

A SURVEY OF THE PLANTS OF GUAM*

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With two plates

INTRODUCTION

The purpose of this study is to group the principal plant species on Guam according to the kinds of situations most favorable for their growth, and to show the geographical distribution of each species. This survey is based, in part, on collections made by the writer in the 16 months, from 1944 to 1946, which were spent on Guam. During this period, 300 specimens of vascular plants were collected, and subsequently were sent to Dr. E. D. Merrill, Director of the Arnold Arboretum. At present, these specimens are deposited in the Arnold Arboretum and in the Herbarium of the University of Illinois. More than 29 localities, ranging from one end of the island to the other, were visited during the course of collecting. An attempt was made to collect plants in all types of situations, extending from the coral reefs to the savannas. At the same time, field notes on the flora and vegetation were made.

The second phase of this study involved a perusal of the literature dealing with the plants of Guam. Much of the information dealing with principal botanical collections, especially the earlier ones, was extracted from "The Useful Plants of Guam," by W. E. Safford, and "An Enumeration of the Plants of Guam," by E. D. Merrill. Notes on the geography of the island were obtained from the above-mentioned work by Safford. Most of the data on the names of species and their geographical distributions were taken from Merrill's enumeration, and from "An Enumeration of Micronesian Plants," by R. Kanehira. Native names of species were derived from the works of Safford and Merrill. The grouping of species is based principally on the writer's field observations and collections.

GEOGRAPHY AND CLIMATE

Guam is the largest island of the Marianas Archipelago, in the west central Pacific area. It is twenty-nine miles long, and four to nine miles wide. The island extends from 13° 14' N. to 20° 30' N. latitude, and from

* The writer is indebted to Dr. E. D. Merrill of the Arnold Arboretum for identification of plant specimens from Guam, and for suggestions in the preparation of this manuscript. This work has been facilitated by the valuable guidance and direction of Dr. G. Neville Jones of the University of Illinois. Thanks are also due to Dr. O. Tippo of the University of Illinois for helpful assistance in the completion of this paper, and to Mr. C. Schweinfurth of the Botanical Museum, Harvard University, for identification of certain species of Guam orchids.

143° 46' E. to 146° 31' E. longitude. It is therefore, approximately 1200 miles east of the Philippine Archipelago, and 3500 miles west of Honolulu. The outline of Guam may be compared roughly to the shape of a human footprint (PLATE I), with the heel north-northeast, and the toe south-southwest.

The southern half of the island is more mountainous than the northern half. Mt. Lamlam, 1334 feet above sea level (PLATE I), is the highest peak in the former region. In the valleys of the southern part of Guam, the soil is deep and black, evidently deposited by slow moving streams. The northern half of the island is a series of raised platforms of coralliferous limestone, often spoken of as the "mesa" or plateau. Mt. Santa Rosa, 870 feet above sea level (PLATE I), is the highest peak in this region. In the northern half of the island the soil is composed chiefly of heavy reddish clay, often only a few inches in depth. The subsoil in many places consists of decomposed coralliferous limestone, and below this there is a solid mass of hard coral.

All the mountain peaks are undoubtedly of volcanic origin. In some of the peaks outlines of craters can be seen. Surrounding the bases of some of the mountains are ancient coral reefs, the margins of which have been changed into crystalline limestone. This fact indicates that volcanic activity took place after the whole island was raised from the sea. On the western side, between the mesa and the ocean, there are several flat terraces showing evidence of having undergone successive upheavals. These terraces mark former sea levels, indicating that there were intervals of rest during the successive elevations of the island.

A number of rivers dissect both the central and southern portions of Guam. Near the middle of the island, about one mile and a half from Agana, is a large spring. This spring drains into a swamp which forms the Agana River (PLATE I). In the southern section of Guam, there are several small streams e.g., tributaries of the Talofofo River (PLATE I), which disappear beneath the surface of the ground, and emerge later from caverns. The northern part of the island is relatively dry because rainfall is absorbed rapidly by the coralliferous limestone. During the rainier part of the year, however, several small streams appear near the bases of hills of Mt. Santa Rosa and Mt. Mataguac (PLATE I).

The ocean bed between Midway and Guam is a vast plain approximately four miles below the surface and somewhat broken by submarine reefs and mountain ranges. When the submarine volcanic range that forms the Marianas Islands (PLATE II) is approached, this plain gradually slopes into an abyss almost six miles deep. The ocean bed between Guam and the Philippines is approximately two to four miles below the surface.

The climate is tempered throughout the year by a brisk trade wind, blowing from northeast and east. According to records of the United States Weather Bureau (14), from 1926 to 1941, the range of temperature was between 64° F. and 93° F. From 1926 to 1941 the average total annual rainfall was 91.06 inches (14). The rainfall is heaviest from July

to November, while the period of least precipitation is from December to June. September is the month of highest precipitation, with a 17 year average of 16.14 inches. April, with 2.18 inches, shows the lowest average monthly rainfall during the same period.

PRINCIPAL BOTANICAL COLLECTIONS

Since 1521, when Guam was discovered by Magellan during his circumnavigation of the earth, several botanists have explored this island. The earliest known plant collections were made in 1792 by Thaddeus Haenke and Luis Nee, botanists of the Malaspina Expedition, whose specimens were subsequently sent to the National Museum of Bohemia at Prague, and the Royal Garden at Madrid. In 1817 Adelbert von Chamisso, botanist of the Romanzoff Expedition, collected some plants on Guam, which later were deposited in the Berlin Herbarium. Charles Gaudichaud-Beaupre, with the Freycinet Expedition, collected a number of specimens on the island, but they were destroyed by sea water when his ship was wrecked on the return voyage. A. Lesson, botanist of the first D'Urville Expedition, collected some plants on Guam in 1828; but there are no records of his specimens. During the second D'Urville Expedition in 1839, J. B. Hombron collected specimens which later were sent to the Museum National d'Histoire Naturelle, Paris.

For the next sixty years no botanizing was done on Guam, but in 1899 and 1900, W. E. Safford, then Assistant Governor of Guam, collected some specimens. The results of this effort appeared under the title "The Useful Plants of Guam" (12), a work containing a list of some 350 species.

During the years 1910-1919, J. B. Thompson, Mrs. J. Clemens, R. C. MacGregor, and other botanists collected plants on Guam. Their collections formed the basis of two works by E. D. Merrill, "An Enumeration of the Plants of Guam" (8) and "Additions to the Flora of Guam" (9).

Before 1929, some 61 species of vascular plants were thought to be endemic on Guam, but when the results of the work of R. Kanehira and other botanists who collected on the Japanese mandated islands of Micronesia from 1929 to 1935 were published (6,7), it was found that twenty-nine of the supposed endemics actually occurred on other islands of Micronesia.

In 1936, E. H. Bryan collected a few hundred specimens from Guam for the Bernice P. Bishop Museum in Honolulu. From 1936-1941, he published a series of articles based on these specimens, under the title of "The Plants of Guam" (1).

Although collections have been made from Guam, further botanical exploration is needed before our knowledge of the flora of this island can be considered to be adequate. This was shown by the recent collections made by the present writer in 1946. Among 300 numbers secured, new Guam records included seventeen species in thirteen genera and three families (11).

DISCUSSION OF THE FLORA

The plants of Guam are listed under the following headings: Coral Reefs, Strand, Mangrove Swamps, Rivers and River Banks, Forests, Marshes, Grasslands and Abandoned Clearings.

No attempt has been made to include all the recorded species. However, the species that are listed, most of which the writer has collected, are the principal representatives of each of the above situations. The writer has not collected specimens of thallophytes or bryophytes, consequently, lists of these groups of plants are taken from publications of the following authors: Safford (12), algae; Graff (3), fungi and lichens; and Merrill (8), bryophytes.

A. PLANTS OF CORAL REEFS

Growing submerged in the ocean, close to the fringed coral reefs, are many species of algae and several species of flowering plants.

The green algae are represented by the following genera: *Caulerpa*, *Rhizoclonium*, *Bryopsis*, *Enteromorpha* and *Halimeda*. *Padina*, *Sargassum* and *Turbinaria* comprise the principal genera of brown algae. The chief representatives of the red algae are *Acanthophora*, *Corallopsis*, *Mastophora* and *Gracillaria*.

Potamogetonaceae and Hydrocharitaceae are the principal families of angiosperms found in the coral reefs. The former family is represented by *Diplanthera uninervis* (Forsk.) Aschers, extending from the Red Sea and tropical east Africa to Polynesia, and *Ruppia maritima* L., widely distributed in most warm and temperate countries. *Enhalus acoroides* (L.f.) Rich., a widely distributed species in the Indo-Malayan region, and *Halophila ovata* Gaudich., a species found only on Luzon and Guam, are the representatives of Hydrocharitaceae.

B. STRAND PLANTS

Many of the species growing along the beaches and cliffs are of extensive distribution in the tropics. Coconuts are abundant on the west coast of the island, but on the east coast, where stiff winds are blowing almost constantly, only a few of these plants occur. *Casuarina equisetifolia*, a common strand tree, grows equally well on both the east and west coasts.

According to A. W. Schimper (13), the strand plants of the Pacific Islands are divided into four formations: the "Mangrove," the "Nipa," the "Barringtonia," and the "Pes-caprae." The first category will be treated under a separate heading, "Mangrove Swamps." Nipa formation will not be included in this discussion as it is not a characteristic strand formation on Guam. The Barringtonia formation comprises the plants immediately lining the beach. Some of the more common woody species are: *Barringtonia asiatica*, *Heritiera littoralis*, *Hibiscus tiliaceus*, *Thespesia populnea*, *Ochrosia parviflora*, *Hernandia ovigera*, *Calophyllum inophyllum*, *Morinda citrifolia*, *Clerodendron inerme*, *Desmodium umbellatum*, and *Vitex trifolia*. The herbaceous species in this group include *Centotheca*

latifolia, *Monerma repens*, *Thuarea involuta*, *Mariscus stuppeus*, and *Crinum asiaticum*.

The Pes-caprae formation consists of herbaceous creepers and woody species of the beach itself. The characteristic creepers are *Ipomoea pes-caprae*, *I. gracilis*, *Canavalia lineata* and *Vigna marina*. Some of the woody species include *Scaevola frutescens*, *Tournefortia argentea*, *Pemphis acidula* and *Casuarina equisetifolia*.

Seeds and fruits of the majority of the strand plants float in salt water for a long time. In a system of classification proposed by H. B. Guppy (4), these species are divided into three groups according to structural modifications of buoyancy. The first group consists of species having air spaces in the seeds or fruits. Group two includes those species having buoyant seed coats or fruit husks. In the third group, the kernel itself is buoyant.

Group I. This group is subdivided into four sections, A. Species with air spaces between the cotyledon and seed coat, B. Those with air spaces between the cotyledons, C. Species with an air chamber in the seed, and, D. Those in which the seed partially fills the fruit cavity.

SECTION A. Lauraceae are represented by *Cassytha filiformis* L. (mayagas or dodder laurel), a climbing saprophyte which is widely distributed in the tropics of both hemispheres. The mallow family includes two species of pantropical distribution, *Hibiscus tiliaceus* L. (pago or corkwood) and *Thespesia populnea* (L.) Soland. (kilulu, quilulu). *Euphorbia atoto* Forst. f., extending from tropical Asia to Australia and Polynesia, is the representative of Euphorbiaceae in this section. The legumes contain one species of pantropical origin, *Caesalpinia crista* L. (pacao). The Rhamnaceae are represented by *Colubrina asiatica* (L.) Brongn. (gasoso), which extends from tropical Africa, Asia through Malaya to Australia and Polynesia. *Ipomoea pes-caprae* (L.) Roth (alalag-tasi), a member of the morning-glory family, is distributed in the tropics of both hemispheres.

SECTION B. This section consists of three species of leguminous plants: *Entada phaseoloides* (L.) Merr. (gaye, gayde, lodusong, bayog) and *Vigna marina* (Burm.) Merr. (akankan malulasa) are pantropical, while *Mucuna gigantea* (Willd.) DC. (akankan dangkulo) extends from tropical Asia to Polynesia.

SECTION C. *Morinda citrifolia* L. (ladda or Indian mulberry), a member of the Rubiaceae distributed from India to Polynesia, is the only species represented in this section.

SECTION D. The Sterculiaceae are represented by *Heritiera littoralis* Dry. (ufa, hufa or looking glass tree), a species extending from tropical east Africa through Malaya to Polynesia. Two species of leguminous plants fall into this section: *Desmodium umbellatum* (L.) DC. (palaga hilitai) ranges from the Mascarene Islands and tropical Asia, through

Malaya and northern Australia, and *Derris trifoliata* Lour. extends from tropical east Africa, Asia through Malaya to Australia and Polynesia.

Group II. This group is divided into two sections, A. Seeds with buoyant coats, and B. Fruits with buoyant husks.

SECTION A. *Cycas circinalis* L. (fadan, fadang), a member of the Cycadaceae, is widely distributed in the Old World tropics. The family Hernandiaceae is represented by *Hernandia ovigera* L. (nonag, nonak), a species which is distributed from Ceylon to tropical east Africa, Madagascar through Malaya to tropical Australia and Polynesia. *Excoecaria agallocha* L. (milky mangrove), a representative of the spurge family, ranges from India to Polynesia.

SECTION B. In this section, Lythraceae are represented by *Pemphis acidula* Forst. (nigas), a species extending from tropical east Africa and tropical Asia to tropical Australia and Polynesia. *Barringtonia asiatica* (L.) Kurz (puting), a member of the Lecythidaceae, occurs from tropical Asia to Polynesia. *Lumnitzera littorea* (Jack.) Voigt (nana or red flowered mangrove), a representative of the family Combretaceae, extends from tropical Asia through Malaya to Australia and Polynesia. Casuarinaceae include *Casuarina equisetifolia* L. (gago or Polynesian ironwood), a species distributed from tropical Africa to Polynesia, and pantropical in cultivation. The dogbane family contains one species in this section, namely *Ochrosia parviflora* (Forst.) Henslow (fago). This plant occurs in the Polynesian region. The family Boraginaceae includes two representatives, *Cordia subcordata* Lam., occurring from east Africa and tropical Asia through Malaya to tropical Australia and Polynesia, and *Tournefortia argentea* L.f. (hunig, hunik), ranging from tropical Asia to Mauritius, Malaya, tropical Australia and Polynesia. *Scaevola frutescens* (Mill.) Krause (nanaso), a member of the Goodeniaceae, extends from India to Polynesia. The vervain family is represented by two species, *Clerodendron inerme* (L.) Gaertn. (lodogao), distributed from India to Formosa through Malaya to tropical Australia and Polynesia, and *Vitex trifolia* L. (lagundi), extending from India to Mauritius and Japan, southward through Malaya to tropical Australia and Polynesia. Palms include two well known species, *Cocos nucifera* L. (niyog or coconut) and *Nypha fruticans* Wurm. (nipa palm). The former plant is found in all tropical countries and is a native of some part of the Old World tropics. The nipa palm was introduced from the Philippines and occurs from India through Malaya to tropical Australia.

Group III. *Calophyllum inophyllum* L. (daog, daok or Palo Maria), a member of the Guttiferae, extends from India to tropical east Africa through Malaya to Polynesia. The leguminous plants are represented by three species. *Canavalia lineata* (Thunb.) DC. (akankan-tasi) and *Sophora tomentosa* L. are both pantropical, while *Erythrina variegata* L. (gaogao, gabgab or east Indian coral tree) is distributed from India to Polynesia. The Olacaceae in this group include the pantropical

species, *Ximenia americana* L. (piod, piut or tallow nut). The family Combretaceae is represented by *Xylocarpus granatum* Koenig (lalanyog), a species extending from India through Malaya to New Caledonia.

In addition to the strand plants with special modifications for floating, there is a number without these modifications. *Sesuvium portulacastrum* L., a member of the Aizoaceae, is found in the tropics and subtropics of both hemispheres. Utricaceae contain *Fleurya interrupta* (L.) Gaudich. (palilolia), ranging from Abyssinia to Australia and Polynesia. *Calonyction album* (L.) House (alaihai-tasi) and *Ipomoea gracilis* R. Br. (lagun, lagun tase) are examples of the Convolvulaceae in this group. The former species is pantropical in distribution, while the latter extends from tropical Asia to the Seychelles, through Malaya to tropical Australia and Polynesia. The madder family contains two species, *Bikkia mariannensis* Brongn. (gausali), found only in the Marianas, and *Oldenlandia biflora* L., distributed from tropical Asia to Polynesia. *Callicarpa paucinerva* Merr., one of the species of Verbenaceae, is known only from Guam, Rota and Saipan. *Rhoeo discolor* (L'Herit.) Hance, an example of the spiderwort family, is a native of Mexico and has been introduced in various Polynesian islands and the Philippines. The Amaryllidaceae are represented by *Crinum asiaticum* L. (piga palayi), an herb which is widely distributed in the Indo-Malayan region. Three species of strand grasses without special floating modifications are as follows: *Centotheca latifolia* (Osbeck) Trin., *Monerma repens* (Forst.) Beauv. (las-aga) and *Thuarea involuta* (Forst. f.) R. and S. (las-aga). The first plant extends from tropical Asia and Africa through Malaya to Australia and Polynesia; the second one is distributed from Ceylon to Australia and Polynesia, while the last ranges from Malaya to Polynesia. *Fimbristylis cymosa* R. Br. var. *umbello-capitata* (Mann.) Hillebr., found only in Guam and the Hawaiian Islands, and *Mariscus pennatus* (Lam.) Merr., extending from tropical Africa to southeastern Asia, Malaya and Polynesia, are the sedges included in this group.

C. PLANTS OF MANGROVE SWAMPS

At the mouth of many tidal streams where the water is brackish and the shores are muddy, mangrove trees extend far out into the water. The descending water of the rivers is stopped temporarily when it meets tide-water, and then deposits its sediment in the form of broad mud flats or deltas. On these deltas the trees forming the mangrove forest find conditions favorable for their development since the fruits or seedlings of these species are transported by salt water. This forest is usually free from undergrowth. The principal species are characterized by the presence of specialized, aerial roots, such as knees, high prop roots, or enlarged roots. At extreme low tide, when the mud flats are not covered with water, these roots give a distinctive appearance to the vegetation.

Trees of the family Rhizophoraceae are the most conspicuous species of the mangrove swamps. *Rhizophora apiculata* Bl. (mangle hembra) and *R. mucronata* Lam., distributed along the tropical shores of the Old World,

are the first species to seed and occupy newly formed mud flats. They are prop-rooted species which grow in the portion of the swamp most deeply flooded by the tides. *Bruguiera conjugata* (L.) Merr. (mangle macho), a tree with root knees, extends from tropical Asia and Africa through Malaya to tropical Australia. This species occupies the inland portion of the swamp which is barely flooded at high tide.

In addition to the species already mentioned, there are several strand plants occurring along the inner edges of these salt water swamps. These strand species include *Xylocarpus granatum*, *Excoecaria agallocha*, *Lumnitzera littorea* and *Heritiera littoralis*.

D. PLANTS OF RIVERS AND RIVER BANKS

The genera of algae growing below the surface of many streams include *Conferva*, a representative of the green algae, *Chara*, a member of the Characeae, and *Thorea*, one of the red algae. All the submerged species of flowering plants fall into the family Potamogetonaceae. *Potamogeton mariannensis* Cham. and Schlecht., found only on Guam, is a fresh water species, while *Ruppia maritima* grows also in brackish water and sea water. Near the mouth of many streams where the water is brackish, *Nypa fruticans* grows in abundance. This palm, which grows partially immersed in water, usually extends up these rivers for a great distance. *Eichhornia crassipes* (Mart. and Zucc.) Solms-Laubach (water hyacinth), a native of the subtropics of America, is a floating species of the pickerel-weed family. *Ipomoea aquatica* Forsk. (cancon), a plant widely distributed throughout the Old World tropics, creeps along the surface of many streams.

Several species of ferns grow along river banks. *Angiopteris evecta* (Forst. f.) Hoffm., a member of the Marattiaceae, ranges from Micronesia to Polynesia. The Hymenophyllaceae are represented by *Trichomanes javanicum* Bl., a plant extending from tropical Asia to the Ryukyu Islands southward to Australia and Polynesia. A very rare, endemic species of tree fern is *Cyathea haenkei* (Presl) Merr. This plant grows in shady places along mountain streams. Polypodiaceae are represented by *Acrostichum aureum* L. (langayao), a species of pantropical distribution, and the endemic *Dryopteris depauperata* Copel.

In addition to the ferns listed above, there are a few angiosperms which commonly grow along the banks of streams. These include *Hibiscus tiliaceus*, a typical strand plant, and *Areca catechu* L. (pugua or betel nut palm), widely distributed in the Indo-Malayan region.

E. FOREST PLANTS

The plants of the forests are classified into trees, shrubs, epiphytes, lianas, and ground cover plants. Trees, epiphytes and lianas are the most abundant, while shrubs and ground cover plants are poorly represented in both number of species and in number of individuals. None of the areas in the Guam forests is dominated by any single species or by small groups of

species. Generally, ten or more species of trees grow side by side in approximately equal abundance. Most of the woody plants are evergreen, but *Pisonia grandis*, a common forest tree is deciduous. The trees are represented by a diversified group of families and species. Annonaceae contain two common species which are native to tropical America, and cultivated in most tropical countries. These include *Annona muricata* L. (laguana or soursop) and *A. squamosa* L. (atis or sweetsop). *Cananga odorata* (Lam.) Hook.f. and Th. (alangilang), another member of this family, and widely distributed in the Indo-Malayan and Polynesian regions, is less common than the other two species. Nyctaginaceae are represented by *Pisonia grandis* R. Br. (umumu), a species extending from the Philippines, Moluccas, northeastern Australia across Polynesia to the Palmyra Islands. *Xylosma nelsonii* Merr., only found in Guam and Rota, and *Pangium edule* Reinw. (raual), of wide distribution in the Malayan region, are examples of the family Flacourtiaceae. The myrtle family contains three species of restricted geographical distribution. These include *Eugenia reinwardtiana* DC. (aabang), *E. palumbis* Merr. and *E. thompsonii* Merr. All except the first, which is found in the Carolines and Moluccas, occur only in the Marianas. *Elaeocarpus joga* Merr. (joga), distributed only in the Marianas, is a member of the Tiliaceae. Two representatives of the spurge family which do not extend beyond the Marianas, are *Claoxylon mariannum* Muell.-Arg. (panao) and *Macaranga thompsonii* Merr. *Artocarpus communis* Forst. (dugdug, dugdog or bread fruit), a species cultivated in many tropical countries, and *Pseudomorus brunoniana* (Endl.) Bur., of wide distribution in Polynesia, Australia and New Guinea, are examples of the family Moraceae. Other members of this family include the endemic *Ficus mariannensis* Merr. (nunu) and *F. tenuistipula* Merr., a species also found in Saipan. The nettle family is represented by *Pipturus argenteus* (Forst. f.) Wedd. (amahadyan), extending from Malaya to Polynesia. *Aglaia mariannensis* Merr. (mapunao) and *Disocalyx megacarpa* Merr., representatives of the Meliaceae and Myrsinaceae, respectively, are found only in the Marianas. Loganiaceae are represented by *Fagraea sair* Gilg & Benedict which also is found in the Carolines. Examples of the Rubiaceae include two species known only to the Marianas, *Tarenna glabra* Merr. and *Psychotria mariana* Bartl. (aplochating). Other members of this family include *Ixora triantha* Volkens, otherwise only known to Yap, and *Randia racemosa* (Cav.) F.-Vill. (sumac, sumag), ranging from the Ryukyus and southern China to Malaya and tropical Australia. Representatives of the screw-pine family are *Pandanus kafu* Martelli (kafu, kafo), known only to Guam and Saipan, and *P. dubius* Spreng. (pahong, pahon), distributed from India to the Carolines and Marianas southward to New Hebrides. In addition to the trees already mentioned, there is a number of strand trees which are characteristic of the forests. These species are *Cycas circinalis*, *Hernandia ovigera*, *Hibiscus tiliaceus*, *Ochrosia parviflora*, *Morinda indica*, *Cordia subcordata* and *Ximenia americana*.

As previously mentioned, the forest shrubs are poorly represented on Guam. Piperaceae contain one endemic species, *Piper guahamense* C. DC. (pupulo aniti). *Guamia mariannae* (Safford) Merr., a member of the family Annonaceae, is known only to the Marianas. *Triphasia trifolia* (Burm. f.) P. Wils. (limon de China, lemoncito), an example of the rue family which is widely distributed in the tropics of the Old World, forms thickets on the edges of forests. The spurge family contains *Glochidion marianum* Muell.-Arg. (chosgo, chosgu), a species otherwise known only to Samoa and Tonga. *Merrilliodendron rotense* Kanehira, a member of the family Icacinaceae, is found only on Guam and Rota.

Even though the vascular epiphytes are extremely abundant, there are only a few families represented. Polypodiaceae contain a number of species which are widely distributed in the Old World tropics. *Antrophyum plantagineum* (Cav.) Kaulf., *Cyclophorus lanceolatus* (L.) Alst. and *Vittaria elongata* Sw., extend from tropical Asia to Polynesia. Two examples of *Asplenium* are *A. laserpitifolium* Lam., and *A. nidus* L. (galak, galag or bird's nest fern). The former species is distributed from Malaya to Australia and Polynesia, and the latter one ranges from Himalaya, Japan, Formosa, eastward to the Society Islands. *Nephrolepis biserrata* Schott is pantropical, *Davallia solida* (Forst. f.) Sw. (pugua machena) is distributed from Malaya to northern Australia and Polynesia, and *Humata heterophylla* (Sm.) Desv. is found in Malaya and Polynesia. *Polypodium* is represented by *P. punctatum* (L.) Sw., extending from tropical Africa, Asia through Malaya to Polynesia, and *P. scolopendria* (kahlau) Burm.f., which is distributed from tropical Africa and Asia to Australia and Polynesia. The endemic species of orchids are *Bulbophyllum guamense* Ames, *Dendrobium guamense* Ames, *Saccolabium guamense* Ames and *Taeniophyllum fasciola* (Forst. f.) Reichb. f. (kamuke nanofe). In addition to the orchids mentioned above, two species of *Phreatia* are found, *P. thompsonii* Ames, also known from the Carolines, and *P. samoensis* (Kranzl.) Schlechter.

In some sections of Guam the lianas are so numerous as to make passage impossible. The most abundant species is *Flagellaria indica* L. (bejuco halomtano), a member of the Flagellariaceae which extends from tropical Asia to Malaya. The screw-pine family is represented by *Freycinetia mariannensis* Merr. (fianiti), a species known only to the Marianas. *Abrus precatorius* L. (kolales halom-tano or coral bead vine), an example of the legume family, and *Ipomoea hederacea* (L.) Jacq., one of the morning glories, are both pantropical. Another member of the morning glory family is *Ipomoea indica* (Burm.) Merr. (fogfu), distributed from Formosa to the Moluccas, tropical Australia and Polynesia. A representative of Cucurbitaceae is *Melothria guamensis* Merr., also known from Ponape and Saipan. The milkweed family contains the endemic species, *Dischidia puberbula* Decne., and the Apocynaceae are represented by *Alyxia torresiana* Gaudich., found only in the Marianas. *Morinda glandulosa* Merr., also known from Saipan, is an example of the madder family.

Cassytha filiformis, *Entada phaseoloides* and *Mucuna gigantea*, characteristic strand lianas, are usually found along the outskirts of forests.

Generally, the forests are not matted with undergrowth to any great extent, except where the trees are few in number. The species comprising the ground cover are usually confined to the forests, but they often extend to the strand, marshes and waste places. Polypodiaceae are represented by *Asplenium macrophyllum* Sw., ranging from India to the Mascarene Islands and Polynesia, *Dryopteris didymosora* (Parish) C. Chr., occurring in the warmer parts of both hemispheres, and *Tectaria crenata* Cav., widely distributed in Malaya. *Peperomia guamana* C. DC. (podpod palauan), an endemic species, is a member of the Piperaceae. The nettle family contains *Procris pedunculata* (Forst. f.) Wedd., extending from Malaya to Polynesia. *Polyscias grandifolia* Volken, known only from the Marianas and Carolines, and *Alocasia macrorrhiza* (L.) Schott, widely distributed in the Indo-Malayan region, are representatives of the Araliaceae and Araceae, respectively. *Tacca pinnatifida* Forst. (gabgab, gaogao or Polynesian arrowroot), an example of the Taccaceae, ranges from tropical Africa and Asia through Malaya to Australia. The ginger family contains *Zingiber zerumbet* (L.) Sm. (asngod halomtano or wild ginger), a native of tropical Asia which is distributed in the tropics of both hemispheres. *Canna indica* L. (mango halom tano), a member of Cannaceae, is pantropical.

According to Graff (3), the following genera of fungi are attributed to Guam: *Phyllachora*, *Auricularia*, *Hirneola*, *Polyporus*, *Fomes*, *Polystictus*, *Trametes*, *Hexagonia*, *Laschia*, *Schizophyllum*, *Lentinus*, *Coprinus*, *Naucoria*, *Phoma*, and *Cladosporium*. The same author also lists the following genera of lichens: *Pseudopyrenula*, *Bottaria*, *Arthonia*, *Graphis*, *Coenogonium*, *Lecidia*, *Leptogonium*, *Pannaria*, *Coccocarpia*, *Pertusaria*, *Parmelia*, *Romalina*, *Physcia*, *Anaptychia*, and *Rhipodonema*.

Merrill (8) has listed a number of bryophytes. The liverworts include: *Frullania*, *Dicranolejeunea*, *Radula*, and *Thysananthus*. *Neckeropsis*, *Macromitrium*, *Syrrhopodon*, *Thuidium* and *Ectropothecium*, comprise the genera of mosses.

F. MARSH PLANTS

In the southern portion of the island, near the towns of Piti and Agate (PLATE I), there is a number of low, damp areas in which marsh plants grow. The Agana marsh in the central section of Guam is the largest marshy area on the island. During the rainier part of the year several small marshes appear in the Mt. Santa Rosa region.

Phragmites karka (Retz.) Trin. (karriso), one of the grasses extending from India to Malaya, is the most abundant marsh plant. Other members of the grass family include *Bambusa vulgaris* Schrad. (pio palaoan), *Echinochloa colonum* (L.) Link (chaguan agaga), *Paspalum conjugatum* Berg., and *P. orbiculare* Forst. All the mentioned species except the last one, which is found in the Indo-Malayan region, are pantropical.

Cyperaceae are represented by *Cyperus difformis* L., *Fimbristylis annua* (All.) R. and S., *F. miliacea* (L.) Vahl, and *Scleria lithosperma* (L.) Sw. *Fimbristylis annua* is also known from the Carolines, while the other species are widely distributed in the tropics of both hemispheres. *Polygonum barbatum* L. (Mamka) ranging from tropical Asia to Malaya, is an example of the buckwheat family. The families Umbelliferae and Scrophulariaceae each contain one species of pantropical distribution, while the legume family is represented by a species of extensive distribution in the Old World Tropics. These species include *Centella asiatica* (L.) Urban, *Bacopa monniera* (L.) Wettst. and *Aeschynomene indica* L., respectively. *Psilotum nudum* (L.) Griseb., a member of the Psilotaceae, extends to the tropics of both hemispheres. Schizaeaceae is represented by *Lygodium scandens* (L.) Sw. (alambrillo), occurring from tropical Africa and Asia to Australia. *Dryopteris gongylodes* (Schkuhr) O. Ktze. and *Acrostichum aureum*, both pantropical plants, are members of the Polypodiaceae.

G. PLANTS OF GRASSLANDS

There are two distinct kinds of grasslands on Guam, savannas and "microsavannas." Savannas are grassy upland regions with scattered trees and shrubs. The soil in these regions is poorly drained, and is deficient in organic matter. Many mountain areas on the southern end of the island e.g., Mt. Tenjo (PLATE I), support a savanna type of vegetation.

The microsavannas differ from the savannas by the absence of woody species characteristic of the latter. Besides this, in the microsavanna regions the soil is rich in nitrates, and is well drained. The most pronounced microsavanna regions are around the vicinity of Mt. Santa Rosa. Some plants, such as *Miscanthus floridulus*, *Paspalum orbiculare*, *Fimbristylis annua*, *Lygodium scandens*, *Schizoloma ensifolium* and *Melastoma marianum*, occur in both kinds of grasslands.

Casuarina equisetifolia, a typical strand plant, is the only tree found in the savannas. Shrubs are represented by several species which are few in numbers of individuals. *Melochia villosissima* (Presl) Merr. and *Timonius nitidus* (Bartl.) F.-Vill., are endemic members of the Sterculiaceae and Rubiaceae, respectively. The myrtle family contains *Decaspermum fruticosum* Forst., extending from India and China through Malaya to tropical Australia, and *Myrtella bennigseniana* (Volkens) Diels, known only from Guam and Yap. *Geniostoma micranthum* A. DC., an example of the Loganiaceae, is known only from the Marianas. Thymelaeaceae is represented by *Wikstroemia elliptica* Merr., found only in the Marianas and the Carolines. *Melastoma marianum* Naud., occurring in the Marianas and the Carolines, is a member of the Melastomataceae. In addition to the shrubs mentioned above, two strand plants occur, *Pemphis acidula* and *Scaevola frutescens*.

The most abundant plant in the savannas is *Miscanthus floridulus* (Labill.) Warb. (neti, tipun-neti), a grass which is distributed from Formosa to Australia and Polynesia. Other members of the grass family are

the endemic *Dimeria chloridiformis* (Gaudich.) K. Schum. & Lauterb., *Centotheca latifolia* (Osb.) Trin., extending from tropical Asia and Africa through Malaya to Australia and Polynesia, and *Andropogon fragilis* R. Br., found in the Philippines, southern China, New Guinea, and in tropical Australia. *Cladium gaudichaudii* W. F. Wright, known only to Guam and the Carolines, *Rhynchospora rubra* (Lour.) Makino, ranging from tropical Africa and Asia to Japan southward to Australia and Polynesia, and *Scleria lithosperma*, are representatives of Cyperaceae. An example of the lily family is *Dianella ensifolia* (L.) DC., occurring from India to Malaya and Polynesia. Amaryllidaceae includes *Curculigo orchiioides* Gaertn., extending from India to Malaya. *Phyllanthus saffordii* Merr., known only to Guam, and *Euphorbia vachellii* H. & A., ranging from southern China to Malaya and tropical Australia, are examples of the spurge family. The composite family is represented by *Glossogyne tenuifolia* Cass., occurring from southern China and Formosa southward to Australia, and *Wedelia canescens* (Gaudich.) Merr. (masigsig chunge), known only to the Marianas. *Psilotum nudum*, a member of the Psilotaceae, and *Lycopodium cernuum* L., an example of the Lycopodiaceae, are both pan-tropical. *Gleichenia linearis* (Burm. f.) Clarke (mano), found in the warmer parts of both hemispheres, is a representative of Gleicheniaceae. Members of the Polypodiaceae include *Blechnum orientale* L. and *Cheilanthes tenuifolia* (Burm. f.) Sw., both ranging from tropical Asia to Polynesia; *Dryopteris cucullata* (Bl.) Christ is distributed from the Mascarene Islands to Malaya; and *Schizoloma ensifolium* (Sw.) J. Sm. extends from tropical Africa and Asia to Polynesia.

As in the savannas, the most abundant plant in the microsavannas is *Miscanthus floridulus*. Other species of grasses found in the microsavannas include *Andropogon aciculatus* Retz., occurring from India to China southward through Malaya to tropical Australia, and *Paspalum conjugatum*. The sedges are represented by *Mariscus cyperinus* (Retz.) Vahl, distributed from tropical Asia to Polynesia, and *Fimbristylis miliacea*. *Eulophia guamensis* Ames, an endemic orchid, also occurs in these regions. Polypodiaceae are represented by *Nephrolepis hirsutula* (Forst. f.) Presl, extending to the tropics of both hemispheres. Several common weeds are occasionally found in the microsavannas. *Hyptis capitata* Jacq. (batunes, botones), one of the mints native of tropical America, is known in the orient from the Philippines, Formosa, Java and Amboina. Acanthaceae and Compositae are represented by *Blechnum pyramidatum* (Lam.) Urb. and *Elephantopus mollis* HBK., respectively. Both species are native of tropical America, and are also known in the Orient from the Philippines, Formosa and Celebes.

H. PLANTS OF ABANDONED CLEARINGS

These areas are usually overgrown with common tropical weeds, escaped cultivated plants and indigenous species. Herbs, especially annuals, dominate these artificial areas; however, several species of shrubs and small

trees, such as *Triphasia trifolia*, *Jatropha curcas*, *Melanolepis multiglandulosa*, *Melochia odorata*, *Cestrum nocturnum* and *Carica papaya*, form thickets. In recently cleared fields, the papaya is able to gain a foothold and dominate the area to an extent that many other species of plants are excluded.

The species growing in abandoned clearings are classified into three groups, those definitely or probably native of the Old World, those definitely or probably native of the New World, and lastly, species of uncertain origin.

Representatives of the first group are as follows: *Achyranthes bidentata* Bl. (chichitun), *Oxalis repens* Thunb. (agsom, apsom), *Luffa cylindrica* (L.) Roem. (pachodag), *Corchorus acutangulus* Lam. (masigsig lahe), *Melochia odorata* L. f., *Abutilon indicum* (L.) Sweet (malbas, matbas or Indian mallow), *Melanolepis multiglandulosa* (Reinw.) Reichb. (alom, alum), *Phyllanthus marianus* Muell.-Arg., *Ricinus communis* L. (agaliya or castor bean), *Alysicarpus vaginalis* (L.) DC., *Crotalaria quinquefolia* L. (cascabeles), *Dolichos lablab* L., *Oldenlandia corymbosa* L., *Emilia sonchifolia* (L.) DC., *Glossogyne tenuifolia*, *Sonchus oleraceus* L., *Heliotropium ovalifolium* Forsk., *Merremia gemella* (Burm. f.) Hallier f. (nyetcor), *M. hederacea* (Burm. f.) Hallier f., *Digitaria stricta* Gaudich., *Oplismenus undulatifolius* (Ard.) Roem. and Schult., *Panicum ambiguum* Trin., *Pennisetum polystachyum* (L.) Schult., and *Thuarea involuta*.

Natives of the New World include: *Amaranthus spinosus* L. (kuletes), *Boerhaavia diffusa* L. (dafau or glue weed), *Passiflora foetida* L. var. *hispida* (DC.) Killip, *Carica papaya* L., *Psidium guajava* L. (abas or guava), *Muntingia calabura* L., *Triumfetta semitriloba* Jacq. (dadangsi), *Waltheria americana* L. (matico), *Malachra capitata* L. (pagopago), *Euphorbia heterophylla* L. (poinsettia), *Jatropha curcas* L. (tubatuba or physic nut), *Cassia occidentalis* L. (mumutun sable, negro coffee or coffee senna), *C. tora* L. (amottomaga), *Calopogonium mucunoides* Desv., *Crotalaria mucronata* Desv., *Leucaena glauca* (L.) Benth. (tangantangan), *Asclepias curassavica* L. (Curacao milkweed), *Mitrocarpum hirtum* (L.) DC., *Ageratum conyzoides* L., *Elephantopus mollis*, *Synedrella nodiflora* (L.) Gaertn., *Heliotropium indicum* L. (berbena), *Capsicum frutescens* L. (doni or Cayenne pepper), *Cestrum nocturnum* L. (dama de noche), *Datura metel* L. (las doce), *Lycopersicon esculentum* Mill. (tomate or tomato), *Physalis angulata* L., *Ipomoea triloba* L., *Quamoclit pennata* (Desr.) Boj. (cebello del angel or cypress vine), *Blechnum pyramidatum*, *Stachytarpheta jamaicensis* (L.) Vahl, *Hyptis capitata*, *H. mutabilis* (A. Rich.) Briq., *H. spicigera* Lam., *H. suaveolens* Poir., *Cenchrus echinatus* L., and *Chloris inflata* Link.

Species of uncertain origin are *Polanisia icosandra* (L.) W. and A. (mongos paloma), *Portulaca oleracea* L., *Momordica charantia* L. (almagoso or balsam pear), *Sida acuta* Burm. f. (escobilla adumelon), *S. rhombifolia* L. (escobilla dalili), *Urena lobata* L. (dadangsi, dadansi), *Acalypha indica* L., *Euphorbia hirta* L. (golondrina), *Desmodium triflorum* (L.)

DC. (agsom, apson), *Teramnus labialis* (L.f.) Spreng. (chaguan cacagua-tes), *Adenostemma lavenia* (L.) O. Ktze., *Solanum nigrum* L., *Dactyloctenium aegyptium* (L.) Richt. (Egyptian grass), *Eleusine indica* (L.) Gaertn. (umog), *Eragrostis amabilis* (L.) W. and A., *Setaria verticillata* (L.) Beauv., and *Cyperus rotundus* L.

GEOGRAPHICAL DISTRIBUTION OF SPECIES

The flora of Guam is essentially Malayan. Nearly all the indigenous genera found there are of wide Indo-Malayan distribution.

There are 66 species endemic to the Marianas. Certain species, such as *Lygodium semihastatum* (Cav.) Desv., *Halophila ovata* and *Bulbophyllum profusum* Ames, are confined to Guam and the Philippines. Some other species, *Ixora triantha* Volken and *Myrtella benningseniana*, occur only on Guam, and the island of Yap in the Carolines. More than eighty per cent of the species found on Guam also occur in the Philippines, and nearly the same percentage of species extend to the Carolines.

According to Hosokawa (5), the floras of the Bonins and the Marianas show a marked phytogeographical discontinuity. The flora of the Bonins forms a transition zone between temperate east Asia and Micronesia, showing a closer relation with the former. On the other hand, the flora of the Marianas is principally tropical, and therefore has not been influenced by floristic elements migrating from temperate east Asia. There are no species of plants found exclusively in these two groups of islands. Certain families common to the Marianas, such as Taccaceae and Casuarinaceae, apparently have never been found in the Bonins.

According to the writer's recent tabulations, approximately 510 species (excluding species of cultivated plants), belonging to 455 genera and 100 families of vascular plants have been listed for Guam. Pteridophytes are represented in this list by 47 species belonging to 27 genera and 11 families. There is only one gymnosperm, *Cycas circinalis*. The remainder consist entirely of angiosperms.

There are no endemic genera, and only 32 endemic species on Guam. The latter number is about seven per cent of the total recorded species, and is surprisingly small when one considers the isolated position of the island. In the Philippine Islands, which are much closer to the continental land mass, sixty eight per cent endemism exists (10), and in the Hawaiian Islands more than eighty-five per cent of the species are endemic to that region (2). The low percentage of endemism on Guam can be explained by the fact that the island is geologically recent, and that extensive destruction by man of the original vegetation has exterminated some of the endemics.

More than one-half of the total number of species are of pantropical distribution. It is impossible to determine in which hemisphere twenty per cent of these pantropical species originated because of their universal abundance, and because of absence of early records. Of the remainder,

however, forty per cent are definitely or probably of American origin, and forty per cent probably originated in the eastern hemisphere.

INTRODUCED AND NATURALIZED SPECIES

According to Merrill (8), the period during which foreign species were brought to Guam, can be divided into four subdivisions of time. In the first or prehistoric period, the Chamorros, who were the aboriginal inhabitants, brought some of their food plants, such as breadfruit, yams, coconuts, bananas and rice from Malaysia, or from Polynesia. Undoubtedly some weeds of wide Indo-Malaysian distribution such as *Glossogyne tenuifolia*, *Merremia gemella* and *M. hederacea*, reached the island at the same time.

The second period extends from the discovery of the island by Magellan in 1521 to the discontinuance in 1815 of the voyages of the Spanish galleons from Acapulco, Mexico, to Manila via Guam. The plants introduced in this era were mainly of American origin, e.g., sweet potato, corn, tobacco, cocoa, peanut, tomato, cassava and papaya. At the same time many weeds of American origin, such as *Mitrocarpum hirtum*, *Ipomoea triloba* and *Elephantopus mollis*, were introduced. It is believed that a number of weeds of oriental origin made their appearance from Manila, for economic plants such as coffee, tamarind, mango, nipa palm and some citrus fruits were also brought in.

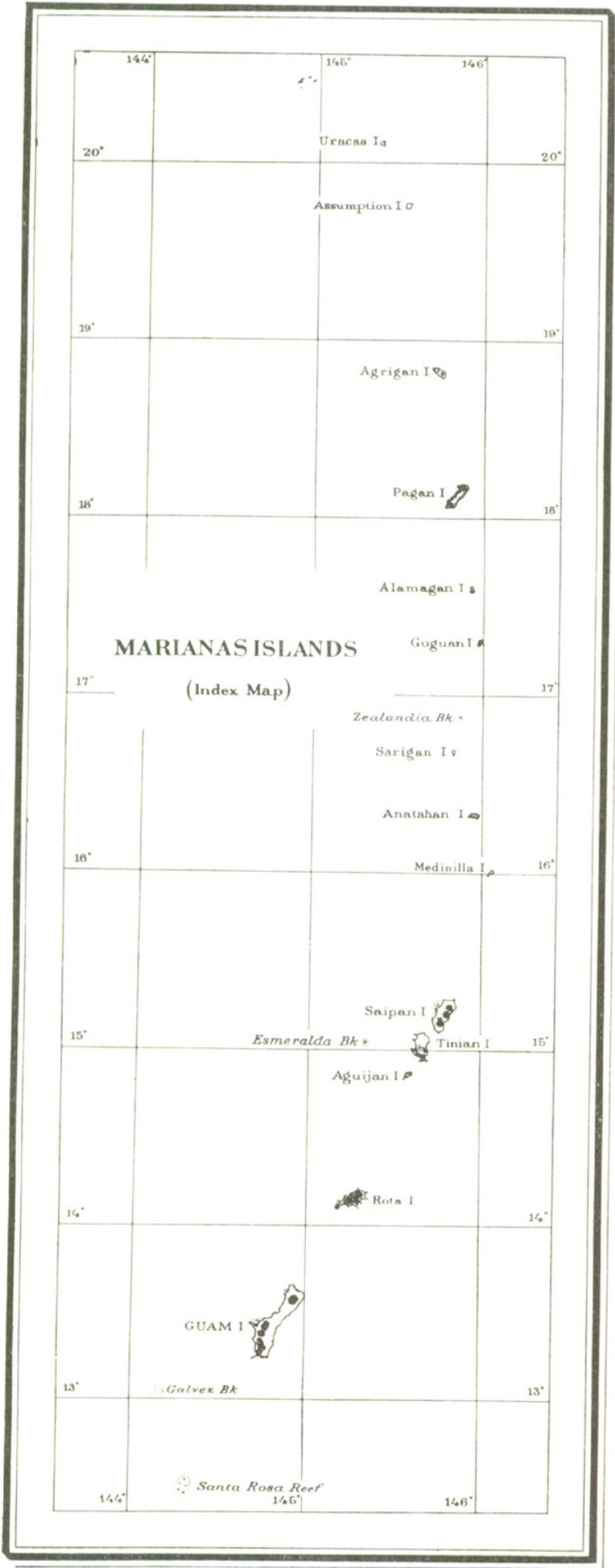
During the third period, from 1815 to 1898, when the visits of the Spanish galleons ceased, and Spain lost control of Guam and the Philippines, relatively few new plants reached the island.

The last period dates from the American occupation in 1898 to the present time. Ornamental species from Hawaii, such as *Carissa grandiflora* (E. Mey.) A.DC. and *Tabernaemontana divaricata* (L.) R. Br., were introduced during this time. According to new records based on the writer's collection (11), several weeds of New World origin, including *Eichhornia crassipes*, *Passiflora foetida* var. *hispidula*, *Calopogonium mucunoides*, and *Chloris inflata*, and one weed species of Old World origin, *Sonchus oleraceus*, has been introduced recently.

SUMMARY

Although there has been a number of collections made from Guam, further botanical exploration is needed before the flora of this island can be thoroughly understood. That this is true is attested by the fact that the writer in 1946 was able to add new Guam records of 17 species among 300 numbers.

The plants of Guam are grouped under the following headings: Coral Reefs, Strand, Mangrove Swamps, Rivers and River Banks, Forests, Marshes, Grasslands, and Abandoned Clearings. The flora of Guam is essentially Malayan, and most of the indigenous genera are widely distributed in the Indo Malayan region. Certain species are known only from Guam and the Philippines, and some other species are confined to Guam and Yap. The floras of the Marianas and the Bonins show a marked phytogeographical discontinuity.



SURVEY OF THE PLANTS OF GUAM

According to the writer's recent tabulations, 510 species, belonging to 455 genera and 100 families of vascular plants, have been listed for Guam. Considering its isolated position, the island has a low percentage of endemic species. This can be explained by the fact that Guam is of recent geological origin, and that extensive destruction by man of the original vegetation has exterminated some of the endemics.

More than half of the total number of species are distributed in the tropics of both hemispheres. It is impossible to determine in which hemisphere 20 per cent of these pantropical species originated, while 40 per cent are of American origin, and 40 per cent originated in the eastern hemisphere.

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EXPLANATION OF PLATES

PLATE I. Guam Island showing the various localities mentioned (U. S. Coast and Geodetic Survey).

PLATE II. Marianas Islands showing relative position and size of Guam (U. S. Coast and Geodetic Survey).

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