ATOLL RESEARCH BULLETIN

No. 33

Floristics and Plant Ecology of Raroia Atoll, Tuamotus

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by Kenneth Wilson

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Part 1

FLORISTIC AND ECOLOGICAL NOTES ON RAROIA[1]

by Maxwell S. Doty

It can be readily understood that nine months is not the period for a complete floristic study. The time available has been spent in initiating such a study and in assembling information on what seem to be the most important and predominant forms. It would seem that it would be wise to continue this course and bring the study to a close in the form of a complete report on the fauna and flora and on the environmental features. To contribute toward a presentation of our floristic information in a form useful to atoll workers in general, certain "keys for identification" are presented with this report.

The various groups have been turned over to interested individuals who have provided taxonomic information or have taken over a major portion of the job of assembling the sectional report. The floristic information is treated in the following sections: A. Myxophyta (by Jan Newhouse); B. Mycophyta (determinations by Wm. Bridge Cooke); C. Lichens (determinations by A. W. C. T. Herre); D. Algae (determinations by Maxwell S. Doty); E. Bryophyta (determinations by H. A. Miller); F. Pteridophyta (by Kenneth Wilson); and G. Spermatophyta (determinations by Harold St. John).

It has been impossible to present a floristic account of the fungi and algae. This is because the taxonomy of these very diverse groups is itself sorely incomplete for the Pacific.

The localities listed may be located on Figure 1, a diagrammatic map of Raroia.

Ecological information and inferences, especially of a synecological nature are in general to appear in later Atoll Research Bulletins.

As a guide to these sections for the more embryonic botanists among atoll workers and readers, the following key is appended:

A. Growing in sea water, or not green; ideally the reproductory bodies are microscopic spores.

  B. Thalli (plant bodies) colored by tints or shades of red, green or brown, or calcareous in texture; if black then soft when wet with water:

    C. Black, orange, blue-green or brown material, no structures visible to the unaided eye other than unbranched filaments; often but a gray or blue-green stain on rocks or wood....Myxophyta (see Section A).

1/ This paper and the following ones in this number of the Atoll Research Bulletin cover field work carried out in 1952 as part of the Coral Atoll Program of the National Research Council's Pacific Science Board. These studies were aided by a contract between the Office of Naval Research, Department of the Navy and the National Academy of Sciences (NR 388-001), and with the assistance of a grant from the Research Committee of the University of Hawaii.

C. Not as above in color, or if so then with structures such as joints, leaves or branched filaments apparent..... Algae (see Section D).

B. Thalli creamy or white or black; never calcareous, if black then carbonaceous..... Mycophyta (see Sections B & C).

A. Growing on the land with green (rarely yellow) parts and ideally plants having leaves or having reproductory bodies visible to the unaided eye:

D. Plants producing spores, no flowers or seeds produced; leaves either minute scales or forming the only erect parts of the plant:

E. Plants dichotomously branched or leaves over 10 cm. in length ..... Pteridophyta (see Section F).

E. Plants not dichotomously branched, leaves less than 1 cm. in length ..... Bryophyta (see Section E).

D. Plants producing seeds from flowers; leaves not all scale like or other parts of plant conspicuous above the ground level Spermatophyta (see Section G).

Section A - Floristic and Ecological Notes on the Myxophyta

At Raroia it was clear that some of the most abundant kinds of living organisms were the blue-green algae. For this reason special care was taken to obtain complete collections of these forms with extensive notations as to their modes of occurrence. Upon returning to Honolulu, the blue-green algae were taken up as having a first priority along with the calcareous algae. The Office of Naval Research, under whose contract with the National Academy of Sciences the field work was carried out, arranged for military transportation to enable Jan Newhouse to spend two months at the Chicago Natural History Museum working out the taxonomy of the Raroia (and Arno) Atoll forms. Mr. Newhouse has taken over the job of preparing the report on the blue-green algae, and this appears as Part 2 of this Bulletin.

Many of the terricolous blue-green algae collected were intimately associated with fungus hyphae in such a way that they might be considered lichens. However, since it is the blue-green algal component that is identifiable, these incipient lichens have been treated as blue-green algae. Physiologically these conspicuous and widely spread associations are potentially of great interest but are quite unknown beyond the realm of speculation.

Section B - Floristic and Ecological Notes on the Mycophyta

About seventy-five fungi were collected on Raroia. These have been sent out for identification.

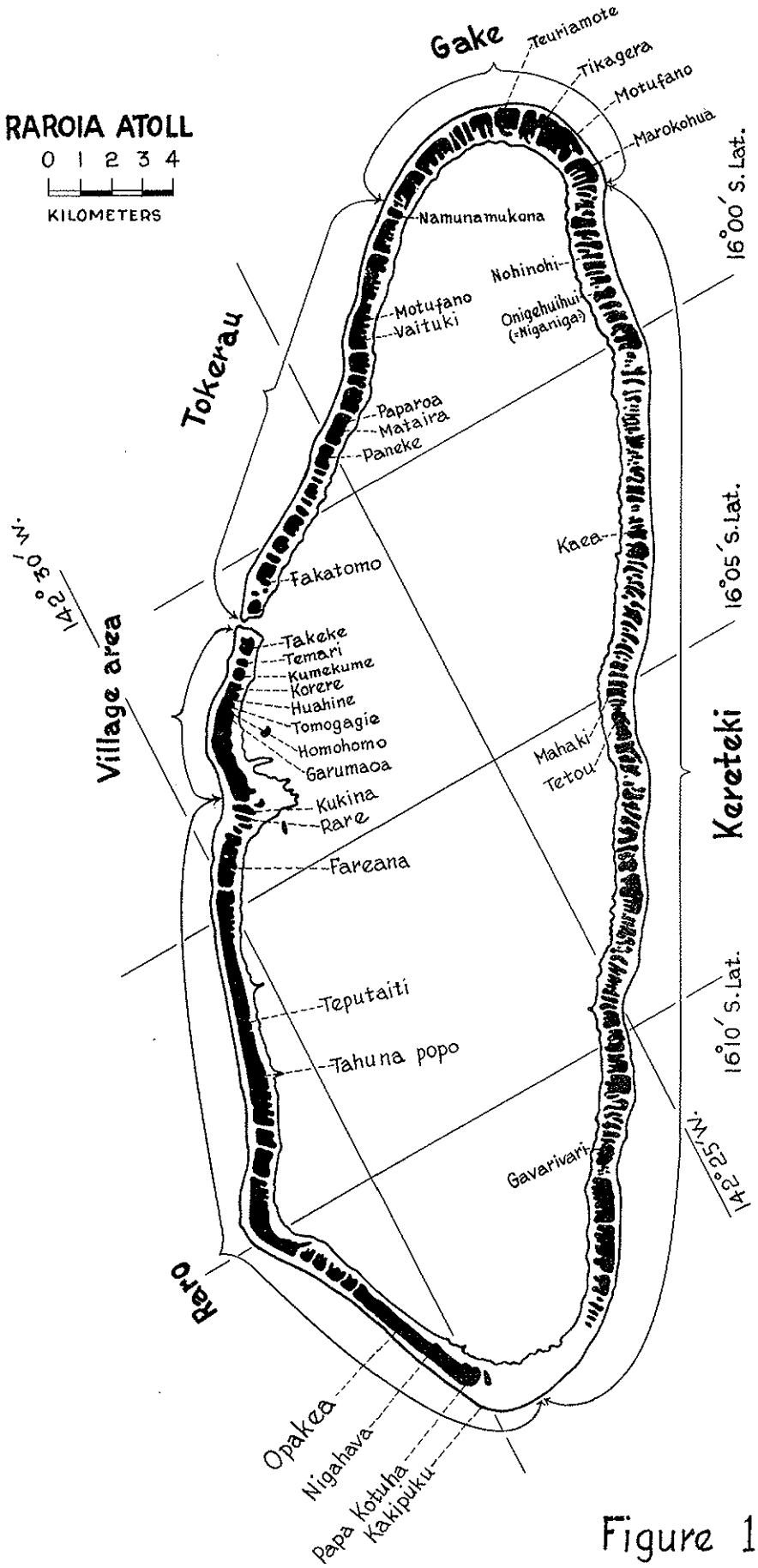
RAROIA ATOLL
0 1 2 3 4
KILOMETERS
Gake
Teuriamote
Tikagera
Motufano
Marokohua
Namunamukona
Nohinohi
Motufano
Vaituki
Onigehuihui
(=Niganiga)
Tokerau
Paparoa
Mataira
Paneke
Kaea
Fakatomo
Takeke
Temari
Kumekume
Korere
Huahine
Tomogagie
Homohomo
Garumaoa
Kukina
Rare
Village area
Mahaki
Tetou
Kereteki
Fareana
Teputaiti
Tahuna popo
Gavarivari
Raro
Opakea
Nigahava
Papa Kotuha
Kakipuku
16°00' S.Lat.
16°05' S.Lat.
16°10' S.Lat.
145°30' W.
145°25' W.

Figure 1

No fungi were seen that were considered to be noteworthy parasites. Most conspicuous of the parasitic fungi were a leaf spot on breadfruit and a sooty mold on Guettarda. One bracket fungus was called TARIGAKIORE. This is notable for almost no lower forms of life had individual names.

Since fungus hyphae are abundant and neither humus nor fermentative decay seems much in evidence it may very well be that decay of vegetable debris is predominantly of the oxidative fungus kind. An observed abundance of fungus hyphae among the terrestrial algae leads to the conclusion that they may play an important synecological humifying role in the more barren atoll soils.

Section C - Floristic and Ecological Notes on the Lichens

Throughout most of the atoll, lichens were present only as minute crustose forms on dead wood. Little or no lichen growth, depending upon definition, was to be found on the plants, soil or rocks anywhere. The coconut tree trunks bore certain crustose species characteristically. Where trees were most dense near the shore a few parmelioid nearly crustose foliose forms appeared; otherwise, truly foliose and fruticose forms were absent. In the most undisturbed regions of the atoll, for example in the old Guettarda areas that had not been planted to coconuts in the Opakea and Oneroa regions, the greatest development of lichens and the most species were to be found. The feeling in the field was that not only the basic few species of less favorable habitats were better developed here, but in addition there were several species not present elsewhere on the atoll.

The Scytonemaceous and coccoid algae which form a more or less sparse coating over the higher parts of the atoll are usually mixed with fungus filaments. Undoubtedly there is a physiological relationship between them. While this relationship is undoubtedly of autecological importance and may very well be of importance synecologically about the only information available is that is exists. For this reason and that the algae members are the taxonomically more recognizable and predominant, such associations are herein included as algae.

To the general collector the lichens of Raroia are not very attractive, and certainly not conspicuous. Dr. A. W. C. T. Herre has very kindly identified the lichens from the Raroia expedition, and provided the information that the Tuamotu Archipelago, as well as the neighboring area of the Pacific, is very poorly known lichenologically. Dr. Herre spent a little time on Takaroa several years back and from that experience and his study of the Raroia collections feels the lichen flora to be representative of a region having considerably less than 25 to 30 inches of annual rainfall. Certain of the results of his study on the present collections have been published elsewhere (The Bryologist 56: 278-282, 1953), including the four species felt to be previously undescribed. Unfortunately many of the lichen growths observed were poorly developed and thus when collected could not be precisely identified.

In the following list the numbers are those assigned in the field by the collectors. The abbreviations immediately following the numbers, USNM and BISH, refer to the herbaria where these particular collections can be expected to be found, the United States National Museum and the B . P. Bishop Museum respectively. Additional specimens were separated and are in the herbarium of Dr. A. W. C . T. Herre.

Anaptychia speciosa (Wulf.) Mass.

On bark of various trees at Opaneke (11402-USNM) and Mataira (11409-BISH on Cocos trunk) in Tokerau, VII-29-1952, and on Messerschmidia or Guettarda on the Homohomo transect (11197-USNM), VII-16-1952. The somewhat cerebriform lobing of the thallose whitish-grey thallus and the capitate sorediose bodies on the surface serve to distinguish this species from the others collected.

Anthracothecium orchraceoflavum (Nyl.) Muell. Arg.

On rather bare wood of Cocos trunk in central part of the island at Tetou (11889-BISH), Kereteki, VIII-21-1952; Oneroa (11601-USNM), Raro, VIII-7-1952; on similar substratum but along the lagoon shore at Homohomo (11254-BISH, -USNM), VII-21-1952; and on Messerschmidia bark on the transect at Homohomo (11203-BISH), VII-16-1952.

Buellia punctata (Hoffm.) Mass.

On dead wood of Messerschmidia at Takeke (11165-USNM), VII-9-1952.

Buellia tuamotensis Herre

TYPE: on Guettarda speciosa bark at Mataira (11414-USNM), Tokerau, VII-29-1952.
"PARATYPE": on wood and bark of Cocos nucifera at Oneroa (11600-BISH), Raro, VIII-6-1952.

Caloplaca magnussoni Herre

On bark of Messerschmidia at Takeke (11163-BISH, ISOTYPE), VII-9-1952.

Candelariella vitellina (Ehr.) Muell. Arg.

On rotten wood of Guettarda at Opaneke (11395-USNM), Tokerau, VII-28-1952.

Coccocarpia cronia (Tuck.) Wainio

On coconut bark on trees in central region of Tetou (11885-BISH), Kereteki, VIII-21-1952 and on same substratum overgrowing moss, Calymperes tuamotuense, at Kukina (11171-BISH), Raro, and again on coconut along lagoon shore just north of Garumaoa (11248-USNM & 11249-USNM), VII-21-1952.

Coccocarpia pellita (Ach.) Muell. Arg.

On bark of Guettarda at Oneroa (11595-BISH, 11596-BISH & 11660-USNM), Raro, VIII-7 & 8-1952.

Lecanora raroia Herre

TYPE: on rotten wood of what appears to be Guettarda speciosa at Oneroa (11591-USNM), Raro, VIII-7-1952.
Co-type: on rotten bark at Opaneke (11403-BISH; 11404-BISH), Raro, VII-29-1952.

Lecidia sp. (Section: Biatora, with spores 4.7 to 6 by 9.5 to 11 microns.) Growing on Suriana on the Homohomo transect (11195-USNM), VII-16-1952.

Lepraria sp.

Various Leprarious stages are represented in the often very poorly developed materials from the atoll. Only some of them are mentioned here. On Messerschmidia (11391-BISH), Cocos (11411-USNM), and on a decorticated bleached Guettarda stump (11415-USNM), all at Mataira, Tokerau, VII-29-1952. On Messerschmidia on the Homohomo transect (11198-BISH & 11201-USNM), VII-16-1952.

Microphiale lutea (Dicks.) A. Zahlbr.

On dead Messerschmidia wood at Takeke (11166-USNM & 11167-BISH), VII-9-1952.

Microthelia dotyi Herre

TYPE: apparently on long dead margin of leaf base of Cocos nucifera on transect across island just north of village of Oneroa (11605-USNM/HOLOTYPE/, -BISH/ISOTYPE/) Raro, VIII-7-1952.

Pannaria mariana (E. Fries) Muell. Arg.

On Guettarda bark, Oneroa (11655-USNM), Raro, VII-21-1952.
On Pandanus, and by far the best developed specimens seen, Oneroa, (11650-BISH), Raro, VIII-8-1952.
On Cocos at Kukina (11171B-BISH), northern Raro, VII-10-1952.
On Cocos along lagoon shore north of Garumaoa (11247-USNM), VII-21-1952.

Physcia cocoes (Sw.) Nyl.

On Guettarda bark, Mataira (11412-BISH,-USNM), Tokerau, VII-29-1952.

Physcia integrata Nyl.

On rotten wood of Messerschmidia mixed in with the fruiting bodies of some fungus, Mataira (11384-USNM), Tokerau, VII-28-1952.
On coconut trunks in central region of Tetou (11886-BISH), Kereteki, VIII-21-1952.

Physcia integrata var. sorediosa Vainio

On Cocos at Oneroa (11500-USNM), Raro, VIII-7-1952.
On Cocos along lagoon shore north of Garumaoa (11251-BISH), VII-21-1952.

Physcia integrata var. ulcerata A. Zahlbr.

From the atoll of Takume (near Raroia), on Guettarda speciosa at Kukina Rahi. (12019-BISH,-USNM) Kereteki, IX-6-1952.

Physcia sorediosa (Vainio) Lynge

This seems to be the most common of the lichens to mature to a specifically recognizable stage. Many more lichens, judging from superficial differences

of color and morphology, develop only partially and remain sterile; as evidence of this are the many Leprarious stages to be seen.
On base of dead Cocos stump, Opaneke (11383-BISH), Tokerau, VII-29-1952.
On Cocos (11410-USNM), and Pemphis (11416-BISH & 11417-USNM), at Mataira, Tokerau, VII-29-1952.
On transect at Tetou (11872-BISH & 11873-USNM), Kereteki, VII-21-1952.
On Guettarda at Oneroa (11579-BISH), Raro, VIII-7-1952.
On Cocos along lagoon shore north of Garumaoa (11250-USNM & 11252-USNM), VII-21-1952.

Rinodina sp.

On Cocos along lagoon shore north of Garumaoa (11253), VII-21-1952.

Section D - Floristic and Ecological Notes on the Algae

A satisfactory floristic list of the algae cannot be made at this time. The group is a large one and identification beyond the generic level is technically complex and even more often just plain uncertain. This is a reflection of the status of algal taxonomy for the Central Pacific. Almost nothing has been published referring to the marine algae of Eastern Polynesia, beyond two papers on the Society Islands and a few on Easter Island.

Flying over the atolls in the Tuamotus one sees them as more or less complete rings of rock just barely submerged beneath the sea's surface. Close inspection can be expected to reveal here as elsewhere an increase in the number of fish, zooplankton population and oxygen production as an atoll is approached and a position inside the lagoon attained. The sea edges of the atolls are of solid stone. This edge was seen to be essentially a pink mass, as is much of the water-covered, flat, upper surface. The lagoon edge of the atoll rings may be sandy shores or coelenterate coral dominated reefs. On the atoll rings there are more or less extensive islands (blacked out areas in Figure 1) which protrude above high tide line. There is a distinct black area clearly visible in most aerial photographs wherever the above-tide shores are of solid material. The outermost edge of this black area on the sea shores can be taken as high tide line in interpreting aerial photographs. Where not covered with vegetation the surface of the islands, whether sandy, gravel or solid rock, is grey.

Each of the observations related above is apparently rather directly dependent upon algal populations. The hypothetical roles of these algal populations are of two major kinds, physiological and mechanical. The physiological roles are effected by the action or the utilization of metabolic products. The mechanical roles are structural, due to the physical nature of the products accumulating through the physiological activities.

Our major objective in going on the Tuamotu Expedition was to make observations that would enable better elucidation of the prospective roles of algae in atoll structure and biology. The algal section of this report is correspondingly an enumeration of the hypotheses developed from the observations of all the Atoll Research Teams insofar as phycological observations were made. It is hoped that this enumeration will lead to testing by future observations

and experiment and that the theories resulting will thereby come to replace these current hypotheses.

Taking Darwin's hypothesis as a description of the way an atoll forms, we are able to open the first scene on the hypothetical roles played by the algae. The first stage-setting is the sudden appearance of an igneous mountain surrounded by the sea. The shores of this mountain could be expected soon to become coated with attached algal material. In Hawaii it is just these sessile algae that are the first organisms to become apparent on new lava flows. The plankton from an open sea situation would not support the fauna found where it is the animals that dominate the reef, and thus one is inclined to think that the benthic algae must have been the primary organisms of abundance on any new mountain appearing in the ocean. In and on this algal material there would develop and feed the host of animals to be found in the intertidal area.

The essential limiting salts for algal growth would become concentrated from the passing sea currents and from the rain water flowing down the mountain. Through this accumulation of materials, passed on to the animals that eat the algae, the materials required for life would continually accumulate. This would be manifest in an increasingly dense population.

Sargent & Austin (Trans. Amer. Geophys. Union 30: 245-249, 1949) have already studied this problem and concluded that the open ocean water is sufficiently rich neither in available food material nor in nutrient salts to account for the reef populations. The concentration of these materials about an atoll as fish, zooplankton and oxygen in the water has been noted above. Plankton forms would not cause an accumulation of materials. They would float away with the ocean currents. This points again to the role of the benthic sea algae as accumulators of material from the passing sea.

Perhaps largely due to the feeding of fish on fleshy algae, especially below the low level of the tides, the benthic algal population which actually forms is predominantly calcareous. These calcareous algae are important in the ocean in that they deposit calcium salts and carry on photosynthesis, making an excess of food materials. The story of the reef that develops through the accumulation of calcareous material by the coral organisms, algal and animal, has been told often. But an aspect that has not been emphasized is this continuous cumulative action. Dead fragments are for the most part passed over the reef edge onto the islands or into the lagoon. Continued sea reef margin growth is probably largely by accumulation of new material from the sea. Thus though the role of typhoons is argued it seems very likely that otherwise atolls continuously increase in mass through the addition of newly accumulated material at their sea margins by the activity of algae.

The algae cover most of the surface of the atoll with a grey, brown or pink coating and wherever this surface is marine, marine organisms live on the algae. The case of parrot fish feeding on coralline reef formers has already been noted above. Sea urchins at the surface and the countless numbers of boring echinoderms, worms, and other organisms are by their homemaking and feeding habits induced to destroy the algae of the reef and reef flat. The sea is essentially saturated with carbonate ions and while the other materials become absorbed as foods or go into solution the carbonates tend to remain as mineral accumulations. This accumulation of carbonates may be in part swept over the

reef into the lagoon sediments sand or gravel fragments. Actually what seems to happen is not so much the solution and production of sediment in situ from the solid algal (and other coral) material but that the structure of the reef locally becomes weakened. Fragments then break off and are carried in over the reef flat and deposited on the islands or as sediment washed on into the lagoon. Undoubtedly many of these fragments fall onto the slope beyond the sea edge of the reef and contribute to the extension of the twenty-meter bench. The most important aspect here is that this breaking away leaves a favorable site for the growth of new coralline organisms and thus induces further accumulation of material from the sea.

From our observations it appeared that erosion of the solid reef surface can go on rapidly. History indicates upward growth takes place rapidly: passes that used to be open to the sailing canoes (e. g. that near Kukina) are no longer open. After studying the history, effects of hurricanes and making various observations on the reef surface one gathers the impression that the atoll surface is in equilibrium with the environment and held to a large extent at the vertical level at which it is found by the activities of, largely, the genus Porolithon.

Another hypothesis of the biological origin of atolls thus comes to mind and should be tested. Observations at Johnston Island as well as at Raroia and elsewhere lead us to suspect that an atoll could form without the sea mount upon which it forms ever breaking the surface. In swimming over the reef edge in the ocean one sees that active Porolithon activity begins at a rather definite level. It seems possible that as the elevation of sea mounts in reference to the sea surface changes with time the sea mount tops could become trapped at the surface by atoll formation. Should the sea mount elevation remain very stable the atoll might gradually mature , i. e. the lagoon become filled in and the reefs broaden. Canton in the Phoenix group and Christmas Island in the Line Islands might be atolls of this type. If the sea mount sinks the lagoons would be deeper and the reefs narrower. Raroia and most of the Tuamotu Archipelago atolls are of this type. If the sea mount base rises faster than erosion takes place a raised reef appears. One corner of Anaa (the northernmost) is such a place, or a raised atoll or island such as Henderson, or more classically Makatea, both in the Tuamotus, may result. Finally if the sea mount may sink so far so fast that reef development does not keep up, the sea mount top then, essentially, escapes from the surface. Examples of this are unknown to the writer unless the southeastern "half" of Johnston Island is an example.

With the energy accumulated by photosynthesis inorganic materials are combined and passed on to other organisms as organic foods. As an example consider Porolithon onkodes, the reef-covering calcareous alga. For a crustose coralline alga it is peculiar in its ability to thrive in brilliant light and withstand brief exposure to the air. This species is eaten by parrot fish. The parrot fish defecate not only calcareous material but nutrient salts and thus enrich the water beyond the reef. Planktonic algae reincorporate this material into algal cells. Plankton feeders can consume the algae material, forage fish and then fish such as the wahoo (Acanthocybium sp.) and yellowfin tuna (Thunus ablunga) and finally the sharks may receive this material. Thus may be outlined the hypothetical explanation of the increase in populations as an atoll island is approached.

This great increase of fish provides food for the island peoples and, potentially, an income source for them. For example production of whole or ground dried fish might very well be developed as a new source of income to atoll peoples. Production of such a product would be feasible on a family basis and require little material beyond what is already available in any copra producing area.

The legal aspects of oceanic waters have an interesting relationship here near an atoll. If one is concerned with the fish population, it would appear that its size would be due to land bound causes. The land owner could cite this in reference to a claim of ownership of the near shore fish. It is to be noted in this connection that the Polynesian peoples did claim the waters that extended away from the shore of their particular piece of land.

With variations in reef exposure and local topography other species of Porolithon, other than P. onkodes, may become locally abundant. They rarely become dominant at Raroia. Rarely a Goniolithon appears in numbers but in the situations seen in the Tuamotus only on the reef flat well inshore. Lithothamnion is a very unusual alga on the reefs in the Tuamotus and it is not likely to be common on any reef edge in the habitats where Porolithon is ordinarily found. The two generic taxa are very distinct, belonging to separate sub-families of the Corallinaceae. Certainly "Lithothamnion ridge" should not be used for the ridge of algal material which often appears near the seaward edge of sea reef flats.

Blue-green algae (or perhaps we should better say blue-green bacteria) grow on and in all surfaces near high tide line. In North Carolina the blue-green algae so solidly bind the surface at sand beaches that airplanes use these places as practice landing strips. On a coral reef and particularly above high tide line undoubtedly such binding stabilizes the sand bars and binds new sand grains that chance to come to rest. It is through such activities that such a sand bar could be expected to increase in size and become an island.

With increase in size an island on an atoll may come to hold in its interior a body of fresh water. Sea water penetrates the island. This body of fresh water floats up and down with the tides on top of the sea water and the fresh water in such a situation gradually become mixed with the salt water. Both the freshness and lateral extent of the fresh water is regulated by such factors (Doak Cox, Atoll Research Bulletin No. 8) as rainfall, island size, tide range and the permeability of the islands, especially near their shores. It has been postulated that the algae play a part in the transformation of the sand at the shore into the beach rock and other atoll rock types. They play a role as well in the destruction of these rock types.

Particularly in this case the algae have a major role in the establishment of the island as a land mass sufficiently permanent that the climax atoll biota may become established.

They are critical agents in the chain of events leading to the removal of another factor limiting to the terrestrial biota, that of available nitrogen and phosphate. The accumulation of these from the passing sea current has been discussed above. However, for the sake of argument, with the appearance of algally induced islands two more possibilities arise. Birds may use the islands as roosts. This effectively initiates a collection on the islands of

nutrient salts from the fishing and roosting activities of the birds. Hatheway (Atoll Research Bulletin No. 16) and Fosberg (reported at the Eighth Pacific Science Congress) have discussed this in some detail in reference to the native vegetation. This seems to be a particularly important factor in the case of phosphate. It is to be noted that the fish phosphate got into the fish as phosphate hypothetically accumulated near the atoll by the sessile algae.

The story of available nitrogen is somewhat different. In part it duplicates the phosphate story. Perhaps in a native climax vegetation with a well developed humus beneath, the birds or bacteria might provide a replacement of available nitrogen lost to the sea. Where there is little or no humus, as in the hurricane swept Tuamotus, the upper ten centimeters of sand and gravel have a dense layer of blue-green algae that may very well substitute for humus. In the coconut plantations and Guettarda groves the soil is largely non-humified sand or gravel, with sand filling a few decimeters below the surface. Yet there is a root zone well developed.

There is no growth of legumes on these atolls that could account for nitrogen-fixation by species of Rhizobium. The soil is exceptionally aerobic and of carbonate buffered pH's. There are but few bacteria known (e. g. Azotobacter and the Itersonia described recently by Derx) that fix nitrogen under these conditions. Bortells, Gerloff, as well as Fogg and others, have investigated the nitrogen-fixing properties of blue-green algae. It is found that many related to those dominating the atoll soils do fix significant amounts of nitrogen. This problem is under investigation at present and preliminary cultural experiments lead us to believe that apparently the soil forms of blue-green algae from atolls are significant nitrogen-fixers themselves.

Much attention has been paid to the black zone at high tide line where algae in cooperation with exfoliation must be principal causes of destruction of the rocks of the islands. Gastropods of the genera Littorina, Melaraphe, Tectarius and their herbivorous cohorts feed on blue-green algae. By their rasping of the algae they remove rock material. The surfaces above high tide on which the algae are growing were found to be softer than those freshly exposed or where no algae are growing.

To a certain extent the algae grow into these high tide carbonate rocks. Their pigments diffuse into the rocks and become adsorbed. It is most likely that it is the chemical results of these processes that are the causes of the observed softening.

It has been postulated that the softening noticed beneath the black algal coating is an evidence of solution and again of deposition. It seems more likely that it is an evidence of solution aided by the pH variations (especially at night) and the considerable amounts of heat accumulated and thus higher solubilities (but not of carbonate) under the black layer of algal material.

The only reefs seen by the present author to be predominantly coelenterate reefs are those in the lagoons. Such developments are reduced toward the windward side of atolls such as Raroia and in the more closed atolls such as Takume. The algae very definitely play a part both in the development and in the death of these animals. Firstly they play a role as the food, directly as

phytoplankton or zooxanthellae or indirectly as food for the zooplankton which in turn may form the food of the coelenterate corals. They may be at least equally important as removers of waste metabolic products from the coelenterates in which they live. What is said here is true also of the sea reef corals and hermatypic corals at greater depths.

The edges of lagoon reefs are of coelenterate corals at Raroia, elsewhere in the Tuamotus and elsewhere in comparable situations, e. g. at Johnston Island and on the island of Oahu (in Kaneohe Bay) in Hawaii. Often species of Pocillopora or Porites form the uppermost surface near the edge as a series of flattened branches condensed behind the reef edge almost into a pavement.

The upward limit of growth for the coelenterate corals on these reef edges seems to be regulated by their tolerance to air exposure. Some algae seem to tolerate air exposure better than the coelenterate corals and grow on the uppermost, often inactive, coelenterate tips just a decimeter or less from the reef edge. This must interfere with the feeding of nearby polyps especially inshore of the algal patches away from the reef edge. Certainly the shading would interfere with photosynthesis by zooxanthellae in the coelenterates.

Between the closely arranged coelenterate branches circulation must be reduced as the reef extends. In such places algae such as Rhipilia geppii grow. They come to fill the spaces between the branches as do such algae as Zonaria variegata. This latter may extend over the top of the coelenterates a few decimeters in from the edge of the reef so extensively as to mask the coelenterate coral completely. The coelenterate corals become weak structurally and break off; so that in from the edge of the reef there is a lower area, a pool area. In this lower area and on the higher parts of shoreward areas of shorebound reefs, crustose coralline algae again come to predominate in some localities where the gravel or reef fragments are large.

In any intertidal region, or above on a lagoon shore, the blue-green algae play the same roles as they do on the sea shores already described, but more often on gravel rather than conglomerate material.

The lagoon bottoms of some atolls are reported to be essentially meadows of the green alga Halimeda. At Raroia, in the Tuamotus, no dredge haul indicated living Halimeda on the bottom. However, there the sides of the reef patches in the lagoon are often clothed with this genus and Caulerpa. The latter, as Caulerpa bikinensis, is a favorite food of the turtles.

Halimeda is apparently one of the minor contributors to the sediments that in turn contribute to filling the lagoon. The calcium salts Halimeda deposits are accumulated from the lagoon waters: the other materials filling lagoons come chiefly from outside the lagoon or from alga-smothered dead coelenterate corals within the lagoon.

So far as the above outline is concerned, the most important algal forms are the Corallinaceae, the blue-greens, the phytoplankton, and the Codiaceae; perhaps in that order. At present there is nothing known of the phytoplankton. It may be that some work in this field was done by the Scripps CAPRICORN Expedition in the Tuamotus, but no results of such work have been seen by the author. The Raroia team received none of the equipment sent out which would have

made such investigations possible. The blue-green algae have received special attention by Jan Newhouse and the results have been incorporated into Part 2 of this Bulletin.

The Polynesians of Hawaii used many marine algae (LIMU KAI) as food. There are about 150 Polynesian names for them. In Tahiti in 1952, RIMU KARA (for Turbinaria) was the only specifically named marine alga (RIMU TAI) found. In the Tuamotu Archipelago, in 1952, RIMU was applied widely to algae, mosses, tunicates, fungi, sponges and the like, with only one specific reference and that not a RIMU. This name was the KOPARA discussed under Anacystis dimidiata in the section on Myxophyta. Beyond this the Tuamotuans paid no attention to the algae. They used none of them for medicine or food.

Section E - Floristic and Ecological Notes on the Bryophyta

The information on the mosses and liverworts obtained at Raroia appears in Part 3 of this Bulletin.

Section F - Floristic and Ecological Notes on the Pteridophyta

The information on the ferns obtained at Raroia appears in Part 4 of this Bulletin.

Section G - Floristic and Ecological Notes on the Spermatophyta

There are perhaps thirty flowering plants growing on Raroia that could be considered native plants. A whole host of plants has been brought recently from Tahiti or sent as gifts of seeds from overseas. There is then the class of plants which were brought to the atoll by aboriginal peoples. It is the plants of the last group that are of direct importance to the Raroians. We include in this list accepted food plants such as the banana, papaya, breadfruit and citrus, though of relatively recent introduction. We exclude ornamentals such as the gardenia and hibiscus and such curiosities as sugar cane though probably of similar period of introduction.

Plants of importance to the Raroians become fewer and fewer in normal times. Currently with copra prices high, about the only plant of regular use is the coconut. It is a source of food, drink, shelter and utensils. It is the source of the income with which they buy all that which they might otherwise improvise from other plants or wrest from nature. In times of little demand for copra they fall back to varying degrees upon the natural resources or upon the plants (e.g. Tacca) and animals (e.g. dogs, chickens and pigs) of aboriginal range.

The major plants of aboriginal introduction are or were most likely: Cocos nucifera (Coconut), Morinda citrifolia, Tacca leontopetaloides, Colocasia esculenta (Taro is now extinct), Pandanus tectorius var. laevis (Weaving pandanus), Calophyllum inophyllum.

Like anything else once established, and the plant is largely responsible for this too, no care is given a plant. About the most one can say is that the

Raroians have brought in certain plants. Tacca is no longer cultivated and occurs in village areas scattered about, with no attention being given it. It, however, can live and reproduce with no care and thus is still around and is used upon occasion as a starch source during local hard times.

Taro was once a big item in the food budget as is evidenced by the large taro pits near the villages. For example, Gake, Takume, has about one-fourth of a square mile of closely placed pits about 5 meters deep, 30 meters wide and 100 meters long. However, in 1952 no living taro could be found at Raroia or at Takume. After the advent of the "copra-tin can" economy the taro pits were abandoned. At Takume the eventual development of hordes of mosquitoes in these abandoned pits led to the abandonment of the whole village there and the development of a new village at the southern end of the atoll.

There are but few trees of Hibiscus tiliaceus on the atoll now and little of the Cyperus species that must in former times have been producers of the raw materials for fine mats. Pipturus incanus appeared in the lists of Raroian plants prepared previous to 1952 by Bengt Danielsson, where it was listed as having the local name ROGA. However, no Pipturus was found on either Raroia or Takume.

Recent arrivals are the duck among animals and the papaya and breadfruit among the plants. Some of these are food plants, but many such as the oleander, hibiscus and jasmine are mere ornamentals. Some are curiosities such as sugar cane and cotton. Some of the flowers are used as bodily adornment and the gardenia is a source of scent for coconut oil for the hair. The nuts of Calophyllum were formerly grated and the powder used as a scent for tapa cloth, but now the tree has little value other than as a source of nice little balls for juggling. A very few of the older plants have taken on new uses. One example is the use of coconut shells for charcoal, a use related to the flat iron and cotton cloth. With changing customs new plant uses have arisen, e.g. now property lines within the village are expressed by hedges that are often of the very same panax that is common in almost all subtropical regions of the world.

The other ethnic uses of the plants are for the most part detailed elsewhere and thus have not been expanded in this section of the report.

To obtain the native names for the plants found, the fresh and pressed plants were shown to various of the local people. Bengt Danielsson provided a list of plant names gathered during his earlier work at Raroia. Some of these plants no longer exist at Raroia. An even more extensive list of names has been published by Kenneth P. Emory (Tuamotuan Plant Names, Jrnl. of the Polynesian Society, 56(3): 266-277, 1947). None of the names used by the Polynesians at Raroia has the least resemblance to any of those used by the Micronesians at Arno or as reported by St. John & Mason (Vernacular names of the plants of Bikini, Marshall Islands Pacific Plant Studies 12, Pacific Science 7: 165-168, 1953) from Bikini. Following is Danielsson's list inserted here for ready reference:

Sicentific names	Raroian names
Achyranthes velutina	Putarau
Boerhavia diffusa	Runa
Bracket Fungus	Tarigakiore

Calophyllum inophyllum	Ati
Cassytha filiformis	Kainoka
Cocos nucifera	Hakari
Colocasia esculenta	Fakea (Extinct)
Cordia subcordata	Tou
Eragrostis amabilis	Nanamu
Euphorbia hirta	Tahetahe
Fleurya ruderalis	Vaianu, Ogaoga
Guettarda speciosa	Kahaia
Hedyotis romanzoffiensis	Koporoporo
Heliotropium anomalum	Parahirahi
Ipomoea tuba	Pohue
Lepidium bidentatum	Nau, Horahora
Lepturus repens	Mauku (grass in general)
Messerschmidia argentea	Geogeo
Microsorium scolependria	Kikipa (when a sprout = Oro)
Morinda citrifolia	Hora
Mosses (in general)	Rimu
Nesogenes euphrasioides	Toroariki
Pandanus sp.	Fara, Tima
Pemphis acidula	Mikimiki
Phyllanthus niruri	Moemoe
Pisonia grandis	Gatae
Pipturus argenteus	Roga (perhaps extinct since 1906)
Polypodium phymatodes	see Microsorium
Portulaca johnii	Pokea
Psilotum nudum	Tumutumuhenua
Scaevola frutescens	Gapata
Sesbania speciosa	Kohai
Solanum viride	Putamagomago
Suriana maritima	u'u, kuku, kokuru
Timonius polygamus	Paketa, Ketoketo
Triumfetta procumbens	Vavai
Ximenia americana	Rama

As an aid to our field work F. R. Fosberg provided a very workable key to aid in the identification of the plants we might possibly expect to find. This key has been modified in various ways, for example, to include additional species found established outside the village areas. Since it proved so valuable this modification of Fosberg's key is included here:

A KEY TO COMMONLY EXPECTED TUAMOTUAN VASCULAR PLANTS

(* indicates those found on Raroia. ** indicates ferns listed in the previous section.)

1. Plants leafless or young leaves unrolling from apex as elongation begins.

   2. Leafless plants

      3. Dichotomously branching, broom-like in appearance--Psilotum nudum**

      3. Irregularly or pinnately branching, not broom-like in appearance

4. Twining, elongate plants, yellow or yellow-green, parasitic--*Cassytha filiformis**

4. Rosettes of pale green flattened roots, with tiny erect flowering stem in center--*Taeniophyllum* sp.

2. Leafy, fern-like plants

5. Fronds entire, plant rosette-like--*Asplenium nidus***

5. Fronds pinnately divided

6. Bases of pinnae wide, confluent; sori round, without indusiam--*Microsorium scolopendria***

6. Bases of pinnae narrow; sori with indusia

7. Sori linear, pinnae not disarticulating from rachis when old--*Asplenium obtusatum*

7. Sori reniform, pinnae disarticulating

7a. Bases of leaflets merely rounded--*Nephrolepis biserrata***

7a. Bases of leaflets auriculate or cordate--*Nephrolepis shirsutula*

1. Plants with leaves and young leaves not unrolling at tip as elongation begins

8. Plants with thin grasslike leaves

9. Flowers large, showy, 2.5 cm. wide, or more--*Zephyranthes rosea*

9. Flowers reduced, without perianth, enclosed in or subtended by scale-like bracts (grasses and sedges)

10. Stem solid; inflorescence subtended by an involucre of leaf-like bracts (sedges)

11. Scale-like bracts arranged spirally--*Fimbristylis cymosa*

11. Scale-like bracts arranged in two ranks (*Cyperus*)

12. Spikelets in a tight globose head--*Cyperus kyllingia**

12. Spikelets loosely arranged

13. Plants large and stiff, gray-green, slightly rough when rubbed by fingernail--*Cyperus javanicus**

13. Plants small, weak, green, smooth

14. Style-branches two; achenes usually biconvex, elongate--Cyperus polystachyus

14. Style-branches three; achenes trigonous

15. Spikelets dark brown, linear, plants tuberiferous--Cyperus rotundus

10. Stem hollow; inflorescence not subtended by leaf-like bracts (grasses)

16. Inflorescence of two to several digitately arranged spikes

17. Spikes two

18. Spikelets relatively few on a spike; leaves stiff--Paspalum vaginatum

18. Spikelets many on a spike; leaves thin, not stiff--Paspalum conjugatum

17. Spikes more than two

19. Rachis of spike strongly excurrent--Dactyloctenium aegyptium

19. Rachis not excurrent

20. Plants tall; spikes stiffly erect--Digitaria stenotaphrodes*

20. Plants unusually low; spikes strongly spreading

21. Spikes 2-3 mm. wide--Eleusina indica*

21. Spikes about 1 mm. wide; plants mat-forming--Cynodon dactylon*

16. Inflorescence not digitate

22. Inflorescence a cluster of burrs--Cenchrus echinatus*

22. Inflorescence not of burrs

23. Inflorescence a cylindrical, brittle spike, disarticulating when old--Lepturus repens*

23. Inflorescence not cylindrical

24. Spikelets in a diffuse panicle; plant tufted--Eragrostis amabilis*

24. Spikelets one or two on an erect leafy stem; plant creeping--Thuarea involuta

8. Leaves thick or not grasslike

25. Leaf veins parallel or pinnately parallel

26. Large herbs

27. Leaves sword-shaped; flowers umbellate--*Crinum asiaticum* (or *pedunculatum*)*

27. Leaves, oblong, obtuse; flowers in a spike-like panicle--*Musa sapientum**

26. Trees

28. Leaves compound--*Cocos nucifera**

28. Leaves simple

29. Leaves linear, spirally arranged

30. Leaves regularly beset with strong spines on margins and dorsal midrib surface; producing flowers and fruits--*Pandanus tectorius**

30. Leaves with margins and midrib weakly and irregularly spiney; sterile--*Pandanus tectorius* var. *laevis**

29. Leaves oblong, opposite--*Calophyllum inophyllum**

25. Leaf-veins forming a network, or obscure, or plants leafless

31. Leaves compound (over 1 cm. long)

32. Trees

33. Leaves once pinnate--*Sesbania speciosa**

33. Leaves twice pinnate--*Leucaena glauca*

32. Herbs or vines

34. Leaves alternate

35. Plants vine-like; leaflets three

36. Flowers yellow; pods cylindric--*Vigna marina**

36. Flowers pink; pods heavy, flattened--*Canavalia* sp.

35. Plants not vine-like; leaflets different

37. Leaves erect from the ground and over 30 cm. long; flowers in heads--Tacca leontopetaloides*

37. Leaves from stems branching above ground, smaller; flowers not in heads--Solanum lycopersicon (Lycopersicon esculentum)

34. Leaves opposite

38. Plant prostrate; leaflets a number of pairs; flowers large, solitary--Tribulus cistoides

38. Plant erect; leaflets usually three; flowers in heads--Bidens pilosa

31. Leaves simple; very small

39. Leaves less than 0.25 cm. long; plants prostrate on ground--Pilea microphylla*

39. Leaves over 0.5 cm. long

40. Leaves opposite

41. Stipules present

42. Herbs or subshrubs with milky juice; ovary superior

43. Plants prostrate

44. Purplish green; leaves not crowded, oval--Euphorbia thymifolia

44. Grayish green; leaves crowded, oblong-ovate--Euphorbia prostrata*

43. Plants upright, arching at tip

45. Plant somewhat woody; inflorescence terminal--Euphorbia atoto*

45. Plant herbaceous (rarely somewhat woody in E. hypericifolia)

46. Plant hairy--Euphorbia hirta*

46. Plant smooth--Euphorbia hypericifolia

42. Shrubs or subshrubs; ovary inferior

47. Corolla several cm. long; fruit subglobose, fleshy, with a large stone--Guettarda speciosa*

47. Corolla 1 cm. or less long; fruit not with a single large stone

48. Ovaries of several flowers fused together; fruit large, potato-like in appearance--Morinda citrifolia*

48. Ovaries free; fruits less than 2 cm. thick

49. Flowers and fruits many, in flat-topped clusters--Taremna sambucina

49. Flowers few, not in flat-topped clusters

50. Leaves ovate, apex short acuminate and margins crenate to serrate--Pipturus argenteus

50. Leaves ovate to obovate elliptic, apex blunt and margins entire

51. Flowers silky outside; seeds large, arranged radially in fruit--Timonius polygamus*

51. Flowers not silky; seeds many, small--Hedyotis romanzoffiensis*

41. Stipules absent

52. Trees or shrubs

53. Juice milky; ovary and fruit double--Ochrosia oppositifolia

53. Juice not milky; ovary and fruit not double

54. Bases of petioles clasping stem; leaves leathery, parallel-veined; fruit spherical, flowers with separate petals, many stamens--Calophyllum inophyllum*

54. Not as above

55. Flowers and fruits in flat-topped clusters; fruit spherical--Premna tahitensis

55. Flower and fruit clusters hemispherical; fruit club-shaped, spiny, very sticky--Pisonia grandis*

52. Herbs

56. Prostrate; flowers solitary, axillary

57. Leaves very thick, linear; perianth in one series--Sesuvium portulacastrum

57. Leaves not very thick, ovate to elliptic; perianth in two series---Nesogenes euphrasioides*

56. Erect or prostrate; flowers in clusters

58. Flowers in spikes

59. Plants fleshy; flowers reduced to a scale with an anther and an ovary--Peperomia subglabra

59. Plants not fleshy; flowers otherwise

60. Perianth not scale-like; fruit sunken in rachis

61. Axis of flowering spike 3/16 in. or more in diameter; fruits buried in deep furrows--Stachytarpheta indica

61. Axis of flowering spike about 1/8 in. in diameter; fruits but slightly embedded in shallow furrows--Stachytarpheta jamaicensis

60. Perianth parts scale-like; fruits reflexed

62. Plants densely pubescent--Achyranthes canescens*

62. Plants sparingly pubescent, green--Achyranthes aspera

58. Flowers in heads or umbels (in some cases heads in terminal compound racemes)

63. Flowers sessile in leaf axils

64. Stems round--Synedrella nodiflora*

64. Stems squarish--Ocimum basilicum*

63. Flowers in pedunculate clusters

65. Flowers over 5 mm. across, bright orange and red; fruit a follicle several cm. long--Asclepias curassavica

65. Flowers 2-3 mm. across, pink or whitish; fruit club-shaped, sticky, up to 5 mm. long

66. Leaves elliptic-oval to oblong, margins regular, firm, inflorescence open--Boerhavia tetrandra

66. Leaves ovate, margins undulate, thin, inflorescence tending to be capitate--Boerhavia diffusa*

40. Leaves alternate or spirally arranged

67. Plants acaulescent or with a thick stem bearing a rosette of large leaves

68. Leaves palmately lobed; flowers in panicles or solitary--Carica papaya*

68. Leaves sagittate; flowers on a spike enclosed in a spathe

69. Leaves dull green, peltate--Colocasia esculenta

69. Leaves bright green, not peltate

70. Basal lobes of leaves sharply pointed--Cyrtosperma chamissonis

70. Basal lobes of leaves rounded or obtuse--Alocasia macrorhiza

67. Not as above

71. Plants woody, at least at base

72. Flowers very irregular, not radially symmetrical, over 1 cm. long, and never in dense heads

73. Flowers 1-2 cm. across, split down one side, appearing as though torn in half--Scaevola frutescens*

73. Flowers much larger, with many stamens, not appearing as though torn in half--Capparis sandwichiana

72. Flowers regular, or very small, in some cases in dense heads

74. Flowers minute, in small heads strung several on a pendant rachis--Pipturus argenteus

74. Flowers larger, not as above

75. Inflorescence a dense axillary cluster--Waltheria indica*

75. Inflorescence not as above

76. Leaves cordate, palmately nerved

77. Leaves smooth and green above and below--Thespesia populnea

77. Leaves densely felty, velvety or white at least beneath

78. Leaves dark green above--Hibiscus tiliaceus* (incl. var. abortivus* and var. sterilis*)

78. Leaves velvety on both sides--Abutilon indicum

76. Leaves neither palmately veined nor cordate

79. Leaves large, over 3 cm. long

80. Leaves thin or leathery, green, entire or not; flowers otherwise

81. Leaves ovate or elliptic, entire; flowers in loose cymes

82. Leaves elliptical; flowers with 4 petals--Ximenia americana*

82. Leaves ovate to cordate; flowers with 5 or more petals

83. Leaf surface with scattered scales---Cordia subcordata*

83. Leaf surface not scaly--Solanum viride*

81. Leaves obovate; flowers not in cymes

84. Young growth glabrous; flowers several cm. long; fruit square--Barringtonia asiatica*

84. Young growth minutely tomentose; flowers small, less than 1 cm. across; fruit not square

85. Young growth pale, ocher-colored; fruit 1-2 cm. long--Terminalia samoensis

85. Young growth brown; fruit over 3 cm. long--Terminalia catappa*

79. Leaves small, less than 3 cm. long

86. Dwarfed, depressed shrubs; leaves densely hairy; flowers in dense, terminal clusters--Heliotropium anomalum*

86. Erect shrubs; flowers not clustered

87. Flowers white, calyx tube prominent, striate; fruit not of separate carpels--Pemphis acidula*

87. Flowers yellow, calyx tube not well-developed; fruit of separate carpels--Suriana maritima*

71. Plants herbaceous

88. Leaves bilobed at apex---Ipomoea pes-caprae

88. Leaves not bilobed at apex

89. Plant a twining vine; leaves cordate

90. Leaves well over 5 cm. across; flowers opening only at apex--*Ipomoea tuba**

90. Leaves less than 4 cm. across; flowers opening completely--*Ipomoea littoralis**

89. Plant not a twining vine, though sometimes creeping and mat-forming

91. Leaves palmately veined; flowers yellow; fruit burr-like--*Triumfetta procumbens**

91. Leaves not palmate; fruit not burr-like

92. Flowers and fruits in erect racems--*Lepidium bidentatum**

92. Flowers and fruits not racemose

93. Flowers in purplish heads, small

94. Heads in loose clusters, involucral bracts imbricate--*Vernonia cinerea**

94. Heads solitary or few, involucral bracts in one series--*Emilia sonchifolia*

93. Flowers not in heads

95. Leaves very small; flowers and fruits in leaf axils; leafy branchlets resembling compound leaves--*Phyllanthuus niruri**

95. Leaves larger, not as above

96. Leaves petiolate, acute, serrate--*Fleurya ruderalis**

96. Leaves sessile, obovate, rounded at apex, fleshy, entire

97. Stems grayish below, 1 cm. or more thick; flower 1.5-2 cm. across; seeds stellately regulose--*Portulaca lutea*

97. Stems green or brownish below, usually not over 5 mm. thick; flowers 4-7 mm. across

98. Seeds shining smooth--*Portulaca johnii**

98. Seeds tuberculate--*Portulaca oleracea*

For the purposes of this floristic treatment it has been felt desirable to distinguish between the native and aboriginal plants established outside the village sites and the village plants. To be sure, this is an arbitrary distinction in many cases. Almost all of the native and aboriginally introduced plants are found variously about the atoll outside the village. The recently introduced plants and ubiquitous weeds, e.g. Euphorbia hirta, Phyllanthus niruri, and Vernonia cinerea, are restricted largely to the villages where they may be abundant. Thus, two lists, arranged alphabetically for simplicity, follow as: (1) native and aboriginally introduced plants; and (2) exotics and village plants.

The localities given in the following lists may be located on the atoll through reference to Figure 1. Prof. Harold St. John, of the University of Hawaii, has gone over all the flowering plant materials and his determinations have been used in all cases. /Differences in nomenclature between these lists, the key, and the Danielsson list appear because of differences of opinion on nomenclature between the authors of each./

NATIVE AND ABORIGINAL PLANTS

Achyranthes velutina H. & A. f. velutina

Raroia: Marokohua 11478; Opakea, 11790-BISH, USNM
Takume: Gake, 12301-BISH, USNM
Occasionally found established outside the village areas.
PUTARAU is given as the native name by Danielsson.

Artocarpus incisus (Thunb.) L. f.

Raroia: Garumaoa, 11728-BISH, USNM
Only in the main village at Garumaoa, and not established very long though several trees of large size were present.
Raroian breadfruit trees do not have the great amount of sticky sap that is common in other regions. The tar spot common to this plant in the collections from Arno Atoll is present here, too. No deleterious effects were attributed to it. The local name was URU.

Boerhavia diffusa (L.) var. diffusa

Raroia: Opakea, 11786b-BISH, USNM; Garumaoa, 11911-BISH, USNM; Homohomo, 11007b-USNM; 11007-BISH, USNM; Garumaoa, 11111-USNM; Orare, 11172-USNM.
Takume: Gake, 12309-BISH, USNM.
Common in various forms in more open Cocos and Guettarda areas. A specific search was made for variations that might represent other species. The population was extremely variable but in closely intergrading series.
This plant is a component of the local fish poison cure.
Danielsson gives RUNA as the Raroian name.

Calophyllum inophyllum L.

Raroia: Garumaoa, 11717-USNM.
Takume: Gake, 12326-BISH, USNM.
There are several trees but only in the village.

While there were extractives of the nuts used in treating some of the symptoms of leprosy in olden times and the dried nuts were grated and sprinkled on tapa cloth as an odorant, there is little use for the tree now. The wood is very hard and durable. The principal usage at present in Raroia seems to be as a source of nice little balls for juggling.

The native name in Danielsson's list is ATI.

Carica papaya L.

Common in the village of Garumaoa. Seedlings are abundant. The variety seems to be a poor one and could not compete with those grown in Hawaii.

Cassytha filiformis L.

Raroia: Teputaiti, 11243-BISH, USNM; Opakea, 11780-BISH, USNM: Gavarivari, 11908-BISH, USNM.
Takume: Gake, 12305-BISH, USNM.

Growing (11243) over Heliotropium, Suriana and dead Cocos leaves. This was not often on Scaevola, said by Taylor (1950: 181) to be its principal host where he found it in the northern Marshalls. It did occur on Scaevola at Opakea (11780), however. Flowering in July.

Danielsson's list gives KAINOKA as the Raroian name.

Cenchrus echinatus L.

Raroia: Garumaoa, 11047-USNM, 11041-BISH.

Isolated plants in the yards about the center of the village and in the coconut groves. The Raroian variety is a soft grass, except for the burrs, and it is quite erect in growth.

Cocos nucifera L.

No collections made.

Known Raroian distribution: In general, planted on all suitable areas for the economy of this atoll is dependent upon copra production.

Raroia is largely a coconut plantation, but there are areas seemingly suitable to its cultivation where it has never been planted insofar as the local history can tell us.

The local name for the whole plant is HAKARI. The pan-polynesian niu is not used for the whole plant anymore.

KAIPOA is the name given to a variety of nut with an edible husk. This variety is not distinguishable other than by experience with the husk. The nuts when planted are said to give rise to both the KAIPOA and the ordinary varieties, thus suggesting either a recessive factor and cross pollination or a hybrid nature and self pollination. Danielsson says this variety is known in Tahiti but not in the Marquesas.

One tree was seen the rachis (11812-BISH) of which was simple. The local name for this was apparently TAKAVEATIKI, though it has not been possible to check this term. While many small nuts begin development along the simple

rachis, usually only two or three mature. The trunk of the tree seemed to be a bit stouter and darker in color than the nearby trees of similar height.

The local uses are detailed elsewhere, but beyond the major economic uses Cocos is a source of coconut cream, drinking water (KOMO VIAVIA), thatch and oil, all of which are still made on Raroia for local consumption.

Rats like coconut meat, especially when roasted, and this would possibly be a major ingredient for an economic rat poison for use on such low atolls.

Natives believe the round fruits give better trees than the longer more slender fruits. Seed for a new grove is sometimes selected, but unfortunately little is done beyond this in the way of crop improvement.

Also Cocos shells are charcoaled and used in charcoal irons. This charcoal gets very hot and if used alone in the irons, burns the irons out more quickly than if the two kinds are mixed. Gasoline drums partially buried and partially filled with IRIIRI (gravel) and with a fairly tight cover are used for making the fuel.

Cordia subcordata Lamarck

Raroia: Opakea, 11777-BISH, USNM; Tomogagie, 11151-BISH, USNM
Takume: Gake, 12299c-BISH, USNM, 12001-BISH.

Tree found (11151) on north end of Tomogagie was toward the inner part of the Guettarda zone. The leaves were rather yellowish as though suffering from drought (they were somewhat limp) or in some stage of defoliation. The tree was about 20 ft. high with many sprouts. The center of the island beginning about 20 ft. away was rather barren and had, perhaps, been wiped off by a hurricane. Almost a rare tree on Raroia. Flowering on Takume in September.

In Danielsson's list, the native name is given as TOU.

Crinum asiaticum L.

No collections made.
In the village spider lilies were present: a larger white-flowered one, the scape of which exceeded the leaf height, and a smaller pink-striped white-flowered variety, the scape of which was shorter than the leaves. These were common, but no collections were made.

Cynodon dactylon (L.) Pers.

Raroia: Garumaoa, 11733-USNM.
Forming an irregular ground voer in a few village areas.

Cyperus kyllingia Endl.

Raroia: Garumaoa, 11739-USNM.
A common village plant.

Cyperus javanicus Houtt.

Raroia: Garumaoa, 11810-BISH, USNM.
Takume: Gake, 12294-BISH, USNM.
South of the village of Garumaoa in brackish abandoned taro pit, and again at Gake, Takume.

Digitaria stenotaphrodes (Nees) Stapf.

Raroia: N. of Garumaoa, 11110-BISH, USNM: Kaea, 11896b-USNM.
Takume: Gake, 12296a-BISH, USNM.

Eragrostis amabilis (L.) Wight & Arn.

Raroia: Kaea, 11897a-USNM; Oneroa, 11550-USNM; Opakea, 11775-BISH, USNM; Garumaoa, 11258-USNM.
Takume: Gake, 12319-BISH, USNM.
This formed a small meadow at Oneroa and was the only such incipient more or less natural grassy area seen. In Garumaoa it was most conspicuous where with a moss ground cover it occurred abundantly with the most luxurious population of Pilea microphylla found. Common elsewhere.
In Danielsson's list MANAMU is given as the native name.

Euphorbia atoto Forst. f.

Raroia: Opakea, 11787-BISH, USNM; Garumaoa, 11009-USNM: Homohomo, 11046-BISH.
Takume: Gake, 12317-BISH, USNM.
Flowers all white at Raroia. Forming cover under Guettarda and often as tall as a meter. Forming in places a low sparse but consistently present stand in less well-kept Cocos plantings. Occasionally extending into Messerschmidia areas. Common in shade everywhere.
Danielsson gives TAHETAHE as the native name for what he lists as E. hirta. According to a tentative manuscript delimitation of the atoll species by Fosberg, that species is herbaceous and has the inflorescences appearing in the upper axils. Only very rarely in the material at hand is an inflorescence seen to arise from what might be called an upper axil and the stems below are quite woody. The local people uniformly named our collections of E. atoto, TAHETAHE.

Euphorbia hirta L.

Raroia: Garumaoa, 11049-BISH, USNM.
Takume: Gake, 12320-BISH, USNM.
A very abundant village weed in more trodden places.

Euphorbia prostrata Ait.

Raroia: Garumaoa, 11050-BISH, USNM.
Common prostrate cover in sandy village areas.

Fleurya ruderalis (Forst f.) Gaud.

Raroia: Nohinohi, 11480; Opakea, 11781-USNM; Homohomo, 11005-BISH, USNM,

Onigehuihui, (KERETEKI) 11892-BISH, USNM: Gavarivari, 11912-BISH, USNM.
Takume: Gake, 12316-BISH, USNM.

VAIANU (11005) and OGAOGA are given by Danielsson as the names applied to this plant by the local people. No use of this second name was experienced in reference to our collections.

A component of the local fish poisoning cure. Formerly used for fish lines and prized as the lines would float.

Guettarda speciosa L.

Raroia: Homohomo, 11036-BISH, USNM; Opakea, 11778-BISH, USNM.
Takume: Gake, 12313-BISH, USNM; Ohomo, 12030-BISH, USNM.

This tree seems to mark the area in which Cocos culture might be successful. It is common throughout the atoll. One is led to postulate it as an indicator of the outer edge of the fresh water lens and tending to dominate the fresh water lens area because of its shade tolerance.

While Catala reports this to be the most important mulch source in the Gilberts, Messerschmidia is the favorite on Raroia. Guettarda is the tree most frequently used as a structural material at Raroia.

Hedyotis romanzoffiensis (C. & S.) Fosb.

Raroia: Homohomo, 11008-BISH, USNM; Kukina, 11226-BISH, USNM; Garumaoa, 11453-USNM; Oneroa, 11547-BISH, USNM; 11548-BISH, USNM; Kakipuku, 11768-BISH, USNM; Nohinohi, 11481.
Takume: Gake, 12300-BISH, USNM.

This plant was strikingly variable. Along the shady lagoon shores of Oneroa it was a tall, relatively unbranched herb. On the sea shores, at the edge of or outside the coconut area, this species formed viney masses several feet in diameter and perhaps two feet high. It was usually found only at the ends of the vegetated areas of islands on otherwise barren channel shores, and there as a low somewhat woody shrubby plant a foot high. Here it was more conspicuous opposite the seaward end of the vegetation than it was toward the lagoon.

The local name is KOBORABORA. A preparation of this was said to be used against earache.

Heliotropium anomalum H. & A.

Raroia: Homohomo, 11001-BISH, USNM; Rare, 11169-USNM; Opakea, 11773-BISH, USNM.
Takume: Gake, 12303-BISH, USNM.

A prostrate vine-like shrub among scattered Scaevola and Messerschmidia plants in the sand. Often conspicuous at the edges of vegetated areas on the sea side of islets.

Danielsson gives the Raroian name as PARAHIRAHI, the pronunciation of which was most difficult.

Hibiscus tiliaceus L.

Takume: 12029-BISH, USNM.

Three trees were seen in the Garumaoa village area, about 30 ft. tall. None were seen outside the village. These three were large and

had apparently grown up after having been cut down and trimmed repeatedly. This tree is of no value, apparently, to the current Raroians. A tree (12029) from a village at Takume was adjudged by St. John to be of the variety abortivus.

Hibiscus tiliaceus L. var. sterilis F. Br.

Raroia: Tetou, 11833-BISH, USNM; 11834a-USNM.

Common in gravel at outer edge of Guettarda and inner Pemphis along sea shore, but only here at Tetou. This is a very distinctive bush or small tree with smooth gray bark. The blades of the cordate leaves were bent down to a sharply vertical position. In many cases they were almost parallel with their erect petioles. The leaf veins were red to pink as was the dentate margin. The large (3.8 cm. long) stipules were red at their tips and along their margins.

This material supported a scale insect in conspicuous numbers.

A rather careful search revealed no trace of flowers or fruits on the shrubs or ground beneath.

This island was formerly the main island of a major tribe on the atoll. It is only occupied temporarily now and no one was found who knew anything about this species.

Ipomoea gracilis R. Br. /the I. littoralis of the key/

Raroia: Garumaoa, 11740-USNM.

Fruits found but no flowers (reputed to be white) on this common village plant.

Ipomoea tuba (Schlect.) Don

Raroia: Opakea, 11788-BISH, USNM; Tetou, 11834-USNM; Homohomo, 11044-BISH, USNM, 11246-BISH, USNM.
Takume: Gake, 12003-USNM; Gake, 12306-BISH, USNM.

Running over gravel at sea edge of other vegetation, and over that vegetation, e. g. Hibiscus tiliaceus var. sterilis (11833 & 11834a), Pemphis, Suriana, Messerschmidia. The leaves on terricolous runners were often strongly trilobed.

Called POHUE in Danielsson's list.

Lepidium bidentatum Montin.

Raroia: Nohinohi, 11421-USNM; Kawa, 11898-BISH, USNM; Garumaoa, 11452-USNM, 11432.
Takume: Gake, 12302-BISH, USNM.

This is a component of the local fish poisoning cure.

NAU and HORAHORA are given by Danielsson as the names used for this plant locally, and were applied to our collections by the Raroians.

Lepturus repens (Forster) R. Brown

Raroia: Tetou, 11866-USNM; Tikagera, 11428-USNM; Opakea, 11774-BISH, USNM; Oneroa, 11551-USNM; Fareana, 11244-USNM.
Takume: Take, 12327-USNM, 12293-BISH, USNM.

Present as a pioneer with Heliotropium. Present in an amazing series of variations. Common on all nonthoroughly vegetated islets.

The Raroians use the word MAUKU for all grasses in general. They are not considered worthy of distinction as they are considered to be of no use. A somewhat similar situation prevails in reference to the shell bearing gastropods which are all called PUPU and are all rather valueless, with a very few exceptions.

Messerschmidia argentea (L. f.) I. M. Johnston

Raroia: Homohomo, 11035-BISH, USNM; Opakea, 11783-BISH, USNM.
Takume: Gake, 12310-BISH, USNM, 12311-BISH, USNM.

This is one of the plants for which the natives have a use. It is reputed to be the best mulch for taro pit development. The related observation that there are usually but few leaves of Messerschmidia on the ground where it is dominant supports this belief on the part of the local people. It is to be noted here that under Suriana and Pemphis, which grow with Messerschmidia, there is usually a goodly accumulation of their leaves but not of Messerschmidia.

The species seems to be very shade intolerant. Skeletons of quite tall trees (30') were found in dense Guettarda areas.

GEOGEO is the name used for this plant on Raroia.

Morinda citrifolia L.

Raroia: Homohomo, 11045-BISH, USNM; Oneroa, 11549-BISH, USNM; Opakea, 11785-BISH, USNM.
Takume: Gake, 12307-BISH, USNM.

At Homohomo this plant forms a rough line of young and older bushy trees inside the Messerschmidia and probably in the outer edge of what was a Guettarda area. One bush was found on the seaward side of the Garumaoa transect in the middle of a Pemphis-Suriana thicket. Thought to be uncommon at first but later found throughout the better vegetated leeward part of the atoll.

There was little insect work noted on the vegetation at Raroia. This Morinda, however, in places did have on the under surfaces of its leaves many white fly females. These insects (Aleyrodidae) look very much like scale insects.

In Tahiti used as a fish poison component and in the Tuamotus used for stomach aches. The fruit is acid and smells of lactic acid.

Called HORA by the Raroians, according to Danielsson, and brought originally as a medicinal and food plant.

Musa sapientum L.

No collections made.

Grown with little success in mulch filled pits in the village at Garumaoa. Fruits were seen on one such patch only.

Nesogenes euphrasioides DC.

Raroia: Kawa, 11897-BISH, USNM: Motufano, 11419-USNM, 11420-BISH, Gavarivari, 11909-BISH, USNM.

Takume: Gake, 12297-USNM.

This little plant was found only on the less populated windward part of the atoll. It extended from under the innermost Pemphis on the sea side of the islet back beyond the edge of where Guettarda predominated.

Danielsson lists as the Raroian name, TOROARIKI.

Ocimum basilicum L.

Raroia: Garumaoa, 11722-USNM.

Only seen as a weed in the village, Garumaoa.

Pandanus distinctus Martelli [the P. tectorius of the key]

Raroia: Namunamukona, 11478; Onigehuihui, 11895, 11894; Gavarivari, 11907; Opakea, 11776; Oneroa, 11653; Temari, 11168.

Takume: Gake, 12292.

This plant has a very fibrous fruit the taste of which has been likened to a mixture of alum and raw parsnips. They are not very good and the Raroians have no use for them.

There were rumors of good "eating Pandanus", but the location of the plants was mercurial; it was always "over there."

We found the name in Danielsson's list of local names to be FARA. Rogo, one of our principal advisors, volunteered the name TIMA, which was said to be the name for Pandanus in the Western Tuamotus. Later he called it TIMA FARA and finally settled on FARA.

Pandanus tectorius var. laevis (Kunth.) Warb.

Raroia: Garumaoa, 11462.

This variety is distinct from the material called here P. distinctus at Raroia for the margins of the leaves are practically devoid of teeth but for the outer one-fourth of the length. There is a cloaking of the stems with old leaves which in nature may hang on the whole length of the stem. This variety was not seen in fruit. It is reputed to have been brought from Tahiti.

There were several clumps of this variety on the atoll. Those near the village were trampled down both incidentally and with the intention of keeping the plant low.

The local name appeared to be PAIORE but this may have been our misunderstanding of the Tahitian PA'E'ORE.

Pemphis acidula Forster

Raroia: Homohomo, 11033a-BISH, USNM, 11033b-BISH; Homohomo, 11002-BISH, USNM; Papakotuha, 11772-BISH, USNM.

Takume: Gake, 12304-USNM.

Forming on Garumaoa, with Suriana maritima, the bush zone bordering the sandy storm beach. While the Suriana is for the most part dominant along the leeward shore, Pemphis is the more prominent along the channels between the islands. See under Suriana for further notes on this species. Common on all atolls visited.

A number of local residents agreed on MIKIMIKI as the name for collection no. 11002, and this is the name determined by Danielsson.

Phyllanthus niruri L.

Raroia: Garumaoa, 11460-USNM, 11507-BISH.
Takume: Gake, 12315-BISH, USNM.

This is one of the most commonly found weeds of the village along with two species of Euphorbia.

MOEMOE is the native name given in Danielsson's list. It is one of the local remedies for earaches. The plant was pounded into mush and the juice added to oil; this preparation was then put into the ear (on cotton).

Pilea microphylla (L.) Liebm

Raroia: Garumaoa, 11037-USNM, 11260-BISH.

Very small where it occurs in the less humidified sandy "roads" in the village. Much more luxuriant where occurring in mossy areas of undisturbed humus with Eragrostis amabilis. Common at least about the village of Garumaoa but usually overlooked.

None of the people questioned had a name for this plant or, indeed, had even noticed this insignificant plant before.

Pisonia grandis R. Brown

Raroia: Paparoa, 11821-BISH, USNM: Opakea, 11782-BISH, USNM.
Takume: Gake, 12298a-BISH, USNM.

Found with flowers in July. This species is almost rare, the above and Kahogi (Tokerau) being almost all, or all, the places where this species is now alive. On Takume it was confined to the ridges between the large taro pits at the northern (GAKE) end of the atoll. Seeds were found on Pisonia on this atoll.

We received the impressions that (1) reproduction is at least mostly vegetative and (2) that the atolls observed were almost too low for its well being. We were unable to find seeds at Raroia with which to test the theory that this species will only germinate in guano.

These records nicely fill a small gap in the known distribution (The distribution of "Pisonia grandis" (Nyctaginaceae) Pacific plant studies No. 10, Webbia 8: 225-228, 1951) of this plant as recently summarized by St. John. It may be noted here that another addition to St. John's distribution map is the record from Arno Atoll (Anderson, Donald. The plants of the Marshall Islands. Atoll Research Bulletin No. 7, 1951).

GATAI was the name used in Raroia and Takume for this plant.

Portulaca johnii Poeln.

Raroia: Opakea, 11789-BISH, USNM; Homohomo, 11006-BISH, USNM; Onigehuihui, 11891-USNM.
Takume: Gake, 12002-USNM, 12308-BISH, USNM, 12325-BISH, USNM.

This species was found growing best under Cocos in the humidified soil to be seen near the leeward shore of the central part of Garumaoa, south of the village. Its distribution was quite general, however, and it was even found growing on top of a large reef boulder, which was about 16 ft. high by 20 feet in each horizontal direction.

Search revealed nothing that resembles P. lutea or any of the other species closely related to this one entity.

POKEA is the native name listed by Danielsson and uniformly agreed upon by the local people questioned. This species is used as a food during times of economic distress.

Scaevola frutescens (Mill.) Krause

Raroia: Homohomo, 11211-BISH, USNM; Opakea, 11771-BISH, USNM.
Takume: Gake, 12314-BISH, USNM.

Common in range of vegetation form and flower color variations. Woody stems up to 4 cm. in diameter were collected.

A native who guided us to the makatea patch at the northwestern cape of Anaa told us that this plant, NAUPAKA, was used in the treatment of coral and other cuts. He indicated that the stems are pounded and that the pulp, so made, is smeared in the cut. Bengt Danielsson tells us that the people of Raroia use NAUPAKA in a similar manner.

Sesbania speciosa F. Brown

Raroia: Tetou, 11835; Oneroa, 11559, Garumaoa.

At Oneroa and Tetou there were many young plants or seedlings under the mature plants. This appears to be a well established species developing into a tree 16 ft. tall.

KOHAI is the name applied to this plant by the Paroians according to Danielsson's list. It appears in the village of Garumaoa as an ornamental.

Solanum viride R. Br.

Raroia: Opakea, 11793-BISH, USNM: Garumaoa, 11742-USNM.

At Opakea this formed a bush nine feet tall under Cocos. In the village of Garumaoa it appeared as a weed.

PUTAMAGOMAGO is given as the local name applied in Takume.

Stachytarpheta cayennsis (L. C. Rich.) Vahl. [the S. jamaicensis of the key]

Raroia: Garumaoa, 11721, 11743.
Takume: Gake, 12322.

Suriana maritima L.

Raroia: Opakea, 11784-USNM; Homohomo, 11034-BISH, USNM.
Takume: Gake, 12324-BISH, USNM.

This plant seems to be the one most successful on practically bare beach rock. However, in sandy places where there are many small seedlings the area may be held by the root systems of Messerschmidia. It does not extend inland far from the shore line. Often a clump of beach bushes is made up of a peripheral ring of Suriana surrounding a more central and larger Pemphis. The reverse situation was not found, and there are few sizeable clumps of Suriana alone. Thus one is led to think of Suriana as being intolerant of shade and suspect that its root systems are limited sharply by some soil water content level and inhibited by plants other than Pemphis. The plant occurs inland only to where there is an abundance of Messerschmidia, Scaevola or Euphorbia.

For this plant there is a series of names used which represents well one course of evolution of words in Polynesia in reference to the dropping out of consonants and syllables. According to the Raroians with whom the matter was discussed, largely by manual means, and according to Danielsson, the names most used are KOKURU, KUKU AND U'U, with U'U being by far the most popular. Local custom includes putting this plant in the water in which a mother and her newborn infant are washed. While this is a durable and hard wood its small size limits its use.

Synedrella nodiflora (L.) Gaertn.

Raroia: Garumaoa, 11736-USNM.

Tacca leontopetaloides (L.) Ktze.

Raroia: Garumaoa, 11464-BISH, USNM, 11463-USNM; Opakea, 11794-USNM.
Common throughout village areas on several islands, but far more abundant around Garumaoa. Flowers were much more in evidence during August than they had been upon our arrival about the first of July. This supports the seasonal development suspected by Taylor at Bikini.
It is used as a famine food and as a source of starch for beverages. It is given no attention by the Raroians otherwise. The local name is PIA.

Terminalia catappa L.

No collections made.
There were two young large-leaved spreading-branched trees in Huri's yard and one at another place in the village.
This plant has been discussed by Petard (Journal de la Societe des Oceanistes 77: 260-263. 1951) as an aboriginal tree in the Tuamotus and elsewhere, furnishing an oily, edible nut, medicine and wood for cabinet work. The Raroians consider it one of their RAKAU TAHITI (i.e., "one of those useless plants from Tahiti").

Timonius polygamus (Forst. f.) Robins

Raroia: Takeke, 11150-BISH, USNM; Garumaoa, 11448-BISH, 11450-BISH, 11449-BISH, 11451-BISH, USNM; Opakea, 11770-BISH, USNM; Tomogagie, 11149-BISH, USNM; Paparoa, 11820-BISH; Onigehuihui, 11893-BISH, Nohinohi, 11482.
Takume: Gake, 12011-BISH, USNM, 12295-USNM, 12312-BISH, USNM.
Abundantly in flower and fruit. Flowers white, fruits blackish. Usually on highest part of island just outside the Pandanus area. The species was extremely variable and there was a host of distinct characters distributed seemingly at random among the many bushes found.
Danielsson's list gives two names for this plant, PAKETA and KETOKETO. A lady in the village gave the latter name to the leaves of 11149, as did Vaea our own helper. Vaea would also apply this latter name to some parts of Hedyotis romanzoffiensis as well; if leafy branchlets of both were presented he called them both KETOKETO, though distinguishing the whole plants.

Triumfetta procumbens Forster

Raroia: Garumaoa, 11048-USNM; Patahiva, 11000-BISH, USNM.
Forming ground cover commonly under Cocos.
In our material from Patahiva (11000) the blossoming material had very little in the way of trilobed leaves. Coarser, perhaps older, and at the time non-blossoming plants, had trilobed leaves. On the blossoming plants often it was observed that the oldest leaves, i.e., those nearest the main stem of the blossoming short lateral branches, were trilobed and yellowish.
VAVAI appeared to be the native name.

Vernonia cinerea Less.

Raroia: Garumaoa, 11709-BISH, USNM, 11042-BISH, USNM.
Takume: Gake, 12296-USNM.
Scattered about old ashes of trash fire under Cocos in the village, and common elsewhere as well.

Vigna marina (Burm.) Merr.

Takume: Ohomo, 12031-BISH, USNM.
Growing among Euphorbia atoto on lagoon side of Ohomo; with flowers and fruits in September. Not seen on Raroia.

Waltheria americana L.

Raroia: Garumaoa, 11811-BISH, USNM, 11710-BISH, USNM, 12090-BISH.
Under Cocos just south of Garumaoa and a common village weed. There appeared to be something odd about the blooming of this species. Though flowers and fruits were common, at least through August, it took repeated observations over many days to catch open flowers, which if remembered correctly were open at midday. They were not open at night or early morning.

Ximenia americana L.

Raroia: Opakea, 11779-BISH, USNM.
At Opakea this plant was up to 15 feet high and only slightly vinaceous. On Raroia there appeared to be only about 6 somewhat separated growths of this plant extending along the center of the island vegetation in areas where Cocos had not been planted between Opakea and Nigahava. The fruits were seen in a circle of ashes where Vaea told us there had been a bush at Vaituki north of the pass in Tokerau.
While reputed to be used as a spice in the Society Islands (Andrews) it was only occasionally eaten as a nut at Raroia.
RAMA is the Raroian name given in Danielsson's list and used by the Raroians for our collections. RAMA in the Marquesas and 'AMA in Tahiti are reputedly "rambling creepers."

EXOTICS AND VILLAGE PLANTS

The Raroians have in general but few names and little use or concern for these plants in this category. One, however, the famous Gardenia tahitensis, is a beautiful single gardenia. The white blossoms are about an inch and a half in diameter and opening on the bushes late in the day seem almost like stars on the rounded bushes, colorless in the evening's grayness. This is their TIARE TAHITI (flower of Tahiti).

To Raroians all exotic plants in general are RAKAU TAHITI (Tahitian plant), which they usually say in such a way with a disinterested shrug of the shoulders that one would be inclined to translate as "another of those useless plants from Tahiti." A bud worn over the ear will open as evening draws nigh. Such a wearing usually is taken as an announcement that the wearer wishes it known, or believed, that he or she has something opening up in the way of a romantic affair with the arrival of the coming evening.

Successful horticultural practice is generally so lacking as to disincline one to ever refer to it as primitive. People pull up a growing plant and stick it in the ground in a new place, usually not even watering it once. If it seems to show signs of surviving that makes it desirable for some other place and the plant is moved again. Thus many of the plants listed here below must be dead now. Indeed their identification was impossible in many cases for, though recognizable as distinct from other village plants, were but mere sprigs too small to yield a specimen and far from being in condition to produce a flower. The coffee plant reported and the guava were hardly more than rooted twigs with less than half a dozen leaves. The Barringtonia was three seedlings, and one disappeared before the team left. It was only through the invaluable assistance of our field assistant Aurora Natua and through her great familiarity with local native and exotic plants that we were able to obtain this rather complete list of village plants.

Again while field determinations were attempted, Prof. Harold St. John went over all the specimens brought back and we have used the names which he could provide.

In addition to the names in the list A below we found the plants in list B for which no satisfactory name has been found as yet and includes three plants for which no name at all was obtained.

List A

Allamanda ?oenotheraefolia Pohl.: a yellow flowered bush with four leaves at each node; thus probably this species. Used as an ornamental.

Amaranthus viridis L. (11732-USNM).

Annona sp.: sugar apple. Growing in one place in the village.

Arachis hypogaea L.: there were several clusters of peanut plants about the village with rather large yellow flowers. These were considered more of a curiosity than anything else, but seemed to grow very well and might possibly be a potential crop, or at least a supplementary food plant, for the region.

Asclepias curassavica L. (11505-USNM): many plants at village edge behind the Catholic church.

Asparagus plumosus Baker (11719-USNM): strictly ornamental.

Barringtonia asiatica (L.) Kurz.: four seedlings planted about the Huri Estall yard and only about 40 cm. tall.

Beloperone guttata Brandegee: at least there was a "shrimp plant" in one of the yards.

Bougainvillea spectabilis Willd.: a common ornamental growing very well without care in several of the yards of the village.

Brassica pekinensis (Lour.) Rupr.: locally called "petsi", which is probably the same as pe-tsai the common name used in the Hawaiian Islands today. This Chinese cabbage might very well be a valuable green vegetable as it is palatable either raw or cooked, at least to the American taste, and it grew prolifically in rather fresh beach sand with little or no care.

Breynia disticha var. disticha f. nivosa (W. G. Sm.) Croizat (11822-USNM): introduced long ago into Tahiti for hedges. This produced bushes about 3 feet high in the village of Garumaoa on Raroia.

Caladium sp.: plant in only one yard; no flowers.

Canna ?indica L.: one canna-like plant in the village.

Catharanthus roseus (L.) Don: growing luxuriantly and planted in many places. This common "vinca" is one of the major ornamentals in this sandy village, as it requires almost no attention other than perhaps removal of the stems which, while woody, tend to become vine like and get out of hand. Most of the plants are white flowered with few colored flowered plants being seen.

Citrus ?medica L.: many varieties of the local limes were found. Two were conspicuous differing among other things, in that one had large leaves and fruits, while the other had smaller leaves and smaller fruits. The French name, citron, was applied loosely to all such plants.

Citrus paradisi Macf.: one small grapefruit bush about 3 feet high was to be found.

Citrus sp.: small bush with leaves having alate petioles that were often half the size of the leaf blade. While this may have been a young grapefruit plant the leaves were different from that enumerated above.

Cleome viscosa L. (11735):

?Clerodendron sp.: a vine-like bleeding heart bearing flowers with both white and pink colors.

Coccoloba uvifera (L.) Jacquin: it was a surprise to find this plant nowhere except planted in the village. There were a number of plants of this species up to about 4 meters tall.

Codiaeum variegatum (L.) Bl.: various varieties of croton were scattered about the village. The narrow green leafed forms with yellow mottling and the broader leafed forms with red and green leaves being the most common.

Colubrina asiatica (L.) Brogn.: (12321-BISH, USNM): Gake, Takume only.

Cordyline terminalis (L.) Kunth.: Several ornamental varieties were seen about village. They are planted as ornamentals and do not have the uses or history this species has elsewhere. It is believed that none of them was the variety ki of Hawaii.

Crinum sp.: a red-striped spider lily is very common in the village.

Crinum sp.: white spider lily, having vegetative parts about three times the size of those of the red-striped variety above.

Cyperus rotundus L. (11726-USNM): common ground cover in some of the more "grassy" yards.

Dahlia spp.: several varieties.

Delonix regia (Boher) Raf.: one "royal poinciana", a tree about 20 feet high and not in leaf during our visit. In mid-August it appeared that the buds were about to burst. This tree was in the yard of the old native chief who only called it a "RAKAU TAHITI" (Tahitian plant).

Euphorbia sp.: not unlike Hylocereus in appearance. Aurora Natua told us that this plant has small pink flowers.

Ficus sp.: several small plants of edible figs were in the village.

Gardenia tahitensis DC.: one of the major ornamentals about the village. The bushes seem to grow without care and produce an abundance of flowers. One of the few ornamentals for which a Polynesian name (TIARE TAHITI) is in common use locally. (11723-BISH, USNM)

Gardenia sp.: a species or variety having smaller flowers than G. tahitensis.

Gossypium ?brasiliense Macf.: several bushes, in form almost like small trees up to 10 feet tall, were found in the village. These were planted as ornamentals for their large yellow flowers and probably as curiosities. The fiber seemed to be very strong and long.

Hibiscus spp.: there were several red flowered species cultivated in the village. One was a double flowered form. There were two single flowered species, one of which looked rather like the common garden variety of Hawaii, and the other of which was peculiar in that the flowers never more than just began to open. (See bell hibiscus in List B.) Both were caney species.

Hippeastrum equestre (Ait.) Herb.: a short-stemmed red lily bearing one or two flowers. Leaves like Clevea but about 2.5 cm. by 20 to 30 cm. long.

Hippobroma longiflora (L.) G. Don (12137-BISH, USNM): an herb having white Nicotiana-like flowers, found in two places in the village. Flowering in June, July and August.

Inocarpus edulis Forst.: one such Tahitian chestnut was located about one ft. high.

Ipomoea batatas Lam.: sweet potatoes grow in ornamental quantities in several places.

Ixora sp.: a village ornamental ranging from a small viney bush to small tree form and size.

Jasminum spp.: there were bushes of at least two species or varieties growing in the village. Both were sweet-smelling kinds with relatively simple flowers.

Lathyrus odoratus L.: sweet pea.

Mangifera indica L.: several trees have been planted in yards but as yet there are few over 0.6 meters high.

Melia azedarach L. (11741-USNM): village plant.

Nothopanax guilfoylei (Cogn. & March) Merr.: forming many hedges about the village. Often only some limbs bearing the distally fimbriate leaves and again apparently these limbs have been rooted and spread out so that a whole hedge is a clone of plants bearing leaves of the fimbriate form.

Nerium oleander L.: the oleander is a major and conspicuous ornamental in the village. It seems particularly well adapted to life in the village as it grows well without care.

Opuntia ?megacantha Salm-Dyck: a fig d'Barbarie was present as about 2 dozen plants scattered through the village. They were usually less than a meter tall, but the tallest plant was a little less than 2 meters high. The flattened stems of this species are favored sites for carving names.

Oxalis sp.: one clump of a yellow flowered species was found around the cultivated base of a small tree in a yard.

Plumeria acuminata Ait.: occurring as many small trees in the village. Nearly all, if not all, are the more or less yellow flowered form.

Pseuderanthemum atropurpureum (Hort.) Bailey (11825-USNM): village plant.

Psidium sp.: seen as one small sprig growing well but only about 1 ft. high. Had characteristic opposite leaves (about 6) and odor.

Rhoea ?discolor Hance: many plants scattered about the village especially inland. In flower during our stay.

Rosa sp.: as several small bushes growing about the village. They seemed to be one of the small-leaved climbers. No blossoms were seen.

Saccharum officinarum L.: present as three small clumps of up to half a dozen canes each, but these only about 1 meter high. It is a slender black-stemmed variety planted seemingly as a curiosity.

Sapotilla sp.: a small tree bearing round fruits.

Sesbania grandiflora (L.) Pers. var. coccinea Pers. (11906b-USNM): one small bush of this species was found in the village. Aurora Natua has brought in seeds of this plant from La Pagerie, Martinique in recent years and has grown this plant successfully in Tahiti. It is a lovely ornamental flowering from seed the first year. The flowers in August were large and showy with the keels being over two inches long. It is now common in Tahiti.

(Solanum lycopersicon: has reputedly been grown in the village areas. We did not see it.)

Sporobolus poiretii (R. & S.) Hitch. (11737-USNM): a rather common grass in the village.

Syzigium jambolana Lamarck: a small tree in several yards cultivated or "permitted to grow" for its astringent purple fruit. Petard (1951) discusses the uses of this plant in French Oceania for fuel, charcoal, jelly and beverages.

Tagetes spp.: various varieties of marigold were found about the village. Most of them grew well.

Tamarindus indica L.: one small bush-like tree.

Vitex trifolia L. var. trifolia (11730-USNM, 11724-BISH): Two small tree-like shrubs.

List B

Bell hibiscus (in Neal, abutilon pistum Walp.): red single flowers that never open.

Brisbane lily:

Cerise de l'hopital: (11734). Bears berries; not sweet smelling; sticky stems.

Coffee: One small rooted cutting about 0.5 meters high was found in a yard in the village. This may have been Acalypha, the so-called "false coffee."

Folier du jeune fille: with lilac-like flowers.

Hedge plant: with violet flowers, introduced into Tahiti by Harrison Smith.

?PITI: (11741)

Herb: "a kind of Gaugau".

Herb: large pink, sometimes red, plant with partially green leaves, i.e. red and green.

KAVA: a few small trees up to 20 ft. tall. Fruiting in August and fruits globose, green, about 3 cm. in diameter and having a thin flesh over a large seed. The flesh tastes mild, not unlike a cross between chestnuts and cabbage. Certainly not Piper methysticum.

Legume: large bush with big trilobed leaves and yellow flowers on terminal spikes. The leaves are bruised and used as a plaster over boils. Called PIPI, which is merely "Beans." A Vitex sp.?

Legume: source of cassis perfume. A weed in the Marquesas. Looks like Leucaenxa glauca, the koa haole of the Hawaiian Islands.

Lily: crocus-like with pinkish (or rarely white or yellow) flowers and almost grasslike spreading leaves. Is used commonly as a border. None was blooming and no one was found who knew a name for it.

Melons: several cucurbits were being rather unsuccessfully grown in pits filled with mulch.

Mountain beauty: pink flowered.

Quenettes: (11731). Found just west or southwest of Rogo's house. Small disagreeable fruit attractive to children.

Plant: introduced by Mmme. Rost from Martinique.

Plant: unidentified. This and the following two entries are included merely as a better record of the extent of the flora.

Plant: unidentified.

Plant: unidentified.

Part 2

ECOLOGICAL AND FLORISTIC NOTES ON THE MYXOPHYTA OF RAROIA

by Jan Newhouse

The blue-green algal collections obtained during the summer of 1952 at Raroia (and Arno Atoll) have been the subject of an intensive study designed to reveal more of their roles on a coral atoll. The present report is essentially a summary of the field observations and the taxonomic study of these organisms. This material is reported in two sections; Section A is a floristic resume listing the species alphabetically with their distributions and a summary of the field notes accompanying the collections. Section B is a resume of the ecology and prospective roles of the major species. This latter phase of the work is extended by cultural experiment, laboratory studies and a review of the pertinent literature.

The localities listed may be located on the diagrammatic map appearing as Figure 1 in Part 1 of this Atoll Research Bulletin No. 33.

Section A

Anabaena torulosa B. & F.

Kereteki: Tetou (11831)

Appearing with Spirulina tenerrima and Hydrocoleum coccineum as a reddish brown scum on beach rock and in the intertidal zone of the lagoon beach.

Anacystis dimidiata (Kuetzing) Dr. & Daily

Tokerau: Vaituki (11372)

Gake: Teuriamote (11433)
Teuriamote Iti (11429)

This species was associated with other blue-green algae forming prostrate mats in brackish pools. There is the following interesting note concerning this rather velvety or gel-like growth form in which A. dimidiata was present. The food material that remains in a pot after cooking and has to be scraped out in cleaning the pot is called PARA by the natives of Raroia. They compound this term as KOPARA for this blue-green algal material that has the same appearance and consistency as the food residue.

On the lagoon side of the islands at the northern end of the atoll, several small pools in the beach rock with exceptionally thick growths of KOPARA were found. One such pool was investigated and is diagrammed in Figure 2. The KOPARA formed a coating around the rim and extended as a surface covering over the shallow parts of the pool. The uppermost orange pink, cartilaginous layer

(A in Fig. 2) was entirely algal in nature and shaded to a deep green algal layer (B in Fig. 2) intermixed with sand. Together these two layers were 4 mm. thick. Beneath these layers and covering the bottom of the 40 cm. deep pool was a beef red sandy sediment (C in Fig. 2). The major elements in this KOPARA were Schizothrix lacustris and Anacystis dimidiata. A number of fish, juvenile Chanos chanos Forskal, inhabited the water (D in Fig. 2) filling the remainder of the pool.

At this same northern end of the atoll there was an incomplete channel shut off from the lagoon by a sand bar. The pond thus formed was brackish (by taste test judged to be 16-20 parts per thousand sea salt). Visual observation and the odor indicated its use as a repository for refuse and excrement. The bottom of this pond was covered by about 15 cm. of very soft sediment over gravel and on this sediment were irregular soft brownish-purple patches made up of A. dimidiata and Phormidium papyraceum. Around the rim at the water level were large areas of KOPARA as found in the afore mentioned pool.

A. dimidiata was also a constituent of soft mats on the bottoms of rain basins in the seaward beach rock. Here it was associated with Entophysalis crustacea, Calothrix scopulorum and Schizothrix species.

Anacystis montana (Lightf.) Dr. & Daily

Tokerau: Mataira (11373)

Gake : Teuriamote (11442, 11443, 11444)

Raro : Garumaoa (11118)
: Homohomo (11179, 11218, 11257, 11276, 11293, 11298, 11300, 11302, 11305, 11703, 11708)
: Oneroa (11557, 11649, 11663, 11665, 11666, 11668, 11671, 11674, 11677, 11679)

This species appears to be restricted to situations rather far removed from the direct influence of salt water. The thalli were often associated with Scytonema hofmannii and Scytonema guyanense in felt-like coatings on coral fragments and Cocos nucifera husks and trunks. The species will be discussed below with Schizothrix longiarticulata as a member of sediment binding associations.

Brachytrichia quoyi B. & F.

Raro: Garumaoa (11800, 11801)
: Oneroa (11675)

Brown coatings just below high tide mark on seaward conglomerate.

Calothrix aeruginea B. & F.

Kereteki: Tetou (11321)

At high tide line on conglomerate in front of the seaward gravel rampart.

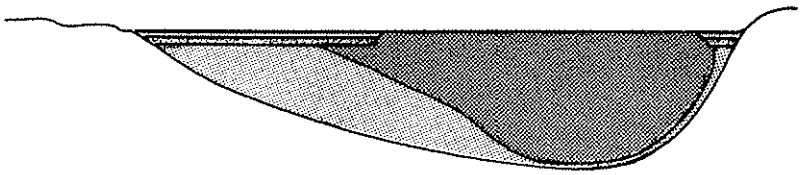

Figure 2

— Cartilagenous

— Sediment

— Algal layer with sand

— Water

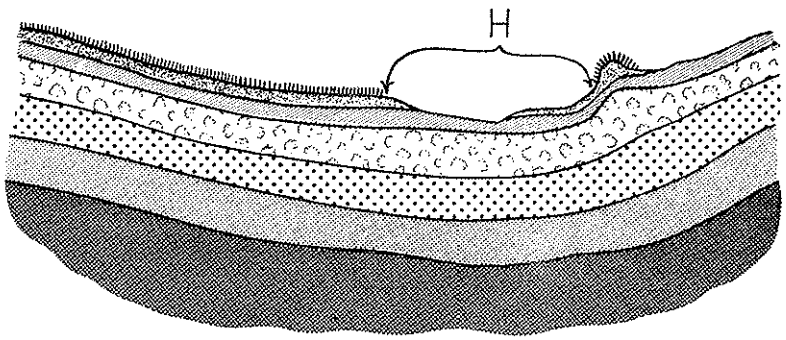

Figure 3

B→F = 6mm.

— Green

— Algal

— Yellow

— Pink

— White

— Blue

H — Bluish grey rasped area with pink borders.

— White

Calothrix crustacea B. & F.

Gake: Teuriamote Iti (11429)
: Tikageri (11483)

Raro: Tahuna popo (11236)

Lyngbyaceous trichome portions associated with masses of other algae in quiescent saline pools.

Calothrix parietina B. & F.

Gake: Teuriamote (11443)

Raro: Garumaoa (11118)
: Homohomo (11290, 11296)
: Oneroa (11666)

Associated with other species in bound sand on both the lagoon and seaward beaches.

Calothrix pilosa B. & F.

Gake: Teuriamote (11433, 11434)

Kereteki: Tetou (11318)

Raro: Garumaoa (11981)
: Oneroa (11233)

Occurring occasionally as a felt-like stratum on gravel, boulders and beach rock just above the high tide line on both the lagoon and seaward sides of the islands.

Calothrix scopulorum B. & F.

Tokerau: Mataira (11373)
Vaituki (11371, 11372)

Gake: Teuriamote (11436, 11439, 11441, 11442)
Tikagera (11483)

Kereteki: Tetou (11320, 11332, 11832, 11878)

Raro: Garumaoa (11117, 11800, 11801)
: Homohomo (11143, 11144, 11145, 11147a, 11298, 11306, 11307)
: Korere (11308, 11309, 11311)
: Oneroa (11566, 11664)
: Tahuna popo (11236)

In all areas investigated where this species was found, it was associated with Entophysalis crustacea. Thalli of this species were present on all parts of the seaward beach conglomerate and in some instances appeared as a constituent of the sand binding associations discussed under Schizothrix longiarticulata.

Coccochloris aeruginosa (Nag.) Dr. & Daily

Raro: Oneroa (11674)

Associated with other blue-green algae in greenish non-bound lagoon beach ridge sand.

Entophysalis conferta (Kuetzing) Dr. & Daily

Raro: Garumaoa (11935b)

Epiphytic on Lyngbya semiplena attached to Garumaoa village wharf.

Entophysalis crustacea (J. Ag.) Dr. & Daily

Tokerau: Mataira (11373)
Vaituki (11371, 11372)

Gake: Teuriamote (11431, 11433, 11435, 11436, 11437, 11439, 11441, 11442, 11443, 11444, 11445, 11446, 11447, 11472)
Teuriamote Iti (11429)
Tikagera (11483, 11484)

Kereteki: Gavarivari (11922, 11929, 11932)
Kaea (11900)
Tetou (11318, 11320, 11321, 11332, 11333, 11832, 11865, 11871, 11875, 11876, 11877, 11878)

Raro: Garumaoa (11117, 11118, 11351, 11800, 11801)
Homohomo (11143, 11144, 11145, 11146, 11147a, 11284, 11285, 11286, 11289, 11290, 11291, 11292, 11293, 11294, 11295, 11296, 11298, 11300, 11302, 11303, 11304, 11305, 11306, 11307)
Korere (11308, 11309, 11311)
Kukina (11224)
Oneroa (11557, 11566, 11662, 11663, 11664, 11665, 11666, 11667, 11668, 11670, 11671, 11672, 11673, 11675, 11676, 11677, 11679)
Tahuna popo (11236)

This was certainly the most ubiquitous blue-green alga on the atoll. From high tide line, extending down into the reef pool on the seaward side and below low tide line on the lagoon shore, the species formed a slippery yellow brown coating over the calcareous substratum. From the high tide line upward through the splash area the rocks are blackish when dry, but when wet they are dark brown from growths of this species. It appears that the best growth, quantitatively, was in and just above the littoral zone. In and around the pools at the landward edge of the sea beach conglomerate the surface is darker or black when wet and gray when dry. Throughout all this conglomerate region the present species is associated with Calothrix scopulorum.

In no case was this alga found growing above the high tide line on other than a calcareous substratum.

The species was also a prominent member of the sand binding associations. The coral rocks and gravel covering most of the island surfaces are generally completely white beneath and gray on top (or black when wet) with a more or less green line around the under edge. The dark color imparted to the tops of these fragments and to the beach rock appears to be due to the discoloration of the sheath material of this Entophysalis by sunlight. Where shaded, as on the under edge of the fragments, the sheath material is hyaline and the protoplasts, having a greenish color in mass, show through.

Fischerella ambigua (B. & F.) Gomont

Raro: Homohomo (11284, 11289, 11290, 11292, 11294, 11307)
Oneroa (11583, 11663, 11672, 11673, 11674, 11676, 11677)

A common algal cover on inland coral fragments and vegetable debris. Specimens recorded under this name may very well be aerial growth forms of Mastigocoleus testarum.

Hapalosiphon pumilus B. & F.

Kereteki: Tetou (11844, 11870)

Green (in low areas) and brown (in raised areas) patches on mud surface of inland swampy section of the islet.

Hydrocoleum coccineum Gomont

Kereteki: Mahaki (11316)

Raro: Oneroa (11565)

Soft flat reddish sheets on Mahaki channel floor and at the low tide line in the lagoon at Oneroa.

Hydrocoleum glutinosum Gomont

Raro: Garumaoa (11342)

On stones exposed in the low tide area near the village wharf.

Hydrocoleum lyngbyaceum Gomont

Tokerau: Namunamukona (11470)

Kereteki: Mahaki (11313)
Tetou (11831, 11839)

Raro: Garumaoa (11945)
Homohomo (11342)

At and just below low tide line of lagoon, sea and channel shores.

Lyngbya aestuarii Gomont

Raro: Kukina (11815)

Attached to Porolithon onkodes and Microdictyon okamurai on surge ridges.

Lyngbya gracilis Gomont

Raro: Garumaoa (11944)

North (shaded) side of the village wharf just below low tide line.

Lyngbya lutea Gomont

Raro: Korere (11309, 11310, 11311)

Together with Entophysalis crustacea, Calothrix scopulorum and Microcoleus tenerrimus in a crust of coalesced sand and silt grains on the east end of the island.

Lyngbya majuscula Gomont

Kereteki: Tetou (11827, 12342)

Raro: Garumaoa (11227)

This species was a common member of the flora below low tide line in the lagoon. It was not found in the channels between the islands or on the sea reefs. At Tetou it grew up to low tide level on fine gravel along the beach shore and on rocks of the lagoon slope that extended above the low tide line. Here it was taken to be a good indicator of the shore edge of the sublittoral zone. In front of the village of Garumaoa it was growing in the lagoon to a depth of 3 to 6 meters.

Lyngbya semiplena Gomont

Kereteki: Tetou (11333)

Raro: Garumaoa (11935b)

Covering the bottom at the lagoon end of the blocked channel north of Tetou. Also at the high tide line on the Garumaoa village wharf.

Lyngbya sordida Gomont

Tokerau: Fakatomo (11376)

Kereteki: Gavarivari (11922)

Raro: Garumaoa (11064, 11944)
Homohomo (11104)
Oneroa (11513, 11526, 11553, 11572).

This species was often utilized by the shrimp Crangon frontalis (Milne Edwards) as building material for its characteristic tubes, appearing as described by Taylor (Plants of Bikini: 110-111, 1950) from the Marshall Islands. These tubes, sometimes reaching a length of 60 cm., were found on the sea reef flat and in channels of the leeward side of the atoll. Taylor discusses this interesting association of shrimp and alga and something of the history and distribution of this association between shrimps and algae. Prof. A. H. Banner, who identified our shrimp specimens, tells us that some of the Hawaiian species of Crangon have similar habitats. This seems to be unknown to the phycologists who have worked in that area.

Mastigocoleus testarum B. & F.

Gake: Teuriamote (11443, 11444, 11445, 11446)

Kereteki: Tetou (11318, 11320, 11871, 11877, 11878)

Raro: Homohomo (11146, 11286, 11291, 11293, 11295, 11298, 11300)
Oneroa (11557, 11664, 11667, 11669)
Tahuna popo (11236)

This species, marine in distribution, is a perforator of shells and other calcareous materials. At Raroia it was found within tidal limits and the splash zone and perforating the fragments making up the inland surface of the islets. The presence of this species quite removed from typical marine conditions suggests three possibilities.

1. The species is capable of at least passive existence under relatively fresh water conditions.

2. Enough salt is released by the condensation of ocean spray in inland areas to sufficiently duplicate marine conditions.

3. The inland fragments had been recently deposited by storm action and the specimens could be expected to die.

All the specimens examined appeared to be healthy and storms of such magnitude as to carry shore fragments far inland are seldom. Thus, the third possibility would seem unlikely. No choice can be made of the other two without extensive culture experiments.

Microcoleus acutissimus Gardner

Gake: Teuriamote (11443, 11444)

Kereteki: Tetou (11871)

Raro: Garumaoa (11218, 11936)

Intermingled with Oscillatoria corallinae on Garumaoa village wharf. Also found in damp inland habitats.

Microcoleus chthonoplastes Gomont

Raro: Garumaoa (11702, 11703, 11705)

On thoroughly algalated foundation of a village house.

Microcoleus tenerrimus Gomont

Raro: Korere (11309, 11310)

See Lyngbya lutea.

Nostoc commune B. & F.

Kereteki: Tetou (11887)

Forming thin olive membranaceous sheets on the ground and on tree trunks in Cocos groves. This species is a ground covering alga at Raroia, Takume, and Hikueru. Dr. Francis Drouet informs us that this species is also commonly found in North America where seepage and limestone occur together.

Oscillatoria corallinae Gomont

Raro: Garumaoa (11936, 11944a)

See Microcoleus acutissimus.

Phormidium crosbyanum Tilden

Kereteki: Tetou (11332)

Forming a cartilagenous coating over the bottom of seaward end of the same blocked channel mentioned above under Lyngbya semiplena.

Phormidium papyraceum Gomont

Gake: Teuriamote (11422, 11424, 11472)

See Anacystis dimidiata.

Plectonema calothrichoides Gomont

Kereteki: Tetou (11864, 11884)

On greenish soil and sand from above the high tide line along shore of the lagoon.

Plectonema nostocorum Gomont

Gake: Teuriamote Iti (11429)
Tikagera (11433, 11484)

Kereteki: Kaea (11900)

Raro: Garumaoa (11703)
Oneroa (11662, 11668, 11673, 11674)

Growing within the sheaths of other blue-green algae in both aerial and marine habitats.

Plectonema terebrans Gomont

Gake: Teuriamote (11438, 11445, 11446)

Kereteki: Tetou (11320)

Raro: Kukina (11224)

Perforating shells and conglomerate at and just below the low tide line of channels and seaward reef.

Porphyrosiphon fuscus Gomont

Raro: Garumaoa (11218)
Oneroa (11665, 11671)

On coral fragments and Cocos nucifera stumps in inland areas.

Rivularia polyotis B. & F.

Gake: Tikagera (11483, 11484)

Kereteki: Gavarivari (11919, 11932)

Raro: Kakipuka (11558)

Slick yellow brown coatings on intertidal conglomerate of both lagoon and seaward reefs.

Schizothrix giuseppei Drouet

Raro: Homohomo (11304, 11305)

With Scytonema crustaceum on heavily algalated inland coral fragments.

Schizothrix lacustris Gomont

Tokerau: Vaituki (11372)

Gake: Teuriamote Iti (11429)

The distribution of this species is similar to that of Anacystis dimidiata.

Schizothrix longiarticulata Gardner

Tokerau: Mataira (11373)

Gake: Teuriamote (11436, 11442, 11443)

Kereteki: Tetou (11875)

Raro: Garumaoa (11118)
Homohomo (11292, 11293, 11294, 11296, 11298, 11302)
Oneroa (11557, 11665, 11672, 11673, 11677, 11679)

Sandy areas between gravel on the seaward and lagoon shores often had gray areas where the sediment was bound into a smooth crusty layer. Occasionally these areas had blistered surfaces bearing black moss-like clumps or knobs up to 2 mm. in diameter. These crusts were usually quite thin and fragile, breaking into fragments when handled. They were not so common inland as along the beaches. Schizothrix longiarticulata, Entophysalis crustacea, Symploca kieneri and Anacystis montana were the species generally found in such formations. The crusts with the small black knobs almost always had Calothorix scopulorum in addition to these four species.

Schizothrix longiarticulata also formed a greenish coating over the mud flat near the center of Tetou.

Schizothrix thelephoroides Gomont

Gake: Teuriamote (11443, 11444)

Raro: Garumaoa (11117)

Occasionally found in crusts as discussed above under Schizothrix longiarticulata.

Scytonema crustaceum B. & F.

Raro: Homohomo (11284, 11302, 11304, 11305)

On heavily algalated inland coral fragments.

Scytonema guyanense B. & F.

Raro: Garumaoa (11218, 11219)
Homohomo (11182, 11293)
Kukina (11176)
Oneroa (11665)

Present on rotten debris and coral fragments in humus areas around the bases of Cocos nucifera.

Scytonema hofmannii B. & F.

Tokerau: Opaneke (11379)

Kereteki: Tetou (11865, 11869, 11884, 11887)

Raro: Garumaoa (11118, 11257, 11706, 11707, 11708, 11257)
Homohomo (11179, 11183, 11276, 11283, 11303, 11685)
Oneroa (11598, 11603, 11649, 11662, 11663, 11668, 11671, 11674, 11679)
Teputaiti (11238)

Very commonly this species formed brownish to black felt-like patches on the moist roots, bark and husks of Cocos nucifera. It apparently grew best on the damp or exposed sides of the trunks of the trees. It was also abundant on algal fragments in the Cocos groves.

Spirulina tenerrima Gomont

Kereteki: Tetou (11831, 11839)

Raro: Garumaoa (11945)

This species was occasionally a member of KOPARA associations and was found intermingled with a Hydrocoleum species.

Symploca atlantica Gomont

Raro: Garumaoa (11063, 11758, 11935a)
Oneroa (11620)
Temari (11026)

Brown cartilagenous crusts in and just below the intertidal zone. Found in channels and on both seaward and lagoon reefs.

Symploca hydnoides Gomont

Kereteki: Gavarivari (11924)
Tetou (11331, 11836, 11853)

Raro: Garumaoa (11759)

Just below low tide line on all shores.

Symploca kieneri Drouet

Gake: Teuriamote (11443, 11444, 11445)

Raro: Oneroa (11666, 11668, 11673, 11676, 11677, 11679)

See Schizothrix longiarticulata.

Symploca laeteviridis Gomont

Raro: Oneroa (11662)

On coral fragments just above the high tide line in the lagoon.

Symploca muralis Gomont

Raro: Garumaoa (11703, 11708)
Homohomo (11257)

On Cocos nucifera trunks and cement foundation of a village house.

The blue-green algae appear to have either a direct or indirect role in bringing about a number of physical and chemical phenomena of the atoll.

Findings are in full agreement with the theory (Cloud: Atoll Research Bulletin No. 12: 28, 1952) that certain species may serve to bind sand and coral fragments prior to cementation in protected areas.

Apparently some blue-green species play a dual role in the removal of material from beach conglomerate and boulder surfaces of both lagoon and seaward shores. Protuberances, from the conglomerate rock and boulders of the reef flat in the intertidal and spray zones, were broken off in the field and appeared as shown in Fig. 3. It is postulated that as the cells of the blue-greens die, the water soluble pigments released move by diffusion into the water saturated rock and there become absorbed in their order of affinity for $CaCO_3$, etc.. The colored bands illustrated in Fig. 3, B-F are thus produced. No such stain was found in living reef-flat corals. The intertidal and spray zones are inhabited by Nerita plicata and Tectarius sp. (11115), the Nerita migrating up and down with the tides. Over large areas the snails had eaten away the algae, thus exposing the underlying pink and blue layers. Upon close examination, grooves caused by the rasping action of the snail's radulae could be seen. With recurring growth of the outer algal layer and browsing by the snails the conglomerate rock face is no doubt continually removed at a rather rapid rate.

It was noted that the surface of beach rock, particularly that covered by blue-green algae, was soft and porous. In some instances, it appeared that the algae were actually "boring" into the calcareous substratum. Perhaps the alternation of night and day, with subsequent solution and precipitation in relation to the CO_2 cycle (Emery: Marine solution basins: Jour. Geology, Vol. 54, No. 4: 209-228, 1946) of these photosynthetic organisms, accounts for this softness and porosity. It is possible that this "boring" may be a result of some product other than acid radicles (Koster: Notes on Javanese calcicole Cyanophyceae: Blumea, Leiden, 3: 243-247, 1939) excreted by the algae. In any case the calcareous material would be in a state that could be readily removed by solution or mechanical action. If this is so, the zone periodically covered by tidal water would be expected to wear down at a more rapid rate than the zone dependent upon rain to wash away the precipitated $CaCO_3$. This could be an explanation for the solution pools found on upper beach conglomerate surfaces and the nip in the intertidal zone of beach rock and sea reef boulders. The additional factor of fresh ground water seepage (Wentworth: Marine bench forming processes: II, Solution benching: Jour. Geomorph., Vol. 2: 3-25, 1939) in the intertidal zone may account for some of the undercutting of beach rock but would not seem to be as completely satisfactory an explanation for the nip in the boulders of the sea reef flat.

Of even more importance to the economy of the atoll, is the possibility that the blue-green algae act as agents in the fixation of atmospheric nitrogen. Even in the vegetated areas, the major portion of the ground is covered with algalated coral fragments and sand. There is seldom a humus layer of the

ordinary kind. Since the higher plants are dependent upon previously fixed nitrogen, it is suggested that the need here is supplied by either blue-green algae, symbiotic bacteria living in their sheath material, or both. It has been shown that certain species of blue-green algae are capable of combining atmospheric nitrogen with organic compounds. It is suggested that the blue-green algae have a hand in initiating the nitrogen cycle and that the decomposition products of blue-green algae bearing nitrogenous compounds are made available to higher plants through leaching. Whether the species present on Raroia are capable of performing this function and in a quantity sufficient to supply the needs of the other organisms remains to be answered.

Part 3

ECOLOGICAL AND FLORISTIC NOTES ON THE BRYOPHYTA OF RAROIA

by Harvey A. Miller & Maxwell S. Doty

The mosses and liverworts from the atolls visited pose several interesting problems. At present there seem to be about 7 species present, representing approximately that many genera. All of these are previously unreported for Raroia.

The localities given may be found by reference to Figure 1 in Part 1 of this Atoll Research Bulletin No. 33.

There was striking correlation between disturbance of the land and vegetation by cyclones and man and the abundance of mosses. The older people claim that the ground of the village was covered with mosses before the cyclone of 1903. They also claim that after the cyclone such plants as tomatoes, which they had either not seen before or which were unusual about the village, became abundant. Few of the islands regularly had mosses on the ground. Indeed on the ground, mosses were to be found only on the drier areas having more humus and there were very few such areas at Raroia. The principal habitat for mosses was tree trunks.

No ethnic interest was found for these organisms by our questioning, in the Tuamotus or in Tahiti. Mosses are possibly used as boat caulking in Micronesia, but this is only a rumor and "moss" might have meant algae or other material.

In the following list note the repositories for specimens: BISH = B. P. Bishop Museum; USNM = U. S. National Museum; NY = New York Botanical Garden.

MUSCI

Calymperes tenerum C. Mueller. Linnaea 37: 114, 1871-1873.

On rotten wet Cocos husk in the transect area across Homohomo (11181-USNM, BISH, NY).

On transect at Tetou (11888-USNM, BISH, NY), Kereteki, VIII-21-1952.

On Cocos along transect just north of village of Oneroa (11582a-BISH), on Cocos husk (11582b), mixed with liverworts (11651), on Guettarda (11657-USNM), Raro, VIII-7-8-1952.

On wet rotten Cocos stump with conspicuous balls of propagulae at the leaf tips, central part of island along transect across Homohomo (11180-USNM), VII-12-1952.

Distribution: Oceania, probably the most frequently occurring moss in the Pacific Islands.

Calymperes tuamotuense Bartram. Occ. Pap. B. P. Bishop Mus. 10: 6, 1933.

On Cocos husk at Oneroa (11648-USNM-BISH), Raro, VIII-8-1952.

On south side of Cocos trunk, sometimes overgrown by the lichen, Coccocarpia cronia, at Kukina (11174-USNM, BISH, NY, 11171A-USNM), VII-10-1952.

Distribution: Tuamotu Archipelago, Pitcairn Island, Henderson Island, Austral Islands, Mangareva Islands.

Brachymenium melanothecium (C. Mueller) Jaeger. Adumbratio Fl. Musc. p. 576, 1875.

Oneroa (11584-USNM, NY), Raro, VIII-7-1952; Kukina (11175-USNM, BISH, NY), Raro, among rocks beneath Cocos, VII-10-1952; ground cover in village of Garumaoa (11259-USNM, BISH, NY), VII-21-1952 and (11718-USNM, BISH), VIII-13-1952.

Where best developed forming a turf over the ground in association with Eragrostis amabilis and Pilea microphylla.

Distribution: Frequent in Society and Tonga Islands.

Trichosteleum pygmaeum Bartram. Occ. Pap. B. P. Bishop Mus. 10: 9, 1933.

On rotten wood south of the village of Oneroa (11556-USNM, BISH, NY), Raro, VIII-5-1952.

Distribution: Endemic to Tuamotu Archipelago. Reported previously from the type collection from Makatea.

HEPATICAE

Cololejeunea minutissima (Smith) Schiffner in Engler & Prantl. Natur. Pfl.-Fam. 1(3): 122. 1895.

On the transect at Tetou (11843-USNM, BISH), Kereteki, VIII-21-1952.

Distribution: Practically world wide in warm and warm temperate regions.

Ptychocoleus pycnocladus (Taylor) Stephani. Spec. Hep. 5: 52, 1912.

In more heavily wooded area just south of Oneroa, (11651-USNM, BISH, NY), on Guettarda (11658-USNM, BISH, NY), Raro, VII-8-1952.

Distribution: Widespread in Oceania and Indo-Malaysia.

Frullania sp.

On Guettarda bark in more heavily wooded area just south of village of Oneroa (11659-USNM, BISH), Raro, VII-8-1952.

Part 4

ECOLOGICAL AND FLORISTIC NOTES ON THE PTERIDOPHYTA OF RAROIA

by Kenneth Wilson

There were essentially only two ferns outside of the village. These are the Microsorium, often not distinguished from Polypodium, and the Psilotum keyed out in the key on page 14 of this Bulletin. Asplenium nidus being present as only two plants was certainly not cultivated. It is considered as a plant not well established.

The localities cited may be found on the map appearing as Figure 1 in Part 1 of this Atoll Research Bulletin No. 33.

At Anaa, the guide, a local man, told the collectors that the rhizome of the Microsorium was pounded to a pulp and given to children in the eastern Tuamotus who were suffering from what was interpreted to be some nervous cramping condition. At Raroia the people are reputed to boil parts of this fern and drink the fluid for some reason or other. No definite uses were discovered.

Asplenium nidus L. (Opakea, 11769-BISH, USNM)

Two plants of Asplenium nidus were found growing on Opakea near a former village site. Both of the plants were growing on a fallen rotten trunk of coconut, and were about two meters from each other. This fern is probably of recent introduction into the atoll since it was found only at this locality. Its proximity to a former village also supports this point of view.

It appears that it may be called OAHA by the Raroians, but this name is possibly a corruption of the Tahitian O'AHA, and not Tuamotuan at all.

Microsorium scolopendria (Burm) Cope. (Opakea, 11173-BISH, USNM; Kukina 11791-BISH, USNM; Kukina, 11793)

This is the most common of all the pteridophytes on the atoll. It occurs on nearly all the vegetated islands of the atoll, even the drier parts. It grows in coconut groves around the base of the coconut trees and also beneath trees of Guettarda speciosa. When growing under Guettarda speciosa the fronds were noted to have a striking orientation perpendicular to the sunlight.

Also found at Takume (12318-BISH, USNM).

During late July (11263-USNM) and early August (11607-USNM) two collections of what appear to be primary leaves and gametophytes respectively of this species were made.

This species is very commonly reported as Polypodium scolopendria. The local name was KIKIPA.

Nephrolepis biserrata (Swartz) Schott var. biserrata (Garumaoa 11824-BISH, 11720-USNM)

A village plant.

Nephrolepis biserrata (Swartz) Schott cultivar furcans Hort. (Garumaoa 11823-USNM)

Both these Nephrolepis varieties were found only in cultivation in the village.

Psilotum nudum (L.) Griseb. (Opakea 11792-USNM, Oneroa 11555-USNM, Homohomo 11004-BISH, USNM)

Psilotum nudum was far more abundant in the more humidified areas. As a rule it was found growing only on trunk bases of Cocos and Guettarda; as an epiphyte up to 50 cm. tall. Occasionally it appeared to be growing on the ground; then usually near either of these two trees. This fern was found also at Takume (12323-BISH, USNM).

Native name: TUMETUME, TUMETUME FENUA, or TUMETUME HENUA.