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FLORA AND VEGETATION OF CLIPPERTON ISLAND[1,2]

By

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1. Publication authorized by the Director, U.S. Geological Survey.
2. Contribution from the Scripps Institution of Oceanography, New Series.

INTRODUCTION

One of the loneliest, most isolated and smallest islands in the Pacific Ocean is Clipperton Island (10° 18′ N, 109° 13′ W). The nearest land, about 600 nautical miles to the NNE is the coast of Mexico. Clipperton is one of the few oceanic islands, and the only coral island, in the Eastern Pacific. The nearest atoll, Pukapuka in the Tuamotu Archipelago, is 2300 miles to the southwest. Although uninhabited, Clipperton has been seriously influenced by short-lived human settlements. The flora is poor and the vegetation meager, yet Clipperton's unique location and the history of its plant life make its study very worthwhile and raise a number of interesting questions. Birds and other animals were collected and observed in the last century, but the plants received little attention until very recently. The geography will be elaborated in separate papers (Sachet, in press), and only a brief description of the features pertinent to botany will be given here.

During the international Geophysical Year and as part of this program, Scripps Institution of Oceanography carried out a number of research cruises, and in the summer of 1958 had several ships in the Eastern tropical Pacific studying the Equatorial Counter Current (Expedition Doldrums). One of the ships stopped at Clipperton and left a number of biologists, including myself as botanist, for a survey of life on the atoll. This is how I came to spend two and a half weeks on this little-known island (Aug. 7–26, 1958). The all-too-short visit was most enjoyable and rewarding and I take this opportunity to express my appreciation for this chance to Scripps Institution of Oceanography and to its director, Dr. Roger Revelle, and to thank the many persons who helped me during the voyage and the stay on the island and in the study of the material collected. Particular credit must go to Professor Carl L. Hubbs, of Scripps, who originally suggested this survey of Clipperton and from whom the invitation to participate was received. The French government gave us the necessary authorization to land and stay on the island. For permitting me to join the expedition and encouraging me to study the material collected I wish to thank my superiors in the U.S. Geological Survey and in the Pacific Science Board, National Academy of Sciences—National Research Council. A grant from the Academy's Joseph Henry Fund was much appreciated. Miss Evelyn L. Pruitt's assistance in securing photographs and her support of atoll research through the Geography Branch of the Office of Naval Research are gratefully acknowledged. For the identification of specimens I am indebted to Mrs. M. L. Farr and to Messrs. E. Balech, P. Bourrelly, E. Yale Dawson, Francis Drouet, F. R. Fosberg, Mason Hale, C. W. Hesseltine, P. L. Lentz, H. A. Miller, E. H. Moore, Jr., John A. Stevenson, H. K. Svenson, and R. D. Wood. Dr. Fosberg also gave me much help in interpreting the data collected and in preparing this paper. Messrs. E. C. Allison, R. W. Becking, A. S. Hambly, C. F. Harbison, W. L. Klawe, Conrad

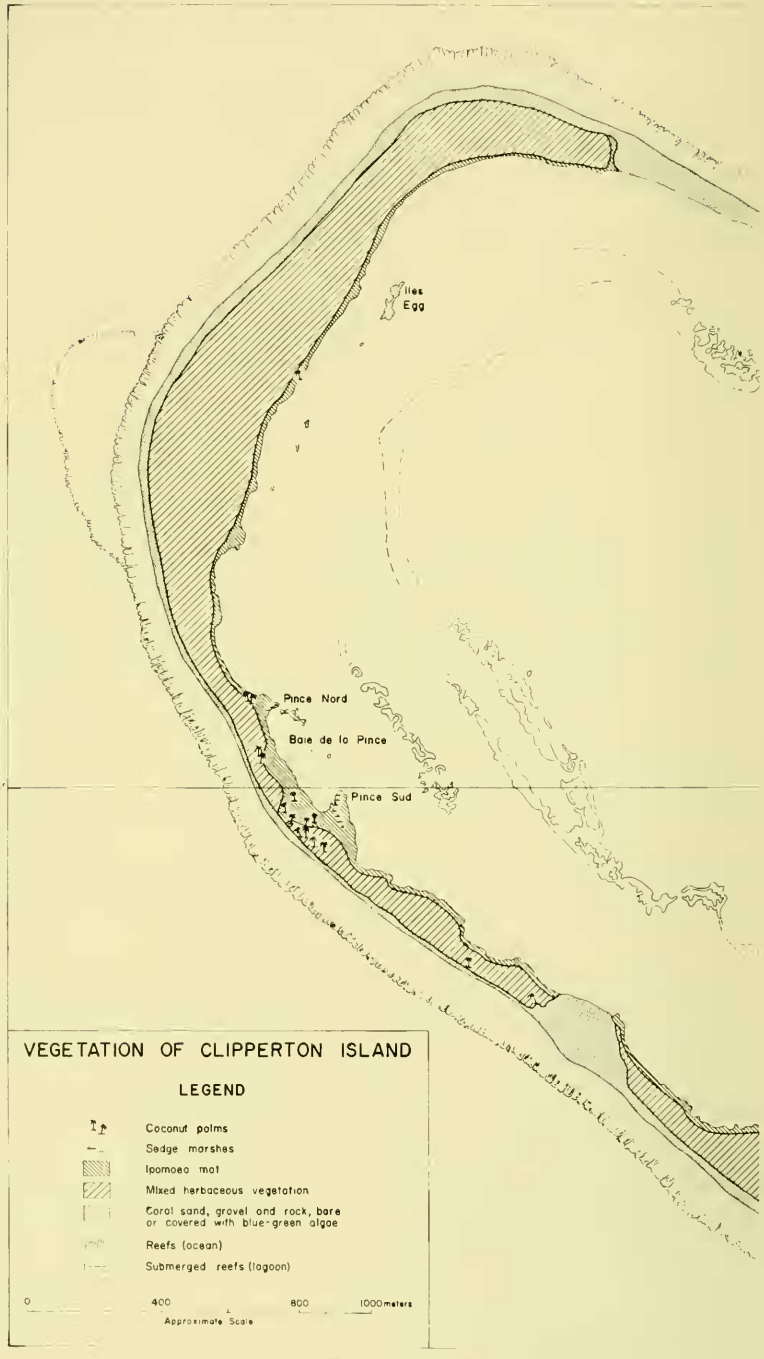
Limbaugh, H. E. Maude, and R. E. Snodgrass gave me unpublished information or helped me study some of the material assembled. Dr. Elizabeth McClintock, Mr. Allison, Professor L. Emberger, Professor Hubbs, and Dr. Philip Ross read the manuscript and made many valuable comments and editorial suggestions. To all my most sincere thanks.

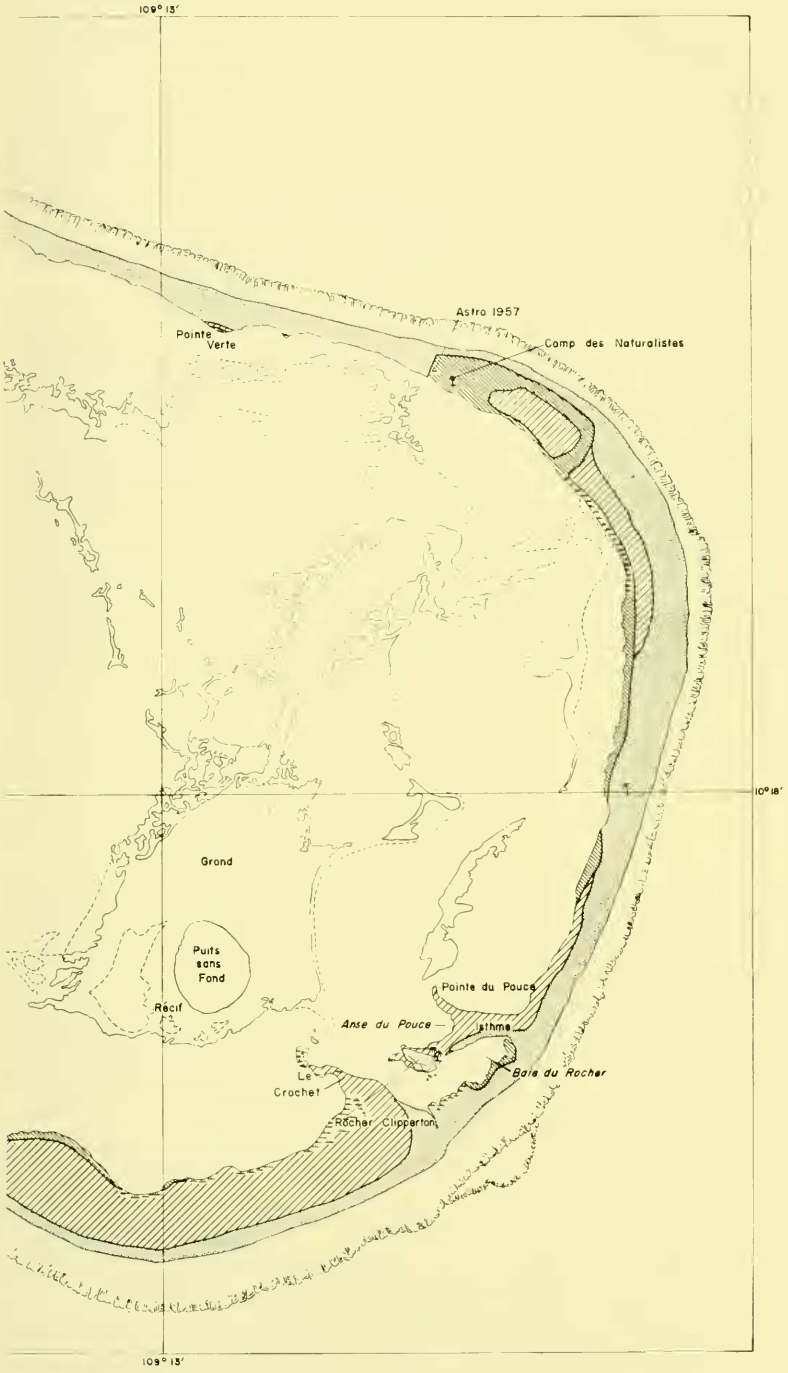
Where the top of the highest peak of the newly described submarine Clipperton Ridge (Menard and Fisher, 1958) reaches the surface of the sea, an egg-shaped coral reef supports a narrow, low, uninterrupted land strip of limestone debris, while a small volcanic rock (Clipperton Rock), 29 m. high, rises near the south point. The circumference of the land is about 12 km., and the long, NW–SE, axis of the island is 4 km. long. The ribbon of land varies in width from 45 m. to 400 m. (much of it about 200 m. wide), and encloses a lagoon of almost fresh water.

The seaward outline of the atoll ring is very even, but the inner edge of the land strip projects into the lagoon in several small points or peninsulas. One of these, about halfway along the northeast side, is triangular Green Point (Pointe Verte).[3] In the southeast the short Isthmus (Isthme) stretches parallel to the land strip. At its western free tip rises the volcanic Clipperton Rock (Rocher Clipperton), and from its northern coast the low rocky Thumb Point (Pointe du Pouce) extends northward into the lagoon. West of the Rock lies another short peninsula, the Hook (Le Crochet). Between the Hook, the Isthmus, and the land strip, the lagoon forms a long and narrow arm, Rock Bay (Baie du Rocher). On the southwest side of the island, two rocky points called North and South Pincers (Pince Nord, Pince Sud) enclose shallow Pincer Bay (Baie de la Pince). Along it rises a grove of coconut palms among which the ruins of a U.S. Weather Station, occupied in 1944–1945, are partly hidden. The lagoon is deep (10 to 20 meters and more) in places but is divided by very shallow reefs. A few small islets occur in it, some near the Rock, and the five Egg Islands along the northwest side.

Cross-sections of the atoll rim show comparable profiles everywhere. Above the intertidal reef-flat lined by sand beaches or pebble or cobble strands rise white ridges of unconsolidated limestone fragments, reaching a maximum elevation of 4 meters. Everywhere the tops of these ridges are also the highest points of the ocean-lagoon profiles and from there the land slopes down to the lagoon. Beyond the shorter lagoonward sides of the ridges, where coral pieces are stained dark gray or black by microscopic algae, the land consists of flat or very gently sloping surfaces ending in small "cliffs" or low muddy shores at the lagoon edge. The sediments forming these surfaces are derived from the skeletons of lime-secreting organisms, mostly corals, and consist of sands

3. These names, used on the accompanying map, have been submitted for approval to the Service Hydrographique of the French Navy.


Iles Egg
Pince Nord
Baie de la Pince
10°18'
Pince Sud
VEGETATION OF CLIPPERTON ISLAND
LEGEND
Coconut palms
Sedge marshes
Ipomoea mat
Mixed herbaceous vegetation
Coral sand, gravel and rock, bare or covered with blue-green algae
Reefs (ocean)
Submerged reefs (lagoon)
0
400
800
1000 meters
Approximate Scale


109° 13'
Astro 1957
Pointe Verte
Camp des Naturalistes
10° 18'
Grond
Puits sans Fond
Récif
Pointe du Pouce
Anse du Pouce
Isthme
Baie du Rocher
Le Crochet
Rocher Clipperton
109° 13'

and gravels, loose or consolidated into rock. In the consolidated sediments the limestone pieces are bound by a phosphatic cement derived from the guano of the numerous sea birds that live on the atoll. In some cases, the coral fragments are themselves partly phosphatized. These phosphatic conglomerates form flat pavements, often interrupted by concentric step-like ledges that parallel the shores. Sand and coral fragments in varying mixtures may be scattered in a thin layer over the rock or form deeper beds.

In most areas on Clipperton the surface soils are very immature—coral sand and gravels only slightly discolored by organic matter. In some areas the soil is of phosphatic gravel, derived apparently from the indurated phosphatic rock, but in many places the surface is of only slightly modified recently deposited material.

On the broad northwest corner are large areas of phosphatic silt with slight admixture of coral gravel, this especially scattered in a thin layer over the surface. The silt is differentiated into a brownish or brownish-gray upper layer as much as 15 cm. thick lying on a pale creamy white layer, more compact, of undetermined thickness. These are both almost entirely calcium phosphate but the percentages of both P_2O_5 and CaO are somewhat lower in the darker upper layers, perhaps indicating some profile development. Similar silty material underlies the gravel sheet on the northeast side, at least in some places. Judging by the similarity of the material in some old stockpiles on the west corner near the lagoon, the silt may be one of the kinds of phosphate that were mined commercially. Therefore its present extent is probably much more restricted than it must once have been.

Otherwise no significant profile development was observed in any well drained site except in the coconut groves where a thick surface horizon of partly decomposed litter and humus had accumulated on the coral. Crab holes are abundant and doubtless there is a continual stirring up and turnover of the soil material, making any incipient horizons less distinct. Earthworms are locally abundant. Drainage seems generally excellent except on ground lying at about lagoon level. Here the soil is, in its upper layer at least, a dark highly organic silty mud. The soil, generally calcareous and phosphatic, may be locally enriched by small amounts of material from the volcanic Rock and of drifted pumice and extraneous rocks carried in drift trees.

Clipperton Rock (fig. 1) forms an irregular pyramid about 29 m. high. At the end of the Isthmus the east face rises as a great triangular wall. Walking around the base, one discovers that the Rock is not a solid mass but is traversed by roughly parallel passages oriented SSE–NNW. It is mostly gray with a dark reddish tinge, and mottled with white trickles of guano and patches of dark or gray-greenish lichens. Every small rock projection or cleft is occupied by nesting boobies and noddies. The volcanic rock is a trachyte,

Figure 1. Clipperton Rock and sedge marsh at base of Hook. Arrangement of sedge species about a small pond. *Eleocharis mutata* in center of photo (growing in water); *Eleocharis geniculata* in front (growing in wet mud); a few small plants of *Hemicarpha micrantha* among stones in foreground.

and under the accumulation of bird guano, has been phosphatized for an unknown depth, at least 30 or 50 cm. It remains very hard and compact. No plants grow on the Rock except for the lichens and a few algae.

The area of the tropical Pacific in which Clipperton Island lies is one of variable surface currents. During the winter, the North Equatorial Current flows westward past the island, and the Equatorial Countercurrent south of it. During the summer months, the Equatorial Countercurrent runs farther north and in some years may bathe the atoll in its eastward flow. This pattern of water circulation is complicated by transverse currents, by tidal currents and by storm waves.

Clipperton Island has a seasonally humid tropical climate. Very few data have ever been collected, and information has to be extrapolated from what is known of the surrounding ocean. The northeast trade-wind is the dominant wind for much of the year but during the summer months winds from the southwest or west become more important, bringing squalls and storms. The

air temperature in August 1958 ranged from 24° to 32°C, the temperature of surface seawater from 26° to 29°C (Limbaugh, unpublished data).

In the summer, rainfall is very high. During August 1958, it rained almost every day, and very heavy rains often lasted all night and all the following morning. A dry season has been reported for the first half of the year but no details, let alone precipitation data, are available. The area of ocean east of Clipperton and the central American coast have indeed a dry season in the spring. In the summer of 1958, the vegetation obviously was recovering from a severe dry spell, as will be described below. In May, 1958, the condition of the vegetation was even worse (Witold L. Klawe, personal communication). It must be kept in mind, however, that on an atoll with extremely porous soils and substratum, and intense evaporation, complete and prolonged dry conditions are not necessary to affect the plant life. Irregular rainfall suffices to cause effective drought for the vegetation.

In the area between Clipperton Island and the American coast, hurricanes travelling principally in a northwest direction are known to occur. Probably only a few of them ever hit the island. One did in October 1944 (P. G. Taylor, 1948). Even when the hurricanes pass well to the east, the storm waves may reach the low island. In the summer of 1958, evidences that a powerful storm

Figure 2. Revegetation of area devastated by 1957–1958 storm. A few clumps of *Cenchrus* and the first vines of *Ipomoea pes-caprae* at the northwest end of the bare land strip looking southeast. Ocean at left, lagoon at right, wrecked LST and Naturalists' Camp in extreme distance.

had recently affected Clipperton were obvious. An area of several hundred meters along the northeast side of the atoll (fig. 2) had perhaps been scoured out, and then had been completely covered by white coral gravel or sand, from ocean to lagoon, and the vegetation here had been totally eliminated (p. 297). The ocean shore had been undercut and eroded. Sea water had certainly poured into the lagoon. Comparison of photographs and notes made in November, 1957, and May, 1958, shows that the storm occurred between these dates. The hurricane season is from June to December with greatest frequencies in August to October, but other storms probably occur in most other months.

Most of the visitors to Clipperton Island have been impressed by the great colonies of sea birds nesting on it and flying over it. Their numbers have unfortunately diminished greatly but they are still the most obvious and striking part of the island's fauna. Great frigates, two kinds of boobies, two kinds of noddies, sooty terns, and a few fairy terns are the principal seabirds. Sooty terns and blue-faced boobies habitually lay their eggs on the ground and do so on Clipperton. The fairy terns use coral boulders, coconut fronds, and the ruins of the quonset huts. The common noddies, which usually build their nests on the ground or more often in bushes and trees, try on Clipperton to find perches on rocks, small cliffs, and abandoned equipment to protect their eggs and chicks from the pigs, but some make crude nests on the ground. The white-capped noddies favor cliffs or tall shrubs and trees, and on Clipperton crowd on the palm trees and on the Rock. They share the palms with the nesting frigate birds and some brown boobies, and the Rock with brown boobies. The latter also nest on lagoon "cliffs" and rocks.

Other sea birds, and various migrating shore birds were seen in small numbers in August, 1958, and may be more abundant at other times.

Ducks of many species were seen on the lagoon in November, 1901 (Beck, 1907), and perhaps still visit the island on their long winter trips to the southern hemisphere. In 1958, we were surprised to find many coots bobbing on the lagoon and nesting in the sedge beds. The presence of land birds had been observed in 1825 by Morrell (1832) and has been mentioned several times since. In August, 1958, an American land bird or two could be sighted almost every day: martin, cuckoo, yellow warbler, etc.

The bird population influences the plant life of the island in various significant ways: the birds probably brought to the island many of its plants, in mud on their feet, in their crops, or on their feathers. Possibly all the phanerogams, and even some algae (Proctor, 1959), found in and around the lagoon were brought by the ducks, coots, and shore birds. Sea birds are believed to eat only marine animals, but a number of species are known to swallow seeds, which can be found in their crops. The phosphatization of soil, coral conglomerates, and volcanic rock by guano has already been mentioned

and the plants growing in such substrata are thus indirectly influenced by the presence of the birds. They damage the coconut palms, keep them from fruiting by crushing the young inflorescences, and may eventually kill some of them. No higher plant has any chance of establishing itself on Clipperton Rock while all the flat spots where a little soil might form, and many not very flat sites, are occupied by booby and noddy nests. These birds may help disseminate some plants such as *Heliotropium* by carrying fruiting twigs around.

In 1958, 58 pigs were roaming on Clipperton Island, feeding on plants, birds' eggs, crabs, and perhaps other animals. They had been introduced at the end of the 19th century, and were all killed in 1958 for the protection of the nesting birds.

The land crabs (*Gecarcinus planatus*) are another very obvious part of the Clipperton land fauna. In the past the island was described as red with them. In 1958, they were much less numerous, but could be seen everywhere hiding in cracks and holes under ledges and stones, or, in the late afternoon, scrambling over rocks on their way to the lagoon or the ocean. Land crabs are reported to go to the water periodically in order to release the larvae from the mature egg masses.

Among the other land invertebrates, the moths should be mentioned for their effect on the plant life. Larvae of various species were feeding on *Solanum, Cenchrus,* and *Corchorus.* The large morning-glory hawk moth (*Herse cingulata* according to Charles F. Harbison, entomologist of the 1958 party) was very abundant in the *Ipomoea pes-caprae* vegetation.

The other components of the Clipperton fauna seemed less directly associated with the plants.

HISTORY OF COLLECTIONS

The first plant collected on Clipperton Island was apparently a water plant from the lagoon gathered by Lt. Griswold in 1861 (Pease, 1868). It was deposited in the California Academy of Sciences, but was lost in the San Francisco Fire in 1906 when most of the collections of the Academy were destroyed. Later scientific expeditions, including the Academy's own (1905–1906), made no plant collections as far as is known. In 1935 the French training ship *Jeanne d'Arc* visited Clipperton and some plants were taken, but what became of them could not be ascertained. They are not in the Herbarium of the Muséum National d'Histoire Naturelle in Paris.

The first collection to be identified in the literature was gathered by Dr. Waldo L. Schmitt of the U.S. National Museum, on the Presidential Cruise of 1938. The algae were identified by Dr. W. R. Taylor (1939); the five phanerogams by Dr. E. P. Killip (1939). The specimens are in the U.S. National Herbarium.

Two small collections of phanerogams, made by Mr. Conrad Limbaugh in 1956 and by Mr. W. L. Klawe in 1958, were sent to Dr. F. R. Fosberg for identification, and deposited in the U.S. National Herbarium. Since the determinations have not been published, and I have worked with the specimens, I will list them here together with my own and those of Schmitt. I am not aware of any other collections, except for a few plants collected in 1958 by Charles F. Harbison, and deposited in the San Diego Natural History Museum.

During the 1958 survey, in 19 days of diligent search, 26 phanerogams were found on Clipperton Island. A few may have been missed, but not many. The cryptogamic collections are more likely to be incomplete. Some fungi, lichens, mosses, and land and fresh-water algae were collected and are listed below. There are no ferns or fern allies on the atoll, and no hepatics.

SYSTEMATIC ENUMERATION

FUNGI

Fungi had never been mentioned from Clipperton Island before the 1958 survey, when only a few were seen and collected, all from the coconut groves. Phanerogams on the island were carefully inspected for possible fungus diseases, and a few plants with spots were collected, but the spots were found to be sterile. The specimens were sent to the U.S. National Fungus collection, Mr. John A. Stevenson, Curator, and identified by the specialists there as indicated below. In addition, a number of fungi were cultured from soil samples submitted to Mr. C. W. Hesseltine, Head of the U.S. Agricultural Research Service Fermentation Laboratory, Peoria, Illinois, where the cultures will be kept alive.[4]

MYXOMYCETES

Dictydiaethalium plumbeum (Schumacher) Rostafiński

Coconut grove at base of east face of Clipperton Rock.

On old rotting coconuts, palm fronds and wood. *Sachet 342* (det. Dr. M. L. Farr).

PHYCOMYCETES

Cunninghamellaceae

Cunninghamella echinulata (Matruchot) Thaxter.

Isolated from soil sample 15.

4. Sample nos. are my own collection numbers, the equivalent numbers of the Fermentation Laboratory are as follows: SS-494 (Sachet 3); SS-495 (Sachet 5); SS-496 (Sachet 6); SS-497 (7a); SS-498 (11-1); SS-499 (14-1); SS-500 (15); SS-501 (20); SS-502 (21); SS-503 (22); SS-504 (26); SS-505 (31); SS-506 (32); SS-507 (34a).

Cunninghamella elegans Lendner.

Isolated from soil sample 21.

Mucoraceae

Absidia scabra Cocconi.

Isolated from soil samples 11–1, 31, 32.
This is a very rare species, according to Mr. Hesseltine.

Rhizopus arrhizus Fischer.

Isolated from soil samples 7a, 15, 20, 26.

Piptocephalidaceae

Syncephalastrum racemosum (Cohn) Schroeter.

Isolated from soil samples 5, 11–1, 14–1.

Ascomycetes

Eurotiaceae

Eurotium chevalieri Mangin.

Isolated from soil sample 3.

Sartorya fumigata Vuillemin.

Isolated from soil sample 7a.

Basidiomycetes

Telephoraceae

Corticium lactescens Berkeley.

Coconut grove at base of East face of Clipperton Rock.
On old rotting coconuts, palm fronds and wood. *Sachet 342* (det. P. L. Lentz) (with *Dictydiaethalium plumbeum* above, and traces of other forms).

Agaricaceae

A number of small mushrooms were found growing on dead coconuts, coconut fronds and wood in the grove at the base of the East face of the Rock (*Sachet 337*), and in the Southwest coconut grove (*Sachet 350*). They were not identified.

Fungi Imperfecti

Dematiaceae

Haplographium sp. ?

Isolated from soil sample 26.

Moniliaceae

Aspergillus flavus Link.

Isolated from soil samples 14–1, 20, 32.

Aspergillus flavus-oryzae group.

Isolated from soil sample 20.

Aspergillus fumigatus Fresenius.

Isolated from soil samples 11–1, 26, 31.

Aspergillus micro-virido-citrinus Constantin & Lucet.

Isolated from soil sample 34a.

Aspergillus niger series.

Isolated from soil sample 26.

Aspergillus phoenicis (Corda) Thom.

Isolated from soil sample 14–1.
This species is not common, according to Mr. Hesseltine.

Aspergillus sydowi (Bainier & Sartory) Thom & Church.

Isolated from soil samples 14–1, 26.

Aspergillus sydowi or **versicolor** (intermediate form).

Isolated from soil samples 3, 5, 6, 14–1, 21, 22.
A very interesting intermediate form.

Aspergillus terreus Thom.

Isolated from soil samples 14–1, 22, 26, 31, 32.

Aspergillus terreus new var. ?

Isolated from soil sample 21.

Aspergillus versicolor (Vuillemin) Tiraboschi.

Isolated from soil sample 31.

Aspergillus violaceo-fuscus Gasperini.

Isolated from soil samples 20, 21, 34a.

Geotrichum sp.

Isolated from soil sample 5.

Hyalopus sp.

Isolated from soil sample 3.

Paecilomyces sp.

Isolated from soil sample 31.

Penicillium chrysogenum Thom.

Isolated from soil sample 7a.

Penicillium citrinum Thom.

Isolated from soil samples 5, 14–1, 22

Penicillium commune Thom.

Isolated from soil sample 15.

Penicillium cyclopium Westling.

Isolated from soil sample 26.

Penicillium funiculosum Thom.

Isolated from soil sample 20.

Penicillium funiculosum series.

Isolated from soil samples 15, 20.

Penicillium lanosum Westling.

Isolated from soil sample 21.

Penicillium meleagrinum Biourge.

Isolated from soil sample 5 and 26?

Penicillium oxalicum Currie & Thom.

Isolated from soil sample 5.

Penicillium (near **P. piscarium** Westling).

Isolated from soil sample 20.

Penicillium sp.

Unidentified species of *Penicillium* were isolated from soil samples 3, 14–1, 15?, 26.

Trichoderma viride Persoon ex Fresenius.

Isolated from soil samples 14–1, 32.

Tuberculariaceae

Fusarium sp.

Unidentified species of *Fusarium* were isolated from soil samples 22, 31.

LICHENES

Lichens were given to Dr. Mason Hale of the U.S. National Herbarium, who identified them as follows:

Pyrenocarp lichen.

Encrusting pieces of volcanic rock piled up on shore. *Sachet 477.*

Buelliaceae

Rinodina sp.

On walls of passages inside Clipperton Rock. *Sachet 469.*

Pyxine sp.

On trunk of coconut palm. *Sachet 352.*
On dead coconut wood. *Sachet 479.*

ALGAE

All the algae collected during the 1958 survey were sent to Dr. E. Yale Dawson who has reported on them elsewhere (Dawson, 1959). While the majority of the marine forms were collected by the marine biologists, my collections included a few, but my algae were mostly of land and lagoon species. By far the greater number of these are Myxophyceae, or blue-green algae. Specimens of these were retained in his herbarium by Dr. Francis Drouet, who identified them. The Desmidiaceae, Oedogoniaceae, and Peridiniaceae were isolated and identified by Dr. P. Bourrelly. Sets of duplicate specimens were sent by Dr. Dawson to the U.S. National Herbarium and the Paris Museum.

The following list of land and lagoon algae is compiled from Taylor (1939), who based his report on collections made by Dr. Waldo Schmitt on July 21, 1938, and from Dawson (1959).

Myxophyceae

Chroococcaceae

Anacystis aeruginosa (Zanardini) Drouet & Daily.

Concentrated near lagoon shore. *Sachet 325* in part.

Anacystis montana (Lightfoot) Drouet & Daily.

Covering coral fragments and rocks everywhere on land. *Sachet 463* in part, *466* in part, *473* in part; *Limbaugh et al. 20009* in part.

Chroococcus turgidus (Kützing) Nägeli.

Lagoon, occasional among filamentous algae. *Schmitt 21* in part.
Lagoon. *Sachet 478* in part.

Gomphosphaeria aponina Kützing.

Lagoon, infrequent colonies among filamentous algae. *Schmitt 21* in part.

Microcystis flos-aquae (Wittrock) Kirchner.

Lagoon, infrequent among filamentous algae. *Schmitt 21* in part.

Chamaesiphonaceae

Entophysalis deusta (Meneghini) Drouet & Daily.

Surface of coral pebbles and consolidated rock. *Sachet 475* in part.

Forming thin layers or crusts on coral sand. *Sachet 305* in part, *308* in part.

In surface sand at top of beach. *Sachet 462* in part, *471* in part.

Entophysalis granulosa Kützing.

Lagoon. *Sachet 478* in part.

Stigonemataceae

Mastigocoleus testarum Lagerheim.

Surface of coral pebbles and consolidated rock. *Sachet 475* in part.

Forming thin layers or crusts on coral sand. *Sachet 305* in part, *308* in part.

Nostocaceae

Nostoc sp.

On dead coconut trunks and husks. *Sachet 467* in part (young plants).

Scytonemataceae

Scytonema hofmannii Agardh.

Covering coral fragments and rocks everywhere on land. *Sachet 463* in part, *466* in part, *473* in part; *Limbaugh et al. 20009.*

Rivulariaceae

Amphithrix violacea (Kützing) Born.

On coral rocks along lagoon edge. *Sachet 328* in part.

Calothrix crustacea Thuret.

In sand and crust along lagoon edge. *Sachet 474* in part.

In surface sand at top of beach. *Sachet 471* in part.

Surface of consolidated ledge. *Sachet 472* (with primordia of green algae).

Thin layer or crust in surface sand. *Sachet 305* in part, *308* in part.

Calothrix parietina (Nägeli) Thuret.

Lagoon. *Sachet 478* in part.

Calothrix stellaris Bornet & Flahaut.

Lagoon, on leaves of *Najas marina*. *Schmitt 21* in part.

Oscillatoriaceae

Lyngbya aestuarii (Mertens) Liebmann.

Lagoon, scattered trichomes in and among the masses of *L. versicolor*, back from landing place. *Schmitt 21* in part.

On coral rock in lagoon. *Sachet 478* in part.

Lyngbya semiplena (Agardh) J. Agardh.

On rocks in lagoon. *Sachet 478* in part.

Concentrated near shore of lagoon. *Sachet 325* in part.

Lyngbya confervoides Agardh.

On coral rocks along lagoon edge. *Sachet 328* in part.

Lyngbya guaymasensis Drouet.

Concentrated near shore of lagoon. *Sachet 325* in part.

Lyngbya lagerheimii (Möbius) Grunow.

Lagoon, scattered trichomes among the masses of *L. versicolor*. *Schmitt 21* in part.

Lagoon. *Sachet 478* in part.

Lyngbya versicolor (Wartmann) Gomont.

Lagoon, forming large masses, probably extremely abundant with other algae and *Najas marina*. *Schmitt 21* in part.

Lagoon. *Sachet 478* in part.

Microcoleus chthonoplastes (Flora Danica) Thuret.

In surface sand at top of beach. *Sachet 471* in part.

Plectonema nostocorum Bornet.

On surface of sand turning to sandstone, slab thrown up on top of beach. *Sachet 476* in part.

On dead coconut trunks and husks, *Sachet 467* in part.

Plectonema terebrans Bornet & Flahaut.

Forming thin layers or crusts on coral sand. *Sachet 305* in part, *308* in part.

Surface sand on top of beach. *Sachet 462* in part.

Schizothrix heufleri Grunow.

In surface sand at top of beach. *Sachet 471* in part.

Chlorophyceae

Desmidiaceae

Closterium parvulum Nägeli, forma.

Lagoon, infrequent in strainings from *Lyngbya* masses. *Schmitt 21* in part.

Closterium parvulum Nägeli.

Lagoon. *Sachet 478* in part.

Closterium parvulum near var. **majus** West.

Lagoon, frequent in strainings from *Lyngbya* masses. *Schmitt 21* in part.
Lagoon. *Sachet 478* in part.

Cosmarium clippertonensis Taylor.

Lagoon, very common in strainings from *Lyngbya* masses. *Schmitt 21* in part.
Lagoon. *Sachet 478* in part.

Cosmarium subprotumidum Nordstedt, forma.

Lagoon, common in strainings from *Lyngbya* masses. *Schmitt 21* in part.

Oöcystaceae

Oöcystis solitaria Wittrock approaching forma **major** Wille.

Lagoon, frequent among filamentous algae. *Schmitt 21* in part.

Oedogoniaceae

Oedogonium sp.

Lagoon, frequent among other algae. *Schmitt 21* in part.

Oedogonium sp.

Lagoon. *Sachet 478* in part.

Sphaerellaceae

Protococcus grevillei (Agardh) Crouan.

On surface of sand turning to sandstone, slab thrown up on top of beach. *Sachet 476* in part.

Characeae

Chara sp.

Seauty in lagoon, with *Lyngbya versicolor,* sterile. *Schmitt 21* in part. The specimen was examined in 1948 by Dr. R. D. Wood who identified it as a form of *Chara zeylanica* Klein ex Willdenow near *C. kenoyeri* Howe. *Chara* was especially looked for in 1958, but without success. However, among lagoon sediments collected in 1958 by E. C. Allison, oospores of a *Chara* were isolated and sent to Dr. Wood. He considers (personal communication) that they may be *C. zeylanica* and thus would represent the same plant as the sterile specimen collected in 1938. The plant may have been killed by the addition of sea water to the lagoon at the time of a storm.

The variable pantropic *Chara zeylanica* occurs widely in the Pacific Islands as well as throughout North and South America. The form of it known as *C. kenoyeri* Howe was described from Barro Colorado Island and according to Wood is found in the vicinity of Panama.

Pyrrophyceae

Peridiniaceae

Glenodinium sp.

Lagoon. *Sachet 478,* in part. A new species of *Glenodinium* was isolated by Dr. Bourrelly and is being studied and described by Dr. Baleeh. It is also represented in a collection by Limbaugh.

BRYOPHYTA

Musci (Mosses)

The presence of moss on Clipperton was noted by Limbaugh in 1956 and Klawe in 1958. I collected 3 species which were identified by Dr. Harvey A. Miller. Sets were kept at Miami University, Oxford, Ohio, others were sent to the U.S. National Herbarium, the Paris Museum, the herbarium of the New York Botanical Garden and the herbarium of the University of California.

Bryaceae

Bryum sp.

Sterile plants of a species of *Bryum* were extremely abundant on rocky pavements all around the island (see vegetation section). *Sachet 303* and *334* were collected on the northwest part of the atoll. Unfortunately most species of *Bryum* cannot be recognized when sterile. This one may be near *B. cuspidatum*.

Bryum argenteum Hedwig var. **lanatum** (Palisot de Beauvois) Bruch, Schimper & Gümbel.

This silvery moss (*Sachet 335*) was found only on a rocky pavement on the northwest part of the atoll, often mixed with the above. It is the variety with percurrent costa, typical of arid situations. It is a pantropic taxon.

Leucobryaceae

Octoblepharum albidum Hedwig.

Found only on a few coconut trunks inside the main southwest grove. *Sachet 351*. It formed a network of small star-shaped plants on the trunks together with some lichens of the genus *Pyrine*. This species is also pantropic.

PHANEROGAMIA

Except for a few unicates, to be deposited in the U.S. National Herbarium, several full or partial sets of Phanerogams were made and were sent to the following herbaria: U.S. National Herbarium; Laboratoire de Phanérogamie, Muséum National d'Histoire Naturelle, Paris; B. P. Bishop Museum; New York Botanical Garden; Rijksherbarium, Leiden; San Diego Natural History Museum; University of California, Berkeley; California Academy of Sciences; and Royal Botanic Gardens, Kew.

Some identifications were made and all were checked by Dr. F. R. Fosberg, whose help is deeply appreciated.

Potamogetonaceae

Potamogeton pectinatus Linnaeus.

Found only near one of the Egg Islands in the lagoon. *Sachet 326*.

This species is widely distributed in North and South America, Eurasia, and Africa, but is lacking in the Pacific Islands. It is most likely indigenous in

Clipperton, probably brought originally in the crops or on the feet of birds. Guppy (1906, p. 513) mentioned that seeds of *Potamogeton* are sometimes found in the crops of ducks. Several species of Anatidae (ducks) have been seen in great numbers in November on Clipperton Island (Beck, 1907) and *P. pectinatus* may well have been brought to the atoll by them.

Ruppia maritima Linnaeus.

Attached to rocks in shallow water along lagoon shore. *Sachet 327, Limbaugh 1, Kluwe s.n.*

This is the short pedunculed form. Setchell (1946, pp. 469–477) demonstrated that the type of this species is a form with short peduncle (contrary to previous typifications) and regarded var. *rostrata* Agardh as a synonym. He considered that the variations in fruit shape and relative length of peduncle and podogynes, beak, etc., are "reversible ecophenic" expressions of form and size.

The short pedunculed plant is well represented along the west coast of America. It is not var. *pacifica* St. John and Fosberg which has a shorter rostrum, and is found farther west in the Pacific.

This is in all likelihood an indigenous plant on Clipperton. It is well adapted for distribution either in the crops or in mud on the feet of birds. It can stand a very high salt content in the water and also, in many coastal situations, endures great fluctuations in salinity.

Zostera marina var. **latifolia** Morong ?

No specimen of this species has been seen, but a photograph taken in 1943 by the Byrd party (Byrd, 1943, vol. 2, photo 15) shows large masses of drift on a lagoon beach, composed almost entirely of a coarse "sea-grass," different in appearance, and larger than any of the three species of phanerogams found in the lagoon in 1958. The plant cannot be identified with certainty from the photograph, but, according to F. R. Fosberg, the masses look very much like the drift of *Zostera marina* var. *latifolia* that sometime pile up on the shores of estuaries on the California coast. The lagoon water was reported by Byrd (1943, vol. 1, p. 22) to be brackish "70 grains of salt per gallon" (1200 ppm), in September 1943. On the Atlantic coast of the United States, *Zostera* grows in brackish water well up Chesapeake Bay and Setchell (1929, p. 430) recorded it from the Baltic and the Black Sea, which have low salinity in their surface waters, so it would not be impossible for this species to grow in the almost fresh water of Clipperton lagoon. Very likely this plant had disappeared or become dormant at the time of my visit (August, 1958), as the lagoon beach drift was then searched carefully for the previously reported

Chara (see p. 268) and no broad-leafed or coarse-stemmed aquatic similar to what is shown in the photograph was found. Here is an important indication that the flora of the island may change from time to time due to chance or environmental fluctuations.

Najadaceae

Najas marina Linnaeus var. **latifolia** A. Braun.

Very common in lagoon from shore to depths of 6 m. (acc. Limbaugh). *Sachet 304, 340; Schmitt 102; Klawe s.n.*

The species is almost cosmopolitan, in temperate and tropical regions. It is known from tropical America and as far north as California, but is absent from the Pacific Islands west of Clipperton. The variety is known from tropical South America (Rendle, 1899, p. 396), and is most probably indigenous in Clipperton, to which it was perhaps brought by birds.

Gramineae

Cenchrus echinatus Linnaeus (glabrous form).

One of the most abundant plants on the island. *Sachet 321; Schmitt 104; Klawe 1460, 1461.*

A common weed in tropical America and the Pacific Islands, possibly introduced to Clipperton by human agency, as it has been on many other atolls.

Dactyloctenium aegyptium (Linnaeus) Willdenow.

Common locally on coral sand. *Sachet 348; Limbaugh 2; Klawe 1452, 1454.*

Pantropic weed, extending into temperate regions (United States). Introduced to Americas and the Pacific Islands from Old World. Certainly not native to Clipperton.

Eragrostis amabilis (Linnaeus) Wight & Arnott.

Common locally on coral sand and rocks. *Sachet 316, 351; Klawe 1463.*

Pantropic weed, frequently introduced on coral islands and thriving there. Introduced to America from the Old World. Certainly not native to Clipperton.

Eragrostis ciliaris (Linnaeus) R. Brown.

Common locally. *Sachet 319; Limbaugh 4.*

A pantropic weed, undoubtedly introduced into Clipperton by man.

Cyperaceae

Eleocharis geniculata (Linnaeus) Roemer & Schultes.

Forming pure stands on wet mud around lagoon. *Sachet 312, 324.*

Warmest parts of America northward to California, Michigan, and Ontario, but widely distributed in Old World also, including Pacific Islands, in wet places. Probably carried around on the feet of wading birds and possibly thus introduced to Clipperton.

Eleocharis mutata (Linnaeus) Roemer & Schultes.

Forming dense beds around lagoon, growing in shallow water. *Sachet 317.* (det. H. K. Svenson).

Occurring in the West Indies, Central and South America, the Galápagos, and tropical Africa, according to Svenson. Possibly brought to Clipperton by birds, either in their crops or more likely in mud on their feet.

Figure 3. Sedge marsh of *Scirpus rubiginosus* on Clipperton Island, at base of Hook.

Hemicarpha micrantha (Vahl) Pax.

Scattered small plants on sand or drying mud. *Sachet 310, 311, 307* (det. H. K. Svenson).

North, Central and South America. Possibly brought to Clipperton in the crops or in mud on the feet of birds.

Scirpus rubiginosus Beetle.

Forming occasional patches (fig. 3) at edge of lagoon, in shallow water. *Sachet 318.*

Pacific coast of North America from Vancouver Island to Baja California, according to Beetle. Probably brought to Clipperton by water birds.

Palmae

Cocos nucifera Linnaeus.

A large grove of palms, together with smaller groups and isolated trees. *Sachet 353* (obtained with the help of Dr. Kenneth E. Stager).

Original home unknown, most likely spread all over the tropics by human agency. Certainly deliberately brought to Clipperton by man in recent years. First noted in 1897.

There appear to be two main varieties of coconut palms on the island: some have more oval, green nuts, and the rachis of the young frond is also green; others have a bright orange young rachis, and rounder large orange nuts. The lone palm opposite the Egg Islands is of the latter type.

Portulacaceae

Portulaca oleracea Linnaeus.

Local. *Sachet 345, 357; Klawe 1453, 1462.*

Small scattered plants are found, mostly on the east side of the island, the most important stand being near the lagoon, a little south of the landing place. For many days no flowers were seen until finally the stand was visited in the early morning when the yellow flowers were watched opening and wilting in the course of an hour.

This species is cosmopolitan and polymorphic, but the seeds of the Clipperton specimens are like those of the common tropical American form. It is widely introduced in connection with human activity, but also appears to be native in many areas. It is uncertain whether it is native or recently introduced on Clipperton.

Figure 4. Dead erect fruiting branches of *Brassica*. Vegetation in foreground mostly *Sida* with mat of *Ipomoea*.

Cruciferae

Brassica juncea Linnaeus.

Forming local colonies in various parts of the atoll, especially in the main coconut grove on the southwest, and on the northwest land strip. *Sachet 331.* Many dead old fruiting branches formed stands up to 1 m. high (fig. 4).

The species is from Asia and was probably deliberately introduced, as the greens are eaten (it is known as Chinese mustard and by other names). Probably brought to Clipperton by guano workers as it is recognizable in photographs taken in 1943. Another species of *Brassica* may have been present in the main coconut grove, but if so was not collected.

Leguminosae

Caesalpinia sp.

A single seedling from drift seed, on ocean beach. *Sachet 302.* Adult plants not found on island. Seeds of *C. bonduc* are common in beach drift on the island.

Canavalia sp.

Seedling growing among *Ipomoea pes-caprae* vines. *Sachet 347.*
Doubtless germinated from drift seed as not otherwise known from island.

Mucuna sloanei Fawcett & Rendle ?

Seedling vines growing at top of beach from drift seeds, *Sachet 349, 338;* also many seeds in drift. Placed here because of 3 veins rather than 4 at base of lateral leaflets. Not distinguishable with certainty from *M. urens* without mature racemes. Could be the "plant resembling sarsaparilla" of Morrell which made his men ill (see p. 286), as it has prurient hairs on the pods. This and related species are widely called "cowitch" because of the terrific painful itching caused by these hairs.

Tropical American and West African shore plant.

Phaseolus adenanthus G. F. W. Meyer ?

Sterile, *Sachet 332*; found only on the northwest side where it was mixed with *Ipomoea pes-caprae* vines. The specimen matches best those of this species but the tips of the folioles are unusually rounded at apex.

Widespread weed of tropical American origin. Cultivated, though not commonly so in United States. Possibly introduced as a cultivated plant, or else from drift seed.

Euphorbiaceae

Phyllanthus amarus Schumacher & Thonning.

Common, especially on the northwest and east sides of the island. *Sachet 323, 359; Schmitt 101; Klawe 1456.*

According to F. R. Fosberg and G. L. Webster, the specimens undoubtedly belong to this species. It is usually, but incorrectly, referred to *P. niruri* Linnaeus.

Phyllanthus amarus is probably of Caribbean origin but now is a pantropic weed. Doubtless accidentally introduced by man. Two variants are present, one with conspicuous pellucid leaf veins, the other the ordinary form.

Sapindaceae

Sapindus saponaria Linnaeus ?

Seedling in drift. *Sachet 339.*

Seed identical with that of *S. saponaria,* simple leaves probably a seedling character, especially in view of a statement by de Candolle (1824, p. 607):

"Frutex nascens, quem viv. in h. genes. video, foliis simplicibus elongatis fere Dodonaeam refert."

Judging from the size of the drift seeds found two forms are represented, f. *microcarpus* Radlkofer and probably, from the distribution, f. *inaequalis* (De Candolle) Radlkofer. The germinating seedling is of this latter form. It is well represented in tropical America along the west coast, in the Galápagos, and in Hawaii. Forma *microcarpus* is widely distributed in the Pacific Islands.

Malvaceae

Sida rhombifolia Linnaeus.

One of the most common plants on the island. *Sachet 315; Klawe 1457.*

Pantropic weed, extremely variable, but variation pattern obscure. Undoubtedly carried around by man, but attained a wide distribution in the Pacific very early. Doubtless introduced by man to Clipperton.

Tiliaceae

Corchorus aestuans Linnaeus.

Very common everywhere on island. *Sachet 346; Limbaugh 5; Klawe 1458.*

A common pantropic weed, doubtless carried around accidentally by man and probably thus introduced to Clipperton.

Sterculiaceae

Waltheria indica Linnaeus.

Only one small patch of this plant was found, near the south corner of the island. It was sterile but with some dead fruiting branches of the previous season. *Sachet 343.*

Pantropic weed, but probably of American origin; probably brought by man to Clipperton, but could have reached the island by other means.

Convolvulaceae

Ipomoea pes-caprae subsp. **brasiliensis** (Linnaeus) van Ooststrom.

Common all around the island. *Sachet 320; Limbaugh 6; Klawe 1459.*

This is the form usually found in America and the Pacific Islands, merging westward with the Indian Ocean form, which is ssp. *pes-caprae.*

Figure 5. Evidence of periodic dry weather on Clipperton Island, northwest land strip. "Trunk" of *Ipomoea pes-caprae*, in mixed herbaceous vegetation.

Most of the vines observed on the atoll were growing out of the ground or from a small root-stock. On the northwest part of the island, however, several plants were seen which possessed massive "trunks," large twisted woody stems 10–25 cm. in diameter and several dm. in length (fig. 5). From these, woody branches and the more common thick herbaceous vines emerged. This curious feature is interpreted as an indication of seasonal drought, the vines dying back in dry months to the thick stems and growing again in wetter seasons. A similar feature was observed by F. R. Fosberg (1955, p. 28) on Pokak Island, where *Ipomoea tuba* formed enormous stumps.

This plant was present on Clipperton at least as early as the 1938 visit of Schmitt, and probably had been there for a long time. It was likely introduced in drift, but a seed of it was once found in the crop of a fairy tern in the Marshall Is. (Fosberg, 1957, p. 234).

Ipomoea triloba Linnaeus.

Occasional on northeast, southwest, and south parts of the island. *Sachet 314, 341; Limbaugh 7.*

Only a few of the plants were in bloom and many of the vines seemed in rather poor condition.

Of tropical American origin, but now a pantropic weed, probably brought by man, but this is not certain.

Solanaceae

Nicotiana glauca Graham.

Scattered plants up to 1.5 m. tall occur on the northwest part of the island, *Sachet 329,* and south of the main coconut grove.

Very likely the species was introduced by the Mexicans and all the plants seen may have been planted. All were in very poor condition (fig. 6); many were dead, and others had dead limbs and only a few tufts of leaves at the tips of live branches. Altogether only a few flowers and some old fruiting twigs were seen.

The genus is American but this species is sometimes cultivated elsewhere as an ornamental. It is sometimes called tree tobacco and occasionally used for smoking in areas where the true tobaccos do not do so well, as in the dry areas of Mexico.

Solanum nigrum Linnaeus var. **americanum** (Miller) O. E. Schulz.

Occasional in various parts of island, especially on the northwest land strip, in the south corner and around the base of Clipperton Rock. *Sachet 309, 358; Schmitt 105; Klawe 1465, 1466.*

This species has a world-wide distribution, but the Clipperton material comes closest to the American variety. Possibly introduced by man, or earlier by birds.

Boraginaceae

Heliotropium curassavicum Linnaeus.

Occasional, especially abundant on sandy areas of east side of atoll. *Sachet 322, 356; Schmitt 103; Limbaugh 8; Klawe 1451.*

Clipperton Island specimens uniformly have very small linear to linear oblanceolate leaves, 6-15 mm. long, 1–2 mm. wide. A few basal leaves spatulate, 2 cm. long, 3–4 mm. wide toward apex. Specimens resembling these in leaf size: Mexico s.l. *Palmer 869* (US), which is more robust and has the leaves somewhat wider; Mexico, Sinaloa, Altata, *Rose 1369* (US), with leaves slightly larger and more spatulate; a similar one from same locality, *Rose et al. 14822* (US); one similar but with leaves a bit wider, from Jalisco, Nayarit, *Ferris 5729* (US). Various other specimens from Mexico and islands as well as several from Chile and one from Peru are somewhat similar. West Indian

material is variable, some rather approaching the above, but not so extreme.

Tropical American except for occurrence on Hawaiian Islands. Probably a native plant, perhaps originally brought by birds or currents.

Figure 6. Introduced plants on northwest land strip. *Nicotiana glauca*, *Cocos*, and *Brassica* in the background.

Compositae

Conyza bonariensis (Linnaeus) Cronquist.

Forming pure stands on sandy areas near lagoon, opposite the landing place, and on the northwest side. Many seedlings covering the ground in the latter stand. *Sachet 313, Limbaugh 9.*

Common introduced plant throughout tropics and temperate zone; origin obscure, but probably American. May have been introduced by wind but more probably by man.

Eclipta alba (Linnaeus) Hasskarl.

Scattered over much of island in mixed herbaceous vegetation. *Sachet 336, 344; Klawe 1455; 1458a, 1464, 1467.*

American, but generally introduced in the tropics; probably brought to Clipperton by man.

DRIFT SEEDS

Seeds of land plants brought by ocean currents come to rest on beaches all over the world, although perhaps more noticeably in the tropics, where a greater number of plants produce large seeds. Drift seeds are found in abundance and are of great interest on the tropical oceanic islands, especially on the atolls, because a large proportion of the flora is of a strand character, and much of it has presumably arrived on the islands in drift. Under special circumstances, for instance after unusual weather conditions, immense quantities of drift seeds may be found on atolls. Such was the case on Canton Island in 1958, where Drs. O. and I. Degener filled many large bags with seed of many species (personal communication). Usually seeds are common on atoll beaches, but represent a limited number of species. On Clipperton in August, 1958, the numbers of seeds and of species found were quite small. Yet all members of the party were gathering them. Only a few handfuls were obtained of the larger foreign seeds. Of course, great numbers of small seeds of plants growing on the island, particularly of *Ipomoea pes-caprae,* were found in the drift. Coconuts also are carried across the lagoon, or perhaps around the island, and found in drift.

After an examination of drift from other islands, and of some of the numerous books and papers that discuss drift seeds, it appears, as could be expected, that the recognizable seeds from Clipperton are all of very common species; in fact, they are among the most common drift seeds listed by Guppy (1906, 1917), and among those that remained afloat longest in his experiments (1906, p. 531).

While the literature on drift seeds and their importance in plant dispersal

is very rich, papers useful in their identification are uncommon. The most useful for the determination of Clipperton seeds were the studies of Guppy (1906, 1917), Ridley (1930), and Johnston (1949). The identities suggested by these works were checked in the herbarium. The following were collected between August 7 and 26, 1958.

Palmae

Several "seeds" or rather bony endocarps appeared to belong in this family and were sent to Dr. H. E. Moore, Jr., for comparison with material in the Bailey Hortorium.

Astrocaryum sp.

One large endocarp belongs to this American genus.

Cocoid palms.

Several other endocarps belong to cocoid palms from tropical America, but could not be identified.

Leguminosae

By far the greater number of drift seeds found on Clipperton are referable to this large family.

Caesalpinia bonduc (Linnaeus) Roxburgh.

The rounded gray seeds common on Clipperton and almost everywhere in drift are of this species.

Caesalpinia major (Medic) Dandy & Exell.

One seed, similar to the above but larger and pale brown, belongs here.

Canavalia rosea (Swartz) De Candolle.

Four bean-shaped seeds correspond very well with Johnston's description of this species.

Dioclea megacarpa Rolfe?

Seeds of *Dioclea* spp., large circular, biconvex, and smooth with a long, thin attachment scar, are extremely common in drift everywhere, and are numerous on Clipperton Island. They are orange to brown. Tentative identifications to species were made with the help of Johnston's paper. Four seeds, larger than the other *Dioclea* seeds, lighter in color and with a narrow attachment scar may be of this species.

Dioclea reflexa Hooker?

Seeds of *Dioclea* are quite variable in size and shape and are not easily arranged in groups of similar individuals. Most of those from Clipperton are probably referable to *D. reflexa,* but some may be of other species.

Entada gigas (Linnaeus) Fawcett & Rendle.

The large, heavy, dark brown snuff-box sea beans are of this species. The plant is confined to the New World and Africa, but the beans of this and similar species are found all over the world.

Mucuna mutisiana (Humboldt, Bonpland & Kunth) De Candolle?

The rounded, minutely hammered seeds of *Mucuna* spp. of the *M. urens* group are dark dull brown, with a dark wide attachment scar, sometimes bordered by a lighter area. Several of those found on Clipperton matched well seeds of this species.

Mucuna sloanei Fawcett & Rendle.

Many of the Clipperton *Mucuna* seeds appear to be of this species.

Mucuna urens (Linnaeus) De Candolle?

One *Mucuna* seed, larger and flatter than the others, may belong here, but the attachment scar is somewhat wider than is described for this species by Johnston.

Strongylodon lucidus (Forster filius) Seemann?

One black seed, with a long, very thin attachment scar may be of this species. The scar is somewhat narrower than in the only seed available in the herbarium for comparison. This is a Pacific Islands species and is commonly found in drift; if the identification is correct this seed provides the only definite evidence of transport to Clipperton of a land plant from westward in the Pacific.

In 1956, Mr. Limbaugh collected seeds of *Caesalpinia bonduc, Mucuna* sp. and *Dioclea* sp. on Clipperton Island.

Sapindaceae

Sapindus saponaria Linnaeus.

A few spherical black seeds of two sizes appear to belong to forms of this species (see also p. 275). *Sapindus* drift seeds are common but "in scanty numbers" (Guppy, 1917, p. 157) in the Caribbean, much less so in the Pacific (one was recently identified from Eniwetok).

Convolvulaceae

Merremia tuberosa (Linnaeus) Rendle.

Two large rounded black seeds, with 2 furrows at right angle dividing one side into 4 sections, and with a large bean-shaped attachment scar on the other side, were recognized with the help of Guppy's work (1917, pp. 161–164). They are abnormal, single seeds of *Merremia*, replacing the usual 4. One specimen in the U.S. National Herbarium from Haiti, *Leonard and Leonard 12680*, includes such a seed in a wood rose attached to a good specimen of the plant. The plant is American and West African but the abnormal seeds drift as far as Scotland and the outlying islands and other parts of Northern Europe (Guppy, 1917, pp. 161–164), together with seeds of *Mucuna* and sometimes *Entada*.

A few drift seeds of some of the species listed above had germinated. Such seedlings of *Caesalpinia*, *Canavalia*, *Mucuna*, and *Sapindus* are mentioned in the preceding enumeration of Clipperton plants.

Unidentified drift trees were seen on the upper parts of beaches or beach ridges, and indeed have been reported repeatedly since 1711. One such tree contained a piece of volcanic rock embedded in its root system.

SUMMARY OF PHYTOGEOGRAPHICAL RELATIONSHIPS

Clipperton Island, the lone atoll of the Eastern Pacific, much nearer to the American mainland than to the nearest Pacific Islands to the west, has long intrigued biogeographers. Collections of marine animals and plants have revealed that both an American and a substantial Indo-Pacific element are represented in its fauna and flora. The proportions vary from group to group and change as each group becomes better known. Prior to recent collecting, the zoogeographic peculiarities of the atoll had been discussed on the basis of the molluscan fauna by Hertlein and Emerson (1953). Ekman (1953) occasionally referred to Clipperton in his general discussions of the tropical Pacific marine faunas.

A better understanding of the biogeographic relationships of Clipperton Island, based on more thorough collecting and correlated with increased knowledge of the ocean around it, was the principal object of the biological survey of 1958. Only a few of the animal groups have been identified and their geographic relationships discussed. Allison's study of *Conus* (1959) may be mentioned especially. No doubt the zoological work when completed will confirm and define more precisely the dual origin of the small atoll's fauna.

The small algal flora, which has been studied by Taylor (1939) and Dawson (1957, 1959), can be looked upon as the ultimate attenuation from west to east of the Indo-Pacific marine flora, with small admixture of American

species. Dawson (1959, p. 5) writes: "The floral composition is almost entirely of species that are common and widely distributed throughout the Indo-Pacific region . . . the very low degree of species diversity, even for Pacific atolls is remarkable."

Unfortunately, the land plants are rather disappointing as a source of information, for the vascular flora is very small and a number of species are certainly, others probably, of human introduction. Many of the remaining plants are pantropic in distribution and could have come to the island from any direction. Some, such as *Heliotropium curassavicum,* the sedges, and perhaps *Portulaca oleracea,* are native and probably came from the east. The palm "seeds" in the drift undoubtedly came from tropical America.

The lagoon phanerogams, and perhaps some algae (Proctor, 1959), were most likely brought by migrating birds that travel along generally north and south flyways and seldom, if ever, visit central Pacific islands.

None of the species in the Clipperton land flora can unequivocally be regarded as having come from the Indo-Pacific region. In fact the complete absence of very widely distributed Pacific plants that are found on a great many atolls is extraordinary. *Scaevola sericea,* for instance, is known on islands, especially atolls, from the Tuamotus to the Hawaiian chain and from the western side of the Indian Ocean to Christmas and Henderson Islands. Of almost equally extensive occurrence are *Triumfetta procumbens, Pisonia grandis, Tournefortia argentea, Lepturus repens* and many others. All the species just mentioned tolerate seasonal dryness rather well and could certainly live under the climatic conditions of Clipperton Island. *Scaevola* and *Tournefortia* are probably disseminated in drift, the others by birds. Evidently Ekman's East Pacific Barrier (1953) is even more effective for land plants than for marine algae and animals. The present fragmentary state of the knowledge of the distribution of terrestrial nonvascular cryptogams, as well as the paucity of the known flora and lack of determinations in some groups, make speculations as to their phytogeography at present futile.

There is reason to believe, as will be shown below, that the present flora of Clipperton is of very recent origin and one might speculate on the possible presence of an Indo-Pacific element in the original flora. However, we know that native trees have never occurred on the island in 250 years of recorded history, and therefore, that a number of very common Pacific atoll species have never grown on it. We may never know whether any herbaceous Pacific species were ever present.

Man has already had much irreversible influence on the ecology of Clipperton. Still, the island continues to form a valuable small laboratory and periodic resurveys will be very fruitful, even in the study of the meager land flora, if the island remains uninhabited and is preserved from further interference.

TABLE I

Possible Means of Transport of Land and Lagoon Plants to Clipperton Island

	Natural means				Human agency	
	Wind	Drift	On birds	In birds	Accidental	Deliberate
Fungi	?					
Lichens	?					
Microscopic algae	?			?		
Chara			?	?		
Mosses	?					
Potamogeton			?	?		
Ruppia			?	?		
Najas			?	?		
Cenchrus			?		?	
Dactyloctenium					?	
Eragrostis amabilis					?	
E. ciliaris					?	
Eleocharis geniculata			?	?		
E. mutata			?	?		
Hemicarpha			?	?		
Scirpus			?	?		
Cocos						x
Portulaca	?		?		?	
Brassica						x
Phaseolus					?	?
Phyllanthus					?	
Sida					?	
Corchorus	?				?	
Waltheria					?	
Ipomoea pes-caprae		x		?		
I. triloba					?	
Nicotiana						x
Solanum				?	?	
Heliotropium		x				
Conyza	?				?	
Eclipta	?				?	

HISTORY OF VEGETATION

While no record has been found of the discovery by John Clipperton of the Rock and Island that bear his name, it is generally believed to have occurred in 1705, during this pirate's crossing from Peru to China, of which there is no available account. The island may have been known earlier to Spanish navigators, although it lies far south of the galleon routes across the Pacific; unsatisfactory accounts and poor determinations of coordinates make it very difficult to identify many of the islands marked on ancient charts, and it is unlikely, in any event, that any recognizable description of the island written before 1705 will be discovered.[5] As far as known, then, the written history of Clipperton Island begins on April 3, 1711, when two small French ships, *La Princesse* and *La Découverte*, happened upon it (France, 1912). The Captain of *La Découverte*, Michel Du Bocage, and a passenger on *La Princesse*, Mr. De Prudhomme, wrote in their ship log and personal diary, respectively, excellent brief descriptions of the island and its Rock; it was named Ile de la Passion, as April 3 was Good Friday. The coordinates fit, as do the descriptions and a small sketch map (although this is wrongly oriented) furnished by Mr. De Prudhomme. There is no mention of openings to the lagoon, and none is indicated on the sketch, but the ships may not have come close enough to see them, if they existed then. Both writers mention low brush as the only visible vegetation of the island, and note the presence of large dead drift tree trunks. De Prudhomme used the word "raquettes" which brings to mind *Opuntia*. Species of this cactus grow in the Revillagigedo and Galápagos Islands and could have occurred on Clipperton.

The first recorded landing on the island took place over a hundred years later (in August, 1825), as a result of which a more detailed account of its vegetation and flora was published (Morrell, 1832): "It produces a little shrubbery and some coarse grass, among which I think fresh water might be found by digging. . . . Among the few vegetable productions of this island we found a plant resembling sarsaparilla, which badly poisoned several of the crew who handled it."

Sir Edward Belcher who sketched the first published map of the atoll as seen from the masthead of HMS *Sulphur* in May 1839 (Belcher, 1843) noted the absence of trees (except for large drift trunks) and remarked that the north side seemed covered with something like grass. His map and description indicate two openings into the lagoon, one at the north end of the northeast coast, and one southeast of the Rock, at the head of what is now Rock Bay. At the present time, these areas are relatively low, free of elevated consolidated rock and formed of coral sand or gravel; therefore they correspond well to possible sites of former openings.

5. For a detailed account of the known history of Clipperton, see Sachet, 1960.

The next well known visit to the island was that of Victor le Coat de Kerveguen, who took possession of it for the French Empire on November 17, 1858 (France, 1912). Several very difficult landings were made by swimming part of the way to the coast, and in his manuscript reports Le Coat de Kerveguen gave detailed descriptions of the island, accompanied by a sketch map and drawings of the Rock. He saw no trace of vegetation, but noted immense numbers of land crabs and birds. The lagoon was closed and its water salty, but how much so is not said.

Lt. Griswold visited Clipperton in August, 1861 (Pease, 1868) and found the lagoon closed, its water "*fresh* and *potable*," much driftwood on the beach, but no vegetation: "I did not find the least sign of vegetable life upon the island. The only plant seen, grew in considerable quantities in the lagoon, which I pulled out of the water, where it was growing."

One might be tempted not to take these remarks literally. Many non-botanists will report an area as totally devoid of vegetation just because there are no trees and tall bushes and what little herbaceous vegetation is present has not interfered with their walking or other activities. However, in the 1890's the Clipperton Island phosphate deposits (called "guano" by most authors) brought many visitors and even residents to the island, and accounts, both casual and scientific, became more numerous (Anonymous, 1893, 1897, Mexico [1911], Snodgrass and Heller, 1902); even photographs are available.

All these accounts imply or remark that there was no vegetation on the island at that time, and the photos (Wharton, 1898, Mexico [1911]) do not show any. In his manuscript diary, made available to me through the courtesy of Professor H. E. Maude and with the authorization of Mrs. Sydney Aris, John Arundel, who visited the island in August, 1897, indicated that there was no natural vegetation.

Snodgrass and Heller, two Stanford students who collected birds and other animals in November, 1898, wrote (p. 502): "No land plant is native to the island, and the birds and crabs are everywhere so abundant that no plant could possibly grow there unless artificially protected." Dr. Snodgrass (conversation, 1960) confirmed this statement, but told me that the guano workers had a small enclosed garden.

In the decade following 1890, both coconut palms and pigs were introduced on Clipperton. A photo probably taken in 1897 (Mexico [1911], fig. 4) shows two small, healthy-looking palms, growing in a square enclosure perhaps 30 to 50 cm. high, and in front of them two large pigs. A long shed, probably where the phosphate rock was crushed and dried, forms the background of the photo. At that time the settlement was on the northeast side (U.S. Hydrographic chart no. 1680, 1897 ed., British Admiralty chart no. 1936, 1898, 1899 eds.) near the present Naturalists' Camp, and the first coco-

nut palms shown in the photo were planted there. It is not known whether the present small group of palms in that location dates from that time, or, as seems more likely, was replanted from the later, larger groves of the southwest coast.

Despite political storms, phosphate collecting continued in the beginning of the 20th century. In August, 1905, the Schooner *Academy* of the California Academy of Sciences visited the island. Slevin (1931, p. 21) wrote of that visit: "We found Clipperton to be a real coral atoll without a sign of vegetation with the exception of a lone cocoanut palm growing by the house of the keepers and bearing about 20 nuts." The scientific party noted the abundance of land crabs. Absence of vegetation and astronomical numbers of land crabs are also recorded in a picturesque newspaper account by Edwords (1906). "Land crabs literally infest the island, in countless numbers, getting into everything unprotected, eating anything soft . . . they eat all the green plants and even burrow to get at the seeds . . .

"The Pacific Islands Co. brought a ship load of soil from the mainland to make a garden. It was spread and seed planted. Next morning the place was red with crabs, and not a vestige of seed or loam remained." He goes on to describe how the garden was later replanted "on stilts" and visited by means of a short ladder which had to be removed every time, as the crabs could climb it. With enough such precautions the garden flourished.

At the time of the first World War the island phosphate digging was discontinued and after the dramatic rescue in 1917 (Perrill, 1937; Morris, 1934) of the group of women who had been stranded there for several years without supplies, the island was abandoned to the pigs, birds, and crabs. Captain Perrill's navigator, R. E. Kerr (Morris, 1934) mentioned great numbers of birds and "millions of crabs" but added "no grass grows on the entire island." There is no information on conditions between 1917 and January, 1935, when the French training ship *Jeanne d'Arc* visited the island to repossess it for France, to whom it had been awarded after international arbitration a few years before. The descriptions of the island at that time, and the photos (Anonymous, 1935, La Veyrie, 1935, Gauthier, 1949, Lacroix, 1939), indicate that the vegetation was generally similar to what it is now: a sparse cover of spiny grass and low thickets, a creeping plant (*Ipomoea*) giving the island its light green color, and several groups of flourishing coconut palms. The low thickets, as well as Morrell's "shrubbery" probably refer to the type of suffrutescent herbs now common on the island.

To summarize: in 1711, 1825, and probably 1839 the island had a low cover of suffrutescent and/or grassy vegetation. By 1858 this had disappeared and between 1893 and 1917 was still nonexistent. In 1935 the low cover had re-established itself and it has persisted to the present. How the vegetation disappeared, why it did not re-establish itself for decades, and

how it eventually did are the principal questions. They can only be answered by conjecture.

Such a possible reconstruction follows:

We have no reason to distrust Du Bocage and De Prudhomme, nor Morrell, in their mention of vegetation; indeed, except for Morrell's sarsaparilla (see *Mucuna sloanei*, p. 275) their descriptions fit remarkably well what can be observed on Clipperton today. We do not know, of course, when the crabs came to the island but very likely they were already part of the scant island fauna in 1711 and 1825. Even if they appeared later, it is difficult to believe that they could have destroyed entirely the natural vegetation of the atoll. While island biotas may be considered as unsaturated and unusually vulnerable to introductions, it seems unlikely that the land crabs would suddenly completely upset the ecological balance of an island.

Land crabs and/or hermit crabs are a normal component of atoll faunas and even in other treeless islands (such as the central Pacific atolls) they do not habitually succeed in eradicating vegetation, or in inhibiting its reappearance.

More probably the vegetation seen by the French navigators, Morrell and perhaps Belcher, was largely destroyed by a catastrophe and the crab population eating it as fast as it grew back, prevented its re-establishment. The catastrophic event may well have been the storm that closed the lagoon openings. At that time storm waves may have washed over much of the island and killed most of the plants. If the storm occurred after a dry spell, when the vegetation was mostly dry and many plants dead, the destruction would have been even easier. Both dry spells and storm waves are known to occur not infrequently on the island.

Re-establishment of the vegetation may also have been retarded somewhat by an increase in the number of birds and later by the exploitation of phosphate, which consisted in scraping off the surface of the land, a process not conducive to the establishment of a plant cover.

What then happened to bring back a better equilibrium between flora and fauna? Very possibly the introduction and multiplication of pigs. At the time of our visit in 1958 there were 58 of them on the island and from an examination of their droppings it was obvious that they ate crabs. Certainly the crabs were not as numerous as they had been at the turn of the century, and they found enough to eat around the island so that they never were a problem in the camp. The pigs may have eaten enough of them, after the island was abandoned, to give the vegetation a chance to take hold. By that time the flora had been increased by various introduced species.

In 1958, all pigs were killed, because they molested the birds.

What will happen next cannot be predicted, but is of great interest and observations should be made at every opportunity.

As late as 1917, the very end of the Mexican settlement, no vegetation was obvious to a visitor, but sources of introduced seeds from which the modern vegetation developed probably date back in part to the Mexican camp. They had a garden and very likely the supply ships brought weed seeds repeatedly. The crews of fishing boats who often stop for brief visits may have carried some weeds to the island. Various plants were observed in 1935, and in 1938 *Cenchrus, Phyllanthus, Heliotropium, Solanum,* and *Ipomoea pes-caprae* were growing on the island. *Brassica* is recognizable on the 1943 photos. P. G. Taylor (1948) mentioned spiny grass [*Cenchrus*], bright green creeper [*Ipomoea*], bushes near the Rock and clumps of wild tobacco, also a green plant the leaves of which could be eaten as vegetables [probably *Brassica*], and great masses of weeds in the lagoon. He was on Clipperton in September and October, 1944.

In December, 1944, a small weather station was established on Clipperton by the U.S. Navy, and it remained in operation until October, 1945. The men had a garden (Denniston, personal communication) and planted some coconut palms in rows as an avenue between the two lines of quonset huts. The ruined station is on the southwest side, in the large coconut grove. Great quantities of equipment, packing material, and evidently seeds of garden plants and perhaps even soil were brought to the island and very likely some of the weeds now found were introduced during that period. The U.S. Forces accidentally distributed many weeds in the tropical Pacific Islands, where, in some cases, the dates of the introduction can be pinpointed with great precision (Fosberg, 1957).

Since the station was abandoned, many fishermen, salvagers of abandoned equipment, and others have visited the island, as have crews of French Navy ships and of course parties of scientists. Chance introduction of weeds may have taken place during any of these short visits. All the while winds, currents, and birds are continuously bringing seeds, some of which germinate, and a very few of which may become established.

PRESENT CONDITION OF THE VEGETATION

The flora of Clipperton Island listed above does not include any trees or shrubs except the coconut, and the vegetation, except for the small groves of introduced coconut palms, is very low, mostly a few decimeters and often only a few centimeters high. While there are some bare places, the vegetation is mostly distributed rather evenly over the surface of the island and the cover is complete over large areas.

Most of the vegetation cannot be easily divided into well-defined types, and fails to reflect the varying characteristics of the substratum as might more

mature vegetation. This is not too surprising if we are right in thinking that this vegetation is less than 50 years old and if we consider the pioneer nature of much of the weedy flora and the profound disturbances to which the island has been subjected in the recent past (pigs, phosphate scraping, storms, occupation during World War II, etc.).

The main vegetation types or plant communities discernible without detailed quantitative phytosociological analysis are described below, as they were observed in August, 1958, with as much explanation of their habitat relations as the data at hand will permit.

COCONUT GROVES. Only a very small fraction of the total land area is occupied by coconut palms. They form one large grove, two small groups of a few palms, and a number of isolated single palms with thickets of seedlings. The large grove, on the southwest side of the atoll, along Pincer Bay, consists of

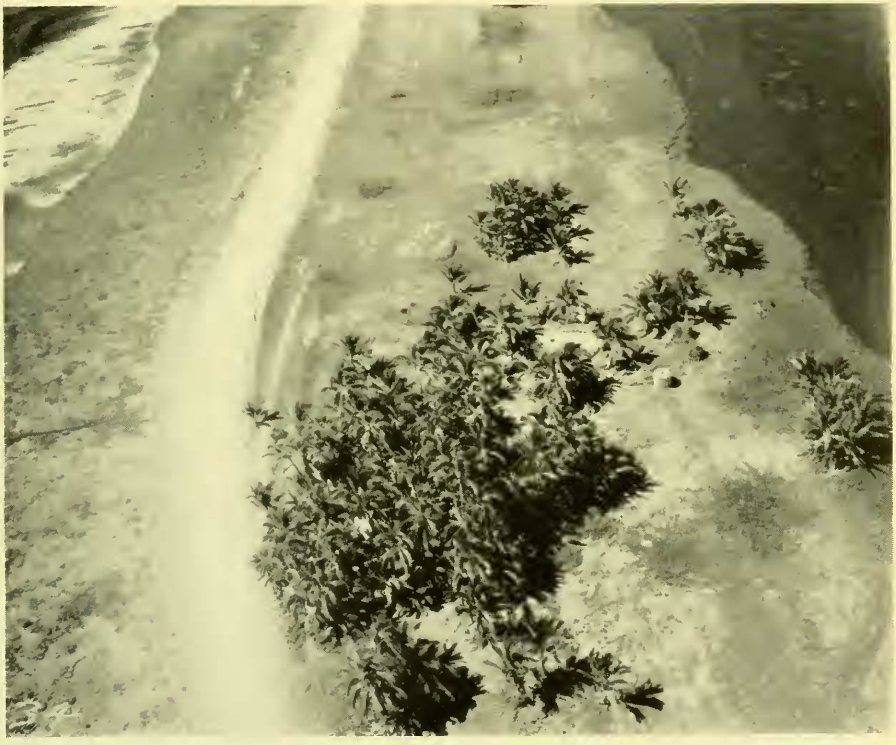


Figure 7. Air view (1957) of main part of the coconut grove on southwest side of the atoll. From left to right: ocean, reef flat (with trace of a ruined pier), beach and beach ridge, land strip, lagoon. The ruins of the U.S. Weather Station are mostly hidden in the palms. Low open mixed herbaceous vegetation, with *Ipomoea* vines forming mat along lagoon shore and creeping across land strip at lower right.

several groups of trees separated by small open areas and by the ruined buildings of the American weather station (fig. 7). The larger and perhaps older group of trees is immediately south of the station; the palms grow so close together as to form a complete canopy, providing such dense shade that there is no undergrowth of other flowering plants. Walking between the trunks is easy except for climbing over the litter of fallen fronds and piles of nuts. The ground is covered by a thick layer of partially formed humus resulting from the decomposition of the litter. Winds are little felt inside this group of trees and presumably the interior is also protected against salt-spray. A few of the palm trunks are bright green with some algae or lichens and a moss, *Octoblepharum albidum*, that forms a network of little star-shaped plants. A few fungi of the family Agaricaceae grow on dead wood. These cryptogams are the only plants to be seen within the palm grove.

South, north, and east of this main group of trees, but still a part of the grove, are smaller clumps of palms surrounded and intermixed with young trunkless palms and seedlings of all sizes. They form quite impenetrable thickets. Adjoining and to the north of the main group, two rows of obviously planted palms form an avenue between the two rows of ruined quonset huts of the American station. Other palms around the buildings may also have been planted. All these palms look very healthy, bearing numerous great green fronds and many infloresceneces and bunches of nuts in all stages of development. The mature nuts are quite large. Many birds, great frigates, fairy terns, and common noddies nest on the fronds and inflorescences of coconut palms and trickles of guano are everywhere; however, here they do not seem to damage the palms.

Along the narrow east face of Clipperton Rock is a small open grove of eleven palms, with seedlings and sprouting nuts, and with a decapitated dead trunk and several rotting stumps. A few lichens and fungi grow on some of the trunks and on dead wood. The litter is like that in the main grove, but less abundant. Again there is no undergrowth, perhaps because the pigs trampled and burrowed much in this area. Sea birds nest all over the palms, on the fronds, on the infloresceneces which they crush and destroy, even on the root system of a tipped-over palm. These palms are much damaged by this activity and perhaps by other factors, and do not bear as abundantly as the others.

On the northeast part of the atoll, a small group of 5 palms (fig. 10) and a number of seedlings mark Naturalists' Camp and one more tree grows a short distance away on the lagoon shore. As mentioned earlier, the first phosphate diggers' houses and sheds were in this general area, and the first coconut palms were planted on this side of the atoll. A thick blanket of *Ipomoea pes-caprae* covers the ground under the palms, which are not very tall and bear some nuts and infloresceneces.

A few isolated palms are scattered around the coral ring. There are two north of the main grove, on the lagoon shore at the base of North Pincer, two others some distance from each other south of the main grove, and one (fig. 6) on the lagoon shore opposite the Egg Islands. One more palm seen near Green Point in 1956 and 1957 was swept away by the storm which hit the northeast coast in late 1957 or early 1958. One of a number of drifted nuts, however, developed a seedling about 2 m. tall on the southeast side. The isolated palms near the main grove may have been planted but the others must have grown from nuts drifting across the lagoon or around the atoll after a storm. The isolated palms are healthy and bear many nuts, and are surrounded by thickets of seedlings and young palms.

Visitors to the atoll like to carry around germinated nuts and a number of seedlings were taken from the large grove to the northeast side in September, 1958.

Mixed herbaceous vegetation. The pioneer nature of plant life on Clipperton Island is evident from the fact that by far the greater part of the land

Figure 8. Mixed herbaceous vegetation on northwest land strip. Arrangement of plants in lines. The most conspicuous plants are *Sida*, some *Cenchrus* and some vines of *Ipomoea pes-caprae*.

area is covered by an ill-defined, variable assemblage of weedy species forming a low grassy or brushy cover. This is best developed on the northwest side of the land strip (figs. 4, 5, 6, 8, 9). It is from this area that this vegetation type is described in detail below. Its extensions elsewhere and its variants or derived discreet sub-units can be studied later.

On the northwest side, the most abundant species are *Cenchrus echinatus, Sida rhombifolia,* and *Corchorus aestuans.* They form a cover up to 30 cm. tall, with an admixture of such other plants as *Eclipta, Phyllanthus,* and *Solanum,* and locally the much taller *Brassica juncea* (fig. 4). Over large areas the cover is complete but some places are open or bare. The plants are often densely intermixed. A very curious feature of this vegetation is its arrangement in long narrow parallel lines (fig. 8) that roughly follow the shores of the land strip. This striated effect is very striking on air photos. On the ground, what may be seen are long narrow lines of taller, thickly packed plants, mostly of *Sida* and *Corchorus,* alternating with more open areas of lower vegetation. The substratum appears the same, with loose pieces of coral covering much of the soil. Occasionally, however, the ground forms slight furrows and ridges like windrows. It is well known of course that the same plants will grow taller, or in a slightly different arrangement, where the soil is deeper or the substratum of a different texture, and thus reveal invisible and unsuspected characteristics of the ground. The only plausible explanation is that the plants thus follow hidden features, including probably the trenches, now filled in, along which the phosphate workers scraped the top phosphate-rich rock. Arundel in his diary (see p. 287) several times mentions trenches, resulting from earlier phosphate collecting, which he observed on the west and northwest sides. Digging a cut perpendicular to the lines of plants would have been most interesting but unfortunately was not feasible. The arrangement of plants in this mixed herbaceous vegetation otherwise seems to be quite random, except for the few variants discussed below.

This part of the land strip is the widest and highest and appears least likely to be disturbed by storm waves. It is here that the curious "trunks" of *Ipomoea pes-caprae* (fig. 5) which must be many years old are growing (see p. 277). Here also, *Solanum nigrum* seemed to be coming back to life: individual plants, in August, 1958, showed short new leafy stems inside a sort of "basket" of taller white dead twigs (fig. 9). The few leaves of *Nicotiana* (fig. 6) also looked like new growth. All these taken together seemed to indicate that the island had only recently recovered from a severe dry season. The annual *Cenchrus* plants probably die during that season, and indeed large areas of dead plants were seen, but there, little new growth had developed as yet. Many of the other plants in this area also seemed to be recovering from the vicissitudes of a dry spell.

The mixed herbaceous vegetation that is best developed on the northwest

Figure 9. More evidence of periodic dry weather on Clipperton Island, northwest land strip. Plant of *Solanum nigrum* with white dead branches and shorter new stems.

side of Clipperton Atoll continues around along the southwest land strip but becomes generally much lower and sparser. The plants are often only a few centimeters high and form a sort of turf. However, in the main palm grove, between the groups of trees and the quonset huts, a few stands of *Sida* and *Brassica* reach 1 m. or more in height.

The species forming this vegetation do not grow on piled up coral gravel and the landward slope of the ocean beach ridge is mostly free of them. However, the top of the ridge is depressed in a shallow longitudinal trench where finer material may have accumulated and where mixed herbaceous vegetation forms a low continuous cover, with *Cenchrus* and *Corchorus* especially abundant. Inland from the ridge, a compacted road made by the tracked vehicles of the American Weather Station is covered with a low grassy vegetation.

Near the southern corner of the atoll and at the base of the Hook, the vegetation is mostly very sparse, with much ground exposed, and the mixed herbaceous type is represented by scattered clumps or short lines of *Sida* and *Solanum* (fig. 12) and small prostrate plants of *Heliotropium*.

Around the base of the Rock, the mixed herbaceous vegetation again includes a low grassy component, and taller plants of *Sida* and *Solanum*. Along the east face of the Rock, just outside the coconut grove, *Corchorus, Sida* and *Solanum* form a large patch more luxuriant here than elsewhere on the island and up to 1.5 m. tall.

Along the Isthmus and Thumb peninsula, the cover of mixed herbs is very low and forms a mosaic of grassy areas and patches where *Corchorus* and *Sida* are more abundant. Along the south side of the Isthmus, a pig trail was very noticeable through the grasses.

The mixed herbaceous vegetation that extends more or less completely along the north, west, and south sides of the atoll becomes less obvious along the east side, where it forms small discontinuous patches interrupted by bare areas or other vegetation, or is replaced by its own variants.

Variants of mixed herbaceous vegetation type. In some areas, the mixture of species forming this ill-defined vegetation may contain up to 15 species, in varying amounts, but with no obvious dominants. Elsewhere some species become more conspicuous, or fewer plants are found growing together. In extreme cases, patches of single species may be found.

Cenchrus echinatus variant. *Cenchrus echinatus* is almost always present in the mixed herbaceous community. In some areas, such as near the north corner of the island, or some parts of the east side which have been recently disturbed by storms, it is the dominant plant in a vegetation of a few species, or may even occur alone. Patches of pure *Cenchrus* may be large areas of dried, dead-looking plants, or small areas of tall, green, luxuriant plants. These patches occur principally on areas of gravel that have suffered recent disturbance. *Cenchrus* behaves as an extreme pioneer in these bare spots, germinating readily, growing rapidly, and maturing seeds early. Being an annual it may die when the next dry period occurs, giving other less abundant perennial species a chance to increase and produce a more diverse vegetation in the next and later growing seasons.

Heliotropium curassavicum and *Conyza bonariensis* variants. These are the only two species of the mixed herbaceous vegetation that obviously prefer a certain type of substratum. Wherever there is a sandy area, they may be present in the mixed vegetation. Where the sandy areas are extensive, they may form pure patches. It is not known how stable these pure vegetation types may be; perhaps they are relatively short-lived.

Pure *Heliotropium* vegetation is best developed near the east corner of the island, a little south of the landing place. There a low, rather flat sandy area is covered with these bluish-gray plants only a few cm. tall. Other smaller patches of pure *Heliotropium* occur elsewhere.

Pure *Conyza bonariensis* vegetation occupies, on the northwest side of the landstrip, a rather flat, sandy area. *Conyza* plants here form a dense stand 50 cm. tall, with an abundant ground cover of small seedlings. Another much smaller patch grows on the northeast side, opposite the landing place, near the lagoon.

Ipomoea pes-caprae TYPE. A little north of the landing place on the northeast side of the atoll, the whole width of the land strip is covered by a blanket of the beach morning glory, *Ipomoea pes-caprae*. In August, 1958, the vines were blooming abundantly and also bore fruits of different ages, including mature ones. The long thick vines, with their characteristically "goat-foot shaped" leaves, bright green and slightly succulent, spread in all directions and generally completely hide the ground. Between the wrecked LST and Naturalists' Camp, the wrecked and abandoned boats from the LST that lie on the land strip are almost completely smothered by the purplish pink-flowered vines. This coast-to-coast blanket extends north past Naturalists' Camp for some 80 m., then ends abruptly. The lagoon shore, along this area, is a low rocky cliff 1 to 1.5 m. above water level, and the *Ipomoea* mat extends to and over the cliffs. On the ocean side, erosion has recently caused the edge of the land to recede and dead and broken vines hang over the low cliffs forming this edge. On the photos taken in November, 1957, the vines can be clearly seen creeping down toward the beach and the present condition is no doubt a result of the 1957–58 storm (*cf.* p. 257).

Beyond the *Ipomoea* blanket this storm had laid coral gravel or sand over the whole land strip and there is no vegetation, except a few isolated *Ipomoea* vines, which, together with a few clumps of *Cenchrus,* may indicate the beginning of the revegetation process (fig. 2). At the north end of the devastated area, *Ipomoea* is again present all the way across the island for a short distance, then gives way to the mixed herbaceous type over most of the width of the land strip.

Along the entire northwest side of the island and around to Pincer Bay the vegetation of *Ipomoea* covers the low rocky cliffs of the lagoon coast and extends varying distances inland from the lagoon edge. In places it forms a very dense layer of vines, 0.50 m. thick or more, that makes for slow walking. From this wide belt, some plants occur oceanward into the mixed herbaceous type, where the large "trunks" were seen (fig. 5) and where long vines creep among the other vegetation. Near the lone palm of the northwest side, the *Ipomoea* blanket is mixed with the thinner stringy stems of a bean, *Phaseolus adenanthus.* The two species compete for this area and in places *Ipomoea,* in others *Phaseolus,* appears to be winning in the struggle.

Near Pincer Bay, the *Ipomoea* type continues along the rocky lagoon coast while some vines cross the rather dry open land strip to the old weather sta-

tion (fig. 7), where they form dense camouflage over some the ruined buildings, over some piles of sand, over phosphate rock, and over parts of the oceanside coral ridge.

South of the Bay the *Ipomoea* mat follows the rocky lagoon coast. Where the coast is very low, this type is replaced by sedge marshes. It is absent, for instance, in the area of the Hook. There are only two small patches on the Isthmus and a large one on the other side of Rock Bay, on the narrow southeast land strip.

Along the low southeast side of the atoll, this vegetation occurs again in close proximity to the sedge marshes (figs. 10, 11). The narrow sand bank that separates the marsh from the lagoon is covered with a luxuriant growth of *Ipomoea*. On the other side of the marsh, landward, a low flat of black mud is criss-crossed by dead *Ipomoea* vines; landward of that, on slightly higher dry ground, a belt of live vines forms the typical blanket as seen elsewhere. The same pattern, but on a smaller scale, was seen also near Green Point.

Figure 10. Vegetation of lagoon shore east side of Clipperton Atoll. Looking northwest toward Naturalists' Camp. Beds of *Eleocharis mutata* in ponded depression, center right. *Ipomoea pes-caprae* invading low sand bank. Masses of plant debris at edge of lagoon.

Figure 11. Same as figure 10, looking southeast.

The mudflats may have been inundated on the occasion of a storm and the water ponded behind the bank may have stagnated long enough to kill the vines. Some other plants are growing among the dead vines on these open flats, mostly small, scattered specimens of *Portulaca oleracea* and, near the landward edge, *Heliotropium*.

Great quantities of seeds of *Ipomoea* are present in the drift in various parts of the island, especially in the sandy area south of the landing place, where many have germinated and formed seedlings and short vines. The large caterpillars of the morning glory sphinx (*Herse cingulata*) were extremely numerous on the luxuriant *Ipomoea* vines in August, 1958, and had entirely defoliated large areas by September (Dr. A. S. Hambly, personal communication).

Sedge marshes. In low wet places, generally along the lagoon shores, sedge marshes are very conspicuous. The different species of sedges seldom mix in these wet places, but form single-species beds, their distribution apparently limited by the degree of wetness of the area. This arrangement is shown by the striking zonation in a pond at the base of the Hook (fig. 1). In the middle of the pond, in water, grows a thick stand of *Eleocharis mutata*, a

bright green sedge 60–80 cm. tall, with triangular stems topped by a pale brown spike. All around, in wet mud, is a strip of the small (15–20 cm. tall) light green *Eleocharis geniculata*. Scattered on drier spots at the outer edge of the marsh are small, gray-green plants of *Hemicarpha micrantha*. The last two species sometimes occur together in small drying places, as on Thumb Point. The *Hemicarpha* species is the only sedge that is occasionally found on high ground. It is the least abundant of the four sedges. The fourth species, *Scirpus rubiginosus,* forms small patches of tules, up to 2 m. tall, in wet mud (fig. 3) or in shallow water. The stems are round, dark dull green. Coots sometimes use them for their nests. *Scirpus* grows opposite the landing place on the lagoon shore, in a few places along Thumb Point Bay and the Hook, and in small areas scattered along the southwest shore, as well as on North Pincer.

The other species that grows in water, *Eleocharis mutata,* is by far the most common. It forms dense narrow strips in channels of water separated from the lagoon by dry sandy banks along much of the southeast shore (figs. 10, 11) and on the northeast shore at Green Point; elsewhere, the sedge beds line the shore itself. Just west of the pond mentioned above, where the land slopes almost imperceptibly to the lagoon, the sedges seem to hold the fine lagoon sediments with their roots, so that when the water-level rises and floods the low shore, the sedges appear to grow on a muddy bank separated from the shore by water. The aspect is similar on the strip of land between the ocean and Rock Bay, where *Eleocharis mutata* forms a scalloped fringe on root-held mud banks a little offshore in the Bay. Near the south corner of the island *Eleocharis* fills a small lagoon inlet. Along much of the southwest side of the atoll, small beds of *Eleocharis mutata* occur among low spots or in shallow muddy areas at the base of rocky cliffs. South Pincer also is lined with such a fringe and low areas on this peninsula are filled with this sedge, to form conspicuous darker green strips across the dominant *Ipomoea* vegetation.

Eleocharis geniculata does not grow in water but occurs commonly as scattered tufts on wet mud on the east side of the atoll and forms large beds immediately west of the Hook on damp mud flats. It is always landward of the *Eleocharis mutata* shore fringe.

Bryum type. In areas where the consolidated phosphate rock is exposed in a flat pavement the vegetation is often a pure cover of an unidentified species of *Bryum* in the form of numerous small cushions. This type is well developed at the base of the Hook (fig. 12) and around the south part of the island, as well as in the northwest, where it forms large carpets on flat rocky ground among the mixed herbaceous type. In the latter area this green sterile species of *Bryum* is in places mixed with a conspicuous, but much less abundant, silvery species, *Bryum argenteum* var. *lanatum*. Small tufts of *Bryum*,

with occasional lichens and blue-green algae, are scattered in such microhabitats as the small crevices and overhangs common on rough surfaces of much of the consolidated rock.

Figure 12. Open mixed herbaceous vegetation (mostly *Solanum* and *Sida*) at the base of the Hook. *Bryum* vegetation type in foreground, on consolidated phosphatic rock.

Blue-green algae type. While most descriptions of coral islands do not fail to mention the blinding whiteness of coral gravel and sand, much of the coral material on dry land is stained by microscopic algae; in fact, some of it is so dark that it looks more like fresh lava than coral. This condition obtains on Clipperton Island where the films of blue-green algae staining the otherwise bare coral fragments constitute one of the most extensive vegetation types. All expanses of dry sand are stained light green or rarely orange-pink to a depth of about 1 cm. by mixtures of blue-green algae, even in areas where sand has been recently deposited by the ocean. All the landward sides of beach ridges, as well as boulder fields extending landward and much of the consolidated phosphate rock ledges and pavements, are colored from dark gray to black by similar mixtures. Only the top fragments are stained, and only their upper surfaces and sides. The color generally becomes increasingly

paler downward along the sides, and the undersides are white, with sometimes a well marked green line between the stained and the white parts, as observed by Newhouse on Raroia Atoll (1954, p. 46).

The thin crust formed on dry sand seems, as far as our samples show, to consist of the following species: *Plectonema terebrans, Mastigocoleus testarum, Calothrix crustacea,* and *Entophysalis deusta,* with occasional admixture of others. A thicker crust of compacted sand from the top of the beach contained mainly *Protococcus grevillei* and *Plectonema nostocorum. Anacystis montana* and *Scytonema hofmannii* are the principal species closely associated on the surface of black coral fragments. On the phosphatized consolidated rock the mixture includes the same species of *Calothrix, Mastigocoleus, Entophysalis, Anacystis,* and *Scytonema.*

Except for the rather constant association of *Anacystis* and *Scytonema* on black coral, the samples are too few to establish firm relationships between the mixtures and these substrata and environmental conditions. The composition, nature, and ecological effects of these widespread crust and film communities are much in need of further investigation and comparison over a wide range of situations on atolls and other calcareous land. In particular, the significance of this type of land vegetation in soil formation and nitrogen fixation in atoll ecology has often been suggested, but not studied in detail or demonstrated conclusively.

Lagoon vegetation. In 1861 Lt. Griswold found the lagoon of Clipperton Island full of a water plant which he collected. Since that time, many authors have contrasted the abundance of plants in the lagoon with their scarcity on land.

Time and facilities were not available to study in detail whether the flora of the lagoon is arranged in recognizable vegetation types, and what they are. Only some brief notes can be made at this time. On the northwest side of the land strip, the lagoon shore is rocky and rocks under water are covered with a very abundant fur of algal filaments several centimeters long, bluish-green or turning to brownish. A collection from here includes *Lyngbya confervoides* and *Amphitrix violacea.* This algal fur occurs in most areas where the rocky shore is bathed by the lagoon water. Along much of the eastern half of the island strong western winds during August, 1958, pushed to shore great beds of algae mixed with higher plants. These were found floating on the surface or deposited as decomposing masses on the beach and included several species of *Lyngbya* associated with other blue-green and green algae. Such material could be found to some extent all around the lagoon, but was especially conspicuous on the east side (figs. 10, 11).

Some of the higher plants are attached to rocks in shallow water: *Ruppia maritima* occurs in various areas and is especially abundant around one of the

Egg Islands. *Potamogeton pectinatus* was found only in that same area. *Najas marina*, by far the most abundant phanerogam in the lagoon, forms thick stands in the shallower areas, with long stems rooting at nodes. Detached stems float in great tangled masses in various parts of the lagoon and are thrown up on the shores, often in a partly decomposed state, together with algal and other debris. Conrad Limbaugh (unpublished note, 1957) reported that "this plant grows from the shore to depths of 20 feet, extending to the surface."

Two macroscopic aquatics, previously known from the lagoon, were not found in the 1958 survey. They are *Chara zeylanica*, collected in 1938, and a plant seen in 1943 photographs, possibly *Zostera marina* (see p. 270). Their absence suggests either a seasonal variation, or drastic changes in environmental factors, possibly resulting from storms, which may bring about irregular but important changes in the composition of the lagoon vegetation.

The bottom of the lagoon, in the deeper areas, was found by the marine biologists in their diving operations to be free of macroscopic plants (Allison and Hambly, personal communications). Limbaugh (*l.c.*) wrote: "On the bottom of the lagoon at depths of 20 to at least 60 feet, there exists a blue-green carpet which can be torn away, but which can be powdered by squeezing. I assume that this is a microalga."

Marine vegetation. While the surveys of the reef and the underwater slopes of Clipperton Island, including work on algae, were carried out by the marine biologists, and will be reported elsewhere, a few very general notes may be included here. A few species of algae grow on the reef flat and over certain corals (Taylor, 1939, Dawson, 1957, 1959), but they are nowhere very abundant. Large scattered boulders on the reef flat are conspicuously covered with algal growth, particularly with a species of *Ulva*. The same *Ulva*, together with a red alga (*Hypnea spinella*), is left on the beaches in great abundance by the receding tide. Other formations are the felt of algae, including various blue-green and green species, covering rocks in shallow water, and lining some tidal pools, the thin slimy covering on slabs, the turfs of *Jania* and *Hypnea* that occur "throughout the seaward reef areas and down to at least 78 feet" (Dawson, 1959, p. 5), and the microscopic algae growing inside living coral heads.

In general, however, the role of algae in the living reef and in the formation of the atoll foundations and rocks is relatively small. Very few pieces of algal skeletons can be found among the enormous masses of limestone gravel and boulders that are thrown up by the ocean in beach ridges or in gravel and boulder fields. Most surprising to the botanist is the lack of a marked algal ridge at the seaward edge of the reef. Allison (personal communication) believes that "coralline algae dominate the outer edge of the

intertidal reef flat, where they are the active rock builders, though they don't flourish to the great extent noted on other Pacific atolls where an algal ridge is evident." The contrast indeed is remarkable with the wide, thick growth of calcareous red algae forming the bright pink "Lithothamnion ridge" so well developed on the windward ocean reefs of many atolls, particularly the Marshall Islands.

In this respect, as well as in the complete absence of native trees and in other characteristics, the vegetation of Clipperton Island is very peculiar, and quite distinct from that of atolls in the rest of the Pacific.

BIBLIOGRAPHY

Allison, E. C.

1959. Distribution of Conus on Clipperton Island. *The Veliger*, 1(4):32–33.

Anonymous

1893. Clipperton's two Crusoes home again . . . *Morning Call, San Francisco*, 74(153):8, col. 3, October 31.

1897. Shipwrecked crew of the Kinkora rescued by the cruiser Comus. *San Francisco Call*, 82(51):8, col. 3, July 21.

1935. Le drapeau français sur Clipperton. *L'Illustration*, 190:262–263.

Beck, R. H.

1907. Notes from Clipperton and Coccos Islands. *The Condor*, 9:109–110.

Belcher, E.

1843. Narrative of a voyage round the world, performed in Her Majesty's ship "Sulphur" during the years 1836–1842 . . . London, 2 volumes.

Byrd, R. E.

1943. Investigation by special mission of certain Pacific Islands . . . Books 1, 2, 4, 5, [Washington, D.C.].

Dawson, E. Y.

1957. Notes on Eastern Pacific insular marine algae. *Los Angeles County Museum Contributions in Science*, 8:1–8.

1959. Some algae from Clipperton Island and the Danger Islands. *Pacific Naturalist*, 1(7):1–8.

De Candolle, A. P.

1824. Sapindaceae. *Prodromus Systematis Naturalis Regni Vegetabilis*, 1:601–618.

Edwords, C. E.

1906. Clipperton Island and its strange birds and crabs (and the origin of its pirate treasure legend). *San Francisco Chronicle*, 89(58), Sunday Supplement, pp. 3–4, Sept. 9.

Ekman, S.

1953. Zoogeography of the sea. London, pp. 1–417.

FOSBERG, F. R.

1955. Northern Marshall Islands Expedition, 1951–1952. Narrative. *Atoll Research Bulletin*, no. 38, pp. 1–36.

1957. The naturalized flora of Micronesia and World War II. *Proceedings of the Eighth Pacific Science Congress*, 1953, 4:229–234.

FRANCE

1912. Mémoire défensif présenté par le gouvernement de la République Française dans le litige relatif à la souveraineté de l'île Clipperton soumis à la décision arbitrale de Sa Majesté Victor-Emmanuel III roi d'Italie en exécution de la convention entre la France et le Mexique du 2 Mars 1909. Paris, pp. 1–503.

GAUTHIER, L.

1949. Levé hydrographique de l'île Clipperton. *Annales Hydrographiques, Service Hydrographique de la Marine, Paris*, ser. 3, 20:5–12.

GUPPY, H. B.

1906. Observations of a naturalist in the Pacific between 1896 and 1899. Volume II. Plant-dispersal. London, pp. 1–627.

1917. Plants, seeds, and currents in the West Indies and Azores. London, pp. 1–531.

HERTLEIN, L. G., and W. K. EMERSON

1953. Mollusks from Clipperton Island (eastern Pacific) with the description of a new species of gastropod. *Transactions of the San Diego Society of Natural History*, 11:345–364.

JOHNSTON, I. M.

1949. The botany of San José Island (Gulf of Panama). *Sargentia*, 8:1–306.

KILLIP, E. P.

1939. Flowering plants collected on the presidential cruise of 1938. *Smithsonian Miscellaneous Collections*, 98(8):1–4.

LACROIX, A.

1939. Clipperton, îles de Pâques et Pitcairn, esquisse lithologique. *Annales de l'Institut Océanographique*, 18:290–330.

LA VEYRIE, J.

1935. Le passage du croiseur "Jeanne-d'Arc" à l'île Clipperton. *L'Illustration*, 190:39.

MENARD, H. W., and R. L. FISHER

1958. Clipperton fracture zone in the northeastern equatorial Pacific. *The Journal of Geology*, 66:239–253.

MEXICO. SECRETARIA DE RELACIONES EXTERIORES

1909 [1911?]. Isla de la Pasión llamada de Clipperton. Mexico, pp. 1–94. (1909 on title page, but contains documents dated 1911.)

MORRELL, B., JR.

1832. A narrative of four voyages to the South Sea, north and south Pacific Ocean . . . 1822–1831. New York, pp. 1–492.

Morris, C. E.

1934. The island the world forgot. *New Outlook*, 164(1):31–35.

Newhouse, J.

1954. Floristics and plant ecology of Raroia Atoll, Tuamotus. Part 2. Ecological and floristic notes on the Myxophyta of Raroia. *Atoll Research Bulletin*, no. 33, pp. 42–54.

Pease, W. H.

1868. On the existence of an atoll near the west coast of America . . . *Proceedings of the California Academy of Sciences*, 3:199–201.

Perrill, C. K.

1937. Forgotten Island. *U.S. Naval Institute Proceedings*, 63(412):796–805.

Proctor, V. W.

1959. Dispersal of fresh-water algae by migratory water birds. *Science*, 130 (3376):623–624.

Rendle, A. B.

1899. A systematic revision of the genus Najas. *Transactions of the Linnean Society of London*, ser. 2, Botany, 5:379–436.

Ridley, H. N.

1930. The dispersal of plants throughout the world, Ashford, Kent, pp. 1–744.

Sachet, M.-H.

1959a. Botany, in: Field report. IGY Clipperton Island Expedition. August-September 1958. *University of California, Scripps Institution of Oceanography, Progress Report, SIO Reference* 59–13, pp. 6–7 (mimeographed).

1959b. Vegetation of Clipperton Island. *Proceedings of the IX International Botanical Congress*, 2:337–338.

1960. Histoire de l'île Clipperton. *Cahiers du Pacifique*, no. 2 pp. 3–32 (includes detailed history, chronology of visits and extensive bibliography).

1961 (in press). Géographie et histoire naturelle de l'île Clipperton. *Annales de l'Institut Océanographique*.

(in preparation). Geography and land ecology of Clipperton Island. *Atoll Research Bulletin*.

Setchell, W. A.

1929. Morphological and phenological notes on Zostera marina L. *University of California Publications in Botany*, 14:389–452.

1946. The genus Ruppia L. *Proceedings of the California Academy of Sciences*, ser. 4, 25:469–478.

Slevin, J. R.

1931. Log of the schooner "Academy" on a voyage of scientific research to the Galápagos Islands, 1905–1906. *Occasional Papers of the California Academy of Sciences*, no. 17, pp. 1–162.

SNODGRASS, R. E., and E. HELLER

1902. The birds of Clipperton and Cocos Islands. *Proceedings of the Washington Academy of Sciences*, 4:501–520.

TAYLOR, P. G.

1948. Forgotten island. London, pp. 1–345.

TAYLOR, W. R.

1939. Algae collected on the presidential cruise of 1938. *Smithsonian Miscellaneous Collections*, 98(9):1–18.

WHARTON, W. J. L.

1898. Note on Clipperton Atoll (northern Pacific). *Quarterly Journal of the Geological Society of London*, 54:228–229.