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THREE MONTHS ON A CORAL ISLAND (LAYSAN)

BY

HUGO H. SCHAUINSLAND
[1899]

Translated by

Miklos D.F. Udvardy

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Drei Monate auf einer Koralleninsel. (Laysan.)

Nach einem Vortrag,
gehalten im Geographischen Verein zu Bremen.

Von

Prof. Dr. Schauinsland,

Direktor des städtischen Museums für Natur-, Völker- und Handelskunde
in Bremen.



BREMEN.

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1899.

Preface

On Saturday, September 2nd, 1961, shortly after the close of the 10th Pacific Science Congress in Honolulu, the Harold J. Coolidge Expedition first made landfall on Laysan Island, Hawaiian Chain, in the northern Pacific Ocean. This undertaking was the brainchild of the late Richard E. Warner, who worked tirelessly for the conservation of rare Hawaiian wildlife, and who secured the approval of the president of the Congress, Dr. Coolidge, to lend his name to the planned expedition. Warner assembled ten of us to study various aspects of the natural and geological history of the island. While in the field (Sept. 2 -10), we developed the idea that a comprehensive account of our findings should be written with all of us as co-authors. However, other duties and obligations led to the procrastination of this account. In addition, the all too early demise of three participating scientists caused the shelving of the project entirely.

One of my assignments was to translate from German to English Professor Hugo H. Schauinsland's book, *Drei Monate auf einer Koralleninsel* (Bremen: Max Nössler, 1899). At the time, all of us had considered it to be a rare source of scientific data about the status of Laysan's nature toward the end of the 19th century. Now, more than 30 years later, I am finally able to present this translation. Following my translation of Schauinsland's "lecture" and appended notes, I have also listed the publications which resulted from his Laysan collections. Many, but not all of these, are also found in the bibliography of Ch. A. Ely & R. B. Clapp, 1973. *The natural history of Laysan Island, Northwestern Hawaiian Islands*. Atoll. Res. Bull. 171.

I am greatly obliged to my friend, Professor Emeritus William E. Huntsberry (University of Hawaii, Honolulu) who agreed to meticulously check and improve my English style and grammar. Professors Dietrich Mueller-Dombois (University of Hawaii, Honolulu) and William J. Sullivan, Jr. (California State University, Sacramento) kindly checked (and improved) the translation against the original text. My son and daughter, M. Andrew Udvardy and Dr. Monica L. Udvardy also checked and improved the manuscript. Dr. Charles S. Papp prepared the map of Laysan Island. Drs. Andreas Lüderwaldt and Dieter Heintze (Übersee-Museum, Bremen) supplied the biographical data of the author. Dr. F. Ray Fosberg and Dr. Ian G. Macintyre (Smithsonian Institution, Washington, D.C.) in many ways encouraged and facilitated this publication as part of the present series.

I am very grateful to the above mentioned people, for their enthusiastic contribution to this project. Nevertheless, as a member of the 1961 expedition myself, I have decided to personally dedicate this translated work to the memory of my three, previously mentioned, fellow scientists on that expedition, the late A. Starker Leopold, William H. Usinger and Richard E. Warner.

Technical notes.

On language: wherever feasible, I rendered a literal translation of the original German

text. In some cases, however, the resulting sentence had a peculiar or misleading context in modern English, which made its comprehension awkward for the reader. Using a little artistic literary licence, these sentences have been altered, although in most cases I retained the literal translation.

On scientific names: The original names and their spellings have been retained, although in many cases both have been historically antiquated, such as the capitalization of the initial letter of some specific names. In the flora list (Appendix note No. 16) I added, in [brackets] the synonyms used by Lamoureux (1963, *Atoll.Res.Bull.* 97.) and/or Ely & Clapp (1973, l.c.). The outdated units of measures and old geographic names have similarly been retained, for instance, nautical miles, Gardener Island instead of Gardner Pinnacles. etc.

On symbols: Numbers in the main text, (enclosed by brackets) from (1) to (22) refer to the author's notes in the Appendix (on his pages 85-104). These numbers have been printed in this translation of the Appendix in bold print, for example **1**, and the subsequent page numbers refer to the translated text.

On printing: The German book printed numerous words, phrases and sentences in a spaced style. I have underlined these, though some words so marked no doubt merely served to avoid a gap in a line.

About the Author.

Hugo Hermann Schauinsland was born of a Prussian landowner family in 1857. Although his studies were interrupted by a long-lasting childhood illness, he graduated from high school in Königsberg, East Prussia, in 1878. That summer he studied natural sciences in Geneva, Switzerland, and visited the world exposition in Paris. This latter visit had a lasting impact on his interest in museum exhibits and expositions. Though not a highly merited high school graduate, he continued with university studies at Königsberg's Albertina University, under the renowned embryologist Richard Hartwig, for whom he worked as a museum assistant. In 1883 he won the doctor's degree with a dissertation entitled "Contribution to the Knowledge of Embryonal Development of Trematoda."

Shortly thereafter, a Prussian government fellowship enabled Schauinsland to spend several months at the famous Marine Biological Station of Naples, Italy, which had been founded nine years earlier by the wealthy German zoologist Anton Dohrn. This experience stimulated him to initiate marine biological studies of the Baltic at the Bight of Danzig (now Gdansk). However, when his mentor and supervisor, Professor Hartwig, moved to Munich in 1885, Schauinsland followed him. By then he had enough scientific work accomplished to be accepted by the Ludwig Maximilian University of Munich as Dozent (i.e., as a titular professor with the right to offer courses in his speciality). Beside teaching, he was soon commissioned to the job of curating the zoological collections of the state of Bavaria.

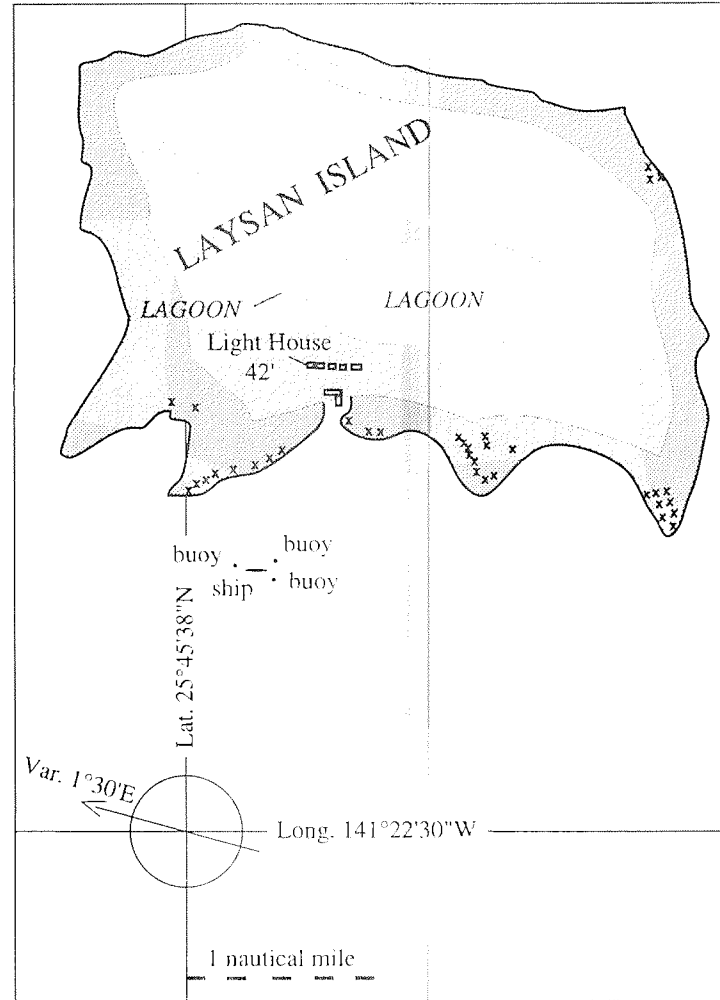
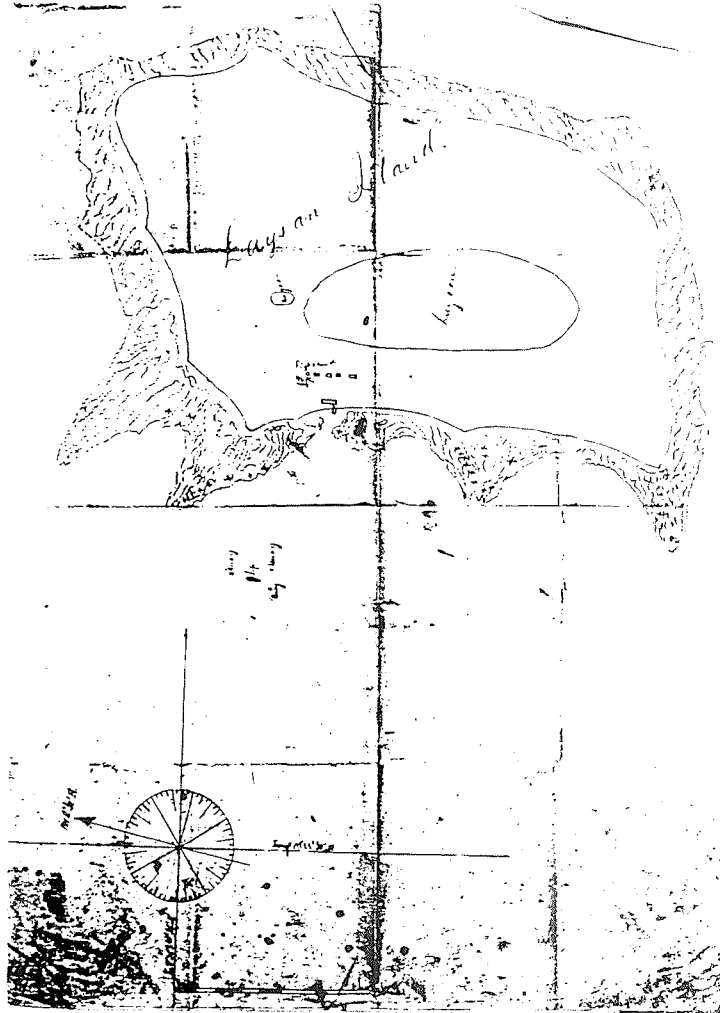


Dr. Hugo Hermann Schauinsland in 1886, as dozent
at the Ludwig Maximilian University in Munich.



Dr. Schauinsland in 1927, as museum director in
Bremen, 70 years old.

Both photographs courtesy of the Übersee-Museum in Bremen.



Schauinsland's sketch map of Laysan Island, which is in the possession of his granddaughter Mrs. Rosemarie Oertwig of Bremen (Courtesy of Dr. Andreas Lüderwaldt). The reef surrounding Laysan is shaded and has cross-marks that are probably collection sites.

Based on this diversified background in zoological research and museum experience, and with the enthusiastic support of his former professors and employers, he was chosen in 1887 out of 14 applicants for the directorship of the City Collections of Bremen, that bustling hanseatic city with long traditions of overseas shipping and commerce. He took over the collections on June 1, 1887, and by October of the same year had reported to the city fathers that the stores of collections were so enormous that their organization would need at least a year without attempting to procure any new material.

In 1890, Bremen opened a Northwestern German Industrial and Commerce Exhibition, and the energetic work of the new museum director greatly contributed to its success. It also helped him to establish a network of contacts with the leading industrialists and business people of Bremen who donated valuable material to the Exhibition. Moreover, these contacts led to substantial financial help, first by these private donors, and subsequently to a matching sum by the city, for the construction of a new, stately museum building for Schauinsland, the City Museum for Natural History, Ethnography and Commerce. In 1896, the new Museum edifice opened, in which Schauinsland's ideas, plans and practical suggestions had all been architecturally incorporated. Schauinsland received all due recognition: a professor's title, a year's leave, and funds for a year's collecting expedition.

Now 36 years old, Professor Schauinsland embarked, with his wife, on a journey which led him not only to the Hawaiian Islands, but, from April, 1896 to May, 1897, to the Pacific coast of the USA, to Samoa, New Zealand, Stephens Islands, Chatham Island, Australia, Ceylon and Egypt. He returned laden with rich collections. The identification of the zoological specimens alone took several years of intensive work by specialists and the resulting scientific works fill many volumes.

The subsequent 16 years (until the outbreak of World War I) saw Schauinsland as organizer of his museum; a completely new type of institution with emphasis on public exhibits to teach and educate the public about the world overseas. The novel methods of presenting the material (synthetically instead of in scientific order), including dioramas containing both natural objects and cultural artifacts and placed in a replica of their natural (or human-made) environments, were recognized by many contemporary German museologists as creations of Schauinsland's innovative mind. During 1907-1911 the museum was renovated. Also enlarged by Schauinsland's subsequent collecting expeditions (1905-06: East Asia, 1907-08: Indomalaya and East Asia, 1913-14: Oceania and East Asia, 1926: Egypt) it now fulfilled his above outlined goals of presenting the natural, but especially cultural and industrial peculiarities of overseas lands as they form coherent entities. This "Übersee—Museum" (Oversea-museum) as it is called today, is a monument of Schauinsland's activities until 1933. In that year he was forced to retire by the Nazi regime. Broken-hearted, he withdrew to his native Prussia where he suffered a heart attack. Though living in Bremen he never again set foot in his Museum: 80 years old, he died in 1937.

IV

Beside being a highly innovative museum director and an extremely well organized collector, Schauinsland also pursued scientific studies in comparative anatomy and embryology. One of his many important contributions is the microscopic anatomy of the "living fossil" tuatara (a reptile, *Sphenodon punctatum*, then known as *Hatteria*, which he collected on Stephens Island off New Zealand) which was unknown until his publications in 1899 and 1900.

Now, almost a hundred years after Schauinsland's first, but perhaps most important collecting expedition, the pleasantly written, fascinating travelogue, "Drei Monate auf einer Koralleninsel," and the accompanying notes have not lost their importance for the scientific assessment of the natural history of the Hawaiian Islands, particularly of Laysan.

M.D.F.Udvardy

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When looking at the distribution of water and land on our globe, in addition to the continents, we may distinguish islands which reveal by their geologic structure as well as by their flora and fauna, that they are nothing more than torn-off pieces of the neighboring continents from which they were separated, a shorter or longer time ago. The best known examples of such continental islands are Great Britain and Ireland. In contrast to these continental islands, a great number of other islands show no relation to their surrounding mainlands, neither with respect to their rock composition, nor to the organisms which populate them. We may call these oceanic islands. The great majority of the mostly small and widespread islands of the Pacific Ocean belong to this category. Here also belongs the tiny and lonely coral island called Laysan, situated at 25° 46' N. Lat. and 171° 49' W. Long. While it is only some 800 miles from Honolulu, it is separated by thousands of miles of ocean from both America and Asia.

This island became the target of my research trip in the summer of 1896, not only with the intention to find out about its structure as a coral island, but also to study its very interesting flora and fauna, and to collect material for phylogenetic studies.

Since Laysan and the Hawaiian Islands have a certain relationship, to which we shall return later, we may be allowed to say a few words about this latter group of islands.

If we look at their position on a map, we notice that the islands of the group, viz. Hawaii, Maui, Molokai, Oahu, Kauai and Niihau (to name only the most important ones) all lie along a SSE — NNW line. The island chain also continues beyond Niihau in the same way; however, from then on, no habitable islands exist, rather there are only steep rocky promontories protruding from the water, or lowly sandbanks and coral islands which are either totally submerged, or are barely emerging from the water surface. These are Bird Island, Necker, French Frigate Shoal, Gardener, Maro Reef, Laysan, Lisiansky, Midway, etc. (1). Depth measurements were made a number of years ago with a planned cable in mind which was to be laid between America and Asia. These measurements showed that the latter mentioned islands rise from a high plateau that is on an average under only 1,000 fathoms of water. But they also provided evidence that, outside of this narrowly delimited high

plateau, the sea bottom sinks to terrific depths north- and southward of the whole island chain. An average of 2000 to 3000 fathoms have been measured here. From this we learned that the island chain in its totality represents a monumental mountain chain that rises abruptly from the enormous depths of the sea bottom. Whereas in the NW the peaks of this mountain chain barely break the surface of the sea, toward the SE they steadily increase in height until, on the last of the islands, Hawaii, they reach heights that surpass those of Mont Blanc. Today active volcanism is restricted to this last island, though there it manifests itself in such a grandiose manner as seen nowhere else on earth. Though neighbouring Maui possesses Haleakala, the mightiest crater of the world, its fire has been extinct since human memory. Although on the remaining islands the lava fields have quite a fresh look, they surely ceased to flow an infinitely long time ago. By the way, I want to mention that all rocks on all these islands are either of volcanic nature or else they originate from coral reefs. One does not find the slightest trace of basement or sedimentary rock formations.

Consideration of the geological structure alone leads us to conclude that the youngest members of the island chain lie farthest to the SE, and that the age of the islands gradually increases toward the NW. The highest island (Hawaii) is also the youngest. The lower the other islands are, the earlier the eruptive forces on them ceased. They are geologically older and were exposed to the powers of erosion for a longer period of time. Wind and precipitation have worn down their mountain peaks and have gradually diminished their height.

Americans, especially those operating the steamboat companies that provide the connections between the mainland and the Hawaiian Islands, call these the Paradise of the Pacific. Anyone who has crossed America and has, during the several months of the journey, read upon every house, fence or rock that Sarsaparilla is the drink, or that you ought to wash yourself with Pear's Soap, becomes somewhat leary of superlative expressions, especially after having noticed the exaggeratedly enthusiastic responses of the true Yankee toward every peculiarly shaped rock formation on the prairie, and how he declares the simplest and most boring landscape as the nicest in the world (providing he has business interest in it). However, in regard to Hawaii, such suspicions are entirely unwarranted, for it really is a piece of paradise on earth, created by the delightful climate, lovely vegetation, friendliness of the people whether native Kanaka or white immigrant.

Even a short stay in Honolulu, and especially a short excursion from there, allows us to sample all these characteristics of Hawaii's nature; anything that we experience there would more or less apply to the whole island chain. When leaving the city we proceed through the fine Nuuanu Street towards the valley that bears the same name; here we find ourselves surrounded by the loveliest flora! There hardly exists a tropical plant that would not thrive here or that could not be grown here. The heat of the sun, although it supports all these plants, is moderated. The thermometer here shows lower values than what one would expect

from the geographic position, owing to the wide ocean with its refreshing winds, and especially due to the cool current which originates at the coasts of Japan and washes over the coasts of Hawaii. The extraordinary uniformity of the temperature also has the pleasant effect of having but a few degrees difference between summer and winter. Even though it is an exaggeration to talk about an eternal spring in Hawaii, it is certainly true that the heat there never reaches excesses that would cause drowsiness as it does in other lands at the same latitude.

Here then, at the beginning of the Nuuanu Valley, the well-to-do Honoluluans have built their dwellings in great numbers and have set up a paradise amidst palms and lovely, blooming trees. It fills a German, especially one from Bremen, with a great feeling of satisfaction to see the German names among the owners, even names from Bremen. The position of a German person in Honolulu is outright trend-setting; the most respected business firms are in German hands. I need not enumerate them by name since they are as well known here in Bremen as over there.

Now we climb higher into the valley. The air becomes cooler and more refreshing, the vegetation loses some of its lushness and naked, picturesquely rugged cliffs of volcanic rock emerge from it on both sides. After some two hours of climbing, we stand suddenly in front of a notch in the rock, on a small platform; from its height one gets an unlimited view over the land and sea. The platform opens up a view onto an abyss of awesome magnitude: the famous *Pali*. This was the place where the great conqueror, the Napoleon of the South Seas, Kamehameha the Ist, fought the last decisive battle a hundred years ago. Before his time, each island was ruled by its own chieftain; Kamehameha subjugated them one after the other. He drove the last small group of his adversaries, who had opposed him here in the Nuuanu Valley, in a decisive battle higher and higher into the mountains until they stood here against him. The killing did not stop at the gaping precipice of the Pali. The fearsome winner pressed the retreating men closer and closer to the cliff and forced them at the end to a fatal jump into the depths. A few decennia ago, the bleached skeletons of the shattered warriors could still be seen at the foot of the precipice. By now, a path has been built across the cliff wall with laborious efforts so that one can reach the east side of the island from the other side, up through the valley and over the Pali.

Stormy winds prevail here at all times, even when only a slight breeze can be felt in Honolulu. The eastern trade wind, which crosses several hundred miles of sea without hindrance, strikes here at the high mountain chain of the island. It is pressed upward and penetrates this narrow opening in the cliff wall as a gale, then glides down into the valley on the other side. There is another phenomenon associated with the rise of the trade winds on the mountain ranges of the islands. The wind becomes saturated with moisture during its course over the sea. As it is now forced to rise up from the lower to the upper, colder layers of air, it can no longer hold the same amount of moisture. This hitherto invisible moisture now gathers into clouds. Hence, the peaks of the islands' mountains are frequently shrouded

in clouds even in the nicest weather. Here at the Pali, the swelling vapors of the trade winds often present a strange and remarkable sight, when sunlight seems to fight the waves of billowing fog, and produces a strangely delightful effect. One may draw the conclusion from the above that there are enormous differences in the amount of precipitation on the islands. The east side, which is turned toward the trades, is considerably rainier and therefore also cooler than the very dry and warmer west side. Even if the trade wind reaches this side, it has already spent its humidity. Thus it may happen that we observe 320 mm of precipitation at a certain point on the windward side; while a few km away, on the other side of the mountain, only 32 mm. The refreshing trade winds blow during a greater part of the year; losing power only during some winter months when supplanted by southern and western winds, which have a fatiguing effect and most often result in a choking, sweltering heat. The island people do not like this kind of weather because several diseases prevail during its presence.

But let us return to the wider view from our vantage point. Happy green fields send their greetings from the low plains of the island at our feet; they are mostly fields of sugar cane, the main source of the island's wealth. Here and there, especially in wet spots, there are a few rice fields, keenly tended by diligent Chinese; or we can see swamps with taro fields, that aroid-like plant the root of which provides the *poi*, a favorite dish of the native Kanakas.

If we look farther away, we notice that the heaviest ocean surf does not follow the coast itself, but is farther out to sea, at the outer margin of the coral reef, which almost totally girdles the island. We see behind us the neat harbor of Honolulu, teeming with masts, among them not seldom those belonging to stately ships from Bremen. These masts are an indication of the significance of Hawaii regarding commercial traffic. This significance will never be lost but it will presumably increase, for the islands are exactly in the middle of the world highway between America, Asia and Australia.

When the air is clear, our eyes may reach the steep cliffs of Molokai, the neighbouring island. There is a narrow peninsula on its east coast which is cut off from the rest of the world by a vertical cliff wall; there the most unfortunate of all sick people, the poor lepers, languish away.

This introductory orientation might suffice to acquaint us, at least to some extent, with the peculiarities of the island chain to which we attach, as its strongly altered member, the remote island *Laysan*.

We arrived in Honolulu during the last days of May; our hopes to sail quickly on to Laysan did not materialize. The sole connection with that island is through the Guano Company, which utilizes the guano that is formed on the island, bringing it for further refining to Honolulu. The guano is a highly appreciated fertilizer; it is especially used on the cane plantations. The ships of the company, which are for the most part also in German

hands, travel two or three times each summer to the island. We not only had permission to visit the island, but we considered ourselves the company's guests during the whole time, for which we are forever very obliged. This particular time, a German ship, the well-known, fine barque *H. Hackfeld*, was scheduled to undertake the journey, but at the time of our arrival, she was not quite ready to sail. We used the waiting time for collecting trips in the surroundings of Honolulu and at times, also for visits to the ship. The first reception on board was unforgettable! The sailors' band, consisting of kettledrum, triangle and accordion, tactfully greeted us with the masterly performed, pretty song "O'Susanna," which is also very much appreciated amongst us on the banks of the Weser.

On the afternoon of 18 June everything was ready for departure; we shook the hands of our local friends for the last time and rushed on board. Our luggage, consisting of 25 large chests, had already been hauled aboard earlier. A little steamer pulled us from the harbor to the open sea where the accomodating trade winds soon filled the uphoisted sails. The sun was just setting, beautifying the lovely sight of Honolulu, surrounded by its picturesque mountains hidden under lush greenery. This view, seen every so often, causes the same delight time and time again. The sailing proceeded in an orderly fashion and next morning we sighted Kauai. The friendly captain steered us in so that we were sailing close to the island, and thus, were able to savour its beautiful coastal landscape. In passing, we noticed the German plantations, Kekaha, Koloha, etc. Kauai is the most German of the islands. For instance, Lihue, that wonderful plantation, is evidence of that which German initiative and German energy is able to accomplish. There you hear almost excusively German spoken, and the numerous Germans, viz. the worker population, living in neat cottages under bananas and mangoes, are educated here in a German school, and, edified in a German church.

We found it rather interesting that here, nearest the island, the trade winds died all of a sudden, with the sails hanging loose on their yards, though a short time earlier they blew with full force. The wind that blows across the high mountains descends only far out at sea, and thus on the coast a nearly complete calm zone exists. It may even be that an air current is created here that blows landward, contrary to the generally prevailing wind direction. Thus, I understood here how it was possible for a sailboat to drift onto the beach in broad daylight and in the best weather, especially when, an additional, unfavourable sea current was drawing it. In our case, however, a clever maneuver brought us back again into the zone of the trade wind. In the evening, we passed by the last inhabited island, Niihau, with a terrible surf at its rugged coast.

Next day carried us past Bird Island, a lonely vertically rising crater (900 ft high) with numerous bird flocks circling its peak. Of the rest of the islets, we sighted only Gardener Island, rising 170 ft above the water like a giant sugarloaf with steep, completely smooth walls. The rest of the journey passed without much variation. We had plenty of opportunity to acquaint ourselves with the ship, we even learned the meaning of "to embrace" and of sailing "by the wind" or "before the wind." We were entertained every evening by this

wonderful group of people, the sailors. The band again played the central role, comical seamen's dances were performed following its tunes. A certain young sailor made himself especially noteworthy; a young baron, sent to sea by his parents to change his lifestyle; this, according to what we learned, was indeed utterly necessary.

There was not much animal life to observe, save that of the birds. But once we saw a mighty flock of shearwaters (*Haloplana fuliginosa* G.M.) fluttering and screaming right above the water surface and time and time again picking up prey from the water. At the same time, a great school of bonitos (*Thynnus pelamys* C.V., a predatory fish related to the mackerels) appeared, and shot by the ship's bow like shiny arrows. Hastily improvised hooks were thrown over board. Pieces of cloth fixed at their ends fluttered just over the water's surface; the greedy robbers must have thought they were flying fish and jumped high and snapped after them. Soon, some dozen of them lay on the deck; they made a pleasant change in the evening meal with their tasty, though slightly dry, meat. At this time, the meetings with the schools of fish and bird flocks ended. The degutting cut in the bonitos showed that their stomachs were filled with small, sardinelike fish which fled in great schools from their pursuers. Under the water, they were pressed by the greedy predatory fish, but, when escaping, they came too close to the surface, where they were caught by the voracious birds. They were menaced from both sides. The struggle for life is hard, even in the water.

At daybreak of the sixth day, we heard for the last time the setting of sails, accompanied by the melodious tones of an English sailor's song. As we rushed onto the deck, we saw Laysan, the goal of all our yearnings.

One cannot deny that the first sight offered by the island, at least from the distance, was surprising but also disappointing. Had we not known that we happened to be in the middle of the Pacific Ocean and nearly in the tropics, we would have had to imagine that this was one of the Friesian islands before us; it lay just as low and flat above the sea, its shores were just as sandy, its green just as pale.

Soon we landed. We had already learned during the first day on the island that there was so much work to be done that we could not accomplish it in the short time allotted. Therefore, we decided to let the ship leave and to stay here until she would have her last island run in the autumn.

Laysan is small, 3 English miles long and 2 1/2 miles wide. Its highest point amounts to about 30 feet. Nevertheless, the greatest part of the island is considerably lower. One may well imagine that a high tidal wave, such as occurs from time to time as a result of earthquakes, could submerge a great part of the island. Actually, such a tidal wave occurred shortly before our arrival, resulting from an earthquake in Japan, and we had witnessed its effect in Honolulu with our own eyes. It also hit this island and rolled up high on its shores.

The soil of the interior of the island is almost entirely composed of sand. But it is not the quartz sand that we know at our islands of the North Sea. It is solely composed of limestone particles that originate from coral and mollusk shells worn down by the waves and storms. The rocks on the island are similarly composed only of limestone of various grain sizes and hardnesses. Also, they are only cemented coral sand. At times, their structure is so fine and so dense that blocks of enormous dimensions resonate sharply when hit with a hammer. Others, again were found to consist of various sized particles. They were conglomerates of larger pieces of coral and mussels.

In the interior of the island, rocks appear only occasionally, forming low and quite loose cliffs, greatly eroded by wind and weather. In contrast, they form most of the coast, where they sometimes occur in regularly deposited layers. They are highest in the southeastern part of the island where they abut the sea as vertical cliffs. They present here a really magnificent coastal landscape. The high waves, driven by the almost steadily blowing trades, disintegrate on them. But if a storm drives the water with more force against the coast, the white foam of the furious waves sprays against the rocks to towering heights and bathes them with mighty cascades! It is perhaps the most sublime sight of surf I have ever seen. The waves chew incessantly on the hard rock, undermining it and gnawing holes in it. One of these holes is connected with the rock surface through a small opening. The water, penetrating it with violent power, is pressed out through that opening with a mighty force; a force that sends it high into the air as atomized spray, like the steam from a valve of a giant steam engine; we could hear from quite a distance the hissing, whizzing sound of the escaping vapor.

The sight of the southwestern coast is not dissimilar. Here the whole surface is filled with honeycomb-like holes, among which rise sharp spines where one can hardly find a foothold. Toward the sea, the coast slopes down into a series of terraces on which shallow basins are carved out and filled with water like small, neat natural aquaria. These are only supplied with water by the upward spraying of the surf. Here, there are many kinds of snails, mollusks and sea urchins fastened to the rock and hidden by green algae. A tiny, handsome fish (*Galaxias edentulus* Bl. Schn.) also dwells here. But, it can hardly be caught by the snatching hand, even though the basin might be quite small and flat. Just when you think you have it, it skips away into another basin, sometimes higher, sometimes lower on the slope.

While the erosion phenomena are varied enough on all these slopes, they are especially interesting on the hard slopes. Here the surface is washed out into innumerable, needle-sharp protuberances and edges varying in height from a few inches to several feet. We may also find formations reminding us of a glacial kettle, especially where the surf is not very strong, at the lower bench of the reef. They have the characteristic rounded shape and are often one or two meters in diameter. Normally, they contain on their bottom a rolling stone that is put into a rotating motion by the waves that reach it, just as the glacial stream does with the kettle, by and by grinding it into a wider and more circular shape.

On the south side, peculiar, tube-like concretions protrude from the great masses of loose sand which the wind has piled up there. They look somewhat like lightning-tubes, but I can (2) not yet explain their origin. In the north, I found a deposition of real peat. According to what I know, peat has never been found at such a low latitude (3).

We have still to mention one more component of the island surface, viz. the guano, since it is the only reason why mankind visits this godforsaken island where only birds dwell. You should not imagine that this material is an evil stinking mass; on the contrary, here in Laysan it is a tidy, completely odorless mineral. Guano is found either close to the surface in a more or less sand- or powderlike form, or else several meters deep in the form of solid rock that must be broken by pick and shovel (so-called rock guano). The origin of this material is obviously different here from that found on the famous, completely rainless guano islands off the Peruvian coast. On Laysan it rains quite often and sometimes very hard, and therefore, I explain the guano formation in the following way:

The island was visited by countless flocks of breeding seabirds during extremely long periods of time. The dung, which they deposited on the pervious sand of the island, was leached out by the rain, the saturated water seeping down to the depths, where it impregnated the calcareous sands and rocks. Chemical compounds were thus formed, mostly calcium phosphate. Quite often, you can find whole geodes of neat, white crystals made from this mineral (4).

In these beds, bones and petrified and well-preserved bird's eggs occur quite frequently, indicating that the bird flocks that populated the island were already then the same as the ones now found on the island, especially the albatrosses and some of the larger shearwaters (*Puffinus*). We are also able to find in these beds, numerous stony-kernelled fruits, nuts, blobs of resin, and, above all, round pieces of pumice which, for sure, at one time passed through the stomachs of the gluttonous birds. These birds swallow everything that floats in the sea when they hungrily scout the surface. I know positively that this occurs even today. I have often been astonished at how big a piece of pumice can be accommodated by the stomach of an albatross (5).

A great part of the interior is occupied by a lagoon which is 2 or 3, rarely 5 fathoms deep on the average. It is filled with a brine of about 12—15 % salt content, somewhat varying in strength depending on the season and the rainfall (6). Its water is clear and on its shores great masses of crystallized NaCl, i.e. table salt, occur, at places clear white crystal drupes, good for the table. There are two species of algae in the lagoon, one of them has a cartilage-like consistency and forms great thick cushions (7). Next, there are enormous quantities of a small, transparent shrimp (*Artemia*), hardly 1 cm long. At individual places, their dead bodies are so piled up that there is a stench from afar. The only other living being, surprisingly, is a small dipteran, a fly, whose larvae develop in this very concentrated brine

(n.b., sea water only contains 3-4% salt). I may mention that the ground surrounding this salt lake is not entirely harmless; its slate white shores are covered by a hardened salt crust, but with a very deep, slimy mush underneath. The deceptive surface is very easily crushed under the foot of a person who carelessly stomps across it. It happened to me that while pursuing a wounded duck, I ventured too far out, sank in, and could only save myself by quickly throwing myself flat on my back. Thus I managed to work myself out from the corrosive salt broth (8).

There is a coral reef around the island. Its width is about 1/2—3/4 miles. It does not entirely encircle the island, but is broken in a few places and thus provides ships with an opportunity to get in close to the island. Anchorages that could, to a certain extent, be used by larger ships are only found at these breaks. This reef is a so-called fringing reef, beginning right at the shore of the island, but is separated from it by a channel which is navigable at high tide by small boats; however, by ebbing, it becomes shallow enough that it is possible to cross it, in many places, by wading (9).

I cannot deny that I was somewhat disappointed when first sighting a coral reef, remembering the depiction of the luxurious colors and forms described by travellers to the reefs of the Red Sea and the Indian Ocean. I was surprised when the banks emerged at low tide¹ and all the eye met was a wide plain of monotonous gray color, only interrupted by the livelier green of lush marine plants. We should not forget, at this point, that in this superficial view we only see the part of the reef that has died off, and which is also frequently covered by sand and debris. For an excursion one should choose the time of the lowest low tide. Extreme care should be exercised when proceeding closer to the outer border of the reef. Although one may arrive there with dry feet, at the next moment a somewhat higher, rushing, wave of the strong surf might cover the whole reef with deep water. Then one has to be careful that it does not grab and throw us to the ground. One might become so wounded on the many sharp edges and borders that one might not be able to swim back. Yet, it is here where the reef begins to present its beauties. There are deep hollows here² and in their crystal clear waters glimmer all those many delicate coral formations that we every time admire anew for their gracious beauty. Yet it is not the multiplicity of forms we admire most; we find here the splendor of colors we missed before. We have before us for the first time the living corals in their full splendor. We are accustomed to seeing their singular branches and leaflets as marblelike, sun-bleached skeletons, which now are ornamented in the most magnificent colors. Next to fine violet-blue coral stocks shine some sulphur-yellow ones, others glitter there in dainty pink, beside succulent-green tussocks. Like motley butterflies over flowers, fishes of all wonderful shapes

¹On Laysan the difference between low and high tide amounts merely to about 50-60 cm.

²Though mainly on the leese side of the island. Kraemer (Dr. A. Kraemer: Ueber den Bau der Korallenriffe und die Planktonverteilung an den samoanischen Küsten, Kiel und Leipzig 1897) likewise noticed (p. 66) that these "wells" belong to the leese side of the reef.

and magnificent patterns pass between the corals. The members of the coral fauna that dwell here in these "coral gardens" show many peculiar adaptations of color as well as aspects of their habits. (10). Nets are of no use in catching them. I lost several nets the first time I tried it; they got caught on the pointed and sharp coral branches. Thus, if I did not want to restrict myself to collecting only the ones that were accidentally thrown out of the water by the waves, I had to force myself to dive for them. Thereafter, I hustled about many hours of the day in these basins, rather more under than above the water, and gained a rich harvest.

Other tenants of the coral have settled more toward the outer edges of the reef, where the waves break steadily and with great force. Numerous representatives of the echinoderms, viz. urchins, of considerable size and in the most lively colors, are wedged in the solid coral rock so one can only get them loose with a chisel and hammer.

The east side of the reef is in places somewhat differently developed. The solid, layered limestone rock, which often appears on the shores of the island, continues here, covered by shallow water, for quite a distance under the surface of the sea. It joins the true coral reef only further out. In this way wide, shallow spaces are formed here, and they can easily be waded through. The bottom of these spaces often consists of a fine sand, but a sand that is different from that at other parts of the island. Besides broken bladelets and branchlets of delicate calcareous algae (especially *Halimeda opuntia*), it is made up exclusively of foraminifera shells, viz. of those tiny beings, whose shells, among others, also built most of the calcareous rocks of Rügen. The ones on Laysan are, without a doubt, the giants of their kind, since the plates of a very common, nummulite-like species attained the size of a lentil. Also, we were able to observe all these beings alive, on the stems and leaves of the kelp and algae (11) that grow here. Observing the remnants of this tiny being in such enormous quantities, found piled up in several, meter-high, dune-like heaps, it is easy to understand how important they have been, and still are in places, to the rock building processes of the earth. Coral stocks grow in the middle of this loose sand, though singly, often covered only by a few feet of water. I want to emphasize this, since not long ago the occurrence of living corals in such a habitat was denied.

Many other animals have their hiding places here. If you roll away one of the rock slabs that lie around, great ophilionids will nimbly scurry away from their retreats. One is quite often able to catch an adventurous octopus; sometimes it is so big that you have to protect yourself from its sucker-covered arms and sharp mandibles.(12). Giant, often half-meter-long, sea cucumbers (*Holothuria*) cosily stretch their cylindrical, black bodies. Hiding under the bottom sand, live numerous worms, among them an interesting *Balanoglossus*. Further out, where the real reef begins, cushions of coral polyps shine through the water in sulphur-yellow and verdigris colors. There are species whose bodies are not hardened by the deposition of lime as are their relatives, the true corals. Here and there one even finds the tiny, delicate trees on which the neat mushroom-corals grow; these later detach themselves in order to grow, henceforward, to their full size, as single animals. Tender sea roses

(*actiniae*) open up their wreath of tentacles, though they rather choose to live on rocks in the vicinity of the coast. At night, one is able to lure large, luscious langustas (13) from their retreats beneath rocky overhangs, and catch them with the help of a lantern and a harpoon (a pity that their meat tastes far from the delicacy of their cousin, the lobster). This method of catching yields good results even in the case of common eels and gay-spotted morays.

How is the more or less compact mass of dead reef and the hard coral-rock formed from the branching coral canopy? When the coral formations grow high enough that they are no longer completely covered by water during the lowest low tide, they die off. Sometimes, the tight masses of calcareous algae have already settled in earlier, and entangled the coral branches. Each wave of the sea throws debris of broken coral and mussel pieces on them, with sand filling in the remaining spaces. This sand is partly produced by the minuscule animals that live in the coral stocks and excavate their home therein, and also produced by the numerous crabs that cut the mussel shells into pieces with their claws while looking for edibles within. In addition, it is also produced, and more than likely, is chiefly produced, by the power of the pounding surf, which atomizes all of this debris. The limestone, that the organisms produced, will partly be dissolved again by the seawater, and will again be precipitated within the debris in crystalline form, binding the whole into a solid mass (14). The hard, layered limestones that one finds everywhere on the island have obviously been formed in a similar manner deeper in the sea, where the more or less fine-grained masses of fragments eventually gather. I would not deny, though, that some of these layers, consisting of fine, sandstone-like particles, could have originated through wind activity on firm land. The wind here blew the fine particles together, which, over a longer period of time, also cemented themselves into rock. Never-the-less, the main rock mass of the island originated in the sea and came to light only because of the elevation of the island.

What a fate these sand particles have, which we see rolling back and forth at the beach, playthings of the waves. They lay on the bottom of the sea and hardened into rock. They were elevated and became part of the surf zone. The surf again uses its annihilating force against them grinding them into sand again, which will again adopt a firm shape at some future date. Thus, the alternating play of formation and breakdown of this inert material could continue through immeasurable periods of time.

Let us consider, for a moment, the theory of coral islands. In the first decades of our century, the savants, among them the poet, naturalist and traveller Chamisso, were of the opinion that coral formations began growing in the depths of the ocean and built up, over time, until they finally reached the surface. Driftwood, kelp masses and other organic debris drifted together on the exposed coral and produced some humus on which seeds, carried there by currents or birds, gradually were able to form a cover of vegetation. This hypothesis, however, does not hold true because the reef-building corals need seawater of a very even temperature, minimum ca. 20° C, and also cannot grow in water deeper than 15-20 fathoms, at the most. Darwin was the first who successfully developed a theory which

satisfactorily explains all kinds of coral reefs. According to this theory, the corals settling around the island, at first form a fringing reef that girdles the island. If the island is sinking, the coral animals keep on building up the reef surface, at the same relative speed, while down below, they sink together with the island until they arrive at a depth where they can no longer survive. Since they find better growing conditions toward the open ocean than on the landward facing side, they develop better there. Thus, they gradually withdraw from the island and leave open between them a, more or less, wide and deep stretch of water. In this way, the fringing reef develops into a barrier reef. The island keeps on sinking until it is completely submerged, while the growth of coral maintains an even pace with the sinking. Now we have a ring-shaped coral reef, a so-called atoll. The atoll encircles a calm water body (in contrast to the agitated sea whose waves it holds off), the so-called lagoon, that replaces the erstwhile firm land. The majority of the thousands of coral islands which fill the enormous basin of the Pacific Ocean were developed in this way. Every ring of coral islands is a wreath over a sunken island.

Even this theory has, as of late, experienced its share of attacks and disputes. Among others, one objection was that Darwin's assumption necessitates a very powerful reef, not like the recently elevated reefs or the ones from earlier epochs. Now as far as this last objection is concerned, there are an increasing number of people who view the metamorphosed coral reefs in the mighty Dolomites of South Tyrolia, admired by so many tourists for their bold formations. The drillings, instigated by the Royal Society and attempted by Australia on Funafuti in the Ellice Islands group, were, at first, unsuccessful, but a few months ago they supplied the evidence: a penetrating drill found only solid coral rock to a depth of nearly 1000 feet (to date).

However, the original explanation for the development of the coral islands may have been more complicated than scientists have supposed, a possibility that may explain their diverging opinions. Coral reefs may presumably be formed, not only in sinking areas, but also in rising areas. There must certainly be a few places that oscillate between sinking and rising. Let us consider the Hawaiian Islands for the first point which was discussed. When artesian wells were drilled on Oahu for the irrigation of their sugar cane plantations, the bore holes found coral rock in some places several hundred feet beneath sea level. Whereas a sinking of the island could thus be demonstrated, elevation was not considered, or was thought to be very small and insignificant. My own observations convinced me of the contrary. I found on Kauai, between Tipukai and Koloa, larger deposits of solid limestone at considerable heights. Even if we believe that in this first case aeolian activity might have been active, such a theory is completely inadmissible in the second case: I have identified on the south coast of Molokai, at about 300 ft above sea level, (in other locations on this island, limestone rocks occur all the way up to a height of 670 ft) a deposit of real coral rock which consisted solely of well preserved, often very large sized coral debris and mussel shells in association with rounded pieces of basalt. It is totally impossible for the wind to have blown them up there. Their occurrence at that site can only be explained by elevation

(15).

Let us return to Laysan and try to clarify the history of its development. First I want to point out that I found several large blocks of basalt at various places on the beach, and when I worked on the coral reef, I also found them a few meters below the water surface. They were situated at places where a ship could never have gone and thus it is impossible that they could have originated from ship's ballast. Moreover, their size and shape made it similarly impossible that they were transported by driftwood. Rather, I firmly believe them to be the remnants of the volcanic rock core of the island. This might have projected above the water as high as neighbouring Gardner, Bird Island, or Kauai itself. It then acquired coral settlements which formed into a fringing reef. Aided by sinking, erosion diminished its height and finally it disappeared under the surface of the sea. Thus, the coral reef developed to a regular atoll with a central lagoon. This period of sinking was followed by one of rising. The lagoon diminished in size, masses of sand and debris diminished its depth and, finally, its connection with the open sea became barred. Still, this did not happen all of a sudden. From time to time, perhaps at times of great storms or tidal waves, the ocean waves still penetrated it. In its relatively shallow basin the water quickly evaporated again; thereby becoming more and more salty. In the end, it became the salt lake, which we now find on the island as the last remnant of the atoll's lagoon. Then, the atoll was again girdled by a fringing reef of younger coral formations. The huge coral blocks that lay high on the western beach on top of the cliffs could not possibly have been rolled up there by the power of the waves. They are evidence that, apart from the great elevations and subsidences mentioned earlier, minor ones must also have occurred. Other evidence is provided by the coral limestone rocks in the interior of the island, still standing 20 feet high in spite of their great corrodability. On the other hand, in the guano pits, at depths way below sea level, numerous bones and bird egg-shell remains are found, often mixed with single, larger pieces of coral. I have even observed, at one site on the east side of the island, that the guano strata continued for a considerable distance under water as part of the sea bottom!

When we attempt to clarify the history of the whole Hawaiian island chain, to which Laysan certainly belongs, we get many clues from the study of their biota. Such a study may as well serve as an example of how the summarizing of small observations enables us to gain far-reaching conclusions, I will delve a little longer into this subject. The Hawaiian fauna is very peculiar; hardly any other island group has so many specific characteristics. There are no native mammals whatsoever. However, on the contrary, there are very many characteristic birds, most of which are entirely endemic (i.e., not only the species but also their genera occur solely on the Hawaiian islands). Only a few of them show relations with those forms that populate the remaining Pacific islands and Australia. Even fewer have very weak affinities to America, indicating that only very rare and certainly very old relations existed between this continent and our island group. The great specialization of the avifauna, which does not exist anywhere else to such a high degree, testifies either to the very great age of these islands, or the proximity of a very old, now defunct landmass from which the fauna originated.

There are very few insects; among them the beetles are especially characterized by peculiar forms which belong to the perhaps most primitive known beetle groups.³ Almost all of them are extraordinarily tiny. The only ones to reach the islands were those able to survive a very long transport, e.g. in cracks of driftwood. The lack of very many important and cosmopolitan groups indicate how unfavourable the conditions were for immigration. The extreme specialization of these insects again teaches us that the colonization by the same species has not been repeated; thus the original, primitive forms were retained and were not changed by many crossbreedings.

The number of land snails is very large and characteristic throughout the Hawaiian Islands. Quite often they show relationships to forms which occur otherwise in different parts of the world, but not in the Pacific area. This can only be explained by the fact that they became native to the islands during a very, very ancient period, viz. when the distribution of the global land molluscan fauna was entirely different from that of today. The local distribution is also very peculiar! For example, in the family Achatinellidae, there are not only species but even genera that are restricted to one of the islands. In addition, the more we proceed from East to West the more specialized they become. Thus, Oahu and Kauai have the most deviating forms. There are also, among the other land snails, genera that belong solely to Kauai; this fact again indicates that the western islands are older than the others.

The highly peculiar and rich flora also shows greater specialization in the West than in the East. Kauai has the most, Hawaii the least specialized forms. 3/4ths of all species are endemic. Indications of relationships are found with America and with the colder areas lying toward the Northwest.

Again, summarizing the above, we can conclude that the volcanic activity ceased first in the west, i.e. that Hawaii is the youngest island, and that the age of the islands decreases from east to west. The long-lasting erosion, together with sinking, has already accomplished its work in the west. Accordingly, we may be allowed to consider the aforementioned shallows, northwest of Kauai, as the oldest, now sunken land, from which the erstwhile populating process of the islands has taken place. Even Laysan is a remnant of this land. Laysan, together with the rest of the other reefs and rocks which are in that relatively shallow area, shows us the bridge through which Asiatic forms could have migrated; the other shallows which lead toward the other Pacific islands show the way taken by those organisms which even today display relations with Oceania. Two shallower areas between San Francisco and Hawaii are perhaps suitable for explaining the connections that have existed in the distant past between these land areas.

³Compare with A.R. Wallace, *Island Life*. 2. Edit. London 1895.

Considering the majority of the Pacific islands, we find indications of eternally long isolation. Taking in account also, that all islands, almost without exception, consist of volcanic rock or are coral islands, probably also on volcanic foundation, and also considering the findings made when studying the flora and fauna, one might conclude, with a certain degree of probability, that at this location on the earth, the division of water and land, of continents and islands, remained to a large extent the same (not so that where there are now islands there was a continent earlier, and vice versa).

Let us again turn to Laysan after this diversion. Its vegetation shows similarities with the flora of the Friesian Islands, not only when viewed from a distance but also when studied up close. We find, here as there, plants of low stature, a lack of trees, the dominance of grasses and the dominance of a gray-green color. Among the 27 species that comprise the flora of Laysan (16), we find, at first, a number of cosmopolites with characteristics so favourable for dispersal that they settled almost everywhere on the tropical coasts. The rest belongs to the Hawaiian flora. It is worth mentioning that some of them occur in Hawaii only at considerable elevations on the lava fields, whereas they grow here only a few feet above sea level; perhaps again another hint revealing that Laysan was not always as low in altitude as it is today.

Foremost among the characteristic plants, is a grass with long reedlike leaves (*Eragrostis Hawaiiensis* Hdb.). It grows man-high on the lower, and therefore wetter, sites on the island, while in dryer places it grows to only one meter. It does not grow in coherent mats but singly, in bunches, with a rootstock 1/4—1/2 m in diameter. Since the bunches are well spaced with some room in between them, and since this bunchgrass vegetation covers most of the island, it attains a very special appearance. Next to this grass, the commonest plant on the island is a goosefoot (*Chenopodium sandwicheum* Moq.). Its leaves and flowers show great similarity to our garden goosefoot. It is a strongly branching shrub of 3/4 to 2 m height, in older specimens with almost arm-thick stems. It forms an almost impenetrable thicket because the single bushes begin branching from the root and the branches of the tight growing individuals interlock. This is not only the most favoured retreat of the small land birds of the island, but also for a few of the large sea-birds such as the boobies and frigate birds which use it exclusively for the foundations of their nests; they bend the top branches of the bushes and interlace them with broken-off twigs.

The nicest plant on Laysan is, without comparison, a man-sized shrub, *Capparis sandwichiana* D.C., with dark green leaves, and neatly built large, white frail flowers, each with a bunch of long swaying stamina hanging graciously from its cup. The splendor of the flower lasts only one night; it opens first at sundown and its life comes to an end the next morning when the sun has hardly raised itself above the horizon. It is not only for its form that it is listed among the most beautiful plants I know, but its charm is also increased by its intoxicating, highly pleasant fragrance. If the night breeze wanders over the blooming shrub, the air becomes filled with its perfume. By the way, all plants of Laysan, even totally

unpretentious ones, have a pleasant smell. This is understandable since the island has very few insects and we can assume that the color and odor of the flowers exist as extreme lures for the insects that the plant needs for fertilizing its flowers.

Further, we should also mention among the peculiarities of the flora that the plant individuals display great lushness, greater than those on the fertile lava soil of the Hawaiian islands. Many share a trait with their Hawaiian relatives, in that their appearance is tree- or bush-shaped, whereas elsewhere they only grow as herbs, e.g. the aforementioned goosefoot and the common portulaca (*Portulaca oleracea*). I also observed that all solitary-growing low plants have rosette-like growth-form, while the taller ones make a dome-like structure with their arched branches.

Although the contrast of the seasons is only slight, some plants will be influenced by it. Many lose their leaves, others dry up (especially the above-mentioned bunchgrass and the goosefoot), dressing themselves with fresh greenery only during the rainy winter or in spring.

Not too long ago, palms have also lived on the island, and, as the many remnants of their rotten stumps show, they were very numerous. However, the last living examples died off a few years ago, and, since we cannot find a spot anywhere on the island to escape the burning rays of the sun, we miss their shade-providing crowns. It is not unlikely that castaways contributed to their demise, for at times, they were for sure present on the island. I found heaps of coal, in a few places, still showing the characteristic structure of palm wood. These could have been remnants of campfires, or else signs of fires kindled by carelessness. A final noteworthy observation about the flora of Laysan is the complete lack of ferns, mosses and lichens.

The waves often drive plant material from faraway lands to the beach. Besides various nuts, beans and other hard-shelled seeds, even big tree-trunks are stranded across the reef. These rarely originate in Hawaii., but mostly belong to conifers from the coasts of Northwest America or Japan. Their origin could only be ascertained by closer scrutiny.

By far the most interesting part of the land fauna of the island are the birds, (17) of which first the five endemic species of Laysan should be treated. Is it not a wonder, that here, on this tiny island in the middle of the endless ocean, we find in fact, five different land birds which do not live anywhere else on earth? They are a duck, a rail, and three small songbirds. Though all show relations to Hawaiian forms, they are definitely different species. They are obviously remnants of the fauna of that previously mentioned old, presently mostly sunken land, remnants that survived on this island. They must have been isolated from the other Hawaiian islands for a very long period of time, at least long enough for different, new species to have evolved from the original stock (since we could not think that they also

occurred on Hawaii in the past and died out there at present).

We could even conclude from their behavior on the island that, they are the last remnants of an erstwhile numerous bird fauna. I could almost say that they display a depressed nature, they are not rulers any more in the area they inhabit. We can never see them rise, rejoicing, into the sky, they fly low over the ground, and hop from bush to bush. They must struggle hard for their existence, since they were forced to adapt to a habitat, and to habits, that were originally totally foreign to them. The only survivors were those which were able to adapt to all the changes of their original habitation; the others perished.

Some of these adaptive features are very interesting. The dominant birds of the island are the sea-birds, and the other birds must subordinate themselves to them, though they may, at times, support themselves through the sea-birds. The finchlike bird *Telespiza cantans*, earlier evidently a seedeater, transformed almost entirely into a carnivore. Among other things, it found that the eggs of the almost year-around breeding sea-birds are as nutritious as they are tasteful. It opens them with a few strokes of its strong, sharp bill and carefully sucks out their contents. It carries on with this so boldly, that the breeding parents are very reluctant to leave their eggs for even an instant. During the exchange of partners while breeding, for example, the male comes back satiated from the sea to relieve his mate, so that she, too, can feed herself. The male positions himself tightly at the side of the incubating female and shoves her off the nest so that the egg becomes unprotected for only a second. And yet, the small *Telespiza* is often able to carry out its thievery during this brief moment. The tiny (just a few inches tall), quaint rail (*Porzana Palmeri* Froh.) has also become accustomed to an entirely new life history. It has become completely flightless; it hardly uses its short wing-stumps to aid it while running, as it scurries around like a shadow, with mouse-like speed, across the sand. Originally a marsh bird relying on worms for food, it has become almost omnivorous here, and it is again, the sea-birds in particular, that contribute to its support. Although it cannot open their hard-shelled eggs with its own thin bill, I have often observed it participating in this tasty meal, after a finch had initially broken open the egg. Nor does its diet pass up the island's abundant dead birds either, but instead, tears nourishing shreds from their decaying flesh, in addition to deftly devouring the flies and numerous beetles that buzz around the rotting carcasses.

Of the others, I only want to mention the neat little red bird, *Himatione Frerhii* Roth. Its nearest relative, *H. sanguinea* Gmel., is still one of the commonest birds in the higher elevations of the Hawaiian islands, where it gladdens the eye as it flitters around in the *Metrosideros* trees and collects honey (and perhaps also insects) from their garnet-red flowers, whose brilliant color its plumage wonderfully resembles. This principal food plant is missing on Laysan, but the honey-sucker still hops busily here, from shrub to shrub, searching for food in the local flowercups, especially favouring the larger flowers of the aforementioned *Capparis* shrub. This bird provides a good example how a new species may arise through isolation. Despite its great resemblance to the Hawaiian form, it differs

sufficiently from it by having a somewhat different nuance of colors in its overall red plumage (having some brownish feathers underneath the tail which in the Hawaiian relative are white) and, by its somewhat shorter beak. Furthermore, it is definitely the hummingbird-like bird which Kittlitz mentions in 1834, following a report of the ship's surgeon Isenbeck, who made a brief visit to the island in 1828. It does have, in fact, a certain resemblance to a hummingbird as it buzzes from flower to flower.

Anyone stepping onto the island for the first time, is immediately surprised by the apparant fearlessness or tameness exhibited by most Laysan birds. Our meals were always accompanied by the presence of the dapper yellow finches (*Telespiza*). Whenever we sat at the table, a few of these pert little fellows would immediately appear, flying in and pecking at the bread that was directly in front of us. They were bold enough to sit on the rim of our plates, sharing our rice and bacon. We had to shoo them away with our hands, as if they were flies, so that our meals would remain undiminished. After dinner, if we sat outside in the shade of our cabin to be refreshed by the tradewinds after a hard day's strenuous work, it would not be long before one of the pretty little brown birds (*Acrocephalus familiaris* Rothsch.) would appear. It would alight on an available knee or perch on the back of a chair to boldly stare at us, or sometimes just to sing us its lovely song. Once, one of these brave little songsters decided to sing its favorite tune perched upon the upper edge of the open book that I held in my hands. The finches were the best songsters on the island. Even when we caught them, they often played their vocal flutes while we held them in our hands, although I must convey some uncertainty as to whether these were indeed vocalizations of confidence, rather than expressions of a certain immediate distress. The quaint rails were our steady companions when working. We could hardly open the door of our laboratory without a few of these small fellows coming in with us, rummaging eagerly through our collections to enjoy the innumerable flies which buzzed around them. It was utterly comical to observe them as they would interrupt their hunting for a moment, in order to warble their most remarkable song, which had a certain similarity to the clanging of the loudest sounding alarm clock. When we were skinning birds, they would even hop bravely right up onto our preparation table, to pick a piece of suet or meat directly from our fingertips.

The seabirds displayed the same confidence. When we chose to walk directly through an albatross colony, some birds would give us room without shyness, but many would hold their ground so tenaciously, that we were forced to give them room in order to avoid trampling them. We often stood so close to them that they pecked, highly indignantly, at our feet, which caused us great pain, considering the size of their powerful beaks. This was the behavior of at least the young albatrosses. The adults only took to flight when they decided that we really had some evil plan in store for them. Therefore, we were able to collect all but a few (duck, *Himatione*, and those species that are only transient visitors on the island) of the Laysan birds without resorting to the help of the gun. There were times when the birds' confident tolerance of us would rapidly change into insolence. Once, a frigate bird making a quick sweep through the air, stole the cap from the head of a Japanese worker, carrying it

high into the sky, where it played for quite some time before dropping it. The bird repeated this scenario for several days thereafter.

All evidence indicates that the birds of Laysan have not learned to fear man and his activities, and that the few years during which the island was visited were not sufficient to teach them these experiences. One day, after a short signalling mast had been raised, an albatross, returning from the sea and certainly never having seen such a thing before, flew into it with such a force that the impact sheared off one of its wings, just as if it had been cut with a knife. On another occasion, a Japanese, rushing home from egg collecting with two full baskets in his hands and daydreaming about his forthcoming feast, was struck from out of the blue in the neck with such force, by a low flying albatross, that he fell forward into the basket of eggs. The activities of most of the birds that visit the island briefly, only to stay in passing, are exceptions to this behavior. Among these, the curlew (*Numenius tahitensis* Gm.) appears to be relatively bold, thereby revealing, that its home territory lies in an area that is relatively free of people; while the plover species, especially the golden plover (*Charadrius fulvus* Gm.) is extremely shy. Laysan's vegetation, lacking any appreciable cover, made very difficult to sneak upon them. To collect them, I often had to crawl on my belly over the ground for several hundred feet while approaching them, and sometimes, I could fool them by swimming toward them across the water, while they were foraging on the beach. They had obviously learned enough about man's treachery on their home grounds.

Laysan is a true bird paradise; nowhere on earth is there another place like this. The land birds occupy an inferior position, enduring their role of barely being tolerated by the seabirds who are the dominant and ruling class here. Next to the seabirds, all others take second place, and their character has a marked influence on the island. Seabirds rush here from the vast expanse of the North Pacific, to carry out their breeding duties. The island is ideally suitable for this, with its sandy soil. Many other uninhabited islands have a rocky substrate which makes them unsuitable to the shearwaters and diving birds who often require meter-deep burrows to make their nests in. Huge masses of birds come to breed here! During our arrival here when we first approached the island, we could see from quite a distance away, a veritable cloud of birds looming over the island. The flocks of storm petrels (*Haliplana fuliginosa* Peale) that were milling around in the distance, looked like a swarm of bees. It is difficult to estimate the numbers in such a multitude. The numbers making up those bird clouds, however, were probably in the several tens of thousands, perhaps even hundreds of thousands. There are some locations on Laysan where literally every square foot of land is occupied by breeding birds. It is virtually impossible, even for a cautious person and especially at night, to take a step without his foot endangering the birds. Moreover, the breeding birds are not only distributed horizontally on the island but also vertically, since they live not only next to one another but also over and beneath one another. There are wide expanses that are literally undermined by the burrows of the different species of shearwaters, especially where the sand is rather loose and the vegetation sparse. Nothing is more difficult than crossing such a place! The thin sandy covering over the burrows breaks through all the

time, leaving you with every step to sink knee-deep with one foot, and then with the other. Where the shrublike goosefoot forms thickets, there are not two, but four parties living above one another. The booby and the frigatebird make their nests on top of the shrubbery. Some of the landbirds prefer to nest deeper below in the branches (mostly *Acrocephalus*, but at times *Himatione*). Below them, shaded by the branches at ground level, is where the gorgeous tropicbirds breed over the burrows where the black shearwaters raise their young in underground apartments. And so, with the birds living in four vertically stacked levels (stories), the comparison of these bird cities to tenement houses is easy to see. Just as a lack of enough living area forces people to build vertically and live over one another, the crowds of birds overpopulating Laysan are similarly forced into selecting any available vertical space as suitable living quarters.

Despite this excellent utilization of existing and available space, there is not enough area on the island for all the bird species that breed on Laysan, to gather there at the same time. They must alternate with one another, as one species ends its breeding cycle, the physical location made available by its departure, becomes the new breeding site for another; while one species is leaving the island, another is arriving. A constant busyness of simultaneously arriving and departing breeding traffic prevails with the result that one can find breeding birds during almost all the seasons on Laysan. This phenomenon deserves special attention, even though it occurs in the tropics, where the timing of the breeding period is generally much more irregular than at our latitudes. This breeding habit, an adaptation which presumably has been developing over many thousands of years, has resulted in the existence of a very strict sequence and timing schedule governing the arrival and departure for every single species.

For several years, it has been observed that the petrel (*Oestrelata hypoleuca* Salv.), which has undermined most of the island with its burrows, arrives between the 15th and the 28th of August, without any deviation outside these dates. The evening of the 17th of August 1896 is clearly fixed in my mind. The sounds of the island birds were less noisy than usual due to the absence of both the raucous terns, who had already raised their young, and the hungry, begging cries of the thousands of juvenile albatrosses, who had said their goodbyes to this place where their cradles once stood, in their rush toward the immense ocean that would, henceforth, become their home. We traced our steps back from the promontory, where we had been trying to spot the sail of the boat that would be taking us from the island back to a more civilized port. The golden reflections of the setting sun were fading and the fine crescent of the rising moon began to glow like silver. At that very moment, my eye, which by now was trained and familiar with every movement of our sky-plowing friends, spotted a new apparition. Against the background of the fading evening sky, the sharply contrasted silhouette of a beautiful flier appeared, demonstrating its unique aerodynamic ability in flight, by slicing gracefully through the air at amazing speed without wingbeats, performing these daring maneuvers with a remarkable elegance. As it was making this abrupt and unfamiliar appearance, we knew that it must have been a new species and that we were

experiencing the arrival of this new species on the island. The next evening there were more arrivals and on the third evening, they filled the island sky by the thousands. They were petite birds, barely attaining pigeon-size, and, from that moment on, they dominated the island so thoroughly that the few remaining breeding pairs of tropicbirds, terns, etc. retreated from them, appearing distressed by the arrival of so many noisy neighbors. On land, they were nocturnal, living underground in deep burrows. By the light of the moon, we were able to observe them busily using their delicate feet to remove the loose sand which had accumulated during the year inside the unused tunnels. There were loving couples who bravely stood by their chosen piece of ground, defending a future household against intruders. They could not accomplish this without the occurrence of a quarrel or a fight, and the various vocalizations that they required. Barely two days after their arrival, the whole island resounded with these, not exactly beautiful "songs". They sang their songs under every bush, from the space between the boxes which were piled up in front of our dwelling, and unfortunately, even from under our sleeping quarters. The song's musical appreciation value falls somewhere between the sounds "that directly irritate most people into anger" and the sounds that are like the incessant utterings made by newborn babies and only appreciated by their parents. As if by some stroke of magic, the whole appearance of the island was transformed.

What an admirable drive the bird has, a drive which directs it as it flutters over a thousand miles of ocean, with an overwhelming, heartfelt compulsion to rush back to the place where its cradle once stood, in order to fulfill its parental role and duties. One is awestruck by the bird's ability to accurately schedule its arrival time, almost to within an hour; where is the compass that guides its flight through the storms and hurricanes over the vast ocean toward this tiny speck of land?

A few months later, the appearance of the island was again changed by the immigration of an even more impressive bird than the one just described. In the last days of October, the first outposts of the magnificent albatrosses appear, and a few days later, from a higher vantage point, the island looks as if it were covered by large snowflakes. There is hardly a spot from which the dazzling white plumage of an albatross does not reflect back. There are often so many of them that many must be satisfied with inferior sites, and even more are forced to move again.

Of the invasions of the other seabirds, I shall only mention the terns, because of the sheer magnitude of their invasion. During the first few days, when most of the birds are still busy searching for a suitable nest-site, the fluttering multitude of these birds cause the island to look, from a distance, as if a heavy smoke curtain lay above it.

As one can see, the struggle for life on Laysan is, by no means, easy. This is verified by further phenomena. For instance, it is curious that all of the breeding seabirds on Laysan lay only one egg, while their relatives at other latitudes have a larger clutch. One species of

booby (*Sula cyanops*), lays two eggs, but generally raises only one of the chicks. The only explanation I can offer for this one-child rearing system is that their foraging task is so difficult, that only one child can be reared, without taking too great a risk.

For a naturalist, a stay on the island is of the greatest interest because it offers a rare opportunity, seldom surpassed anywhere else on earth, to closely study its wildlife, and especially, the most intimate behaviours of its birds. In our homeland, which has been dominated for thousands of years by human culture, we are no longer able to observe animals in their natural state, because their original behaviours have become dominated by a justified shyness toward our presence; and therefore, we can only obtain the most superficial impressions of them. In contrast, the animals on Laysan behave as they really are, without any fear. They had not yet learned to consider us their enemy, and therefore, we were constantly in a position (thus unbiased) to study not only their objective behaviour, but also and more specifically, their emotional life and their spiritual character. We were amazed to discover how much direct comparison to human characteristics, we were able to observe in a creature which is generally considered, by the majority, to be a "lower" form of life. This made it simple to differentiate the birds according to their temperaments. For example, it was easy for us to identify the tropicbird as a choleric type, by observing its constant quarreling, the strict rearing of its young, and its bad tempered response to almost every little thing. This temperament was already displayed by even the smallest of their downy chicks. On the contrary, the chicks of the stoic albatross exhibit a quiet, agreeable, but somewhat feeble-minded disposition; quite opposite from the pedantic, eternally fidgeting, sanguinistic tern, which spends every day and night feverishly maintaining itself or its family. Despite its successful achievements, the tern's bold confidence lacks a reasonable sense of caution, which often leads it into many failures. The black shearwater (*Puffinus nativitatis*) however, has a decidedly melancholy disposition. It spends the day quite calmly, sitting still in its underground home. However, at night, its voice when heard for the first time, instills a horror in the listener, with a sound that I can only compare to the sighing moans and cries of lament made by a very unfortunate person who is totally depressed about his life and about the world. I can still vividly recall the strange impressions of those spooky, soul-shattering wails welling up from the ground all around us, as we rested from the heat and work of our first day, in the dark night outside of our dwelling. Indeed, only a person with a truly tortured soul could moan and groan in this manner. We now understood why the Portuguese call this bird "the souls of the damned."

Observing the love and family life of Laysan's birds is an uncommonly appealing activity. The one reason which begins and guides their journey to the island, the unconscious drive for the survival of their species, is the same reason that rules them during their entire stay there. When their goal of successfully producing the next generation, is fulfilled, most of them leave the island.

All of the seabirds on Laysan live in strict monogamy, and, as far as I could observe, their

marital relations are truly exemplary. Mated pairs cling together in tender love. This is exemplified by the shearwaters, who are not only constantly side by side, but also face one another, gazing loving, for hours at a time, into one another's eyes. From time to time, they will tenderly caress one another's neck feathers, whereupon the fondled one will respond by contentedly lowering its head, visibly communicating its appreciation. They are quite often seen billing, just as pigeons do, which is comparable to our kissing. It is a sign of tenderness that, in this act, they do not wound or hurt each other with their needle-pointed, hooked bills. And yet, I have often experienced the very opposite: a single bite was quite enough to result in a heavily bleeding wound on my hands.

Another quite charming love display is the mating flight, as I wish to call it, of the black tern (*Haliplana fuliginosa* Gm.), which I found carried out so beautifully in no other birds. On quiet afternoons, when the sun has already set, a couple will separate from the rest of the flock and, following one another, rush toward the sea, now with slow measured wingbeats, and then shooting forward, or floating away almost motionless. Then again, they perform the most daring turns, while simultaneously rising high into the air only to sink down again immediately thereafter. Male and female fly tightly above one another, and together, they carry out each maneuver in such tight precision and with such uniform wingbeats, that it seems as if their two bodies were given life by one spirit, and directed by one will. The gracefulness of this flight display is utterly enchanting, and is noteworthy in revealing the emotional life of birds. It is obviously triggered solely by passionate love and totally mutual devotion. Would we not find this enraptured, coordinated veering through the air, this delightfully rocking, and stormy, wild flight, comparable to the fiery dance of a lovestruck human couple? And how much more affectionate, how much more graceful it seems when performed by the children of the air!

The drive which governs the bird to partake in these parental pleasures must be irresistable. Albatrosses whose eggs have been stolen, will still sit week-long on the nest. I found that many of the dainty, small, white terns (*Gygis alba* Sparrm.), whose eggs I had taken away for the benefit of our museum, had continued sitting all day long, seemingly busy incubating, on a round bit of rock, and one, even on the bleached skullcap of its dead sisters. This bird also deserves our admiration in regard to its nest site. Though the breeding birds of Laysan generally do not take much trouble to artfully prepare their nests, this one goes to the extreme. She lays her egg just about anywhere when the mood strikes her. And so, one can find it on the bare sand, on the salt crust at the margin of the lagoon, on the barren rocks next to the surf, and, what is most admirable, occasionally, even in the forked branch of a shrub. There is nothing funnier than to see how the bird tries to completely cover the egg with its body in this uncomfortable position. But she will succeed, in fact, to raise a charming downy chick there, that similarly, must learn the art of acrobatics to prevent itself from tumbling from its precarious perch.

I found it touching when I once observed a tropicbird whose still tiny offspring I removed

to incorporate into our collection. The next day, she adopted the similarly aged young of a noddy (*Anous stolidus* L.), certainly against the will of its parents, to satisfy the desire to fulfill her maternal responsibilities.

Concerning parental love, the majority of the birds we observed displayed admirable selflessness. Once the young had hatched, they could not be frightened off the nest by any threat; with the boobies and the frigatebirds, we had to use considerable force to remove the violently and painfully defensive birds from their nest. The frigatebird had the most noteworthy defense, being a clever and cunning pirate which otherwise did not refrain from swallowing the unguarded babies of weaker birds, even those of its own kind.

Male and female generally take an equal share in raising the young. The parents come back from the sea with pedantic punctuality (in the case of the albatross and the black tern, between 3 & 4 P.M., the tropicbird, between 9 & 10 A.M.), with richly filled crops to feed their little ones. When the young grow larger, they have to be taught the profession, work, and skills of a grownup bird. Thus, we observed daily the terns leading their recently fledged young to the sea. The mother rushing ahead a short distance, constantly uttering its "weide-weck" ("wide-awake" in English, the German is more to the point: "away from the meadow!") call, now encouraging, then warning the young. The obedient little ones would answer with a frail "peep-peep." We could scarcely believe the size and scale of vocal expressions that this bird (and also others) used to express all the stimuli of its emotional life. It not only had numerous different utterances, but its accent was also extremely variable and a trained ear could soon distinguish, as easily as its fellow bird, whether the call expressed a desire for love or hate, a question or a demand, or an encouragement or warning. It always reminded me of a particular northeastern Siberian tribe, whose language contained a word which could express very different concepts depending upon its accenting.

Some of the birds undoubtedly possess a sense of play. Around noon, many of the skilled flyers, apparently just for fun, will rise so high into the air over the island, that they can barely be seen. They circle there for hours at a time. I fully agree with others who have witnessed this phenomenon, that the soaring flights to those lofty heights by the mighty frigatebirds, can even delight the indifferent observer. There is another aerial display that serves solely as entertainment and is even more admirable, not only because of its gracefulness, but also, I hesitate to say, from a psychological point of view. We can see, even back home, great numbers of circling storks. During the spring and summer months on the seacoast, we might even see larger gatherings of gulls circling. But these aerial dances are very plain compared to the magnificent bird-quadrille which we had the pleasure of enjoying on Laysan. During the midday hours on relatively calm and warm days, we saw what began as a mostly disorganized flock of terns, often counting into tens of thousands, become reorganized into the discernable shape of an enormously big cylinder, its lower end near the sea surface, its upper end rising to considerable heights. At its peripheries, thousands upon thousands of birds moved in and out, so that they flew alternately, from one side to the other.

All this commotion took on an ordered appearance, making it look like the well-choreographed turns of a round dance. Aside from the circling movement of the single birds around the surface of the cylinder, the whole bird mass pushed up and down in rhythmic waves, while also proceeding forward according to slight variations in the wind current. It is easy to understand that every one of the thousands of birds described an extraordinarily complicated flight line, yet the whole flock looked rhythmic and harmonic. When the young began to fledge, they were a funny sight to see as they tried to participate in this formation, but most often, blundered and were forced to veer off. It was very unusual to observe that not just the one bird species carried out this flying dance, but was often joined by a substantial number of frigatebirds. Normally, they do not live on good terms with the terns at all, but for some reason they will amicably participate in the game. These two species always formed the great majority of the spiraling flocks, but occasionally, single tropicbirds, white terns and boobies were seen; and sometimes, an albatross also flew with them.

However, bird life is not always that idyllic on the island; often quarrels and fights prevail. Most are occasioned by that highwayman, the frigatebird. In its other habitats, it must procure its food from the sea as other seabirds do. Here on Laysan, I have come to know it only as a robber. When shearwaters, boobies, and tropicbirds return with their crops loaded from fishing, the thievish frigatebirds, spying them from afar, attempt to acquire their quarry by force. They attack their victim with a dashing flight, having a velocity unparalleled by the others, reaching it like an arrow and pinching with their long, scissorlike and hooked bill until the victim empties its full crop to lighten itself. Like a bolt of lightning, the robber shoots behind it, and the tidbits gets buried in its insatiable gullet before reaching the sea in its fall.

It is surprising that the frigates only pinch and nip the smaller birds but never seriously hurt or kill them; otherwise they would rob themselves of their providers. I often viewed compassionately as tropicbirds, having spent perhaps half a day fishing diligently, were forced in the immediate vicinity of the island to pay their tribute to the robbers despite all their skills and efforts, only to arrive with empty crops for their young. They crawled sadly beside their hungry chick, which looked on in surprise at the mother who was forced to delay the desired meal. The chicks becoming impatient, pushier, and more demanding; finally received some rough bill-blows instead of the much hoped for food. It was a sorry day for the family; the chick had a hungry stomach and the old ones had a greater burden.

I want to close the description of the bird world of Laysan with a few episodes from the life of the albatross. During our stay, their very small, quite helpless chicks grew considerably. Behind each tussock of grass, one could see the trusting face of a well-nourished albatross chick, which appeared as quite a comical sight, especially when the downy hood on its head was blown up by the wind from behind. Every one of them looked identical, at least in our eyes, though not for their mothers, who, when returning well stocked from the sea, could soon spot their own little one among the thousands, even if it had

wandered a little instead of waiting at the usual place where its cradle stood. At times, we observed some quite comical scenes, as a number of young would gather around, and beg for food from any albatross bringing it in. The adult would tolerate this for a while, and then, disturbed by the impertinence of today's youth, would raise her head and neck up vertically, uttered a howling call of complaint, and thereafter avenge the vexing crowd with blunt strokes of her bill. Only by doing this, did she get enough room to feed her own chick. Having achieved that, she would crouch down beside it, and then the family could enjoy a few pleasant hours in happy togetherness. The wing quills of the chicks grew gradually and they exercised their power daily, unfurling them and rushing along over the sand, leaping into short flights. At the same time, a yearning for the sea began to awake in them. Every day they pushed closer to it, and it was surprising to observe that, even those which could not see the coast from their location, took the shortest route to it. Once they reached the beach, they did not stop there but trusted themselves to the desired element. Quite often, they had to pay with their lives for this first daring step. One could find the corpses of not quite fledged albatrosses after heavy weather, especially in places where there had been a heavy surf on a steep shore.

To summarize the life of this bird on that island, we are forced to compare it with the human condition. Those that arrive there first may choose for themselves the best places on which they can raise their young easily and safely. Their chicks will thrive successfully and will transition well equipped into adult life (Berlin West!).⁴ But the last arrivals, regardless of the reason and fault for their delays, must choose from among the worst places, often the shores of the lagoon consisting of pure salt which, after even a short rain, becomes covered by a sticky, lye-like ooze. Here is where most chick casualties are found, with their plumage ruffled and feet wounded from the action of the concentrated brine. Here is where the highest juvenile mortality rate occurs (as with the most miserable basement tenements of the poorest inhabitants in a big city). But quite often the offspring perish because the parents find the struggle for survival too difficult. They become delayed by storms which drive them far away, and when they finally make it home, they find their chicks dead from hunger or thirst, if not altogether missing, the relentless waves having already prepared for them an early grave. Thus it seems that richness and poverty, luck and misfortune on this earth, whichever it may be, is partially self-inflicted, and partially the necessary outcome of environmental conditions that affect all beings, and that are stronger than their own natural abilities. All must submit to these conditions, for there is no escaping them; no matter how much a higher justice may feel indignant about the situation.

The rest of Laysan's fauna, though very valuable to the researcher, does not have many

⁴Berlin West must have been a fashionable suburb at Schainsland's time; comparison with the slums follows below (Translator's note).

noteworthy peculiarities of a more general interest. For this reason, I shall only report briefly about it. Seals occur singly but quite rarely on the island. Turtles (*Chelonia viridis* Schn.) however, are numerous on the coasts of Laysan. One can often see entire groups frolicking about in the clear current, especially in such places where the rocky coast has formed a steep ledge. If it is justified to refer to the flight of some birds as swimming, then it may not be altogether unfitting to compare the swimming of turtles to flight, especially when they flutter up and down with their heads through the clear waves. They possess a considerable swimming ability, venturing into the strongest surf without any harm at all. Moreover, I never succeeded to capture them in the water; even when I could tell from the reddened water that my bullet had struck home. They just swam away quietly as if I had not hit them. But this does not seem so remarkable knowing how tenaciously they hang on to life. We discovered with horror that there was no way to kill a captured one. They will even produce life signs when decapitated, or when their hearts have been removed. However, we were able to catch many on land when they crawled up onto the beach at night to lay their eggs, although nowadays, this happens less frequently, because the sea turtles are more cautious than they were before, when human visits were less common on the island.

Those dark, cool evenings when we spent hours waiting for them, crouched motionless, flat upon the sand, often wetted by a higher splashing wave, will become lasting memories. Never before have I been so excited at hunting a noble game, as at the time, when, after a long wait, the eye, which could hardly penetrate the darkness, caught sight of a black mass, hesitating and, with a snail's pace, glided out from among the waves. We had to take care not make even the smallest motion or the slightest sound which might arouse the suspicion of the animal, which is equipped with very sharp senses despite its dull-witted behaviour. Only after it had distanced itself quite a ways from the sea, often after a good hour, did we dare to jump up, hurrying as fast as possible in an effort to throw the colossus on its back, despite the raging threshing it made with its giant fin-feet. When you look in the Museum at the huge specimens that we collected from Laysan, you will understand that I could often not tackle them alone but needed the assistance of my wife. Once turned onto its back the turtle was completely helpless (except for its giant parrot-beak which we had to watch not to approach too closely). But if it had gained enough time to turn toward the sea again, and get its front fins into the water, the power of several men was not enough to restrain it.

Though the turtles came to land solely and entirely for egg-laying purposes, we were surprised when, several times, we caught males. Would they perhaps have been helpful in digging out the deep hollows which would receive the eggs? By the way, I was never able to find such nests complete with contents. And so, I was delighted when one day we caught a turtle containing in its innards several hundred ball-shaped eggs, covered with a white flexible membrane, about the size of those of the domestic hen. We carefully collected and buried them in the sand about two feet deep. I must have found the right depth because all eggs developed further. The last ones which we took from the artificial nest just before our departure, already contained tiny ones, which, when put in water, swam around happily. You

can understand the pleasure I felt then, as a stepfather and embryologist, when I thereafter came into the possession of a complete, and scientifically very rare, material for study of their developmental history.

The sea around the island was crowded with fish of many different species. I have been able to gather a large collection, some of rare and hitherto unknown species (18). Most pleasing to the eye are the kind that are adorned with lively colors, observed elsewhere by us only on flowers and butterflies. They dash around the coral rocks and are therefore also called, coral fish. The curious pipefish was present in schools and provided us with many tasty dishes. But, we carefully avoided eating the poisonous flesh of a remarkably blown-up fellow, the porcupine fish.

Corresponding in numbers to this multitude of smaller fish, were their enemies, the sharks (*Carcharias gangeticus*, and *Carcharias* sp. ?). They were really so numerous at one place on the reef which they had chosen for their residence, that we could count hundreds of them at low tide, when they swam to and fro right under the surface with their dorsal fins sticking right out of the water. Quite a number of them are now hanging in our Museum and, upon viewing them, one is easily convinced that there are some really big members among them. We caught them, mostly by wading up to our hips into the water, and then hurling a harpoon on a line into the nearest one. If it hit its target it became highly advisable to immediately climb up onto a coral block, because as harmless as they appeared before, a great frenzy broke out soon followed. I firmly believe that among the sharks, as is also reported about the tiger, there are special man-eaters, which prefer catching this noble prey after they have tasted its tender meat the first time. Apparently, none of the sharks had yet tasted it, because, although we refreshed ourselves every evening with a swim in the lukewarm water, we remained unharmed. We also heard that during all of the time that the guano workers visited the island, no shark attack on humans was ever reported. By the way, the shark disappears from the vicinity of the island during some winter months, when it presumably descends to deeper waters to deposit its young.

To the contrary, another leviathan, the ray (*Aetobatis Narinari* Euphras.) with its broad, square, platelike fins, appears only for a short time off the coast where it deposits its two young off in the shallower water. These young look very amusing, having a thin tail, which is many times longer than their body. They presumably inhabit greater depths where they feed on mussels using sizeable bony mandibular plates, which they have instead of teeth. During some August days, when the trade winds had stopped and the sea looked like a mirror, except for the ceaselessly pounding surf, we noticed a sudden foaming of the water at the margin of the reef, quite far out; they were skates, ascending from the depth and lashing the surface of the sea with their huge winglike fins. We quickly launched a boat and tried to approach with silent beating of the oars, to within harpoon-throwing distance. Quite often, we missed but on a few occasions, we were able to bring home this heavy fish, often weighing several hundred kilograms. I was fortunate beyond all expectations when, in the

last catch, I obtained a pair of recently hatched, newborn young as well.

With this, I will terminate the discussion of the fauna and want only to note that the lower land animals are poor in species but extraordinarily rich in numbers. For instance, a simple gray moth (19) appears, at times, in swarms of several thousand individuals, providing almost the sole food supply for some of the land birds (for example, *Acrocephalus*).

It would be wrong to imagine that the island is only attractive to the natural scientist. On the contrary, every friend of nature would find unexpected enjoyment in it, if he was also able to recognize its beauties as they are displayed in other than "the usual old garment." Truly, it is a hard beauty, that surrounds us here! The impressions, called forth by the roaring of the surrounding sea, the white sands, the pale green vegetation, all remind us somewhat of the magnificence of the desert. The colors that we are able to observe on the island, in the sea and on the substrate, have a wonderful splendor. While as a rule the whitecaps contrast blindingly with the dark blue sea, when the sun stands high and the tide is low, in the places where the sea bottom is sandy or at least not covered with plant growth, the water shifts into a lovely green color, as the bottom reflects back the intense, penetrating light. When at sundown, the clouds of the western sky radiate a golden, violet, yellow or even greenish light, while the eastern horizon takes on an almost threatening blue-black hue, here and there mellowed to light blue or dainty pinkish, words can only touch upon the nuances of the true colors. The night sky was also especially clear and beautiful, perhaps because the white sand reflected and magnified the moonshine, making it seem almost like daylight, or perhaps the stars shone against the dark ground. Even the Milky Way here looked like a fully lit-up cloud: its mild glow brightening the sky, and even the famous Southern Cross faded before its beauty.

The esthetic impression which the island commands is quite sobering and really very grandiose, perhaps also magnified by the thought of the loneliness and solitude that is this tiny grain of sand island amidst the vast watery desert. It was just exactly this that had considerable influence on our spirit. I never understood so well Rousseau's exhortation about returning to nature as I did right here. Here, we learned to understand anew the language of nature, which rarely rings in our ear amidst the noise of culture and civilization. Here we feel like we are back in our true home, withheld from so many of us during our peregrination through modern life. Every one who, like me, enjoyed the good fortune of delving for a time in such a solitude, only comparable with what we find in the desert, would agree that the impressions acquired here would last for a lifetime. The thoughts we had there were more serious, and even perhaps deeper; the pettiness of everyday life disappeared and the dissonances resolved themselves.

As I already mentioned, we enjoyed in many odd ways the hospitality of the company since we left Honolulu.

We lived next to the inspector's building, in a neat room constructed of boards. A small space in the "lighthouse" served as our laboratory. The numerous chests and boxes of the

travel equipment stood outside, in the open, covered by tarps. Our rich and good fare consisted mainly of canned food; yet the tasty bird's eggs, the gourmet "kolios" (*Numenius tahitiensis* Gm.), and fish and turtles added the necessary fresh nutrition. Respecting the otherwise very highly esteemed turtles, I must note that they lose their high desirability after having been consumed frequently; on Laysan a variant of "toujour tortues" as an "aside" was at times well justified. Since there was no consumable plant on the island, we were forced, especially in the beginning, to get used to the lack of any kind of fresh vegetable or fruit.

The drink situation was not as good as the food. Water on the island is brackish, one relies solely on rainwater gathered from the roofs. Since they had been freshly pitched just before our arrival, one can imagine that our drinks were not exactly tasty. At times, when we were sitting at our work and felt unbearably hot, we found pleasure in elaborating upon the inhumane idea of how nice it must have been in the chilly halls of the Löwenbräu Cellar in Munich. To top it all, at the beginning of our sejour, a very long drought prevailed, which had already killed almost everything green on the island. Little water remained at the bottom of our tanks and washing etc. with fresh water ceased to be possible early on. We were already anxiously thinking about the future. How we rejoiced when, one night, we awoke to the drumming of heavy raindrops on our corrugated iron roof and found the containers filled to their brims the next morning.

In the beginning of our stay, I would spend the early morning hours strolling across the island, bringing materials, birds, etc. for my assistant, i.e. my wife, to work on. Day in and day out, she would painstakingly prepare the specimens truly by the sweat of her brow as long as daylight lasted. Later in the morning, I would rush to somewhere on the reef and spent many hours half or totally submerged, weeks at a stretch. I couldn't believe that it was possible for this work to exhaust even a strong body. I mostly observed, after coming out of the lukewarm water, that I had to throw myself totally exhausted onto the sand. I believe now what someone said to me later in Honolulu, namely that beginnings such as this almost always lead to a heavy, or even deadly, fever.

We should not at all suppose that the activities of a busily collecting naturalist are easy in the tropics. Totally apart of the work in the water (which by the way was absolutely necessary for it was impossible to catch anything with a net amidst the pointed coral branches), the novice needs a considerable degree of strong will to amble about the totally shadeless island in the burning heat of the sun, wading through deep sand, breaking through, kneedeep into subterranean burrows. Every activity with which one is used to having helpers, must be carried out with one's own hands, in the open without shelter, from soldering tin cans stuffed with specimens, to hammering steel bands onto the chests, filled for the long transport across half the globe.

There was one circumstance that nearly brought us to despair while working. I'll not lament about the incessantly buzzing fly swarms, nor of the inch-long cockroaches, which

not only ate our candles and bookbinding covers while we slept, but also our very own fingernails. Instead, I'll complain about an insect (*Dermestes domesticus* Fb.), which perhaps does not occur anywhere else in the world in such multitudes but which housewives find once in a while in their pantries, a small blackish-brown beetle: the carpet beetle. Castaways probably introduced the first ones to the island. Since they have an unending food supply here in form of bird carcasses, and a lack of any population of insect-eating birds to keep them in check, their numbers have increased into the billions. We had hardly finished the tiring work of preparing a bird specimen, poisoning it with three times as much arsenic as usual, when columns of this tiny pest came dashing over to it, trying to annihilate our work. Too often, they succeeded because the drying of the skins was retarded by the humid sea climate, and the poison lost its power on the areas that remained wet. On days when the trades did not blow with their usual force or stopped entirely, and the oppressing air alone was hard to bear, their plague became altogether intolerable. Before, the wind hindered their flight, but now they would come streaming into our habitation, like entire armies, and even attacked us, considering our hair to be something palatable. During the evenings of days like these, we had to literally sweep out the hordes from our stores. What these tormentors had not ruined of our preparations, were eventually consumed by the ants; [a quite tiny species (20)] which, once their pioneers reconnoitered the whereabouts of our treasures, rallied in whole armies to the war of annihilation. I often found my wife in tears over the lost efforts. In the end, the only thing left for us to do was to hang all bird specimens (there were hundreds) singly on wires which were poisoned with mercury, making even this narrow bridge impassable to them. Evenings were mostly devoted to rest after the days labor. The main meal was eaten about sundown, and thereafter, we would sit quietly in front of our cabin. The nights were always cool and pleasantly refreshing. These evenings of rest were among the nicest times we spent on the island. Since we had a clear view of the sea and the western horizon, every evening we would admire the diversely changing, yet always equally beautiful, color display conjured up by the setting sun and the reflexions in the sea, a display which was not supplanted by the dark night as quickly as elsewhere in the tropics. There was on Laysan, a real twilight, when the sun had just finished glowing and it gradually became dusk; the evening star lit up with such brightness that tall objects cast a shadow against its light. These were the moments when our thoughts rushed homeward. We would intentionally not discuss our children in order to decrease our longing for them. Yet, how ardent was our unspoken wish that the same benevolent star, which beautified our evenings, would smile at the other side of the earth on the small beds of our two little ones, and awaken them to a new day filled with joy and good health!

As nightfall became darker and visual stimuli became weaker, those for the ear increased. The surf sounded gentler becoming a monotonous rhythm; from above, one could heard the cheerful call of the never-roosting terns, and all around us, the wailing moan of the shearwaters resounded. All foreign sounds, even the music of the Portuguese chime of the inspector, which sometimes played wild and at other times melancholy tunes sounding very strange to our ears, contributed to making these nights feel even more peculiar.

Not far from us, a simple cross stood over a lone grave. Some years earlier, a man was left behind to watch the properties on the island during the winter, as opposed to the multitudes which are now left to guard them. Seven months later when the next ship returned, he was found in the same cabin which we now occupied, dead, in front of his diary which had entries up until 14 days before he was discovered. They buried him right there on the beach. Shortly after our arrival, as we looked with sadness at the quiet grave, the dark outlines of the cross filled me with horror. After the barque left the island having brought us here to fend for the next months entirely for ourselves, my wife came down with a serious disease. How horribly the anxiety gnawed me as I imagined in the twilight, a second cross there! The strong physique of my wife overcame the sickness though, and in eight days, the danger was over.

We had counted on about two months between the time of our arrival and the return of the ship. These months had come and gone, and we searched the horizon daily, but in vain, for the appearance of a sail. Thus, the last part of our stay became less pleasant, since our work was mostly finished and there was not enough to keep our minds busy. And so, after many weeks passed, we began to fear that the ship had met with some disaster. It had happened just a few years earlier to the "Wandering Minstrel" as it became stranded on neighboring Midway Island. The captain and his wife, who were the sole survivors, were forced to live for 14 months on albatross meat in this entirely barren and, compared with Laysan, quite desolate island, until they were rescued entirely by chance. Finally, one afternoon, as I again stood at the lookout point, I noticed a white point appearing on the horizon which could be nothing else but the sail of our barque, shining in the afternoon sun.

Even the great joy occasioned by its arrival became somewhat dampened. From the moment that the ship appeared before the island, the weather changed, although up until that time it had been quite steady. The trade winds stopped, replaced by winds from different directions, making a landing on the island risky, or even impossible. It was a phenomenon that we had never observed before during this time of year (September); it normally occurred only in the winter months. The winter on Laysan generally differs from summer mostly in its lower temperatures (21). Our past experience of the island's constant and temperate summer weather, was that it did not pose any danger, even to the Guano Company's larger visiting ships. This year however, as noted, the weather deviated from the norm. The barque that I sighted wanted to land at the "landing" on the west side of the island, but the wind and weather became so bad that it had to retreat, and much to our regret, was forced to cruise in front of the island. Finally on the third day, the captain succeeded, with a beautiful maneuver, to anchor at just the right spot and secured the ship. But the weather did not improve; it was either stormy or dead calm. When the mighty western swell was not held back any more by the eastern trade wind, it found its way unobstructed and caused the ship to roll to such an extent, that the sails almost touched the water every time they were hauled over. No wonder we rushed to the window daily, at the crack of dawn, to see if anchor and

tow had held, or perhaps to see if our ship was perched upon the reef. But it held its anchorage steadfastly, and even while being loaded by the guano scowl, although this was accomplished at a slower and more difficult pace than usual.

On the evening of September 22nd, we received an unexpected message from the captain, saying that we must board at once. He wanted to sail away immediately before the masts were ruined by the extremely strong rolling action. We rushed to get ready, gratefully shook the hands of the inspector who would stay with his family and a dozen Japanese (all others came with us), and left in the small boat, as the last rays of the setting sun once again displayed the unique splendor of the island. Anyone who knows what it's like to climb the rope ladder up the side of a violently rolling ship, will understand how relieved I felt when I saw my wife safely on deck.

But our departure from the island was to be further frustrated. After we boarded, the weather became completely calm, and for better or worse, we were forced to lie around almost two full days.

A few people who never get seasick, might find the sojourn on a heavily tossing ship pleasant, but almost no-one could find any pleasure in remaining stalled, at anchor, while being rocked to and fro from deck to water level and back again. Under these circumstances, there was no way for us to get any sleep for two nights. Finally, 40 hours after we have boarded, a favourable current of air, which could drive us away from the island, arrived. It was cleverly utilized, the tows were untied from the buoys, the anchor was weighed and we floated happily away from the menacing reef. From the top of the "lighthouse", the people remaining on the island, waved the last greeting of the flag. We now understood completely the meaning of the kind of courage that was required to stay there in total solitude for 6 to 8 months, completely separated from the rest of the world.

As the lovely island gradually disappeared from sight, we were happy that the first hour of the journey went so well. But I was especially moved when I read later in the diary of the inspector, about September 25th, 1896: "It was lucky that the barque got away from the island yesterday; today it would be sitting on the reef; the surf is as high as a house and our harbour a single white foaming mass."

In our hope of making the return journey, if not in the same time as our outbound voyage, since the trades now blew against us, but perhaps in twice that time, we were bitterly deluded. We needed four entire weeks to put behind us that approximately 890 nautical sea-mile stretch of ocean. This was not unusual, since the weather hindered us with tiresome regularity being either calm or stormy, but always blowing from the wrong direction. We had to exercise great patience! Another form of sailor's virtue was to eat salt meat; we had plenty of opportunities to practice this virtue. Our normally pleasant memories became somewhat disturbed by the Japanese ship's cook, Matsuda. There were times when I really

wished that the very tolerant captain would act upon his threat to "throw him before the headwind." For example, one day this peculiar culinary artist ran short of yeast. He continued baking though, as usual, which resulted in the bread having such a solid consistency that, in the event of carelessly dropping it, it would have been falling like a stone and crushing our tabletop. We set our highest hopes on a few stately roosters which we had visualized with longing glances, for weeks at a time, that they would serve to us for a Sunday meal. But the "son of the rising sun" cruelly betrayed us. The *pièce de résistance* of his art consisted of an endlessly thin gruel, in which lonely remains of the deceased birds swam. We attempted to substitute for the missing enjoyment theoretically. While confined in my childhood to a strict and tedious diet, I found solace in reading Voss' "Louise" and amused myself by vicariously consuming the tasty meals that the good minister's family often enjoyed. Our reading material on the ship was not that classic. Fortunately however, my wife found at least one magazine from home in our cabin, which in a philanthropic way, described in detail a number of fine dishes to be enjoyed by ladies. We often read aloud these pleasant tidbits to one another, and thereby, distinctly awakening in us the most soothing of gastronomic feelings.

These small deficiencies were nothing compared to all the friendliness we received. How can I find words to praise you, you most excellent of all captains, Andreas Barber! How we rejoiced every evening when you amused us with your fabulous storytelling talent and your inexhaustible humour; how you amused me especially, allowing me to temporarily forget my bed of pain. I suffered during the whole journey, from rheumatism and furunculosis resulting from my diving work and various kinds of overexertions. Skits about the instructive activities of the honourable professors Breusing and Romberg were alternated with stories about the hilarious pranks of Messrs. Novice Sailors, and the more serious adventures of a sailor life. But when heavy weather arrived, and it came often, we felt snug and calm under the guard of our captain.

Little else can be recounted of this journey. We did not expect, as fictional stories would have us believe, that the tropical sea would be so richly bountiful. The part of it which we plowed through was like a desert. Only now and then would a flying fish dart across our bow, soon to fall back, fluttering, into its element. Once, we were able to observe the exciting hunt of a dorado (*Ciryphena* sp.?). This beautifully shiny raptor fish was chasing a flying fish. These apparently evolved their flying ability for the exact purpose of escaping the pursuits of their voracious relatives. Even this skill did not always help them. The flying fish had barely risen up from the surface of the water, when the dorado, with a forceful leap, also made its appearance. Although it lacked the ability to pursue its prey in the air, it could locate the exact spot where the prey would fall, arriving there by swimming in a straight line, almost paralleling the flight of the pursued. This was repeated several times, the flying distance of the pursued becoming shorter and shorter, the leaps of the predator, wider and wider, as it chased its prey like a tiger. After a few minutes, neither of them showed up anymore. The flying fish had found an early grave.

One afternoon when complete calm prevailed, we saw one of the mighty octopuses. Though not as big as the floating island in the legends about Krake the sea monster, still, it must have measured 7-8 meters in diameter.

Since calm weather often prevailed, I was able to use the net to collect those tiny, transparent beings that often filled the water in stupendous numbers. Most of these barely visible plankton (22) animals were able to glow so brightly at night, that when a great mass was gathered in the net, one could read boldy printed letters by their light. Often, we also found the tiny insect (*Halobates sericeus* Eschr.) in these catches, a close relative of the water strider, which we see gliding away on the surface of our creeks and ponds and which adapted to life on the vast open ocean.

Our longing for land increased gradually as we neared it. Again, we sighted birds more often, but the resentful wind somehow always retarded our passage. Then, on the 27th day after we started, the vague contours of a mountain range emerged from the cloud masses on the horizon. This was the precipitous coast of Kauai. The next morning saw us in the immediate vicinity of the pretty Koko Head of Oahu. In front of us towered the silver-shiny forehead of Diamond Head which still hid Honolulu from view. To the right, a black, white & red flag stuck out from the dark green coppice of coconut palms in the Isenberg property of Waialae; it was hoisted up and down three times! We were astounded that the first welcoming greeting came from Germans. Soon we had a small steamer at our side and in a short while, were able to hop on land. The following day was the beginning of a southern storm. Had we not landed then, we would have had to cruise for another week within sight of Honolulu.

Years have elapsed since then, but we still experience in our dreams those extraordinary times. In our minds, we can see the spray of the mighty surf; inhale the intoxicating fragrances of the lovely flowers; and hear the songs of our bird friends. The feelings we have are of a longing, yearning desire to be on that tiny island amidst the imposing solitude of the ocean.

A p p e n d i x

The scientific results from my collections will be published (and have already been partly published) by the various collaborators; thus I will restrict myself here merely to a few data.

The numbers (1 to 22) you find here and there in the previous text refer to the bold numbers of the notices that follow.

1) p.1. The islands lying NW of Kauai, enumerated from E to W, are as follows /Compass directions shall be abbreviated by the translator/ (elevational data in English feet following the English Admiralty Chart of 1895; cf. also the few data in: Report to the U. S. Bureau of Navigation, December 1867, by Capt. Wm. Reynolds):

1. Bird Island (Nihoa); extremely steep, entirely volcanic rock, its highest elevation is 903 ft; about 3/4 naut. mi. long and 1/2 naut. mi. wide, entirely without coral formations although on the chart there is often a remark at the depth locations such as "corals." For example, "at a depth of 21 fath off the N of the island 1/2 naut.mi. from land; at 22 fath to the E 1/2 naut. mi. from land; at 11 fath to the S 1/2 naut. mi. from land; also at 23 fath likewise to the S 1 naut. mi. from land."

2. Necker Island, a longitudinally stretched, 1/2 naut. mi. long, 1/8 naut. mi. wide and up to 300 ft high volcanic rock. In the N the chart indicates coral rocks very near the coast at a depth of 2 to 8 fath. I do not know whether they are part of a living reef.

3. French Frigate Shoal; an isolated volcanic rock of 120 ft height and several lower sand banks which are situated in a large lagoon surrounded by coral reefs.

4. Gardiner Island, a sugarloaf-shaped, 170 ft high volcanic cone, on the NW corner of which towers one more, isolated, volcanic rock. Apparently without coral formations.

Whereas, with the above islands, the volcanic rock is still visible, this is not the case with the following ones. These are pure coral islands.

5. Maro Reef. An about 7 naut. mi. long, 6 naut. mi. wide reef which does not reach the water surface. Whether it is a coral formation (which is very likely) or not, I do not know.

6. Laysan, 25 ft high.

7. Lisiansky, about 50 ft high; it is similar to Laysan in its composition in that it is a compact coral island girdled by a strand reef. It seems to have no water-containing lagoon.

8. Pearl and Hermes Reef is an atoll formation with a perimeter of about 42 naut. mi., with 4 or 5 lowly sandbanks lying in the enclosed lagoon.

9. Midway Island. Likewise is an atoll formation. Inside of the reef (18 naut.mi. in perimeter) there are two elevated areas of which the one, Green or Eastern Island (5/4 naut. mi. long, 1/2 naut .mi. wide and up to 15 ft high) is covered with thick vegetation (*Scaevola*, *Eragrostis*, etc.), the other (1 1/2 naut. mi. long, 3/4 naut. mi. wide and up to 57 ft high) is almost without any plant growth.

10. Ocean Island, the last of these islands, (at 28° 24' N. Lat., and 178° 27' W. Long.) is an atoll formation very similar to Midway, with a reef of almost 15 naut. mi. in perimeter.

Morell and Beyer Islands which are also on the chart, cannot be found nowadays (Dr. Averdam, 1898) and seem not to exist.

Apart from those found on Laysan, I was only able to study, among the above islands, a few rock samples from Necker Island by the courtesy of Dr. Averdam. This island consists only of eruptive rocks through which basaltic threads and veins pass. On some slopes there is a curious iron- and clay-phosphate soil with about 40% phosphoric acid and very little limestone. This occurs in relatively large amounts upon the volcanic rock and is a product of decomposition (of bird excrement and bones). The other volcanic islands, Bird I., French Frigate Shoal and Gardiner I. are geologically and mineralogically similar to Necker I.

2) p.8. These tubes, stacked in sand, often reach the length of several meters while their diameter can be up to 5 cm and their lumen up to 2.5 cm. Often, though not always, they are dendritically branched. They could not be lightning tubes since the sand kernels are not melted together.

3) p.8. In the N of the island, at the bottom of the slope of its highest elevation, I excavated at a low site richly covered by growth of *Scirpus laevigatus*. According to my information, there should have been a coal deposit there. Beneath a humus layer I found first sand, then a hard mass of marble-like material, and finally, in not inconsiderable amounts, peat (mixed with some sand), consisting of long plant remnants in layers (*Scirpus?*). I could not penetrate this mass of peat deeper than 1 to 1 1/4 m because of the rapid flooding of (slightly brackish) water.

4) p.8. The analysis of some probes of exploitable guano yielded the following proportions of phosphoric acid and limestone: 1). Brown guano (lying on the surface) 11.5% P₂O₅, 48.64% CaO. 2). Light colored guano 36.99% P₂O₅, 33.30% CaO. The rough Laysan guano that was freighted away contained on the average 25-30% phosphoric acid.

5) p.8. It appears that these brimstone pieces have been deliberately collected by albatrosses, perhaps to stimulate their digestion. Smaller pieces have been also a part of the food mash with which the older birds feed their young. Yet, I would not want to state that all the brimstone found on Laysan had reached the island in this way. During my stay, I never found any pieces on the beach, they were always in the interior of the island, partly on the surface, partly in the guano pits.

6) p.8. 1,000 cc water taken from the lagoon of Laysan in August 1986 contained: evaporation residue 165.8 g, lime 2.9 g, magnesium 10.3 g, SO₃ sulphuric acid 11.2 g, chlorine 86.7 g (corresponding NaCl 142.4 g). For a comparizon I submit that water from the salt lake Moanaloa near Honolulu, taken in June 1896 contained chlorine 139.3 g, corresponding NaCl 229.4 g. Besides, the water is very rich in magnesium. In spite of this high saline content, I also found *Artemia* here. The organisms in the lagoon of Laysan mentioned above on p. 20 are the only ones occurring there. It goes without saying that coral formations do not occur there.

In the surroundings near the lagoon, where there is already plant growth (*Cyperus laevigatus*, etc.), in addition to an amphipod, the tussocks of these plants are inhabited by an earthworm (*Pontodrilus ehippiger* Rosa var.n. *laysanianus*).⁵

7) p.9. Both algae which occur in the lagoon represent not only new species but new genera. *Chondrocystis Schauinslandi* Lemm. nov. gen. et spec. forms hard, cartilagelike, sometimes several feet thick, more or less rosy colored masses. It occurs in the water and also on the shore of the lagoon as long as their is moisture. In this latter case, the alga is mixed with crystallized salt and thus thrives here in a completely saturated brine solution. The second form, *Coelosphaeriopsis halophila* Lemm. nov. gen. et nov. sp. consists of hollow spheres that float in the water of the lagoon.

8) p.9. On the driest strands of the lagoon which are only flooded at high water, one finds rock fragments which, in places, are peculiarly kidney-shaped, in other locations, they form coherent rock benches, up to 45 cm high. These benches consist of almost half of Calcum carbonate, besides having a very large content of magnesium. If the future, thorough analysis shows that this rock has a dolomite-like character, this would then be evidence that in waters with strong magnesium content, dolomite-like rocks are being formed even today.

9)p.9. This "beach canal" separating the reef from the island, is missing only in some

⁵Michaelsen, Oligochäten von den Inseln des Pacific. Zool.Jahrbücher Syst. 12th Bd. 1899.

parts of the S and SE side. The biggest opening of those which break through the reef (mentioned on p.9), is on the W side, hardly 3/4 naut. mi. away from the NW point. This is now almost exclusively used for mooring of the guano-loading ships (especially since, with the dominant NE trade winds, there is almost always calm water here). These ships find, at a distance of not quite one naut.mi., good anchorage in 8-12 fathom water here. There is a second, similar, passage on the opposite (E) side. In addition, there are two smaller ones on the S and N side.

To date, unfortunately, there are not enough depth measurements in the proximity of Laysan. Still, according to the measurements of Capt. Brook in 1859, there is a 5 naut. mi. wide bank with 14-20 fathom-deep water outside the reef, but nearby, the bottom seems to sink into the abyss quite abruptly. Capt. Barber (Bark H. Hackfeld) measured in 1896, off the W of the island, depths of 45 fath, 5.5 naut. miles off 5.5 naut. mi. from land, and noted depths beyond recording limits 6.5 naut. mi. off the SW and 6 naut. mi. SE of the island.

10) p.10. To date, only the larger forms of sea shells from Laysan's reefs have been identified (by Prof. von Martens), therefore, I am omitting a listing of these. "Most of the species identified so far, are widely distributed in the coral reefs of the Indian and Pacific Oceans. Some, already known from Mauritius and Madagascar, testify to the homogeneity of the fauna of these coral reefs. *Strombus aratum*, *Cypraea tessellata* and *C. sulcidentata*, *Nerita picea* and *Littorina obesa* are more rare and seem to be restricted to Polynesia and, are all absent already in the Malayan Archipelago. The occurrence of *Latyrus nodatus* Martyn is very interesting since its home was not well known until now, although it appeared in the European collections already from Cook's material, though rather rarely."

Of the Opisthobranchs⁶, numerous *Aplysias* occurred on the reef, up to 20 cm in length. I also found there the very interesting, hitherto hardly known *Chelidonura elegans* Bgh, further pleasant *Hexabranhus lacer* and *Samta annuligera* Bgh., nov. gen. et spec.

Of Polyclads⁷ *Thysanozoon Brocchii* Grube was not uncommon on the reef.

11) p.10. Major Th. Reinbold worked up my algal collection.⁸ I collected the following sea algae from Laysan:

⁶ R. Bergh, Malakologische Untersuchungen, 1899.

⁷ M. Plehn, Die Polycladen der Sammlung Schauinsland. Zool. Jb.Syst. Abh. Vol.12. 1899.

⁸ Abh. Nat. Ver. Bremen, Vol. XVI., Issue 2..

<i>Ulva rigida</i>	<i>Liagora coarctata</i>
<i>Halimeda opuntia</i>	<i>L. valida</i>
<i>Dictyosphaeria favulosa</i>	<i>Laurencia obtusa</i>
<i>Microdictyon umbilicatum</i>	<i>L. vaga</i>
<i>Caulerpa racemosa</i>	<i>Amansia glomerata</i>
<i>C. pinnata</i>	<i>Polysiphonia polyphysa</i>
<i>Turbinaria ornata</i>	<i>Ceramium Kützingianum</i>
<i>Sargassum polyphyllum</i>	<i>Amphiroa fragilissima</i>
<i>Hydroclathrus cancellatus</i>	<i>Corallina Sandwicensis</i> n. sp.
<i>Ectocarpus simpliciusculus</i>	<i>Lithothamnion</i> sp.?
<i>Styopodium lobatum?</i>	<i>Dictyota acutiloba</i>
<i>Microchaete vitiensis</i>	

The single calcareous segments of *Halimeda opuntia* occurred in such masses that, mixed with foraminifera, they formed considerably large calcareous deposits. Lithothamnium /sic/ spec. is very important to the growth of the reef. It covered the dead coral branches with a thick calcareous layer.

12) p.11. Besides the common *Octopus* species of Laysan, one can also find the cephalopods (Identified by Pfeffer) *Ommastrephes oualaniensis* Less. and *O. Sloanei* Gray, as well as *Onychoteuthys Banksii* Fér. The last three species form the main food of the albatrosses, at least during the period during which they feed their young. Their feces consisted almost entirely of cephalopod beaks. Even the *Sula* sp. fed their offspring with digested cephalopods, although later, also with fish.

13) p.11. The spiny lobster of Laysan is *Palinurus japonicus* de Haan. Apart from this, the two most common decapods are *Grapsus maculatus* Cal. and *Grapsus tuberculata* Lam. *Scyllarus Sieboldii* de Haan, *Carpilius maculatus* L., *Calappa hepatica* L. and *Lophaactaea actaeloides* A. M. Edu. are not rare either. (Dr. Lenz worked up my crustacean material.)

14) p.11. The growth of corals on Laysan — we are almost at the northernmost limit of reef-forming corals here — seems to me relatively slow compared with the more southerly situated coral islets of the Pacific (at least in the present developmental period of the island) and likely contributes, although slowly, to the growth of the reef. Calcareous algae (in the first place), mollusk shells, *Serpula* tubes, etc. have, in their totality, contributed at least as much to the increase of the calcareous deposits as the corals have.

15) p.13. Of the limestone rocks I found and collected on Molokai, two consist of a peculiar conglomerate rock which is made up predominantly of large, well preserved coral skeletons, as well as marine mollusk shells and opercula (of *Turbo*, *Trochus*, etc.) and even including rounded basalt fragments.

My findings may disprove Agassiz,⁹ who, up to now, denies a more considerable rise of the Hawaiian Islands and also does not believe that Dana's¹⁰ data demonstrate even a slight rise of these islands. The rocks from higher elevations (up to 670 ft) show an even, finely grained structure without microscopically documentable coral remains. A limestone layer from 400 ft elevation is very peculiar as it is apparently a freshwater deposit containing well preserved fossil *Achatinella* shells, as well as a great deal of preliminarily not identifiable tiny freshwater or land mollusk shells. It is interesting that two samples of the limestone collected on Molokai contain human footprints (of a grown-up and a child) which were apparently chiseled into the rock by the natives long ago.

16) p.15. According to the preliminary identification by Dr. Bitter, Bremen, the flora of Laysan consists of the plants listed below. I can only add to this list a few notes about habitat, etc. Their distributional data are from W. Hillebrand.¹¹ As for the rest, I refer to the forthcoming publication of Bitter.

1. *Lepidium oahuense* Cham. & Schl. [*L. bidentatum* var. *o-waihiense* C. & S.] There was only one specimen of this plant on the E side near the beach. It was a small stunted bush of 30 cm height, its lower woody stem about 8 cm wide. According to Hillebrand, it occurs on all Hawaiian islands in the lower zone, from the coast to 2000 ft elevation.

2. *Capparis Sandwicheana* D.C. [*sandwichiana* DC.]. Approximately man-high bushes are numerous on the W side of the island not too near the beach, but not far from it either. Blooming time begins in early May. The splendid, fragrant flower lasts for only one night on Laysan. It opens shortly before sundown and is already withered shortly after daybreak. Though the flowers are numerous, one rarely finds its fruit (lack of pollinating insects?). Only a few exemplaries develop fruit, on most, none can be found. According to Hillebrand it is numerous on Kauai along the coast, on dry lava fields. Otherwise, it also occurs on the Paumotu Islands and on Matia near Tahiti. On Kauai the plant is much lower than on Laysan (only 2 to 3 ft high).

3. *Portulaca oleracea* L. [*P. lutea* Sol.]. In places, this plant forms mats, although, it primarily grows solitarily, presenting a cushion (of 20-40 cm height, 3/4 to 1 m diameter)

⁹ Agassiz, Alex 1898. The coral reefs of the Hawaiian Islands.

¹⁰ Dana: Coral and coral islands. New York 1874 and 1890. 1. to 3. edition.

¹¹ W. Hillebrand: Flora of the Hawaiian Islands. Heidelberg 1888.

using the numerous side branches which branch off the heavy, woody, main stem. It occurs only in dry locations, never in moist ones and avoids loose sand. I found the first flowers in August. These remain open only during the hot hours of midday, otherwise they are always closed. They are so frail that they wilt immediately after being picked, and so, I had to press them immediately. The plant is, more than likely, identical to *Portulaca lutea* Sol., which is described from the Viti Islands and according to Hillebrand also occurs on some dry, rocky places near the sea on Oahu.

4. *Tribulus cistoides* L. Occurs almost everywhere on the island, especially in sandy areas between the single *Eragrostis* bunches. It forms uniformly sized rosettes of 1 to 2 m diameter. Stems and leaves lie flat against the surface, so that the whole plant rises only a few cm above the ground. The big, rigid thorns of the fruits were often pernicious under our feet. According to Hillebrand, it occurs here and there on all Hawaiian Islands on the coast and lower plains (even on Midway). It is a widely distributed plant of American origin, found on most low coral islands of the N. Pacific.

5. *Sicyos hispidus* Hbd. [*S. atollensis* St. John]. Not uncommon on the brackish pond of the southern guano field. According to Hillebrand it occurs on Maui.

6. *Sicyos microcarpus* Mann. [*S. nihoaensis* S. John], occurs singularly on the margin of the lagoon climbing on the *Cyperus canescens* which grows profusely there.

7. *Sesuvium portulacastrum* L. Individuals of this plant are standing alone, only occurring in the low-lying, yet mostly still dry, salty soils in the vicinity of the lagoon. There, it grows profusely and builds, in the company of *Heliotropium curassavicum* and *Cyperus laevigatus*, the only vegetation on this part of the island. It forms a thick, about 15-20 cm high cushion in the absence of any other plant. Its bluish-red flowers open only during the hot midday hours, I never noticed a blooming specimen during the morning or afternoon. It has a peculiar, aromatic fragrance which totally permeates those parts of the island where it occurs.

8. *Lipochaeta integrifolia* Gray. Occurs where the flat strand of the lagoon ceases and is supplanted by the sandy soil characteristic of the rest of the island, it forms, so to say, the transition between the three plants occurring there (from No.7.) and, the grasses and *Chenopodium* thickets which grow especially luxuriantly just at this border strip. It is mostly an herb, although older specimens may have the appearance of a bush, elevated to form a 60 to 75 cm high half-dome, covered with leaves and flowers, the thick tangle of which may reach one to two meters in diameter. This tangle was so thick and sturdy, that young albatrosses often chose to roost on top of it. According to Hillebrand, it occurs in sandy soils on the coasts of Kauai, Oahu and Maui, although its branches do not grow over one foot in length there.

9. *Scaevola Koenigii* Vahl. [*S. taccada* (Gaertn.) Roxb.] is restricted to the beach zone of the island. Luxuriant on the W side, more stunted on the E. side, it forms a bush which,

although only 1/2 to 1 m high, can reach a very considerable diameter. Individuals standing alone form a flat, uniformly leafed dome of 4-5 m diameter, reaching to the ground. The branches lying near the ground remind us of elfin woods; one can commonly see runners that creep several meters tightly over the sand. For the most part, the leaves form twirls which close in the evening. The small white flowers have a pleasant, although not very strong fragrance. Hillebrand: It is widely distributed in Polynesia, the coasts of tropical Asia and its islands. 4-6 ft high.

10. *Solanum laysanense* Bitter nov. sp. [*S. nelsoni* Dunal]. Is restricted to only one locality on the northern side of the island, there, on the sand dunes near the beach, it forms a lowly, ground-hugging shrubbery which looks shabby and rises barely more than 25 cm above ground. The circular leaves are covered with gray, feltlike hairs, the small flower is bluish and the fruit is pea size. Blooming season begins at the end of August. There are only about a dozen specimens on Laysan. I observed, from photos, that this plant seems to occur, in masses and profusely, on Pearl and Hermes reef, where it covers the ground, in some places, with a low, thick shrubbery.

11. *Ipomaea pes-caprae* Sw. occurs everywhere on the higher areas on the beach. One often finds specimens creeping distances of 6 to 10 m on the sand. I found it in bloom at the end of June; by the end of August, early September, it had finished blooming. The leaves take up a sleeping position at night. Common in all sandy bays in almost all tropical areas.

12. *Ipomaea insularis* Steud. [*I. indica* (Burm.)]. Though not common, it occurs scattered across the island, except the area around the lagoon. The hirsuteness of the leaves varies among the individual plants. Hillebrand: Very common in the lower vegetation of the Hawaiian Islands; occurs also on Tonga, Viti, Ladronen, Norfolk and on the coast of E. Australia.

13. *Nama sandwicensis* Gray. [*N. s.* var. *laysanicum* Brand.] This plant grows on the higher parts of the beach around the island. It is thickly covered with leaves; the specimens form very evenly developed dome-shaped rosettes (10 to 25 cm in diameter) which rise about 10 cm high above the sand.

14. *Heliotropium curassavicum* S. [*H. c.* L.] is restricted to the area of the lagoon which is not under water (see Nos 7. and 21.). There it forms a uniform cover of about 30 cm height. On this plant, as on *Sesuvium*, there are quite a few individuals of two small moth species, and so both plants are often visited by the three songbird species. Hillebrand: Common on the Hawaiian Islands on low, wet places near the sea. In America, from Oregon to Chile and from Mexico to Patagonia, also in Morocco and the Cape of Good Hope.

15. *Phyllostegia variabilis* Bitter nov. sp. Here and there on the E and W side near the beach. The numerous small flowers appear first during the winter, beginning in November.

It is a herbaceous plant, with few unbranched runners which I found to be 3/4 to 1 m long.

16. *Boerhaavia diffusa* L. is distributed everywhere on the island, especially between the singularly spaced tussocks of *Eragrostis*. This plant creeps low on the ground and rises but a few centimeters above it since its branches form quite a regular rosette out from the thick rootstock. The main root, which is sunk almost vertically into the ground, may reach a diameter of 15 cm, does not remain in real proportion with the quite scanty parts of the plant above the surface. The whole plant is sticky, one has difficulty cleaning off the adhering sand grains.

17. *Achyranthes splendens* Mart. [*A. s.* var. *reflexa* Hillebr.] is restricted to an area of about 100 steps in diameter on the NW side, quite near the beach. This is a tightly compressed stand, not mixed with any other plants. Height 25 to 60 cm. It had already withered by August. According to Hillebrand, it also occurs on Maui and Lanai.

18. *Euxolus viridis* Moq. [*Amaranthus viridis* L.]. Solitarily growing at the brackish pond in the southern guano field, a few specimens also occur at the N end of the island near the lagoon among *Chenopodium*. Forb-like, 2 to 3 ft high. According to Hillebrand, accidentally introduced to the Hawaiian Islands; there, in much shorter growths than on Laysan.

19. *Chenopodium Sandwicheum* Moq. [*C. oahuense* (Meyen) Aellen] next to *Eragrostis*, is the commonest plant on the island. Mostly growing tightly beside one another, giving quite the characteristic appearance of a 3/4 m high, very thick shrub. Individuals which stand alone are dome-shaped, tightly leaved to the ground, and often several meters in diameter. It lost its leaves in the beginning of September in dry areas, where it looked completely dead. By the first half of the winter, all individuals had lost their leaves. Hillebrand: on all Hawaiian Islands, but most commonly occurring on the high plateau of Hawaii. It is but a few feet high near the coast, but Hillebrand found it to be 12 to 15 ft high in the higher situated forests of Mauna Kea .

20. *Santalum Freycinetianum* Gaud. [*S. cuneatum* var. *laysanicum* Rock.] occurs in the coastal zone of the island, most luxuriantly on the NW side. This bush is the tallest plant on the island since it may reach 2.5 m or more in height, whereas its main stem reaches 10 cm in diameter. The wood is very fragile. The fruit is the size of a small cherry, having a stone and a little flesh, which in the beginning, looks gray, and later, is colored bluish red. Almost all fruit is eaten by the birds. According to Hillebrand: in the forests of Maui, Lanai and Molokai, there growing to 12 to 25 ft height.

21. *Cyperus laevigatus* L. This plant forms thick, 60-7- cm high tussocks of great luxuriance, in large areas in the vicinity of the lagoon. Also, it occurs in a very deep area on the north side; the quite deep peat-like mass which one finds there is likely formed by this plant. According to Hillebrand, it is common near Honolulu in the proximity of brackish water. It is a common plant in many tropical tracts of the New and Old World.

22. *Cyperus canescens* Vald. [*C. pennatiformis* var. *bryanii* Kükenthal]. It occurs by itself, as well as mixed with *Eragrostis* and may, circumstances permitting, grow at least as high as the latter grass. Although widely distributed, it is by no means as common as this latter one, because it only thrives in moister places and does not occur at altitudes. Thus, it is restricted to the closer or wider surroundings of the lagoon. Hillebrand: In the lower regions of Oahu, Molokai and Maui: 1 to 3 ft high (thus considerably lower than on Laysan). It is spread from the Mascarenes and India through Malaysia, Australia, S. China to the Phillipines and to most Pacific islands.

23. *Cenchrus calyculatus* Cav. [*C. agrimonioides* var. *laysanensis* F. Br.]. This grass occurs as individual plants, 1/2 to 3/4 m high, among *Eragrostis* and only on dry sites. It begins to flower at the end of December, most specimens have finished blooming already in July. Hillebrand: on dry sites between 1000-3000 ft elevation, likely occurring on all Hawaiian islands, although mainly in old lava fields of Maui and Hawaii. Elsewhere, also on the Society and Friendship islands, Pitcairn, Samoa, Viti and New Caledonia.

24. *Sporobolus virginicus* Kunth. [*S. v.* (L.) Kunth.]. It grows in very tight bunches at higher locations in the proximity of the seashore, especially on the N side. The stiff, peculiarly dry stalks may be 1/3 - 1/2 m long. It begins to bloom in August. Hillebrand: In certain places of the beaches of Oahu and Maui, otherwise in tropical and subtropical America, also in S. Africa and Australia.

25. *Eragrostis hawaiiensis* Hdb. [*E. variabilis* (Gaud.) Steud.] next to *Chenopodium*, is the most widely distributed plant on the island (see p.37). One to 1 3/4 m high. Mostly grows in single bunches, more rarely in tussocks. The main blooming period is October and November. According to Hillebrand, in Hawaii (Kohala), but there only 2-3 ft high.

26. *Lepturus repens* (Forst.) Occurrence is similar to that of No. 24, there quite common. It is a dry and hard grass which grows partly in clusters, and partly growing along the sand in several meter long, straight runners. It begins to flower only in August (whereas by then, the main blooming period of Nos. 22,23 & 25 are already over). It seems that only some specimens bloom, while most others remain sterile. Hillebrand does not list this grass among the Hawaiian flora; it grows elsewhere in Australia and in the surrounding Pacific islands.

Finally, we should remember the palms (see p.16), which Kittlitz already mentions (in 1834, in the Museum Senckenbergianum). In 1859, there were still 5 specimens on the island (according to Capt. Brooks); the tallest reaching 15 ft. I myself saw no more living specimens, although I found numerous stumps and pieces of root in the northern part of the island; some having a diameter of 50 cm. I also found numerous remnants in the southern part of the island, not far from the lagoon. Thus, the original numbers of trees were certainly several hundred. According to verbal information, the palms had hugh fan-shaped leaves

and long florescences and fruit racemes. In all likelihood it was *Pritchardia*.

27. *Pritchardia Gaudechaudii* H. Wendl., [*Pritchardia* sp.] which occurs in natural conditions on the rocky cliffs of the northern coast of Molokai, singly in Hawaii and also on Bird Island.

It has already been pointed out on p.16 that, remarkably, many plants on Laysan show a rosette- or dome-shaped growth. I cannot give a definite reason for this fact. The wind conditions cannot be responsible for it. The only effect of the NE tradewind, the wind that predominates on Laysan, is that the vegetation on the E side is very much lower and poorer than on the protected W side.

It is a remarkable fact that the plants of Laysan seem to be considerably larger and more robust compared to specimens from the Hawaiian Islands.

I found most plants in bloom during my sojourn on the island (24.VI — 24. IX) ; the exceptions have been especially pointed out above.

Although the difference in seasons on Laysan is not significant and mainly manifests itself as a change in the winds, and in the different amounts of precipitation, some plants are still affected by it. Most of them certainly remain relatively unchanged the year around, although they look greenest in winter and spring, becoming faded and dry in high summer months (e.g. *Eragrostis*, *Sporobolus*, etc.). Others, to the contrary, are beginning to lose their leaves in September, especially *Chenopodium*, *Capparis* and *Scaevola*; the first two looking quite bald and dead all winter and, e.g. *Capparis* gets new leaves first in March. The salt plants near the lagoon (*Sesuvium* and *Heliotropium*) look quite black during the winter and first become green in the spring.

17) p.17. The following is a preliminary list of the birds of Laysan. I will shortly be giving a detailed account in the Journal für Ornithologie.

A. Specific for Laysan : *Acrocephalus familiaris* Rotsch. 2. *Himatione Freethii* Rotsch. 3. *Telespiza cantans* Wils. (*T. cantans* Wils. and *T. flavissima* Rotsch. are one species and therefore the latter must be cancelled). 4. *Porzanula Palmeri* Froh. 5. *Anas laysanensis* Rotsch.

B. Other breeding birds. 6. *Fregatta aquila* Lin. 7. *Sula cyanops* Sundev. 8. *Sula piscatrix* L. 9. *Phaeton rubricauda* Bodd. 10. *Gygis alba* Sparrm. 11. *Haliplana lunata* Peale. 12. *H. fuliginosa* Gm. 13. *Anous stolidus* L. 14. *A. hawaiiensis* Rothsch. 15. *Puffinus nativitatis* Streets. 16. *P. cuneatus* Salv. 17. *Oestrelata hypoleuca* Salv. 18. *Bulweria bulweri* Jard. & Selby. 19. *Oceanodroma fuliginosa* Gm. 20. *Diomedea chinensis* Temm. 21. *D. immutabilis* Rothsch.

C. Regular visitors of the island (but not breeding there). 22. *Charadrius fulvus* Gm. 23. *Strepsiles interpres* L. 24. *Totanus incanus* Gm. 25. *Numenius tahitiensis* Gm. 26. *Sula sula* L.

D. Winter visitors . 27. *Limosa novae Zelandiae* Gray. 28. *Calidris arenaria* L. 29. *Tringa acuminata* Swinh. 30. *Tringa (Pelidna) americana* Cass. 31. *Crymophilus fulcarius* L. 32. *Larus glaucescens* Brun. 33. *Phalacrocorax pelagicus* Pall. 34. *Anas boschas* L. 35. *Nettion crecca* B. 36. *Dafila acuta* L. 37. *Querquedula circa* L. 38. *Spatula clypeata* L. 39. *Clangula albeola* L. 40. *Diomedea* nov. spec. ? (close to *nigripes*).

The nest and eggs of *Himatione Freethii* were not known until now. I have found these and may briefly describe them as follows: since the selection of building material is very limited, the nests of the land birds of Laysan show a great similarity regarding their materials. The nest of *Himatione Freethii* consists predominantly of fine rootlets with only a few intervoven grass blades. Contrary to the nest of *Acrocephalus* which it almost resembles in size, it uses few or no feathers at all in its construction. It also differs from the latter in that its nest is more firmly fitted together and is not as deep. I found it mostly in the centre of high grass bunches, and also, sometimes in very thick *Chenopodium sandwichensis* shrubbery. In a clutch of 3 eggs, the only one I found, the basic color of two eggs was clear white, of the third with a tinge of light chamois. Next, there are numerous brownish-violet spots, but only on the blunt pole; these were, on two of the eggs, somewhat darker than on the third. Over these lay another set of larger or smaller, chocolate-colored spots and splashes. Although these are also mainly restricted to the area of the blunt pole, a few, smaller spots are also scattered over the remaining, pure white surface of the egg, and especially in the case of the third egg, with a yellowish tinge. It is typical that the blunt end appears as a lighter disk owing to the wreath-like arrangement of the spots around it. Length of two eggs was 20.5 mm, breath 14.5 mm; these measurements for the third egg were 19.75 and 14.0 mm.

18) p.28. My fish collection will be studied by Dr. Steindachner and published in the memoirs of the Academy of Vienna.

19) p.29. Of the insects I found on Laysan, only the following (excepting Diptera and Formicidae): Lepidoptera, Noctuidae (identified by Dr. Rebel): *Apamea chersotoides* Butl. and *Spaelotis crinigera* Butl.; the latter occurred in astonishingly high numbers. Its "grublike caterpillar" lives under ground on the roots of *Eragrostis*. Pyralidae: *Zinckenia recurvalis* F. Also a small, unidentifiable Tineidae. Hemiptera: *Nabis spec.* Hymenoptera: *Chelonus cameroni* D.T. (= *carinatus* Cam.) (Transact. Ent. Soc. 1881). Coleoptera: *Dermestes domesticus* Garm., occurring in unbelievable large masses. *Silvanus surinamensis* L., *Tribolium ferrugineum* F., *Clytus* is North American, the other three are cosmopolitan. Surely all four beetles must have been introduced only a short time ago.

Finally, there was a large, introduced *Periplaneta*.

The following are the spiders¹² of Laysan: *Theridion rufipes* Lucas., *Smeringopus elongatus* Vins., *Sapinatus melanognathus* Lucas. (These three species live in the hot belts of the whole world. *Lycosa stygialis* E. Simon (also on the Hawaiian Islands), *Melanophora pacifica* spec. nov. (belongs to a family which otherwise has a temperate palaeartic distribution; it is even related to *M. rustica* Koch, a European species, and it seems to stay near the only known species from Australia (*M. flavescens*). *Chelifer Laysanensis* spec. nov. (related to some species already known from Oceania).

20) p.31. The ants occurring on Laysan are, according to the identification of Prof. E. Emery, Bologna¹³ 1. *Monomorium gracillimum* F. Sm., 2. *Tetramorium guinense* F., 3. *Tapinoma melanocephalum* F. (these three are cosmopolites). 4. *Ponera punctatissima* Boy subsp. *Schauinslandi*.

21) p.33. The climate of the island, corresponding to its position, excels through a relatively high, but also a very even temperature. During our stay (24. June — 24. September), the minimum/maximum thermometer recorded the lowest temperature, 21°C (at night), and the highest, 37°C (in the shade). The coldest day of 1896/97 was 31st December with 17°—18°—17°C (6 am, 12 noon, 6 pm), while the 23rd February still showed 26°—29°-28°C. One of the highest temperatures observed on Laysan was on 7th October 1897, and was 41°C. The temperature, and other meteorological data, shall be prepared later. During the summer months, from May to early September the trade wind is not only the dominant, but almost the only wind. It blows mostly from the NE, but it may turn to N, or through E to S. In winter, contrarily, westerly and northerly winds predominate; they blow at times, quite violently, although real hurricanes were not observed. During my stay on the island, I was able to observe that almost all the time when calm prevailed, a heavy westerly swell pressed onto the island, this making passage through the western entry often impossible. Apparently, not far N of Laysan, the westerlies are dominant, and the swell they cause would be stopped by the E tradewind that predominates Laysan, but when the eastern trade is missing the swell is able to reach the island.

¹² E. Simon: Arachnoideen aus dem Pacific. Zool. Jahrbücher, system. Abth. 12. Bd. 1899.

¹³ Zoologische Jahrbücher, syst. Abth. vol. 12. 1899.

22) p.35. Of the catch up to now, the plankton algae were the first to be worked up.¹⁴ The Crustaceans are being studied by Prof. G. O. Sars. Besides typical planktonic algae such as *Rhizosolenia*, *Ceratium tripos* Nitzsch., *Asterionella actata* Grun. etc., the plankton in the vicinity of Laysan also contained many bottom dwellers, which obviously were torn off by the heavy surf.

The plankton material which was collected during the journey from Laysan to Honolulu contained both warm and cold water forms. It is characterized by the numerous occurrences of *Rhizosolenia*, *Ceratocorys*, *Ornithocereus*, *Ceratium*, *Haliarachne lenticularis* Lemm. nov. gen. & spec. *Katagnymene pelagica* Lemm. & *spiroides* Lemm. nov. gen. & spec., and by mass occurrence of an normally sessile alga: *Enteromorpha flexuosa* (Wulf.) J. Ag.

¹⁴ Lemmermann, Abh. Nat.Ver.Bremen 1899. Issue 2.

Publications resulting from the Schauinsland expedition.

(Compiled by M. D. F. Udvardy)

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