



Cambridge to Tierra del Fuego: Charles Darwin's first Atlantic traverse aboard HMS *Beagle* in relation to his time at Christ's College, Cambridge.

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ABSTRACT

This paper is the third of a series that attempts to analyze Charles Darwin's development aboard HMS *Beagle* in terms of descriptions of the oceanic transects that constitute the Ship circumnavigation. It also aims to show that in many respects his time at Cambridge, far from being dissociated from his later scientific career, in many respects formed an ideal preparation for it. His reading, his extra-curricular activities, the contacts that he made in his three years at Christ's College, and the summer vacation that followed, led to the development of skills and conceptual frameworks of the utmost value to him. A case can even be made for saying that even some of his theological and mathematical studies served useful functions. In some respects, his reading and activities in the first few months aboard ship came seamlessly from the incidents and activities of the Cambridge years. Moreover, he was fortunate that the islands he experienced early in the Atlantic transect were geologically and biologically relatively simple compared with environments encountered later.

Keywords: Charles Darwin, Cambridge, Atlantic, Ecology, Geology, Islands, Complexity

1. Introduction

The voyage of HMS *Beagle*, 1831-1836, can be seen in terms of four major ocean transects Atlantic Southbound... Pacific, Indian and Atlantic Northbound. I have previously discussed the second and third of these, and their significance in terms of Darwin's development (Armstrong 2015 [1] and 2022 [2]).

There were of course deviations and doublings-back, and shorter sectors such as the stormy but otherwise uneventful crossing from Hobart to King George's Sound in early 1836, and there were many weeks when Darwin was on land journeys away from the ship in South America, New South Wales and at the Cape of Good Hope. But the four transects, and the island visits thereon, were vitally important (see also Armstrong 2004 [3]).

Here I focus on the first of these ocean traverses, again aiming to show how it is of significance in the context of his formation as a naturalist. I emphasize the period up until the end of the first visit to the Falkland Islands (4th April 1833). An appropriate map was included in. [2]

2. Cambridge

It has been sometimes remarked that Charles Darwin's years in Cambridge, intended to prepare him for the priesthood of the Church of England, did little to prepare him for his scientific career. Here I aim to show that his years at Cambridge merged almost seamlessly with the early months aboard the *Beagle* and, that numerous aspects and incidents of his student years prepared him superbly for the voyage ahead, and that many incidents of the early part of the sojourn aboard HMS *Beagle* were related to his reading, training, and activities during the terms at Christ's College (January 1828 - June 1831) and the summer vacation that followed.

Darwin was studying for a pass BA (not Honours) in what was then thought of as a not particularly academically rigorous college.

He was required to read at least one of the Gospels and the Book of Acts in Greek, some classical authors, as well as Locke, and Adam Smith, in addition to studying some mathematics (which he detested, apart from Euclid which appealed to him). He also was required to read William Paley's *A View of the Evidence for Christianity* (1817).

However, several of his Cambridge contemporaries were passionate collectors of beetles and to a lesser extent, moths. These included his second cousin, William Fox (later a clergyman), Charles Cardale Babington (who also took Holy Orders, in due course becoming a Cambridge Professor) who was a particular rival in beetle-collecting, and Frederick Watkins (later Archdeacon of York). Darwin collected extensively from the countryside around Cambridge employing a net and examining rotting wood, the carcasses of animals, the moss on trees, and even the debris from the bottom of barges.

He claimed that he was not good at identification, but he did have some illustrated publications, and he made detailed lists of scientific names. He wrote 'I identified them anyhow' (*Autobiography* [4]), and sometimes from June 1829 onwards



published details of his captures: his first publication was the announcement of the capture of a moth (*Graphiophora plecta*) in Cambridge (Stevens 1828- [5]).

He, from this early stage, understood the importance of identifying his specimens, and the nature of nomenclature and taxonomy.

He was a good friend of the Reverend Professor John Henslow, Professor of Botany, and although it was not part of his academic program, went to some of his lectures on Botany and a number of his field trips to the nearby Fenland, and Gamblingay Heath, collecting plant specimens (including *Utricularia* and *Anemone pulsatilla*). He also came to know the Reverend Leonard Jenyns, Vicar of Swaffham Bulbeck, not far distant, and went plant and insect collecting with him:

[Darwin] was at that time a most zealous Entomologist ... He occasionally visited my Vicarage... we made Entomological excursions together, sometimes in the Fens that rich district yielding so many rare species of insects and plants - at other times the woods and plantations of Bottisham Hall. He mostly used a sweeping net, with which he made many successful captures (Blomefield, 1887 [6]; van Wyhe, 2009 [7]).

His accounts of those beetling days, and those of the friends with whom he collected, such as Watkins, Henslow, and Jenyns, suggest that he appreciated the importance of habitat and the environment in which a species lived. He sometimes noted the location and habitat from which a specimen was obtained.

The science of ecology lay far in the future, but Darwin's *Autobiography* gives modest clues that at this early stage there were times when he at least appreciated ecological thinking, and understood the links between an organism and its environment.

Summarizing his thoughts on his time at Cambridge in later life, he wrote:

To pass the B.A. examination it was ... necessary to get up Paley's Evidence of Christianity ... The logic of this book and as I may add his Natural Theology gave me as much delight as Euclid. The careful study of these works ... was the only part of the Academical Course, as I then felt and as I still believe, was of the least use to me in the education of my mind.... I was charmed and convinced by the long line of argumentation. (Autobiography: emphasis mine.)

Natural Theology is a profoundly ecological work, emphasizing as it does the relationships between organisms and their environment in the quest to show how the beauty and complexity of the natural world provide evidence for the existence and nature of God. Darwin does not state that he read this at Cambridge, but from the way he bracketed together *Evidence* and *Natural Theology* (1802), it seems likely.

There is more. Charles Darwin, as did many of his class and era learned to ride as a young lad and brought a horse back with him to Cambridge for the Michaelmas (autumn) term of 1830, using it on his natural history excursions. He also went shooting: his family had given him a new double-barrelled shotgun in 1828, and he went shooting in the surrounding countryside. He used to practice in his rooms in Christ's: he wrote that he

...used to practice throwing up my gun to my shoulder before a looking glass to see that I threw it straight.

Another and better plan was to get a friend to wave about a lighted candle, and then fire at it with a cap on the nipple, and if the aim was accurate the little puff of air would blow out the candle. (Autobiography)

Darwin had completed his required studies for his BA, and passed his examinations (quite well) by the end of January 1831, but had not resided in Cambridge for a sufficient number of terms to have his degree conferred. So for his final two terms, he continued to reside in Christ's College, to 'keep terms' but without the pressure of examinations.

Some of the reading and thinking he did, therefore, in Cambridge between late January and June 1831, although in some senses consolidating his earlier work, were amongst the most important he did before embarking on the *Beagle*.

He read two books of supreme importance to him in this period. Professor Henslow seems to have lent his young disciple (for Darwin was by then known as 'the man who walks with Henslow') a copy of the English translation of Alexander von Humboldt's *Narrative of a Voyage to a New Continent, 1799-1804* (1822). He 'read this book with care and profound interest'. Humboldt, oftentimes referred to as 'the father of modern geography', is a great integrator: he emphasizes the links amongst rocks, landforms, vegetation, animals, climate, and human activities. Here again, was displayed in Humboldt's accounts of South America, what would now be described as an ecological approach. Charles Darwin wrote that it was this book, along with Sir John Herschel's just-published *Preliminary Discourse to the Study of Natural Philosophy* (1831) that stirred within him a burning zeal to add even the humblest contribution to ... natural science'. In the latter volume, the author stated that the highest aim of natural philosophy (science) was understanding the fundamental laws of nature through inductive reasoning - finding the fundamental explanation of phenomena through repeated specific observations. It may be from here that Darwin gained his 'habit of comparison that leads to generalization' which stood him in such good stead throughout the voyage, and after.

Darwin stated that 'No one or a dozen books' influenced him as much as these two. In the spring and early summer of 1831 he 'copied out from Humboldt, long passages about Teneriffe, and read them aloud'. These readings probably occurred



during excursions into the local countryside with Henslow and a couple of other young Cambridge academics. He planned an expedition there, with at least some support from the others. His letters from this period confirm his preoccupation: for example to his sister Caroline, 28 April 1831:

... my head is running about the Tropics: in the morning I go and gaze at Palm-trees in the hot house and come home and read Humboldt ... I will never be easy till I see the peak of Teneriffe and the great Dragon tree. I am working regularly at Spanish ... I have written myself into a Tropical glow. [8]

Darwin was to take on the voyage, his copy of Humboldt's *Narrative*, inscribed as a gift from J S Henslow 'on his departure'.

There was a third volume of which the young Darwin became aware at this time: Charles Lyell's *Principles of Geology*. Again a copy of volume 1 was given to him by Captain Robert FitzRoy, HMS *Beagle*'s commander. This book contained a plea for 'uniformitarianism', the idea that the earth could be understood in terms of a series of long-continued changes, rather than having experienced a series of catastrophic events. Nevertheless, Lyell had quite a lot to say about changes in sea level. Henslow encouraged Darwin to read the book but cautioned him against accepting everything within it.

Darwin had not enjoyed the few geology lectures he attended while a medical student in Edinburgh, but may have attended some of those of the Reverend Professor Adam Sedgwick, Professor of Geology, during those final months in Cambridge. Certainly, Henslow encouraged Darwin to 'begin the study of geology' in the spring of 1831 and suggested that he accompany Sedgwick in the field in North Wales.

Accordingly, he [Sedgwick] came and slept at my father's house ... Next morning we started for Llangollen, Conway, Bangor, and Capel Curig. This was of decided use in teaching me a little of how to make out the geology of a country. Sedgwick often sent me on a line parallel to his, telling me to bring back specimens of the rocks and to mark the stratification on a map I have little doubt that he did this for my good, as I was too ignorant to have aided him. (Autobiography)

By late summer 1831 Darwin therefore had:

*A liking for and considerable skill in fieldwork, both biological and geological
A good understanding of the importance of accurate identification of organisms
Experience in using collecting equipment
Ability to ride and manage horses
Familiarity with firearms and shooting
An integrated, ecological understanding of relationships within the environment
Basic knowledge of Spanish
A burning desire to experience something of the Tropics.*

Less obviously one might mention his grasp of the scientific method, the habit of comparison, the ability to compare organisms, landforms, and rocks as well as his ability to reason logically. Conceivably also his liking for Euclid gave him something of an ability to think in three dimensions, always an advantage for a geologist.

Most of these skills and abilities were acquired, or at least enhanced, while he was in Cambridge, or (as in the case of the field training in North Wales) through contacts made in Cambridge. To some extent, he was an autodidact, but that spring and summer of 1831 gave him opportunities. His reading of Paley and Euclid, and his enthusiasm for collecting and identifying beetles of his earlier years may have given him a 'certain something' that enabled him to make the best use possible of the voyage of HMS *Beagle*. He had, in one way or another, picked up both the practical skills and some of conceptual frameworks he needed to become a naturalist.

3. The Atlantic traverse-sea crossings and the first islands

HMS *Beagle* sailed on her surveying voyage to South America from Plymouth on 27th December 1831.

The midwinter departure, together with the notoriously rough traverse of the Bay of Biscay meant that the first few day's sails were unpleasant for the young naturalist. The first few days recorded in his diary include many phrases such as 'became sick and remained so', 'nausea several times a day', 'giddiness', 'staggered for a few minutes on deck', 'miserable state', 'very uncomfortable', 'unceasing suffering', 'Heavy weather. I very nearly fainted from 'exhaustion', 'great & unceasing suffering'.

New Year's Eve brought a slight respite: 'I spent a pleasant afternoon ... reading Humboldt's glowing accounts of tropical scenery. Nothing could be better adapted for cheering the heart of a sea-sick man.' Less than a week later, as the ship approached the Tropic of Cancer: 'Already can I understand Humboldt's enthusiasm about the tropical nights; the sky is so clear and lofty, & stars innumerable shine so bright'. The reading program commenced in Cambridge a few months before continuing.

His brief entry for 3rd January 1832 reads as follows:



We looked for the eight stones & passed over the spot where they are laid down on the charts. Perhaps their origin might have been Volcanic and have since disappeared. (Diary [9])

Bearing in mind that a copy of volume Lyell's *Principles of Geology* had been given to him by FitzRoy, whose accommodation he was sharing, shortly before the sailing, and that they were passing close to the Canary Islands and Madeira it is tempting to believe that that Lyell was open close to the pages of Charles' diary. Lyell's chapters xix to xxiii describe volcanoes and earthquakes; the book makes mention of the Canary Islands under the heading of 'volcanic archipelagos'. Teneriffe and Lanzarote are mentioned and accounts are given of submarine volcanic eruptions, along with appearing and disappearing islands. It seems likely that Charles was reading up on what Lyell had to say about this part of the Atlantic, and applying what he read to his own experience.

Alas, Teneriffe, with which, following the reading of Humboldt's account, Darwin had become fascinated, was not to be visited. A state of quarantine had been declared, and the ship would have been required to delay 12 days before landing. Captain FitzRoy would not countenance this, and to Darwin's great disappointment he had to content himself with describing the white houses and churches, and the cloud-covered mountain, from the sea. (*Diary*, 6th January 1832)

Having recovered from seasickness, Darwin was active.

January 10th. We crossed the Tropic this morning. ... I proved today the utility of a contrivance that will afford me many hours of amusement & work. It is a bag four feet long, made of bunting & attached to [a] the semicircular bow: this by lines kept upright, & dragged behind the vessel, this evening it brought up a mass of small animals & tomorrow I look forward to a greater harvest.

January 11th. I am quite tired having worked all day at the produce of my net. The number of animals that the net collects is very great & fully explains the manner so many animals of large size live so far from land. Many of these creatures, so low in the scale of nature, are most exquisite in their forms & rich colors. It creates a feeling of wonder that so much beauty should be created for little purpose. (Diary)

Darwin had been introduced to the diversity of marine creatures along the Firth of Forth, with Robert Grant, while in Edinburgh during his abortive two years at medical school. Darwin refers to animals as 'low in the scale of nature', a concept he might have gained from Grant, who had vaguely evolutionary ideas. Moreover, can we not see, dimly perhaps, an ecological appreciation of the notion of a large number of small organisms providing enough food for the fewer large creatures (whales, dolphins, large fish)? Finally phrases such as 'most exquisite in their forms', 'rich colors', 'so much beauty', and 'feeling of wonder' suggest a recollection of Paley's *Natural Theology*.

Besides sorting and studying the creatures pulled from the net, Darwin's notes and diary refer to the sea mammals, birds, and on occasion flying fish that he saw from the deck. Insects occasionally came aboard. His entry for 15th January reads: *Birds have been hovering around the vessel & a large gay-colored cricket found an insecure resting place within reach of my fly-nippers. He must have flown 370 miles from the coast of Africa.*

In a separate set of *Insect Notes* (Smith, 1987 [10]) he annotates on 'Acrydium' (the genus that includes the locusts): 'Vide Kirby Vo. 11, Page 224'. A copy of William Kirby's *Introduction to Entomology* (1818 edition) was on board. The account mentions that 200 miles from the Canary Islands, on 1st Nov 1811, Captain Stokes of an American ship, *Georgia*, recorded:

'A light air sprung up from the north-east, at which time there fell from the cloud an innumerable quantity of large grasshoppers ... the insects were of a reddish hue, with red and grey speckled wings ...' It is clear from this account ... that insects can go far from land when the wind is strong.

Darwin, even at this early stage of the voyage, comparing his observations with published information, is using the 'habit of comparison' perhaps picked up from Herschel, that served him so well. Later he would use similar facts when describing the colonization of remote islands by long-distance dispersal.

On 16th January, the *Beagle* arrived at 'St Jago' (Santiago) in the Cape Verde Islands: much of the landscape was arid and desolate but, with a party from the ship, he

... came to a deep valley. Here I saw the glory of tropical vegetation: Tamarinds, Bananas & Palms were flourishing at my feet. I expected a good deal, for I had read Humboldt's descriptions & I was afraid of disappointment: how utterly vain such fear is, none can tell but those who have experienced what I have. It is not only the gracefulness of their forms or the novel richness of their colors, it is the numberless & confused associations that rush together on the mind ... I returned to the shore treading on volcanic rocks, hearing the notes of unknown birds, & seeing new insects fluttering about still newer flowers. It has been for me a glorious day. (Diary)

In a deep ravine, they came on an enormous baobab tree (*Adansonia digitata*), confirming the African nature of the biota: 'the view is truly African'.



Despite the ecological diversity of the valleys and ravines, much of the landscape of the Cape Verde Islands is an arid desert, having an: ‘unusually sterile character’ as Darwin described it.

This means that the geology is well exposed, and he was in his element, applying both the techniques learned with Sedgwick in North Wales, and the conceptual frameworks of Lyell’s uniformitarianism, and appreciation that sea levels had both fallen and risen. Late in life, he wrote that in the ‘investigation of the geology of a district, reasoning comes into play’ (shades of Paley and Herschel, perhaps).

On first examining a new district nothing can appear more hopeless than the chaos of rocks; but by recording the stratification of rocks and fossils at many points, always reasoning and predicting what will be found elsewhere, the light soon begins to dawn ... and the structure of the whole becomes ... intelligible. (Autobiography)

Detailed observation, comparison of one site with another, logical reasoning, and thinking in three dimensions. St Jago (and particularly Quail Island, just off the mainland) was Darwin’s geological nursery. He covered pages with notes, finally seeing the whole pattern.

The geology of St Jago is very ... simple; a stream of lava ...flowed over the bed of the sea, formed of ... shells and corals, which it has baked into hard white rock. Since then the whole island has been upheaved. But the line of white rock revealed to me a new and important fact, namely that there had been afterward subsidence around the craters, which ... had poured forth lava. It then first dawned on me that I might perhaps write a book on the geology of the various countries visited, and this made me thrill with delight. That was a memorable hour for me, and how distinctly I can call to mind the low cliff of lava beneath which I rested, with the sun glowing hot, a few strange desert plants growing nearby and living corals in the tidal pools at my feet. (Autobiography)

Here was where it came together: Humboldt, Lyell’s interpretation of geology and his appreciation of uplift and subsidence, an understanding of the living world, and the field training in North Wales. If there was a Eureka point in Darwin’s voyage it was on St Jago in the Cape Verdes, not the Galapagos. He was indeed fortunate that the first environment in which he attempted to reconstruct the geology had a ‘simple’ structure and was one where the rocks were well-exposed.

From the Cape Verde Islands, HMS *Beagle* sailed to the south and west to the tiny archipelago of St Paul’s Rocks, which comprised about a dozen islets little more than sea stacks. The highest point is about 18m, and the total surface area is less the 1 sq km. The group is 870km from the coast of Brazil.



Fig.1. HMS Challenger moored at St Paul’s Rocks, 28 August 1873.

This image, by J J Wild (1824-1900), was made 40 years after the *Beagle*’s visit, but gives an idea of what Darwin and the *Beagle*’s crew might have encountered.

Edinburgh University Collection.

Darwin and some of the crew went ashore on 16th February and started killing sea birds in large numbers with geological hammers, clubs, and rocks. Fish were caught offshore. Darwin collected rock specimens and later noted that they were ‘unlike any which I have met with, and which I cannot characterize by any name’. They were dissimilar to the rocks of any other islands that he had already seen or would see later in the voyage. They are now identified as peridotites, from the deep mantle, 45km from the earth’s surface, emplaced while the Atlantic Ocean was opening. The biota of the island group and the surrounding ocean were described in the following terms:

*The booby [probably the brown booby (*Sula leucogaster*)] lays her eggs on the bare rock: but the tern [possibly brown noddy (*Anous stolidus*) and white-capped noddy (*A. minutus*)] makes a very simple nest of seaweed, By the side of many of these nests a small flying fish was placed, which I suppose had been brought by the male bird for its partner. It was amusing to watch how quickly a large and active crab (*Graspus*), which inhabits the crevices in the rock, stole the fish ... as soon as we had disturbed the parent birds. Not a single plant, not even a lichen grows on the islet; yet it is inhabited by several insects and spiders. The following list completes, I believe the terrestrial fauna: a fly (*Olfersia*)*



living on the booby, a tick that must have come here as a parasite; a small brown moth, belonging to a genus that feeds on feathers; a beetle (Quendius) and a woodlouse from beneath the dung; and lastly numerous spiders, which I suppose prey upon these small attendants and scavengers ... The smallest rock in the tropical seas, by giving a foundation for the growth of innumerable kinds of seaweed and compound animals, supports likewise a large number of fish [including] sharks [some of which took the fish - and fishing tackle - from the Beagle's fishermen!] [11]

Some of Charles Darwin's specimens from St Paul's still exist (but some are lost). Those who studied them, and who have visited the islands more recently confirm that although some of the scientific names have changed, his identification was sound.

Charles compares the simplicity of the terrestrial biota with the complexity of that offshore. He emphasizes the microhabitats and relationships of the organisms present. It would be possible to construct a food-web diagram from the facts he gives: food chains from the sea to the land appear. Just as his first venture in geology was in the 'very simple yet striking' St Jago, so his first real study of a living environment was made up of barely a dozen species, yet he comes close to identifying the ecological niche of each species he mentions. He was fortunate that it was so.

On 19 February 1832 he paid a 'short visit' to the island of Fernando Noronha, which he later described in the following terms:

[S]ituated ...in lat 3° 50' S, and 230 miles [370km] miles distant from the coast of South America. It consists of several islets, together nine miles in length by three in breadth. The whole seems to be of volcanic origin; although there is no appearance of any crater or any one central eminence. The most remarkable feature is a hill 1,000 feet high, of which the upper 400 feet consist of a precipitous singularly shaped pinnacle of columnar phonolite, containing numerous crystals of glassy feldspar, and a few needles of hornblende. From the highest accessible point of this hill I could distinguish in different parts of the group several other conical hills, apparently of the same nature ... Near the base of this hill, I observed beds of white tuff, intersected by numerous dikes, some of the amygdaloidal basalt others of trachyte... On the beach, there were numerous fragments of compact basalt, of which a distant façade of columns seem to be formed. [12]

This elegant, succinct description (composed after the voyage from notes) shows that Darwin's powers of detailed observation were already excellent. His identification of minerals and rock types was good, and he was able to integrate his accounts of landforms, mineralogy, and petrology: accurate measurements are given where possible.

He compared the landforms in different parts of the archipelago, and incidentally with those of St Helena which he saw much later in the voyage (in his field notes he also compared the steep hills of Fernando with the more rounded 'paps' a Scots word perhaps picked up in Edinburgh of St Jago). There is scientific caution in the use of the word 'apparently'. He also, speculated that 'denudation has been on an enormous scale' a very Lyellian remark.

It is also, incidentally, possible to trace Darwin's route, from the beach up the steep flanks of the hill, to the 'highest accessible point', presumably, where the gradient becomes vertical (see illustration).

Surprisingly he prefaces his *Geology of the Voyage* account with the words 'I observed little worthy of description' [13]. But perhaps this was true as the island was covered in fairly thick tropical vegetation, and it was not possible to observe the geology as clearly as on desert island St Jago and wave-splashed St Paul's.

In the single day (seven hours) of fieldwork on the island, other aspects of natural history were not neglected:

The whole island is one forest & this is so thickly intertwined that it requires great exertion to crawl along [perhaps up the flanks of 'the hill']. The scenery was beautiful ... large Magnolias and Laurels & trees with delicate flowers. (Diary)

Specimens were collected: a large porpoise was harpooned offshore, and he secured some 'Termites and Part of their nest' [10]. His notes on the ecology of the islands are brief but surprisingly comprehensive.



Fig. 2 Site on Fernando Noronha visited by Darwin in 1832. Wikipedia/Creative Commons.



*The whole island is covered with trees, & from a height looks like one single wood, with a few spots 'cleared for cultivation the soil which...' results from the decomposition of the Felspathic rock is a pale clay, containing unaltered crystals, although exceedingly dry it appears very favorable to vegetation, On the hills, Leechens [lichens] and mosses cover the rocks, & I there remarked a grass. - I could not help being surprised at the rarity of monocotyledonous plants except those cultivated by the inhabitants. ... & the bright sight of a tropical scene could not fail to render the more distant islands & wild outline of the coast exceedingly striking. The woo[ds] were full of birds, but not of many sorts. Doves [possibly the eared dove (*Zenaida auriculata*)] & a bird like an English willow wren [willow warbler *Phylloscopus trochilus*; the species CD saw may have been the *Noronha vireo Vireo gracilirostris*]....] I was surprised to see Terns settling on trees. - Both noddys & a most graceful little tern of the snow-white color [probably the white tern *Gygis alba*] when disturbed from the branches hovered around our heads like little angels - I did not observe any hawks or ravens; which is curious considering the number of birds that would serve as prey, & the secure building places the rocks would afford them...*

Mice & Lizards are in great profusion ... The commonest animal is a little ant, which builds a nest often 3 feet high & 2 thick, around the stem of trees. It is formed of a tough dark brown substance & is full of irregular cavities, disposed of without any order. From the bottom, a broad covered way goes to the ground, and from the top small ones branch off along the boughs of a tree. (Geological Notes [13])

Darwin observes the behavior, habitats, and ecological relationships of the organisms he encounters: he notes also the creatures (and plants) that were missing, an idea that became important later when he speculated about the distinctive biota of remote islands. The emphasis is on relationships throughout, and again a comparative approach is evident.

4. The ecology of the South American Tropics: remembering Humboldt

There was much in the island environment that the young naturalist found attractive, but although the forest was quite thick 'from the dryness of the climate there is no appearance of luxuriance'. The flowers, the forests, the birds, the attractive landscape 'ought to have satisfied me' he pondered, but he was looking forward to the tropical rainforests of South America that he had been reading about in Humboldt, during the voyage and for months previously.

Perhaps he was feeling lonesome and found the tropical heat difficult when he jotted in his little note-book (page 46b, 25 February 1832):

Solitude on board enervating heat ... hard to look forward pleasures in prospect [14]

But look forward he did:

I am sure all of the grandeur of the Tropics has not yet been seen by me. We had no gaudy birds, no hummingbirds, and no large flowers. I am glad that I have seen these islands ... (Diary 19 February 1831)

... for the anticipation generated by Humboldt had been high, and Cape Verde, St Paul's, and Fernando had not quite satisfied him. He had seen the 'striking simplicity' of the geology of St Jago, collected almost every organism making up the simple ecology at St Paul's, and completed a competent task in his succinct, but the well-integrated account of Fernando.

Then, two months into the voyage (28 February-18 March 1832), Charles Darwin was finally able to sample the 'pleasures' so long 'in prospect' of the true topical environments of the environs of the Brazilian coastal town of Bahia, 'embosomed in a luxuriant wood'.

Of the vegetation he wrote:

Humboldt's glorious descriptions ... fall far short of the truth. The delight one experiences ... bewilders the mind: if the eye attempts to follow the flight of a gaudy butterfly, it is arrested by some strange tree or fruit; if watching an insect one forgets it in the strange flower it is crawling over ... The mind is a chaos of delight, out of which a world of future & more quiet pleasure will arise. I am at present only fit to read Humboldt: he like another Sun illumines everything I behold. (Diary)

The next day 'passed delightfully' as he wandered by himself in a Brazilian forest:

[D]elight is however a weak term for such transports of pleasure: ... among the multitude it is hard to say what set of objects is most striking: the general luxuriance of the vegetation bears the victory, the elegance of the grasses, the novelty of the parasitical plants, the beauty of the flowers, the glossy green of the foliage, all tend to this end.

He noted the loud noise from the insects, but after a few hours 'was overtaken by a tropical storm'.

Sheltering beneath a thick-canopied tree he noted

... in a couple of minutes, a little torrent flowed down the trunk. It is to this violence we must attribute the verdure in the bottom of the wood: if the showers were like those of a colder clime, the moisture would be absorbed or evaporated before reaching the ground. (Diary 28 February 1833)

This last a sound piece of observation and deduction. He was working out how the complex rainforest ecosystem worked, as well as noting its structure. On 15 March he extended his ecological observations in his field notebook: 'small black



ant [probably driver ants, possibly *Eciston*] putting everything to flight, spiders, and blattae [cockroaches] in great agitation'. He attempted a sketch of an unusually shaped spider's web. Here too he encountered some of the ancient igneous and metamorphic rocks that underlay much of Brazil, about which Humboldt had much to say.

He and a companion, his friend midshipman Philip Gidley King, borrowed horses for a tour of the area. Very large numbers of insects, especially beetles, and plants were collected. 'King shot a few birds & I a most beautiful large lizard'. However, it was here that the terrible reality of slavery and the squalid, smelly nature of some of the narrow alleys of South American towns first impinged on him.

A few weeks later he wrote to Henslow from Rio a summary of his work in Tropical Brazil:

I formerly admired Humboldt, I now almost adore him: he alone gives any notion, of the feelings which are raised in the mind on first entering the Tropics. ... I tell Entomologists to look out and have their pens ready for description. I have taken, as minute ... as in England, Hydropori, Hygroti, Hydrobii, Pselapgi, Staphylini, Curculio, Bembididous insects &c,- It is exceedingly interesting the differences of genera & species from those I know.

It is however much less than I had expected. I am at present red-hot with spiders ... & if I am not mistaken have already taken some new genera. [8]

Time and again Darwin compares the biota and the structure and 'working' of environments with those with which he was familiar from England (and Wales). He appreciates the complexity of tropical systems (eg biodiversity and structure) compared with those with which he was familiar. He sees the Tropics through Humboldt's eyes, and daily employs the collecting and research techniques taught him by Henslow and Sedgwick and picked up informally from his contemporaries and his reading in Cambridge. His identifications are not inappropriate for the time (Smith 1987 [10]).

By June 1832 Darwin had completed his apprenticeship; he had examined environments of increasing complexity and collected many hundreds of specimens with a net, gun, and geological hammer. He was beginning to compare environments one with another, and with those from his earlier fieldwork, and to analyze their dynamics.

While at sea, sailing south, Darwin seems to have been sorting and conserving his collections and writing his notes. A view of a waterspout interrupted one day, and a successful attempt at shark fishing enlivened another. A flying fish landed on the deck with a crab in its mouth, and 'Mother Carey's chickens' (possibly Leach's storm petrel, *Oceanodroma leucorhoa*) followed the ship.

Captain FitzRoy had been given full instructions to prepare detailed charts of the low Arolhos Islands, a little off the Brazilian coast and Darwin was interested in the survey techniques, his notes are quite brief, but he noted disturbance by the occasional visits by fisherman, the large numbers of seabirds such as gannets, tropic birds and frigate birds, dozens of which were slaughtered by the *Beagle's* crew 'by sticks, stones, and guns'. Rats were 'in great numbers', but the flora was rather poor. He compared the biological poverty of the limestone islets themselves with the surrounding sea with large brain corals and the occasional turtle.

Bearing in mind that Darwin at this time was profoundly influenced by Humboldt, there is one other point of interest here. On 27 March 1832, on page 13a of the field note-book that he had opened in the Cape Verde Islands, he tabulates a series of observations on the sea-water temperature at different times of the day, and at different depths (there is not a great deal of variation). In a letter in 1839, he sent these data to Humboldt! [15]

There were other more immediate connections to his previous life. On 16 June he wrote to Prof Henslow in the warmest terms, remembering also Leonard Jenyns, and continuing:

Tell Prof Sedgwick he does not know how indebted to him I am for the Welch [sic] expedition. - It has given me an interest in geology ... I do not think I ever spent a more delightful three weeks than pounding the NW [North Wales] mountains. At Bahia, the Pegmatite & gneiss in beds had the same direction as observed prevailing over Columbia... [8] (The last phrase is a reference to Humboldt.)

From Montevideo, a few weeks later, he sent the first batch of the specimens he had collected back to Henslow. A diary entry for 19th November 1832 reads: 'Employed in packing up specimens of Natural History for England'. Henslow, meanwhile, had printed out extracts from some of the letters Charles had written, circulating them to interested naturalists. Even from South America, the umbilical cord connecting the young naturalist to Cambridge remained.

5. Tierra del Fuego and the Falklands

The *Beagle* spent some months surveying the coast of Patagonia, between times encountering severe weather, and during which period Darwin spent considerable time inland. The final two island groups that Darwin encountered on his Atlantic traverse were Tierra del Fuego and the Falklands. I have discussed the significance of these sojourns elsewhere (Armstrong 1992 2004, [17, 3]) and will concentrate on Darwin's ecological awareness, and his 'transect' approach to fieldwork.

The little ship 'made the coast of Tierra del Fuego a little to the south of Cape St Sebastian' on Sunday 16th December 1832, and, true to the name the 'Indians must have lighted fires immediately on observing the vessel' and 'the usual signal of smoke' was sighted.

Three days later (on the 19th) he set out to explore: he found the forest so dense that his best line of advance was to follow 'the course of a mountain torrent ... to considerable elevation'.

The trees are so close together & send off their branches so low down, that I found extreme difficulty in pushing my way through... In every direction are irregular masses of rock & uptorn trees... [T]he whole wood is composed of antarctic beech [Nothofagus] (the winter's bark [Drimys winteri]) & the Birch are comparatively rare [the genus Betula does not occur in South America]. (Diary)

Darwin made a thorough study of some of the ecological relationships within the beech forest:

There is one vegetable production deserving notice for its importance as an article of food to the Fuegians. It is a globular, bright yellow fungus, which grows in vast numbers on the beech-trees,

When young it is elastic and turgid with a smooth surface; but when mature it shrinks, becomes tougher and has its entire surface deeply pitted or honey-combed. How singular is this relationship between parasitical fungi and the trees on which they grow? [11]

The fungus had other organisms dependent on it; he describes how he found large numbers of a small carabid beetle [*Abropus splendidus*] 'flying about ... in the evening. These insects live amongst the small yellow balls which are excrescences or fungi growing on *Fagus antarcticus*'.

Not only was Darwin very observant but he perceptively reports on the relationships among the tree species, the fungus, a beetle, and the indigenous human population.

At somewhat higher altitudes:

The wood is not quite so thick: but the trees, though not high, are of considerable thickness. Their curved and bent trunks are covered in lichens, and their roots are covered with moss. (Diary, 19 December 1832)

Higher still he encountered a compact mass of little beech-trees about 4 or 5 feet [c.1.5m] high. They were as thick as a Box in the border of a flower garden, for many yards, my feet never touched the ground'.

At the very highest point on this transect there were 'rocks covered with Lichens', close to 'the very summit', grazing in this area were:

Guanaco ...These beautiful animals are truly alpine in their habits, & their wildness well became the surrounding landscape.... I collected several alpine flowers, some of which were the most diminutive I ever saw. ... The snow was lying on the E.S.E side of the hills. (Diary December 20th, 1832)

Darwin describes each of what a more modern ecologist might refer to as 'life zones' in terms of their plants, animals, and sometimes the links between them. He had a clear conception of how the plant and animal communities changed with altitude. Humboldt had recorded the same types of transition elsewhere in South America.



Fig 3. Guaco (*Lama guanicoe*) at a high altitude. (Wikipedia/ Creative Commons).

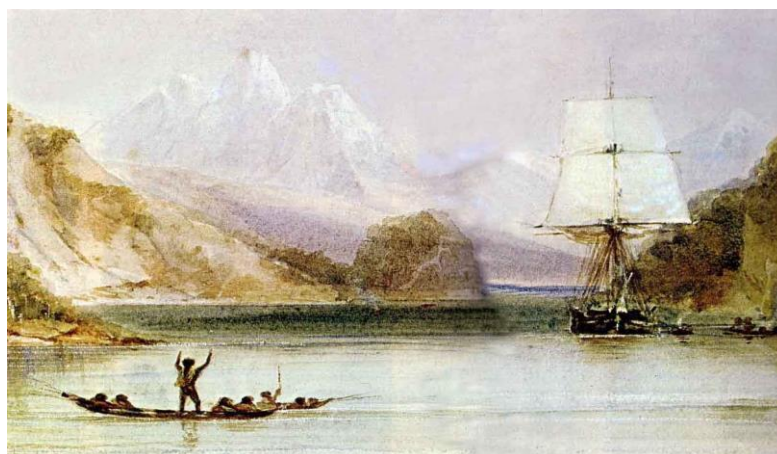


Fig. 4 HMS *Beagle*, coast of Tierra del Fuego, 1833. Painting by Conrad Martens (1801-1878), expedition artist.

Darwin was quite active in the field of geology in Tierra del Fuego, and in describing the island's geology, employed a version of the transect concept, comparing the fossiliferous tertiary deposits of the eastern part of the island with the old 'clay-slates' and igneous rocks of the west. There are several large-scale and smaller-scale geological cross-sections in *The Geology of South America*: the transect technique picked up from Sedgwick in North Wales, writ large, although the technique was also used by Humboldt. [16]

HMS *Beagle* took leave of Tierra del Fuego on 26th February 1832, and on 1st March commenced the first of two visits to the Falkland Islands (at Berkeley Sound).

I have discussed Charles Darwin's visits to the Falklands in detail elsewhere (Armstrong, 1992 [17]) and will avoid duplication here.

Two days later:

[March] 3rd. Took a long walk: this side of the Island [the east] is very dreary: the land is low & undulating with stony peaks & bare ridges it is universally covered by brown wiry grass. Which grows on the peat.

In this tract, very few plants are found, & excepting snipes & rabbits, scarcely any animals. The whole landscape from the uniformity of the brown color [sic] has an air of extreme desolation. (Diary)

A good summary, but not very analytical. When he comes to a detailed investigation of the geology of the islands, the transect training he received from Sedgwick kicks in:

I will detail what is met with in an irregular & N & S line, which crossed the head of Berkeley Sound. We have seen that [to] the North of this bay there are many low crests, which all dip to the S by W at an angle from 40 to 50°. [18]

Much of his geological description of the island, both in his notes and in his publication, Darwin 1846 [19], on the subject, is in terms of linear transects, and cross sections. Moreover, the 'comparative technique' comes into play.

The desolate landscape of the island stood in striking contrast to complex plant and animal communities that had existed in the remote past. On 19th March 1833, he walked to the little settlement of Port Louis: his outlook on the Falklands was 'forever changed'.

He found a sandstone 'abounding with fossil shells & those of a most interesting geological era.

The comparative notion is in his mind a few days later when he wrote to his sister Caroline:

I have been very successful in geology: as I have found several fossil shells, in the very oldest rocks that have organic remains, - this [has] long been a great desideratum in geology, viz the comparison of animals of equally remote epochs [sic] at different stations in the globe. [8]

He compared the apparent richness of the fossil fauna of the seas of the distant past with the poverty of the fauna of the contemporary bleak environment. Later he wrote to Professor Henslow:

*I have here had the high good fortune, to find amongst primitive-looking rocks, a bed of micaceous sandstone, abounding with *Terebratula* & its subgenera and *Entrochitus*. As this is so remote a locality from Europe I think the comparison of these impressions, with those of the oldest fossiliferous rocks of Europe, will be pre-eminently interesting ... many of these are very perfect.*

I hope sufficiently to identify species. As I consider myself your pupil, nothing gives me more pleasure than telling you my good luck. [8]



Darwin gives detailed descriptions in his geological notes of the fossils and their containing rock. In due course, the fossils were described by palaeontological experts (Morris and Sharpe, 1846) [20].

Darwin compared the bleak ecological community of the Falkland Island landscape with the impression of prolific life in the seas that had occupied the location in the remote past (Devonian/Silurian).

He also compared the islands' 'brown wiry grasslands' with the prolific kelp beds that surrounded both the Falklands and Tierra del Fuego. Their 'striking feature' was 'the immense number of kinds of organic beings which are intimately associated with kelp.' He compared the 'immense number' of creatures found in the kelp beds with that of tropical forests.

Crustacea of every order swarm, - Encrusting Corallines & Aztias are excessively numerous. Every leaf ... is white with them. On shaking the great entangled roots it is curious to see the heap of fish, shells, crabs, sea eggs, cuttlefish, starfish, Planariam, and Nercilae which fall out, ... one single plant forms an immense and most interesting menagerie. If this one Fucus was to cease living: with it would go many of the seals, the cormorants & certainly the small fish and soon or later the Fuegan Man must follow. [21]

The terminology lay in the future but Darwin appreciates that the kelp bed is a complex tightly integrated *ecosystem*, with high *biodiversity*.

6. Conclusion

Darwin's extra-curricular beetle-collecting, horse-riding, and shooting at Cambridge may not have enamored him with his tutors.

But it was exactly the preparation he needed when confronted with making a collection of the diversity of insects in South America when riding through the South American countryside (or exploring the Falklands on horseback) and shooting bird specimens. The transect methods taught by Sedgwick, his familiarity with fossils, and his knowledge of animal and plant preservation methods were methodologies extensively used in the first 15 months of the voyage. The books he read, particularly those he read in the 'last two terms at Christ's Humboldt, and Lyell...' were sometimes being re-read in the cabin of the *Beagle*. He wrote to Henslow and sent him specimens: the umbilical cord was not broken.

Even some of the theological works may have been of use to him. Paley's *Natural Theology* gave him the idea of the importance of the relationship between plants and animals and their surroundings and way of life. And that author's *Evidence* may have given him what he needed in structuring an argument, and reasoning logically; Herschel gave him the scientific method and 'the habit of comparison'.

The well-exposed, relatively simple geological structures of Cape Verde provided the 'Preliminary level' geological laboratory. St Paul's provided a very simple biota, with examples of ecological links between land and sea. The low coral islets of the Abrolhos and the sub-Antarctic Falklands followed.

So too did the biological complexities of the Brazilian tropical forests and the geological complexities of the Falklands and Tierra del Fuego. When they came he was ready for them.

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