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A Summary of Information on Rose Atoll

by

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by
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Rose Atoll, the easternmost of the Samoa Islands, is one of the smallest atolls known and is of special interest, because it has hardly been influenced by man. Its situation not too far from the settled islands of the group, the fact that it is generally easy to enter the lagoon and land on the islets, and various other circumstances have made it one of the better known uninhabited atolls. The literature concerning it has been brought together by Setchell (1924) and by Bryan (1942). This paper is not intended to replace these contributions but to summarize all available information on land aspects of the atoll. It necessarily repeats much information contained in these earlier compilations but may thus be helpful to those students of atolls to whom these are not easily available. In addition to published accounts, it includes notes based on letters of Mr. E. H. Bryan, Jr. and on conversations with Dr. L. P. Schultz and data obtained from their photographs and unpublished records. Their valuable help is gratefully acknowledged.

Geography

Rose Atoll is located between $14^{\circ}31'$ and $14^{\circ}34'$ S and between $168^{\circ}08'$ and $168^{\circ}10'$ W. It is a very small atoll, roughly square in outline and about $1\frac{3}{4}$ miles from north to south and 2 miles from east to west. Just west of the north point, or corner of the square, is the only channel into the lagoon. The channel is 100-150 feet wide and of variously reported depth: 6 fathoms or more (Rantzau in Graeffe, 1873), 30 or 40 feet (Anon., 1953) with records of 6 to 9 feet, or 6 feet or more that are probably erroneous or refer to the part of the channel that is choked with coral: Bryan (1942) reported the channel partly blocked with coral heads on the west side. The lagoon is about 2000 yards across its greatest width, and its depth is variously estimated as 6 to 12 fathoms (Wilkes, 1845); not more than 8 fathoms (Mayor, 1924) or up to 50 feet (Bryan, 1942). The floor of the lagoon is sandy, and generally free of living corals (Couthouy, 1942, p. 138). But some corals do grow in it. Wilkes described one such formation: "like a submerged tree, thirty feet in diameter over its top [it] was found in the center of the lagoon rising to the level of low water and having all around it a depth of six fathoms." This may be part of the two coral patches mentioned by Rantzau (Graeffe, 1873) as occurring in the southwest corner of the lagoon and indicated on his and later maps.

The reef is remarkably uniform in width, about 500 yards everywhere, with a very flat surface, most of which is under water even at low tide, though some areas emerge as smooth platforms about a foot above low tide. There is very little loose material on the reef. It supports only two islets. Sand Islet, to the north, near the entrance to the lagoon, is a bank of sand and broken reef material, devoid of vegetation and about 5 feet above sea level. Although the charts are not entirely reliable, there is some indication that the islet has been

larger (see discussion of Rantzau's chart, (pp. 4 - 5)). Sand Islet is quite possibly variable in area, especially as no plants are present that are capable of colonizing and fixing its soil. In 1938 its dimensions were estimated as 200 yards in length and 50 yards in width (Bryan, 1942). It lies on the lagoon side and has a wide expanse of reef on its seaward side.

At the eastern corner of the square is Rose Island, which is larger than Sand Islet. Mayor, in 1920, gave the length as 240 yards along a north to northeast direction and the width as 200 yards. Bryan, in 1938, estimated the island 350 yards long and 250 yards wide. Schultz (1943, p. 3) says that in 1939 it seemed to be building up on the northwest and being eroded on the south end. This agrees with some notes by Mayor and Bryan. Rose Islet has a greater elevation than Sand Islet, reaching 11 feet above high tide a little inland of the southeast corner (Mayor, 1924, p. 74). It is higher in the south than at the northern end and, like Sand Islet, it is located on the lagoon half of the reef.

History

Rose Atoll was discovered on October 21, 1819, from the ships l'Uranie and la Physicienne, and was named Rose Island by the commander of the expedition, Louis de Freycinet "for a person extremely dear to me." The ships did not enter the lagoon or come very close to the island. However, Freycinet described the island as observed from the sea, and Duperrey drew a chart that is included in the atlas of the expedition reports. In his volume on navigation and hydrography (1826, p. 85), Freycinet gave information on the weather, on the animals observed off the atoll, on the longitude, and on the latitude estimated at noon. He described his discovery (1826, p. 250) marveling at the fact that the atoll had not been observed and charted earlier. He mentioned only Rose Islet, but he said of it:

"Its height generally mediocre, is greater in the SW; the land gradually slopes down toward the NE where it merges with the sand of the shore.

"Although very small, this island is well wooded, which gives it a very pleasant look of freshness. Various sea birds seem to be the only inhabitants of this lonely place; we particularly noticed frigate birds, boobies, tropic-birds, noddies, and terns [apparently two small species]. Among the trees, there are no coconut trees nor any other kind of palms.

"The whole island, as we have said, is surrounded by a bank just below water level, grossly triangular, of mixed sand and madrepores; it is bristling with small black rocks, not very much raised above its surface, and all of about the same height. One of the angles of the bank is to the SW, another to the E, and the third to the N; its dimensions are 3 miles [nautical] from N to S, and a little less from E to W. The sea breaks much all around, and the surge can be felt from one or two cable lengths at sea; we followed its eastern part at a distance of one

and a half mile [s], without seeing bottom under us.

"When one stands to the N of Rose Island, it shows a semi-circular shape; seen from the E it looks like a 'coin de mire' [is wedge-shaped] with its higher part looking to the south. To the NE, and very close [to the islet?] a little black rock, a regular cone, rises above all the rocky heads just mentioned."

This literal translation shows that Freycinet observed the islet and reef exactly, which makes it all the more difficult to understand some aspects of Duperrey's chart, namely, the two areas that Setchell interpreted as two additional sandy islets. Although Freycinet did not mention any sandy "islet", his drawing of the landfall, presumably made from about east to southeast, showed on either side of the wooded islet some little black rocks and a broad mound. These may be sand banks and correspond to the patches of the chart. Freycinet's description of the islet is detailed enough for us to believe that the trees may have formed two groves, a large one to the southwest and a tiny one to the northeast, which apparently does not exist any more. The northeast grove either joined the other one or was destroyed by a change in the shape of the islet. Freycinet described Rose again later in his historical account of the voyage.

The Russian expedition of the *Predpriatie* (Enterprise), commanded by O. de Kotzebue, passed a little coral island on April 2, 1824, and named it Kordinkoff (Kotzebue, 1830, p. 256), later to realize that it was the same as Rose. Kotzebue's sketch of the atoll is not much better than Duperrey's, although it shows a closed lagoon.

On September 23, 1838, Dumont d'Urville, on another French expedition, passed Rose Island following the reef at a distance of less than a [nautical] mile and gave a brief description of it (1842, pp. 91-92):

"Rose Island is but a pile of sand about 200 m. in diameter, covered with a grove of verdure very fresh looking and pleasant.

"Passing about 600 m. to the north of the reef edge, we saw in the reef a break about 100 m. wide, leading into the lagoon where the water seems rather deep, and which ought to be able to offer shelter to ships as small as ours."

The French expeditions were scientific in purpose, and their instructions placed much emphasis on obtaining physical, nautical, and meteorological information. The discovery and surveying of new lands was recommended also, but these lands were especially worth investigating if they could bring new people and their customs, new plants, new animals, to the notice of Science. The fact that low islands present danger and difficulty in landing, especially with a sailing vessel, as well as their recognized paucity in scientific novelties, resulted in a general avoidance of atolls by most early expeditions, including the French.

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The U. S. Exploring Expedition was different in scope and aims, and without neglecting scientific discovery, visited many of these atolls, reputedly all alike, for the purpose of charting them. It was much larger than any of the previous expeditions both in ships and in naval and scientific personnel. In spite of its vessels and the unending arguing, prosecuting and fantastic mishandling of the results which followed it, the expedition was generally remarkably successful, and, although some of the information has never been published, it brought back vast amounts of data, charts, scientific collections, and drawings. It was the first "Atoll Program", and after surveying many of the Tuamotus, one of the ships, the Vincennes arrived at Rose Atoll, on October 7, 1839. A part of the day was spent in observations, and Wilkes (1845, p. 64) in the narrative of the voyage gave an account of them, but the best description published, and the only one of an eye-witness, is that of Pickering (1876, pp. 235-236):

"14. ROSE CORAL-ISLAND. As the Vincennes drew near, the supposed rock proved to be a dense clump of trees upon a small coral-island; 'in S. Lat. 14°18' and W. long. 168°05', and about eighty miles' from the nearest rocky island of the Samoan Group. Rose coral-island, though hardly 'two miles' in diameter, was found to contain a lagoon; having a large outlet deep enough to admit a ship, and 'six fathoms' inside, except at the centre of the lagoon, where a column of coral-rock rises to within 'three feet' of the surface. The tide rising 'about five feet', most of the island is submerged at highwater; but the outline continues distinguishable by the line of surf, with here and there a projecting massive coral-block; at all times, we found much water beating over from the windward, and running in streams into the lagoon, and afterwards in a strong current through the outlet.

.....

"Two banks on the rim were never overflowed by the tide; one of them devoid of vegetable growth; the other, containing the above-mentioned dense grove of trees, found to be three or four acres in extent."

Dana (1849, p. 78, 308) also discussed Rose Atoll, but unfortunately he did not see it, as he was traveling in another of the ships. Couthouy, however, was still on the Vincennes (he was going to abandon the Expedition shortly, in Samoa), and presumably landed on Rose. Parts of his account (1842) seem different from what was reported by Wilkes, Pickering, and Dana, and his account has been termed "somewhat fanciful" (Setchell, 1924): but he did give some information on the entrance and lagoon. He noted (p. 99) that the entrance is to leeward, as is often the case on atolls, and water pours out of it at ebb tide "so as to resemble a mill race."

The next recorded visit was that of Captain Rantzau (Graeffe, 1873, p. 32), who visited the atoll at various times while a German firm was trying to establish a fishing station there. He transmitted some valuable information to Graeffe and drew a sketch of the atoll, on which Sand Islet

is represented as large and extending far into the lagoon and Rose Islet as covering the whole width of the reef and supporting a house and trees. During these times coconut trees were planted and reported to do well and to bear fruit. The island was settled for a while by an Englishman and a few natives. Later one native alone remained with his family, and then the island was finally restored to its loneliness. Rantzau's sketch, together with excerpts from Graeffe's text, was reproduced in the first volume of the Hydrographische Mittheilungen (later Annalen der Hydrographie...) p. 64, 1873. His outline of the reef may have been based on some earlier chart, but his sketch was apparently used at later dates by the Hydrographic Offices of England and the United States.

In 1899, after much tension and political difficulty, Eastern Samoa became an American territory. The first governor, B. F. Tilley, visited Rose Atoll on July 10, 1900, hoisted the American flag "with appropriate ceremonies," and planted coconuts. In January 1920, Governor W. J. Terhune visited the Manu'a district, and on January 12 landed on Rose Atoll, erected a sign to warn trespassers, and planted a variety of fruit trees, including coconuts. His stop at Rose was reported in the monthly government newspaper O Le Fa'atonu, in the issue for February 1920 (Dumstreya, 1920). In June 1920, he returned there and was accompanied by the marine biologist A. G. Mayor who was working in Samoa. The July issue of O Le Fa'atonu gave a short but informative account of the visit and mentioned the value of the information collected by the distinguished scientist. More coconuts were planted, including two on Sand Islet. The invitation extended by Governor Terhune to A. G. Mayor resulted in valuable observations that are the most important body of information on Rose Atoll and are described in other parts of this paper.

There were yearly governor's visits to the atoll after this and more plantings of coconuts. In 1922, Governor Pollock found that Governor Terhune's coconuts had disappeared, so he planted some more. He also collected soil samples for Lipman.

Wray Harris now conchologist at the B. P. Bishop Museum, made at least two visits to Rose in 1937 and 1938 and collected mollusks and a few plants.

In 1938 the U. S. Coast Guard cutter Taney visited the Equatorial Islands and landed a party of scientists on Rose Atoll on August 4, for an hour. E. H. Bryan wrote accounts of his observations (1939 and 1942, pp. 91-93), and much of our knowledge of Rose Atoll is derived from them. W. Donagho (1953, p. 68), assistant to G. C. Munro, wrote some notes on the birds observed.

In 1939 the U. S. S. Bushnell made a survey of islands in the central Pacific, and Dr. L. P. Schultz, of the U. S. National Museum, spent 11 days collecting fish around Rose Atoll and in the lagoon (June 11-21).

On February 14, 1941, Rose Atoll was made a Naval Defense Sea Area by an Executive Order of President F. D. Roosevelt.

This order was rescinded by Executive Order 10,341 signed by President Truman on April 8, 1952. Earlier (July 1, 1951) the Samoan

Islands had come under the jurisdiction of the Office of Territories in the Department of the Interior. In February 1953 a fishing survey was conducted near Rose Atoll, and some information on the island was published in the Weekly News Bulletin on February 21, 1953. Excerpts from this bulletin were received through the kindness of Mr. Emil Sady, chief of the Pacific Division, Office of Territories. This is the latest information available on Rose, and it brings up to date our knowledge of this little atoll.

Meteorology

There are no meteorological records whatsoever from Rose Atoll. Even the visitors whose accounts are used here gave almost no information on the weather at the time of their stays, except for the weather at sea described by Freycinet. The only source of data that gives an idea of meteorologic conditions in the region is the Weather summary for Naval Air Pilot, H. O. 272 of the U. S. Hydrographic Office, which is used throughout this section, without further acknowledgment. It offers information that can be used in getting an idea of weather and climate at Rose Island and is compiled from ships' observations, mapped and tabulated for 5-degree ocean areas, together with general trends as expressed by isobar or isotherm charts. The island nearest to Rose Atoll from which are available data that cannot be collected by ships' observations (such as temperature variation and total rainfall) is Tutuila. But this is a high island, and its weather station at Pago Pago is dominated by a mountain called the "Rainmaker", because it precipitates moisture from every cloud passing over it. The atoll nearest to Rose with some weather data is Puka-Puka (Danger Island). It is in the same 5-degree square as Rose but in the northeast corner ($10^{\circ}53'S$, $165^{\circ}54'W$.) The records available since 1929 are summarized in a note by the New Zealand Meteorological Office (Seelye, 1943) and in the Great Britain Pacific Islands Pilot (v. 3, 1946). Both of these publications also offer some information on weather and climate at Aitutaki, the other weather station nearest to Rose Atoll, although much to the southeast. This is a high island (460 feet) on an atoll-like reef. The observations are made on the west side of the main island ($18^{\circ}52'30''W$.) at an altitude of 10 feet. Rather than use data from the high Samoan Islands or Niue, those from Puka-Puka and Aitutaki are occasionally mentioned, because they can at least give an idea of the order of magnitude of conditions on Rose Atoll.

Atmospheric pressure: The 1008-millibar isobar for January passes just north of Rose Atoll and just south of Puka-Puka; the 1012-millibar isobar for July passes near the location of Rose, whereas the 1010-millibar isobar for July passes close to Puka-Puka. (Great Britain Pacific Islands Pilot, v. 2, pp. 18-19). These figures probably express the range of variation at Rose Atoll, except, of course, for depressions accompanying possible hurricanes.

Tropical cyclones and hurricanes: No cyclones and hurricanes are reported from Rose Atoll, but among the Samoa Islands, years may pass without a destructive storm, though two or three cyclones have been known to occur in a single year, with January and March as months of highest frequency. The most famous hurricane in Samoan history is that of March 13 to 23, 1899, which, occurring at a moment of great international tension, kept everyone so busy that political issues became

secondary and were solved more amicably than they might otherwise have been. The track of this hurricane (Chart 23, H.O. 272) does not pass near Rose Atoll, nor do any other tracks of the few cyclones plotted on this chart. East of Rose Atoll, hurricanes have been known to occur and cause much damage, at Puka-Puka, Nassau, and especially at Suwarov, but they are rare.

Prevailing winds at sea: Rose Island lies in the region where the northeasterly trade winds penetrate the south latitudes: In the 5-degree square just north and west of that of Rose (5° to 10° S., 170° to 175° W.), surrounding the Union group, 29 percent of the annual winds are from the northeast, 32 percent from the east, and only 13 percent from the southeast. At about the 10° S., the southeast trade winds definitely become more frequent; and in 10° to 15° S., 165° to 170° W. (Rose Atoll square) southeast winds are recorded as 25 percent of the annual winds, north-east trades as 17 percent, and east winds, the most frequent, as 34 percent (see table p. 9).

Ocean gales, squalls and thunderstorms: Rose Atoll lies in an area where both gales and squalls are rather common, being reported in 14 percent of the ships' weather observations. Thunderstorms are reported in 4 percent of the ships' observations. All the figures for gales, squalls, and thunderstorms are much less for the 5-degree square of Rose Atoll than for the next one west, where the high Samoan Islands are situated.

Sea temperature: Rose Atoll lies in a region between the two 82° F isotherms for sea temperature (north and south of the Equator) for February (southern summer), and the 80° F isotherm for sea temperature (Southern Hemisphere) for August passes just north of Rose (Great Britain Pacific Islands Pilot, v. 2, pp. 18-19). These figures probably express the range of yearly variation of sea temperature at Rose. At Puka-Puka the variation is reported as from 81° to 83° F (Seeley, 1943).

Air temperature: There are no figures at all for air temperature at Rose Island or the ocean around it. At Puka-Puka the mean for the year is 82.2° F, with very slight variation from month to month (83.1° for May, warmest month; 81.8° F for January, coolest month). The averages of the annual extremes are 93° F and 71° F, and the absolute extremes are 97° F and 70° F. At Aitutaki the Southern Hemisphere seasons are well marked; the warmest months are January and February (81.0° F mean temperature), and the coolest is August (75.4° F). The yearly mean is 78.2° F. At Rose Island the southern seasons are probably slightly felt, whereas Puka-Puka still has Northern Hemisphere seasons. Rose probably has a rather even yearly temperature, of about 81° F, the extremes not reaching much above 90° F or below 70° F.

Clouds and visibility: Table p.8 is made from Charts 13 to 17 of H.O. 272, for the 5-degree square of Rose Atoll. The total of ships' weather observations for this square is 760 for the period 1879-1933.

Feb. 78	May 49	July 74	Oct. 63	Dec. 63
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Figures express percent of observations recording lower type clouds.*

3.4	5.1	4.4	9.5	5.4
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Percent of observations with exceptional visibility.

1.7	1.3	1.5	0.0	1.8
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Percent of observations with haze.

0.0	0.0	0.0	0.0	0.0
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Percent of observations with fog.

* Lower type clouds are apparently the trade wind cumulus and various rain clouds.

Relative humidity: At Puka-Puka the mean relative humidity for the year is 79 percent, with a variation of 2 percent above and below for the individual months (morning observations); the mean dew point ranges from 74° F in July to 78° F in April, the average being 76.3° F (Seelye). It may be assumed that figures for Rose Atoll would be similar.

Rainfall: The evenness of rainfall is an important factor on atolls, in making the amount of precipitation effective. The rain water percolates immediately through the extremely porous material forming the islands, so that the amount of rain that corresponds to extremely arid conditions on an atoll may mean much moister ones on large islands or continents. On Puka-Puka the rainfall is usually heavy, the average for 1930-1942 being 117.57 inches a year, the totals ranging from 85.46 (in 1938) to 155.13 (in 1931). There is a marked rainy season from November to March. The average number of rainy days (with 0.10 inch or more rain) is 170 days per year. This is rather low. At Aitutaki the yearly average is 77.57 inches in 92 days, and there is a wet season from December to March (Seelye, 1943). Rose Atoll probably has a similar rainfall, although the number of rainy days may be greater.

High seas: It may be of interest to mention that on Puka-Puka in February 1935 a hurricane that affected Rarotonga brought rather high seas (Seelye, 1943). The seas rose on the 8th, and canoes left under trees 200 yards from the usual low-tide mark were nearly washed away. Conditions were worse on the 9th and 10th, but the sea went down rapidly the following day. This phenomenon might have affected Rose Atoll also.

Geology*

The reef of Rose Atoll is almost entirely made up of Lithothamnion rock as are the boulders scattered on it. The surface of the atoll rim, where awash at low tide, is covered by vigorous growths of Porolithon that form connected pink patches or -- west of the lagoon entrance -- ridges 6 inches high and 6 inches to several feet wide. The ridges,

* The geology and soils sections were prepared with much assistance from F. R. Fosberg and utilize unpublished data from his investigations in the northern Marshalls in 1952.

Ocean area S10 165. Position: Latitude 10° - 15°S, Longitude 165° - 170°W.
Greenwich noon observations. Years covered 1883-1933.

Month	Number of observations surveyed	Mean velocity (knots)	Wind										Weather										
			Percentages of observations from										Percentages of observations recording -										
			N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm	Haze	Mist	Fog	Drizzle	Rain	Light Squalls	Showers	Thunderstorms	Heavy squalls	Gales (force 8 or over)	Exceptional visibility	Mean cloud amount (0-10)
January	: 45	: 11.1	: 8	: 27	: 16	: 21	: 6	: 5	: 7	: 5	: 5	: 0	: 0	: 2	: 0	: 15	: 20	: 9	: 2	: 0	: 8	: 4	: 4.6
February	: 59	: 8.9	: 11	: 30	: 19	: 5	: 2	: 11	: 4	: 17	: 1	: 2	: 0	: 0	: 2	: 8	: 8	: 10	: 5	: 0	: 0	: 3	: 4.6
March	: 57	: 8.4	: 14	: 19	: 29	: 19	: 5	: 0	: 5	: 7	: 2	: 2	: 0	: 0	: 0	: 18	: 16	: 7	: 4	: 0	: 2	: 5	: 5.5
April	: 66	: 5.7	: 5	: 19	: 31	: 15	: 7	: 2	: 0	: 6	: 15	: 2	: 0	: 0	: 0	: 5	: 2	: 3	: 3	: 0	: 0	: 3	: 3.8
May	: 78	: 9.7	: 5	: 19	: 44	: 27	: 1	: 1	: 0	: 0	: 3	: 1	: 0	: 0	: 0	: 8	: 12	: 6	: 3	: 0	: 0	: 5	: 4.2
June	: 76	: 11.1	: 5	: 8	: 54	: 25	: 2	: 1	: 1	: 1	: 3	: 1	: 0	: 0	: 0	: 4	: 12	: 10	: 3	: 1	: 3	: 0	: 3.6
July	: 68	: 11.6	: 5	: 8	: 50	: 29	: 6	: 0	: 0	: 1	: 1	: 1	: 1	: 0	: 0	: 9	: 12	: 12	: 1	: 1	: 0	: 4	: 4.8
August	: 64	: 11.1	: 0	: 10	: 40	: 43	: 3	: 2	: 0	: 2	: 0	: 2	: 0	: 2	: 2	: 5	: 11	: 11	: 0	: 0	: 0	: 8	: 5.5
September	: 66	: 12.0	: 3	: 20	: 34	: 41	: 2	: 0	: 0	: 0	: 0	: 0	: 0	: 0	: 0	: 0	: 15	: 11	: 3	: 2	: 2	: 0	: 4.7
October	: 63	: 8.0	: 7	: 13	: 36	: 29	: 2	: 2	: 4	: 4	: 3	: 0	: 0	: 0	: 0	: 2	: 9	: 14	: 3	: 3	: 0	: 9	: 4.2
November	: 62	: 8.0	: 10	: 10	: 35	: 22	: 5	: 7	: 4	: 7	: 0	: 3	: 0	: 0	: 0	: 5	: 11	: 8	: 5	: 0	: 0	: 8	: 4.9
December	: 56	: 6.8	: 21	: 17	: 20	: 21	: 0	: 7	: 0	: 10	: 4	: 2	: 0	: 0	: 0	: 6	: 4	: 5	: 11	: 0	: 0	: 5	: 4.8
Mean	: _____	: 9.4	: 8	: 17	: 34	: 25	: 3	: 3	: 2	: 5	: 3	: 1	: *	: *	: *	: 7	: 11	: 9	: 4	: 1	: 1	: 5	: 4.6
Total	: 760	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:

which are separated by channels, are occupied by other algae. The slopes of the reef are not different in their algal constituents from the flat top, except for the presence of some stunted Acropora and Pocillopora (corals) "at the extreme edges of the atoll rim fronting the lagoon or the sea." The algal ridge at the edge of the reef is very weakly developed, as also are surge channels (Schultz, conversation 1953). Freycinet mentioned small black rocks, all of about the same height, and the U. S. Exploring Expedition found them to be limestone boulders. Mayor gave them much attention and wrote (1924, p. 75):

"Hundreds of large blocks of limestone lie scattered over the flat, wave-washed rim of Rose Atoll. These loose boulders are quite uniformly about 5.5 feet high, and only when tilted are they any higher. In addition to these boulders there are a few others which are mushroom-shaped and still remain attached to the floor of the atoll-rim, of which indeed they form an integral part. One of the most remarkable of these mushroom-rocks lies to the eastward of Rose Islet, and is supported upon so slender a pedicel that it would seem as if the next storm must cause it to topple over. In many places over the flat, wave-washed floor of the atoll-rim one finds remnants of pedicels which once supported 'mushrooms'. In addition, some of the boulders have become secondarily cemented to the floor of the flat by the growth of Lithothamnium around their bases. The largest boulder we observed lay loosely upon the reef-flat east of Rose Islet and was somewhat tilted by being jammed against another rock. It was 12 feet 5 inches long, 8 feet wide, and 7 feet 6 inches high, and as its specific gravity was 2.3 it apparently weighs 46 tons."

He concluded that the boulders showed that sea level must have been at one time 6 or 8 feet higher than now and that the scattered detached boulders were mushrooms that had been completely undercut. He reported that the boulders were made up of the same algae and had generally the same chemical composition as the solid reef platform, with the same high percentage of magnesium attributable to Porolithon.

Among these boulders, the Exploring Expedition found some scattered blocks of volcanic stone. They are mentioned by Wilkes, Dana, and Couthouy and also by Pickering, who says (1876, p. 235):

"For the first time on a coral-island, the mineral kingdom was represented; several blocks of vesicular lava being met with by our party; in all instances resting upon the coral-shelf, not imbedded. Two or three of these blocks were seen by myself, the largest weighing perhaps twenty pounds. From the mineral composition, they had evidently been derived from some volcanic island; and there seemed no means of transportation, unless entangled in driftwood. This actually takes place at the Tarawan coral-islands; where Mr. Hale found a native name for 'basaltic stones in the roots of trees drifted to those shores'."

Mayor failed to find these rocks among the coral blocks and supposed that the members of the Exploring Expedition had mistaken blackened limestone for basalt. The matter rested until 1939, when Schultz again found them. He only mentions (1940, p. 48) collecting lava but (conversation, 1953) observed many volcanic blocks, a dozen or more up to the size of a man's head, scattered on the reef. His specimens were brought back to the U. S. National Museum and were found to be compact olivine basalt. They are being studied further by Gilbert Corwin, who says the rocks are olivine basalts, such as are typical of Pacific islands. Schultz supposed that they might have been thrown up from the sides of the island with the niggerheads.

For an idea of the geology of the two bits of land on this reef, we must rely almost entirely on Mayor's account.

Sand Islet is "a mere accumulation of fragments of Lithothamnium shells, and broken coral only about 5 feet above high tide level." The loose and unstable nature of such debris lying on a flat reef surface makes entirely probable the changes in size and shape of the islet indicated in the different accounts and maps. There is no suggestion anywhere that any of this material is consolidated or cemented to the reef.

Rose Islet, on the other hand, seems to be mainly a mass of such debris that has been consolidated into a "coquina" or reef-conglomerate such as is a common feature of other atolls. Probably the word "coquina" is improperly used here, as the material is not primarily composed of shells. Mayor's description of this follows (1924, p. 74):

"The tree-covered rocky center of the islet is composed of a coquina consisting chiefly of wave-worn fragments of lithothamnium and also rare and occasional fragments of broken coral, such as Favites, Porites, Symphallia, Pocillopora, and still more rarely Acropora. Embedded in it are many wave-worn half-valves of Tridacna and gasteropod shells, and spines of Echini such as Cidaris were found, as was also the much corroded ulna and part of the skull of a small cetacean about the size of a blackfish, the latter being embedded in the coquina about 8 feet above high-tide level. A large amount of organic matter, dark brown in color and derived from the decomposed roots of the Pisonia trees, permeates this coquina to a depth of several feet. All of the fossils found embedded in the coquina are forms now living on the reef-flat, which have simply been tossed on shore by the waves."

The height of this conglomerate above the reef surface is rather remarkable for such a small islet. Mayor says, "On the southeast side of Rose Islet the sand-beach is reduced to from 1 to 5 feet in width at low tide, and cliffs of coquina from 5 to 8 feet high front the sea A few feet inland this rocky ledge rises to a height of about 11 feet above high-tide level."

Schultz (1943, p.3) says that on this southeast side the island apparently is being eroded away. Here, again, on the southeast shore, is some beach-rock, said by Mayor to be more recent than the "rocky matrix of the islet." Schultz (1943, p. 3) adds, "To the east of the island for a few hundred feet are loose slabs of coral-shell conglomerate rock left on the reef, which may have at one time formed part of the island." These must be slabs of beach-rock as shown by photographs.

On the northwest side the islet is reported by Schultz to be building up by accumulation of coral debris (incorrectly called breccia by Mayor). Here the beach is much wider. On the surface of the conglomerate where it is covered by the Pisonia grove there seems to be little accumulation of loose material (Schultz simply says that the conglomerate is "overlaid by coral-shell gravel"). No boulder ridges, dunes, or "ramparts" have been described.

Soils

The surface of Sand Islet and the bare north part of Rose Islet are apparently of unaltered or scarcely altered limestone debris, largely of algal origin. This debris is similar to what is found on bare or newly formed parts of most atolls, except that the proportion of algal material is unusually high here.

The soil within the Pisonia grove is very different and is the subject of an extensive study by Lipman and Shelley (1924). A good description of the profile does not exist, but from Mayor's casual remarks and Lipman and Shelley's descriptions of the materials they analyzed, a profile can be roughly reconstructed as follows:

- Top layer -- (Mayor) "a rich chocolate-colored humus which is of considerable depth near the southern end of the grove."
- Intermediate layer -- (Lipman and Shelley) "a loose porous mass, very light in weight," (Mayor) "dark brown in color to a depth of several feet."
- Bedrock -- (Lipman and Shelley) "a compact, fine-textured, almost pure calcium carbonate which shows no vital structure. It is pure white, fairly soft ..." (but see Mayor's description of the coquina, which is the same material, p. 11).

Lipman and Shelley regard the intermediate layer as being an intermediate product in the decomposition of the bedrock, to form, with the addition of much humus, the surface layer of "fine-textured, mellow, organic soil." They had only a small bit of soil adhering to a partly decomposed rock, this rock, and some of the bedrock to examine and work with. Their interpretation of their analytical results is completely dependent upon this conception of the origin of the profile, and if more recent studies in other atolls (Fosberg, in press; Hatheway, 1953) are reliable, their interpretation is erroneous, the situations seeming more

or less comparable. Stone (1951, p. 10) regards Lipman and Shelley's conclusions as entirely vitiated by the presence of basalt fragments on the reef.

Lipman and Shelley's analyses are as follows (p. 208):

	Rose	Inter-	Litho-	Water soluble constituents
	Islet	mediate	thamnium	
	soil	product	rock	Rose
				Islet
				soil
				p.p.m.
	p.ct.	p.ct.	p.ct.	
H ₂ O at 100°C	5.12	2.49	0.40	Total
Loss on ignition	22.84	31.09	46.22	soluble salts
Si O ₂	.18	.20	.16	Na ₂ CO ₃
Al ₂ O ₃	16.72	9.20	.46	Na ₂ SO ₄
Fe ₂ O ₃	.40	.48	NaCl
P ₂ O ₅	20.94	14.60	.57	
CaO	29.26	35.78	44.01	
MgO	1.75	3.34	7.46	
SO ₃	1.14	.87	.61	
Na ₂	1.38	1.39	.35	
K ₂ O	.23	.23	.15	
TOTAL	99.97	99.66	100.40	

The striking facts about these analyses are the increasingly high percentages of Al, P, S, Na, and K (from bedrock to soil), compared with decreasing percentages of Ca and Mg and very little change in Si, also the greater moisture-holding capacity of the organic soil and the "intermediate product."

Lipman and Shelley's explanation of the high aluminum content and low silica content is ingenious. They explain, "The aluminum silicate in the original rock undergoes decomposition through reaction with ammonia, formed from the decomposition of the soil organic matter or of the bird droppings on the islet. Such a reaction would be followed by the leaching out of the ammonium silicate formed and, while allowing of the accumulation of alumina in the soil, would prevent accumulation of silica there." This would necessitate a reduction of 36 times in the weight of soil decomposed to yield this amount of alumina.

The two authors interpret the increased of sodium, potassium and sulfur as results of the great adsorptive capacity of the soil, differential leaching, and increment from spray.

The astonishingly high phosphate content of the soil and the rather high content of the "intermediate product," they regard as resulting from

simple accumulation of the phosphate of the original rock, without even taking into account the bird droppings usually considered the source of such phosphates. The correspondence of the figures with those for aluminum would suggest this conclusion, but then the problem would arise of what had actually become of the phosphorus in the droppings of the large bird population that is found on the island.

The picture, in light of investigations, incomplete as yet, in the Marshalls, supported by a survey of the literature, appears to be actually quite different. Generally, under Pisonia forest, a layer of pure humus, corresponding to Mayor's description and acid in reaction (pH 4.5 to 6), accumulates. Usually these forests are inhabited by large numbers of birds, as on Rose Islet. Their droppings (normally pH 6) are acidified by the humus as they are washed down through the humus layer, and the finely divided calcium phosphate is dissolved. When it reaches the sand and rock beneath, it becomes alkaline and therefore insoluble, precipitating out and cementing the loose calcareous material together. The acid solution tends to dissolve out the calcium carbonate and permits it to be replaced by calcium phosphates. Thus a cemented layer or hardpan is formed immediately beneath the humus layer.

This process is not at all similar to the one suggested by Lipman and Shelley. It would not account for the enormous concentration of aluminum, nor the relatively low loss on ignition. It is clear, from the two authors' description of their soil sample "containing many undecomposed particles of the original lithothamnium rock," and the fact that their sample was material adhering to the surface of the partially decomposed rock, that they did not have a typical sample of the pure humus as described by Mayor. The ignition loss would likely have been much higher if the sample had been representative. The high aluminum content may well have been the result of contamination by decomposed pumice pebbles, common enough on atolls, or even from the basalt. How the silicon was lost if so, is not clear, except that it tends to leach out under tropical conditions.

There is a record of subsequent samples being collected for Lipman by Governor Pollock, but though they were studied for soil micro-organisms, no more chemical analyses were reported. Further studies to ascertain whether this high Al content is a general feature or only a localized one would be desirable.

One other fact revealed by Lipman's investigations is the unusually high concentration of water soluble salts in the soil (see table of analyses, p. 13). The authors mention, "If our analyses are to be considered as even approximately correct, the Pisonia tree is to be regarded as one of the most salt-tolerant plants of which we have record at present." They point out that the toxic effects of the salts may be somewhat mitigated by the high content of organic matter present but consider that the tolerance is still remarkable. This concentration may well be of significance in connection with the extremely small land flora of the atoll and possibly with the lack of success of the coconuts planted there repeatedly.

In a bacteriological study of the soil samples collected by Governor Pollock, Lipman and Taylor (1924) found that the numbers of organisms were enormously higher in the humus-rich soil in the Pisonia

forest, much lower in the soil where Boerhavia and Portulaca were growing, and extremely low where there was no vegetation. This is exactly what would have been expected and does not require further comment.

The authors found, also, that both nitrite and nitrate producing bacteria are present in all the soils, and that their nitrifying activity is more or less proportional to the amount of organic matter in the soils. What was probably Azotobacter was found, but it was concluded that such organisms "do not find conditions propitious for their rapid development in competition with other forms which occur there."

Land Flora

The land flora of Rose Atoll was first described by Pickering (1876, p. 236):

"The whole flora of the island consisted of but two species of plants: one of them, as will be perceived, additional:

Portulaca (No. 1). Normal; multicaul and prostrate, having the habit of P. oleracea, but much larger flowers; petals five, yellow. Growing in a scattered manner on top of the beach, and in all instances outside the grove.

(Calpidia ovatifolia?); bis (No. 1 Paumotu coral-islands). Constituting the grove; some of the trees being fifty feet high, with the trunk four feet or more in diameter. Additional anomalies of growth were here observed: as two proximate upright branches anastomosing ladder-like at intervals; and several instances of upward-tending branches, as in the trees seen in the distance on Serle and other coral-islands. The timber proved on examination to be brittle and to all appearance worthless."

Pickering's observation of the two plants had been reported earlier by Dana (1849, p. 309). The plants were discussed and identified as Pisonia grandis R. Br. and Portulaca lutea Sol. by Setchell (1924) who was studying Mayor's specimens. Mayor gave the second enumeration of the flora, and found one more plant, Boerhavia tetrandra Forst., growing on the rough limestone surface of the north part of the islet, with Portulaca.

In 1938, Bryan recorded no native plants other than those three, which is a remarkable fact. It would be interesting to know when Boerhavia took hold. It would probably not have been missed by Pickering, who was familiar with it and had found it on several of the Tuamotus. No account mentions plants other than the grove of trees, between the time of the U. S. Exploring Expedition's visit and Mayor's visit.

In the U. S. National Herbarium there are no specimens from Rose Atoll collected by Pickering. He may not have made any collections. There are several sheets of Pisonia grandis from later collections, however:

Bryan 1382, Aug. 4, 1938; Wray Harris 287, April 1938; Schultz 26 and 27, June 11, 1939. There is also a sheet of Portulaca lutea, Schultz 25.

In the B. P. Bishop Museum (information kindly supplied by E. H. Bryan, Jr., curator) there are sheets of the three phanerogams: Pisonia grandis: Setchell 50 (collected by A. G. Mayor, June 6, 1920); Wray Harris 274 and 287, April 21, 1938; Bryan 1382, Aug. 4, 1938. Boerhavia tetrandra: Setchell 51 (collected by A. G. Mayor, June 6, 1920); Wray Harris 303, April 21, 1938, and 304, November 30, 1937; Bryan 1384, Aug. 4, 1938. Portulaca lutea: Setchell 52 (collected by A. G. Mayor), June 6, 1920); Wray Harris 301 A, Nov. 30, 1937; Bryan 1383, Aug. 4, 1938.

The latest addition to the flora, due to human interference, is that of the coconut palm. The story of the Rose Atoll coconut palms is quite intriguing; the palms flourished at the time of Rantzau's visits, but had disappeared by 1900. Of those planted by Rantzau, one remained in 1920, sterile, probably as suggested by Dumstrey, because it was choked by the Pisonia trees. The nuts planted by Terhune in January 1920 were growing in June, but had all disappeared by 1922, when Pollock planted some new ones. Bryan in 1938 found about 20 palms, 8 large and a dozen small. Schultz (unpublished notes) observed seven large trees and two small ones, besides several recent plantings now 1 to 3 feet high. The tall palms were bearing nuts, and photos show that some of the fallen nuts may have been sprouting. By 1953 the total number was reduced to 12 and these were bearing heavily, and it is hoped that no more were planted, and that Rose Atoll will have a chance to increase its flora by natural means only. Why the palms have failed to survive and multiply, when some did grow into adult trees from planted nuts, is hard to explain. Perhaps the coconut palms were destroyed by a typhoon between 1873 and 1900, whereas the Pisonia grove was seemingly unaffected; this is possible since Pisonia trees are practically indestructible, new trunks springing up from fallen ones (see below, Vegetation). Most of the plantings of nuts probably failed very early. Another possible explanation has been suggested on page 14; it is possible that the high concentration of water-soluble salts in the soil prevents coconut seedlings from developing. The rainfall of Rose Atoll, if estimated at 77 to 110 inches a year, is not very heavy; and it may be irregular. In any case, the minute islet may not be sufficient in area to permit the formation of a fresh-water lens, and the palms may suffer from physiologic drought. There may be also too great an amount of sea spray for coconut seedlings to do well. In this connection, it may be remarked that the three native plants are very hardy ones, often found alone or with a few other such halophytic species, on the most destitute atolls. Schultz (unpublished notes) also records plantings of bananas, papayas, and a few other plants, and indeed a very small banana plant is discernible on one of his photographs. But it is not known whether these plants have persisted.

There is only one record of a macroscopic land cryptogam, a lichen, which Bryan collected on the trunks of the Pisonia trees, and which has not been identified as yet (Bryan 1385, in Bishop Museum). In the study of the soil flora, Lipman and Taylor isolated 19 bacterial colonies of which they gave descriptions (pp. 213-214). Most of them were actinomycetes, one or two could clearly be recognized as other than actinomycetes, and one was a mold. The presence in the soil of nitrifying bacteria and Azotobacter has been mentioned in the section on soils.

Vegetation

According to all available reports, Sand Islet is completely destitute of vegetation. Governor Terhune planted two coconuts on it, but they did not grow.

The fresh green grove of trees is the most conspicuous feature of the vegetation of Rose Islet, giving it from afar the appearance of a low rounded hill, for which it has often been mistaken. Freycinet seemed to indicate the presence of two separate groves (see History); Wilkes wrote, "The islet is entirely covered by the clump of trees." Pickering said of Portulaca plants that they grew on the top of the beach, which might indicate that indeed the grove covered most of the island surface. Later, Mayor estimated that the trees occupied one half of the land area, and in 1953 this was reported as only one third. It is difficult to decide whether the grove has decreased or the island grown larger. The latter is possible, especially since its estimated dimensions are reported larger in 1938 than 1920, and it seemed in 1939 to be increasing on the northwest side (see Geography). It is more unlikely that the Pisonia grove should become much smaller, unless parts were removed by a hurricane.

The forest is made up entirely of large trees of Pisonia grandis with no undergrowth at all. Pickering, Mayor, and others emphasize the fact that the other plants do not grow at all under the trees. This is, furthermore, quite normal in luxuriant Pisonia groves on atolls. When Mayor visited Rose, one coconut tree, probably planted by Governor Tilley, grew among the Pisonia. Rantzau's sketch map of the island showed mixed coconuts and other trees, but this may not have been meant to express the exact condition, as the Pisonia would probably shade out the growing coconut seedlings. Pure Pisonia forest occurs on various atolls in the Pacific, for instance on some islets of the northern Marshalls, and especially on Vostok Island, which must be very like Rose. The trees have many twisted stems with creamy white bark and large light-green leaves. Pisonias can attain enormous sizes, and those on Rose Atoll were fifty feet in 1839, 80 in 1920 and estimated at 85 feet in 1953. The largest are on the southern part of the islet, and, in 1920, one had a girth of 25'7" at 3 feet (Mayor, p.73). Pisonia can form sprouts from practically any part of the tree, roots, branches, stubs, and fallen trunks, forming luxuriant tangles of stems and branches. This forest on Rose Islet must be a magnificent sight. Two good photos of it by Mayor accompany Setchell's paper, and Bryan published two of his own that show well the rounded contour of the grove.

Along the northeast edge of this grove are the coconut palms. They have been discussed in the description of the flora.

The whole north part of the islet is free of trees, and the surface of broken reef material supports Boerhavia and Portulaca. One of Mayor's photos (in Setchell, 1924) shows well this tangle of low plants. The Boerhavia plants have a thick woody root crown, with creeping stems up to 3 feet long. The Portulaca form little bushy succulent herbs up to 2 feet high, with erect, much branched stems, fleshy but firm. Besides the north part of the island, these two plants seem to be scattered on

the strand along the Pisonia grove, at least on the lagoon side (Mayor, p. 74).

Except for the lichen collected by Bryan, no mention is made on macroscopic cryptogams in any of the available accounts. Possibly other cryptogams occur on Rose, and a search might discover them. The black limestone boulders strewn over the reef doubtless owe their color to microscopic blue-green algae.

Fauna

There have been a few collections of land animals on Rose Atoll, by Mayor, by members of the 1938 and 1939 surveys (see History), and by others. The specimens have been added to museum collections but have not been mentioned in the literature.

Birds are the most conspicuous animals on the atoll. Freycinet (see History) mentioned frigate birds, boobies, noddies, tropic birds, and terns. At sea (p. 85) he also observed curlews on the day of the discovery of the atoll. Wilkes observed at least four kinds:

"Birds were seen flying over the island, and on landing we found them in great numbers and very tame. The frigate-birds, and boobies (sula), whose nest had before been observed on low bushes, were here found on the tops of trees fifty feet high. The noddies laid their eggs on the parts of the island destitute of vegetation. Tern were in great numbers; their breeding-place was in a thicket on the weather side of the island, or that which was exposed to the wind and sea, and was remarkable from the regularity with which the eggs were placed, about three feet apart, without any nest, and, with but few exceptions, out of many thousands, each egg lay separately. The colour of the eggs is a dirty white, mottled with brown. The noise made by these birds when disturbed was almost deafening; but on making a loud sound, such as the firing of a gun, their cries would cease for a moment or two, producing a singular stillness."

Graeffe only said that a great many birds, especially species of Sterna or sea-swallows, nested in the trees.

Mayor wrote:

"Several hundred boobies (Sula), most of which had half-grown young, were nesting on the coral breccia of Rose Islet ..., while others had constructed nests of sticks high among the branches of the Pisonia trees. A few boatswain-birds with eggs were also nesting in the trees, and several nearly grown young sooty terns visited the island at night. Frigate-birds were hovering over the island, but none were nesting. Wilkes states that the noddies and sooty terns were nesting on

Rose Islet on October 7, 1839, and these species were still nesting when Governor Terhune visited the island on January 10, 1920."

In 1938 (Donagho, 1953, p. 68) frigate birds were flying above, brown boobies were nesting, and red-footed boobies were sitting in the trees, as did the fairy terns. Munro (1949, p. 50) said that there were numbers of these lovely white birds, and he hoped that they did not too often get gummed with the sticky fruit of Pisonia. Bryan (1942, p. 92) also reported some wandering tattlers; and reef herons, one blue, one white.

Schultz in 1939 (1940, p. 48) observed that in the Pisonia trees were nesting boobies and frigate birds and "underneath, on the ground sooty terns were nesting." This had been mentioned by Donagho and seems rather unusual. In his unpublished notes Schultz also recorded yellow-billed / blue-faced/ boobies, nesting on the ground with their white and downy young, and brown boobies. He vividly described the enormous numbers of birds, their incessant clatter, the terrific stench of guano, which falls "like rain all day and night" from the trees. His collections of bird skins are preserved in the U. S. National Museum:

USNM 358134	<u>Sula leucogaster plotus</u> (Forst.)	brown booby
USNM 358138	<u>Demigretta sacra</u> (Gmel.)	reef heron
USNM 358149	<u>Anous stolidus pileatus</u> (Scop.)	common noddy
USNM 358155	<u>Heteroscelus incanus</u> (Gmel.)	wandering tattler

Summary of other birds recorded:

<u>Sula sula rubripes</u> Gould	red-footed booby
<u>Sula dactylatra personata</u> Gould (Schultz photo)	blue-faced booby
<u>Fregatta minor</u> (Gmel.) (?) (probably this, but could be <u>F. ariel</u>)	frigate bird
<u>Phaeton lepturus</u> (Daudin) (probably this, as Mayor says it nests in trees)	white-tailed tropic bird
<u>Sterna fuscata</u> L.	sooty tern
<u>Gygis alba</u> (Sparrm.)	fairy tern
<u>Numenius tahitiensis</u> (Gmel.) (Freycinet, probably this species)	ourlew

The 1953 survey only mentions the presence of birds. It is rather interesting to observe the fact that the same species have visited Rose Atoll for more than 100 years and were found in the same situations.

Wilkes and Graeffe do not mention any land animals other than the birds. Mayor on the other hand found a small brown-gray rat, very tame and very abundant, which is probably the Polynesian rat, Rattus exulans (Peale). Besides, he observed a small brown short-tailed lizard that was identified by Thomas Barbour as Lepidodaotylus lugubris (Dum. and Bibron). Bryan also noted rats and lizards, but the 1953 survey does not mention the latter.

The only other vertebrates occasionally visiting the land at Rose Atoll are the turtles. Wilkes saw several small ones, "feeding upon a species of fucus that grows upon the reefs." Girard (1858, pp. 459-461) described Chelonia tenuis giving the locality as Honden / Pukapuka, Tuamotus/, Tahiti, Eimeo and Rosa Island. He quoted the "Notebook" of the Expedition which said that the turtle captured at Rose "had the alimentary canal crowded with sea-weeds (the Caulerpa seen at Raraka)." Girard's name, Chelonia tenuis was recognized as a synonym of Chelonia mydas L. by Boulenger (1889, p. 182). Rantzau (Graeffe, 1873) gave the best account of turtles:

"On the sand island, in the months of August and September, a great number of sea turtles came to lay their eggs. Most of them were the common sea-turtle (Chelonia mydas L.). More seldom came the caret (Chelonia imbricata L.). When the time came for the young to hatch, the surrounding sea was full of sharks who avidly snapped up the little turtles as fast as they arrived in deeper water."

The 1953 survey reported evidences of the presence of turtles, but gave no details. It is often recognized that turtles visit some uninhabited islands repeatedly, and natives of certain groups protect these "turtle-islands": thus the Marshallese know that turtles come to Jemo and Bikar, and certain islets of the larger atolls, and had very strict rules concerning them (Tobin, 1952, pp. 23-27). It is to be hoped that Rose Atoll will remain a bird and turtle island.

Very few land invertebrates are recorded from Rose Atoll. Mayor observed a sphinx-moth larva of the genus Celerio (Oken) feeding upon the Portulaca. He also observed a few gnats and flies, but supposed that they might have been introduced by the ship. Most of the reports of Governors' visits, in O Le Fa'atonu, point out the absence of flies and mosquitoes. There are no mentions of insects in the published accounts of the 1938 and 1939 visits. However, Bryan (unpublished field notes) collected small moths, crickets, numerous flies on the Pisonia foliage and adjacent Boerhavia, and ants. The ants were especially noticed by Schultz, who said that they were small, red, nonbiting, but quite a plague because of their enormous numbers. He also noted a small beetle and collected various other insects. Neither of these collections has been identified. On the specimen of Portulaca lutea seen in the U. S. National Herbarium, a scale insect was found. Dr. Harold Morrison, of the U. S. Department of Agriculture identified it as a species of Coccus, very close to or possibly identical with Coccus hesperidum L. The specimen was too poor to permit a more positive determination.

Strangely enough, the only group of Rose Atoll land animals on which some systematic work has been published is that of mites. Ewing (1924) found two species in the fur of some rats sent him from the Bishop Museum in 1920. It is supposed that these were the rats that Mayor mentioned presenting to the Museum. The mites identified were: Laelaps echidnidus Berlese on Rattus sp., Laelaps hawaiiensis n. sp. described from Hawaii (on R. hawaiiensis) but recorded also from Rose on Rattus sp.

Of other invertebrates, Bryan simply reports "the usual hermit-crabs." Schultz collected an earthworm, a very interesting fact, but the specimen has not been identified.

The land fauna of Rose Atoll is undoubtedly larger than is indicated by these sketchy records, and it would be interesting to have a complete investigation of it and to correlate it with the flora, the paucity of which certainly must influence the number of animal species, especially small invertebrates, that can take hold on the atoll. Some larger invertebrates, such as Birgus latro, may be absent because of lack of food.

Conclusion

In many ways, Rose is an unusual atoll. Its pink Lithothamnion reef, and the basalt on it, its interesting soils, its enormous trees, and its curiously small flora and fauna are some of its striking features. More is known about Rose Atoll than about most uninhabited islands, but this knowledge is just sufficient to show that a detailed survey of the little atoll may be extremely interesting and may help us to understand certain features and ecological aspects of larger and more disturbed atolls.

A comparison with Vostok Island, which is very like Rose Islet, with a dense Pisonia forest and some Boerhavia, might be of use to explain some of their common characters. Vostok, unlike Rose Atoll, is very difficult to land on, and therefore no attempt at coconut plantings has been made (Fosberg 1937).

Few undisturbed atolls remain in the Pacific, and the pressure of increasing populations makes the utilization of unoccupied atolls likely. To maintain an example of a natural atoll, it may be suggested that Rose Atoll, so remote, so tiny, so devoid of economic possibilities, except for the fish found in the surrounding water, be protected in its present state. Some measures should be taken to prevent the introduction of coconuts and other fruits, and of animals transported by ships, especially large rats, and to instruct fishing parties in the purpose of conservation. The recent colonization of the almost unstudied Phoenix Islands by Gilbertese with resulting destruction of natural conditions makes urgent the preservation of one of the few undisturbed atolls. Phoenix, McKean, and Birnie Islands had previously been officially declared sanctuaries for birds but have been turned over to these colonists for plantations (Maude, 1952, p. 87). Experience in the Marshalls shows that sea birds, in numbers, do not persist in proximity to human settlements. Conceivably, Rose may soon be the only refuge left for breeding of the sea bird and turtle faunas of the Central Pacific.

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