoken piece.

The article (which is in English) amounts to an attempt at a point by point refutation of the subsidence theory of the origin of coral atolls. Ross's views seem to coincide most closely with those earlier held by Charles Lyell, but, by 1855, long since abandoned by him, that atolls had formed as the result of the growth of a coral material upward from the rim of a submarine crater. Ross denied that coral growth was confined only to shallow water, and dismissed the notion of "three great classes of coral reef". Nor did he like the idea of gradually subsiding atolls.

But it is not the ideas expressed in this rejoinder to Darwin's book that are of especial interest; rather it is the manner in which Clunies Ross conducted his side of the debate. His dismissal of Darwin's ideas is conducted in the most vicious and sarcastic tones. Instead of the measured language usually found in learned journals, "weighted" words and inuendo abound. Darwin's account is a "palaver"; he does not "describe" or "explain" but "assert". A few quotations will illustrate the general temper of the Captain's analysis.

He starts in relatively moderate tones:

... it is impossible for him, or any one for him to shew even a probability in support of [his subsidence theory]. (p4)

Mr Darwin forgets the fact... (p6)

Mr Darwin, an enlightened modern geologist, should have remarked ... (p6)

But in due course Captain Ross warms to his task:

Mr Darwin is not merely a master of the art, but a perfect adept of the science of assertion... (p7)

Mr Darwin certainly sets Eolus [the God of the winds] to perform an extremely long-winded task [that of carrying material from the outer shore to the lagoon]. (p15)

[In associating earthquakes with both uplift on one Pacific island and subsidence on Cocos] we are left to imagine, that the phenomenon can only be accounted for on the principle, that is said to have been memoranded by a certain physician, to wit, eating a red herring is a cure for a sick Englishman, but death for a sick Frenchman. (p18)

Doubtless I have to blame my own dunctishness, not Mr Darwin's logic for not being able to perceive ... any reasonable solution. (p19)

Ross was a real master of the art of sarcasm; some of the ideas in the earlier attack reappear. Still later in the article he wrote:

Mr Darwin's assertions and inferences are both alike erroneous and untenable. (p 22)

Mr Darwin's theory ... [is] at once hors de combat. (p27)

Mr Darwin should be very careful of the books and charts, on whose authority he sets forth these assertions, for assuredly those documents are unique, or at least, have been engraved and printed for geologists of his class and calibre; therefore, if lost, will most likely be lost to the world. (p27)

Clunies Ross also takes issue with Charles Darwin's use of the term "recent period" in his geological writing, remarking that he "has no where defined its duration, nor beginning nor ending etc." The reader is therefore, according to Clunies Ross

reduced to guess, that it may mean, the whole or part of the time elapsed since the creation of Adam (according to the commonly received chronology). (p11)

The former sea Captain is evidently someone of somewhat traditional views.

It is somewhat unfortunate that the intemperate language, together with the abundance of typographic, spelling and punctuation errors (possibly due to the letterpress having been typeset by someone whose first language was not English) combine to have an almost comical effect. The more so because buried amongst the invective are some valid points. Having lived on the archipelago for many years, Clunies Ross had a much more detailed knowledge than Darwin was able to acquire during his short sojourn. He pointed out that corals did in fact grow very vigorously on the sides of "gateways", or gaps between the islands, and felt that they grew better there than on the outer reef. And he also felt, as might the sceptical modern inquirer, that more evidence than that of a few undermined coconut trees was required to establish subsidence!

Perhaps most ironic of all is the idea expressed in the final few lines of Clunies Ross's essay. Here, affecting to attack Darwin's subsidence hypothesis, fundamentalist Clunies Ross, arch-enemy of everything that appertained to Darwin, makes a plea for the recognition of the fact that all things are mutable:

... we have to remark, that if the geologist has information worth of his profession, he needs no theory, much less one, so wild and as worthless as this of Mr Darwin's conception, to be deeply impressed with the fact, that the levels of land and sea are, in common with every other created entity, always in a state of mutability, motion being the primary agent, employed through all time, in the evolutions of creation throughout the universe. (p43)

NOTES AND REFERENCES

Introduction

1 See Jean Russell-Gabbett, *Henslow of Hitcham*, Terence Dalton Ltd, Lavenham, 1977.

2 F J Sulloway, Darwin's early intellectual development: an overview of the *Beagle* voyage (1831-1836), in D Kohn (ed), *The Darwinian Heritage*, pp 121-154, Princeton University Press, 1985.

Chapter 1

The Sources and the Relationships Amongst Them

1 For example:

Whenever I enjoy anything I always either look forward to writing it down either in my log Book (which increases in bulk) or in a letter. (Charles Darwin to Dr Robert Darwin, 8 February 1832.)

2 Charles Darwin to Catherine Darwin, 20 July 1834.

3 H Gruber, Appendix: The many voyages of the *Beagle*, in *Darwin on Man: A Psychological Study of Scientific Creativity*, 2nd edition, Chicago University Press, 1981.

4 Nora Barlow (ed), *Charles Darwin's Diary of the Voyage of the Beagle*, Cambridge University Press, 1933. Mrs Barlow, the last surviving grand-daughter of Charles Darwin died in the early summer of 1989. The original Diary is held at Down House, Downe, Kent, the Darwin family home from 1842 - 1896. The house is now owned by the Royal College of Surgeons, who maintain it as the Charles Darwin Memorial. (A fresh transcript of the Diary, edited by R D Keynes, was published by Cambridge University Press in 1988.)

5 The Family letters from the *Beagle* period are held in the Darwin Archive in the Cambridge University Library at DAR 223. They are published in F Burkhardt and S Smith (eds), *The Correspondence of Charles Darwin*, Volume I (1821-1836), Cambridge University Press, 1985.

6 Darwin's complete title for this batch of notes was "Diary of observations on the geology of places visited on the voyage"; they are held at DAR 38.1.

7 See D R Stoddart, ed, *Coral Islands*, by Charles Darwin, with introduction, map, and remarks. *Atoll Research Bulletin*, 88, Pacific Science Board, National Academy of Sciences, Washington. 1962.

8 The "little notebooks" are held at Down House, Kent (see note 4). Microfilms are available in the Darwin Archive at Cambridge. See also P H Armstrong, Charles Darwin's geological notes on Mauritius, *Indian Ocean Review*, 1(2), 2 and 16-20, 1988; 3(1), 4-5, 1990

9 D M Porter, Charles Darwin's vascular plant specimens from the voyage of HMS *Beagle*, *Botanical Journal of the Linnean Society*, 93, 1-173, 1986.

10 J S Henslow, *Florula Keelingensis*. An account of the native plants of the Keeling Islands, *Annals of Natural History*, 1, 337-347, 1838.

11 Darwin's insect collection is listed and described in: K G Smith, ed, *Darwin's Insects*, *Bulletin of the British Museum (Natural History)*, 1, 1-147, 1987. The text is partly based on a document in the Entomology Library of the British Museum (Natural History), in Syms Covington's hand, entitled "Copy of Darwin's notes in reference to Insects collected by him". A number of specimens from Cocos are in the museum.

The Cocos plant specimens held in the Botany School Herbarium at Cambridge are extremely well curated, and working on them is a genuine pleasure. The Darwin specimens are held separately from the remainder of the collection. A unified Darwin-material card-index allows the enquirer to go direct from the modern scientific name to a numbered specimen in the Darwin Collection; a label on the folder containing the specimen gives the complete entry for that species in D M Porter's *Linnean Society* paper on Darwin's plant specimens, giving virtually everything that is known of the provenance of the specimen, including all former scientific names. Some specimens have notes by Henslow on them.

12 DAR 29.3/3.

13 C R Darwin, *The Zoology of the Voyage of HMS Beagle under the command of Captain FitzRoy, RN, during the Years 1832-1836*, Parts I - V, Smith, Elder and Co, London 1840-1843.

14 Zoological Museum, University of Cambridge, List of Fish from the Voage of HMS *Beagle*. A number of fish specimens (preserved in spirit) are in the British Museum (Natural History), South Kensington, having

been deposited there from the Cambridge University Zoological Museum in 1917. Thus it is possible to examine the specimens of *Salaria quadricornis* (BM (N Hist) 1917.714 65 and 66) which were the basis of Leonard Jenyns' description of this species in volume IV of the *Zoology of the Voyage of the Beagle*, and compare them with Jenyns' notes.

15 C R Darwin, *The Structure and Distribution of Coral Reefs, being the First Part of The Geology of the Voyage of the Beagle, under the Command of Capt. FitzRoy, RN, during the years 1831-1836*, Smith, Elder and Co, London, 1842.

16 Thus pages 10 and 11 of the Red Notebook (RN) make reference to submarine volcanoes; page 15 to the gently shelving coasts of some coral coastlines, important concepts in the development of the coral atoll theory - see chapter 6 of this work. See also: Sandra Herbert (ed), *The Red Notebook of Charles Darwin*, British Museum (Natural History) and Cornell University Press, London and Ithaca, 1980.

17 The full title of the complete work was: *Narrative of the Surveying Voyages of Her Majesty's Ships Adventure and Beagle, 1826-1836 Describing Their Examination of the Southern Shores of South America, and the Beagle's circumnavigation of the Globe*, Henry Colburn, London, 1839. Darwin's section was simply headed: "Volume III, Journal and Remarks, 1832-1836".

18 Syms Covington's Diary is owned by the Linnean Society of New South Wales, and is held in the Mitchell Library, Sydney, at ML MSS 2009/108, Item 5. A photocopy was made available to me by the library.

19 DAR 223, see note 5.

20 Charles Darwin to Caroline Darwin, 23 October 1833, although dated in error by Darwin "23 September" (DAR 223).

21 King Papers, Mitchell Library, Sydney, NSW, at Af 75.

22 The principal chart of the Cocos Island held in the Ministry of Defence Hydrographic Office Archives at Taunton is drawn at six inches to the mile, and is numbered L985. Another chart is numbered L986, and a sketch of North Keeling showing HMS *Beagle's* route around it, L984.

23 Appendix IV of Volume I of *The Correspondence of Charles Darwin* (see note 5) gives a list of books known to have been available to Charles Darwin aboard the *Beagle*.

- 24 J H B de Saint Pierre, *Voyage a l'Isle de France par un Officier du Roi*, Amsterdam, 1773.
- 25 L C D de Freycinet, *Voyage autour du monde, enterpris par ordre du Roi, 1817-1820*, Paris, 1824.
- 26 W Dampier, *A New Voyage round the World* , London, 1697.
- 27 F W Beechey, *Narrative of a Voyage to the Pacific and Beering's Strait ... 1825, 26, 27, 28*, London, 1831.
- 28 M Flinders, *A Voyage to Terra Australis*, London, 1814.
- 29 C Lyell, *Principles of Geology, an Attempt to Explain the Former Changes of the Earth's Surface, by Causes Now in Operation*, London, 1830-1833.

Chapter 2 Island Days

1 ADM 1 1820 Cap F 56. In Captain FitzRoy's letter to the Admiralty from Hobart Town, dated 12 February 1836 (ADM 1 1820 Cap F 58), he said he was "probably" going to the Swan River, and "perhaps to the Keeling Islands" on the way to Mauritius.

2 Almost certainly either masked boobies (*Sula dactylatra*) or brown boobies (*Sula leucogaster*), both of which still nest on North Keeling, but are now seldom seen on the southern atoll.

3 The relationship of Mr Liesk and Captain Ross, proprietor of the Cocos Islands, is described in Chapter 4. Ross uses the spelling "Leisk".

4 The giant clam is not in fact as dangerous as Darwin implied! A semi-popular account of the large scale extermination of the clam throughout the Indo-Pacific, the creature's ecology, and an attempt at conservation appeared in: Stephanie Ocko, The return of the giant clam, *Earthwatch*, June 1989, pages 28-33.

Chapter 3 The Naturalist at Work

1 C R Darwin, *Manual of Geology*, extracted from *Admiralty Manual of Scientific Enquiry*, third edition, 1859, page 4.

- 2 Mitchell Library, ML MSS 2009/108 item 5/678
- 3 *Zoology of the Beagle*, Part IV, page 13, and Leonard Jenyns notes in Cambridge. See chapter 1, notes 13 and 14.
- 4 See chapter 1, note 11. The specimens appear to have been lost.
- 5 See chapter 1, note 10.
- 6 *Manual of Geology*, from *Admiralty Manual*, page 7, see note 1, above.
- 7 *Voyage of the Beagle*, chapter 20.
- 8 The plant grows in the Oceania House area, and in a number of gardens in the kampong on Home Island.
- 9 Darwin's own copy is in the Archive at Cambridge at DAR LIB. *Preliminary Discourse on the Study of Natural Philosophy*, by John Frederick William Herschel, Longman, Rees, Orme, Brown & Green, London, 1830, rebound as *The Cabinet Cyclopaedia*, 1831. One of several passages in this book scored by Darwin is the following on page 167:

It is in precise proportion that a law once obtained endures this extreme severity of trial, that its value and importance are to be estimated; and our next step in the verification of an induction must therefore consist in *extending* its application to cases not originally contemplated; in studiously varying the circumstances under which our causes act, with a view to ascertain whether their effect is general; and in pushing the application of our laws to extreme cases.

It is worth remembering that Darwin met, and dined with Sir John Herschel in Cape Town, a few weeks after leaving Cocos.

- 10 *Manual of Geology*, page 12, see note 1, above.
- 11 See chapter 1, notes 23 - 28, for some of the accounts of previous voyagers that Darwin had available to him.
- 12 *Physa* is the scientific name for a type of gastropod (snail). Could Darwin have meant *Physalia*, the Portuguese man o' war, a stinging jellyfish?

Chapter 4
A Human Community

1 A census conducted during a Royal Naval visit on 15 December 1837 revealed a total population, including the Clunies Ross party, of 138. PRO Admiralty Records, quoted in Appendix of: Pauline Bunce, *The Cocos (Keeling) Islands: Australian Atolls in the Indian Ocean*, The Jacaranda Press, Milton, 1988.

2 Pauline Bunce, in her book (see note 1, above) gives a concise summary of the early settlement history of the islands. It is worth emphasising that many of the written accounts are based on Clunies Ross sources, and that these may be coloured by the fact that Alexander Hare, once a business associate of John Clunies Ross, later became a rival. Latterly at least, they seemed to have a fairly vigorous detestation of one another.

3 H Forbes, *A Naturalist's Wanderings in the Eastern Archipelago*, Samson Row, London, page 14, 1885.

4 F Wood-Jones, *Coral and Atolls*, Lovell Reeves & Co, London, page 20, 1910.

5 H van der Jagt reported in 1829 that Hare's group included 98 Malays (Gibson-Hill Documents, quoted by Pauline Bunce, 1988, see above, note 1). The Clunies Ross papers (see chapter 1) suggest a rather larger number, and give a quite detailed breakdown of the origins of the members of the community. Besides "a native of Mozambique ... perfectly African .. and his wife a negress of the Papuan variety and their seven sons and daughters" there were folk from several parts of Sumatra, Celebes, Timor and Malacca, Dyaks from Borneo, and about fifty "Java-Chinese". The Clunies Ross estate did not commence regularly recruiting labour from Batavia in any quantity until after 1860.

6 For example, F Wood-Jones, 1910, note 4, above, page 21. The African element will have largely been added when Hare lived with his entourage on a farm near Cape Town for a while after having been displaced from his estates in Borneo. See note 5 above.

7 J S Henslow, 1838, see chapter 1, note 10.

8 A brief account of the modern Malay people's hunting methods and other customs is given in: Pauline Bunce: *Cocos Malay Culture*, Australian Department of Territories, Cocos Islands, 1987.

9 FitzRoy mentioned the strength and agility with which the Malay people climbed the tall coconut trees for nuts, again comparing them with the Tahitians. Step-like nicks to ease the ascent of some of the coconut trees on Home Island can be seen today.

10 The species is found widely on islands, and along seashores throughout much of the Indo-Pacific region. It grows, for example along the coasts of Hawaii, where the fruit was traditionally eaten by the Hawaiians. The local name there is Indian mulberry (*noni*).

11 Pauline Bunce describes, for example, the imam's role in wedding rituals and festivities in her 1987 and 1988 publications.

12 It may have been H B Guppy, who, on his visit in the 1880s made the suggestion that for health reasons the burial ground should be relocated.

13 Raymond's sojourn on the islands is mentioned by Pauline Bunce, see note 1 (above). The *Clunies Ross Papers* make a number of scathing references to a "certain British-American" plotting with Liesk.

Chapter 5

"A Sketch of the Natural History of These Islands"

1 The *Sketch of 1842 and Essay of 1844*, Darwin's two "trial runs" in his development of evolutionary theory, were unpublished during his lifetime, but are available with an introduction by Sir Francis Darwin and a foreword by Sir Gavin de Beer in *Evolution by Natural Selection: Darwin and Wallace*, Cambridge University Press, 1958.

2 *Zoological Diary* : DAR 31.2/358.

3 Chapter 1, note 29.

4 D G Williams, *Cocos (Keeling) Island - Plant Species Checklist*, August 1987, personal communication.

5 F J Sulloway, Darwin's conversion: the *Beagle* voyage and its aftermath. *Journal of the History of Biology*, 15, pages 327-398, 1982.

6 Arthur G Keating, along with Norman Ogilvie were recruited by Alexander Hare from a passing ship in 1828. Keating left a year later, but Ogilvie remained, but was drowned off North Keeling in 1834.

7 H B Guppy, in his paper: The Cocos-Keeling Islands, *Scottish Geographical Magazine*, 5, pages 281-297, 1889, as well as describing large masses of pumice being floated ashore following the Krakatoa eruption in 1883, mentioned a "large volcanic bomb" in the mangrove-fringed lagoon on Horsburgh Island. This is described as being there since the very early years of the settlement, and being of "a dark reddish cellular lava". It had been largely destroyed by the time of Guppy's visit, just a few fragments remaining. Guppy noted that the cellular part of the "bomb" was light, and floated, but "the more solid parts of the outer crust" upon which he also experimented, sank. The possibility that the fragment mentioned by Darwin had a similar origin remains, but in view of the nature of the rock, this appears unlikely.

8 *Zoological Diary*, DAR 31.2/361 (Reverse)

9 *Ibid*, DAR 31.2/362. Howard Gray, in his *Christmas Island - Naturally*, published by the author, Geraldton, 1981, refers to "the apparently mistaken belief" that robber crabs can open coconuts, but mentions that they can climb some types of trees. Here he seems to be at one with Darwin for, in the slightly expanded version of the account of the robber crab in the *Voyage of the Beagle*, Darwin wrote:

It has been stated by some authors that the Birgos crawls up the cocoa nut trees for the purpose of stealing the nuts: I doubt very much the possibility of this; but with the Pandanus the task would be much easier. I was told by Mr Liesk that on these islands the Birgos lives only on the nuts that have fallen to the ground.

Chapter 6 The Theory of Coral Reefs

1 Charles Darwin to Caroline Darwin, 29 April 1836, DAR 223.

2 Notebook 1.18, pages 6-8, 12, 15; letter R E Alison to Charles Darwin, 25 June 1835.

3 Captain R FitzRoy's letter to the Secretary of the Admiralty, dated 12 February 1836 stated:

... after the *Beagle* had completed the survey of the Galapagos Islands; - (in October) - she went to Tahiti - passing through the Dangerous Archipelago - and adding two, if not three, new islands to the list of those known. (PRO ADM 1 1820 F 58)

4 DAR 41/1-22; here referred to as the "*Coral Islands*" Manuscript.

5 Compare the first and last paragraph from the extract with the following from the *Cocos Coral Manuscript*, DAR 41/ 3 - 4, 10:

41.41 [p. 3]

It being very low water & spring tides, & extraordinary smooth water, by the aid of the leaping pole, we reached very far into the seaward breakers.- Here we found great masses with a curvilinear outline up to 8 ft in diameter....The *Astea* was on its surface to a depth of 3 or 4 inches was [sic] dead, to seaward without doubt the whole surface was living...

The upper parts of the lagoon are much filled up with coral ... *Astrea* (the bulwark species) infrequent, as are the two other kinds which are found outside ... These corals are brittle & soft ...

6 It is possible that William Liesk was mistaken in this, as he was in one or two of the other "facts" he put before Darwin.

7 *The Structure and Distribution of Coral Reefs*, chapter 1, pages 24-25. Once again the text of the *Coral Reefs* volume closely reflects passages in the *Cocos Coral Manuscript*. During his stay on the islands, Darwin was obviously thinking very carefully about some of the evidence for submergence:

Cocoa nut trees & old store encroached on by Lagoon

There are on Water Isd several stores & other buildings, built 6 - 8 years ago, which were built on the beach above common high water mark: now these are surrounded by water during every tide: fact agrees with cocoa nut trees.

41.45 (Darwin's p. 11) reverse
(DAR 41/11 Reverse)

There is in fact little sign of *measurable* submergence since Darwin's day, although partially undermined coconut trees can be seen in many places around the lagoon, and elsewhere on the islands.

It has been suggested more than once that despite the essential truth of his subsidence theory, some of the evidence on which it was based is suspect! Not for the only time the great naturalist reached the right conclusion on the basis of evidence that might well not satisfy the modern enquirer.

8 DAR 38.1/885. See also P H Armstrong, Charles Darwin's geological notes on Mauritius, *Indian Ocean Review*, 1 (2), pages 2 and 16 - 20, 1988, and 3(1), 43-5.

9 C R Darwin, On certain areas of elevation and subsidence in the Pacific and Indian Oceans, as deduced from the study of coral formations, *Proceedings of the Geological Society of London*, 2, 1837, pages 552 - 554, 1837. Reprinted in P H Barrett (editor), *The Collected Papers of Charles Darwin*, The University of Chicago Press, 1977.

10 The idea of the earth's crust undergoing "an endless cycle of change" has a Lyellian ring. But it is also oddly prescient, presaging the ideas of "the cycle of erosion" of W M Davis. See, for example, P H Armstrong, The evolution of an idea: the influence of Darwin, Davis and Clements on the development of the cultural landscape concept, *National Geographical Journal of India*, 34(2), pages 156 - 167, 1988.

Chapter 7 Concluding Summary

1 See chapter 5, note 1.

2 C R Darwin, *The Formation of Vegetable Mould through the Action of Worms*, John Murray, London, 1881, corrected edition 1882.





Charles Darwin spent 12 days at the Cocos (Keeling) Islands in the Indian Ocean during the Voyage of HMS *Beagle* in 1836. He explored many parts of the archipelago, and collected a large number of geological, plant and animal specimens. He paid particular attention to the form of the islands, and the surrounding coral reefs, for he had, only a few months before developed his coral atoll theory; this was his first flirtation with the thought-form of gradualism that was to be so important in his later work.

This book seeks to reconstruct the young naturalist's activities on the island during his visit, using Darwin's notes and diary, the log of the *Beagle*, and other contemporary documents, and also to assess the importance of the few days he spent on the beautiful tropical atoll in the broad sweep of his work. In a number of the ways in which he recorded his observations, and arranged his data, can be seen signs that he was using techniques and ideas that were to be important to him later. The Galapagos Archipelago was not the only group of islands visited during the famous voyage that influenced Darwin's thinking. This book also shows how, to some extent at least, the way in which Darwin evaluated the island environment, was a product of his personal background, education and previous experience.

This work is jointly published by the Department of Geography of the University of Western Australia, and the recently launched Indian Ocean Centre for Peace Studies. The link with the Centre is not inappropriate for the Cocos (Keeling) Islands, together with their population of Cocos Malays, illustrate many of the problems (strategic, economic, environmental) that are typical of remote islands in the modern world. The writings of Darwin and his contemporaries about the islands provide an interesting basis for comparisons with the present environment.

The author is senior lecturer in geography at the University of Western Australia, and has made an extensive study of Charles Darwin's life, work and influence.