The Phytogeography of Guam, Marianas Islands*

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Our knowledge of the flora of Guam has accumulated rather slowly since Magellan's discovery of the island in 1521, and is based on the studies of a number of botanists, including Gaudichaud, Safford, Merrill (1914), Glassman (1948), Walker and Rodin, Wagner and Grether, Bryan, Stone (1964) and Fosberg, to name but a few. The island is the southernmost in the Marianas Chain, and phytogeographically can scarcely be considered alone, but forms with the southern Marianas Islands—Rota, Tinian, Agiguan, and Saipan—a natural phytogeographic unit. Virtually all plants known in Guam also occur in the other Southern Marianas, and only a few plants occur in the Marianas except for Guam. These are mostly plants of the Northern Marianas, or a few species of Rota or Saipan not yet found in Guam (but probably occurring there). Thus, the phytogeographic position of Guam is essentially the same as for the Southern Marianas as a whole. Our knowledge of the islands of Rota, Tinian, and Saipan, is very largely due to the studies of R. Kanehira, T. Hosokawa (1934a-c), T. Tuyama, N. Fukuyama, and other Japanese scientists.

The total flora so far recorded for Guam comes to 931 species, including the native and the introduced vascular plants. There are 6 gymnosperms, 58 ferns and fern-allies, 262 monocots, and 605 dicots. These are distributed among a total of 546 genera, of which 37 are fern genera, 5 are gymnosperms, 142 are monocots, and 362 are dicots.

Of this grand total, the introduced element comprises approximately 63% of the total (585 of 931 species). Many of the introduced species are however quite rare. This grand total of 931 exceeds provious estimates by Glassman (of 510 species) and Hosokawa, (of 480 species for the whole Marianas Chain).

The Introduced plants may be arranged as follows:

(1) Crops and experimental plantings.
Monocots 51, Dicots 125. Total 176.

(2) Ornamental plants.
Gymnosperms 5, Monocots 56, Dicots 144. Total 205.

(3) Weeds.
Monocots 36, Dicots 136, Ferns 2. Total 174.

(4) Probably weeds, waifs, and rare escapes. Total 30.

Thus there is a total of 585 species of introduced plants.

This leaves a total of 346 species for consideration as native. Of this group, about 20 species are questionably native, of uncertain derivation, or of uncertain specific status, or are unsatisfactorily determined. Most of them will probably

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prove to be weeds or escapes. The remainder make up the native flora, which therefore comes to 327 species. This total includes 56 species of ferns and fern-allies, 1 gymnosperm, and 270 angiosperms (86 Monocots, 184 Dicots).

These 327 species are considered under the following 8 headings: (1) Endemic elements, found only in the Marianas Islands, especially the southern Marianas (Guam, Rota, Tinian, Saipan). (2) Endemic Micronesian element; found, in the Mariana Islands and Caroline Islands only. (3) Polynesian element, found in Polynesia and Micronesia. (4) Melanesian element, found in New Guinea, the Solomon Islands, New Hebrides, and environs, and in Micronesia, sometimes, but not necessarily, also in Polynesia. (5) Indomalaysian-Pacific element, found from India, Indian Ocean islands, through Malaysia to most Pacific Islands; sometimes not extending beyond Malaya to the west; sometimes found only in the Philippines in Malaysia. (6) Paleotropical element-Tropics of the Old World, Africa, India, Malaysia, and the Pacific. (7) Pantropical element-tropics generally. (8) Obscure or Special distributions.

The distribution of the 270 native species of Angiosperms is as follows.

(1) One genus (*Guamia* Merr., Annonaceae) is endemic in the Mariana Islands. It has one species, *G. mariannae*. It is close to the Malaysian genus *Polyalthia*.

Sixty-eight species and varieties (25.2%) are endemic in the Mariana Islands. [A very few, not counted below, are endemic but do not occur in Guam; for example, *Styphelia mariannensis*, *Meryta capita*, *Boerlagiodendron rotense*.]

Two taxa, *Balanophora pentamera* and *Leucaena insularum* var. *guamense*, have been found only in Guam]. Glassman (J. Arn. Arb. 29 : 183. 1948) concluded that 66 species were endemic in the Marianas.

(2) Micronesian element.—16 species or varieties (6%). A number of these are Marianas-West Carolines (Yap-Palau) or Marianas-West Carolines-Central Carolines (Yap-Palau, and Truk) in their distribution. Very few species show a Marianas-East Carolines (Ponape-Kusaie) distribution. This accords well with the proximity of the Marianas, Yap, and Palau, to the "Andesite Line."

(3) Polynesian element (including Fiji).—4 species. (1.4%).

(4) Melanesian element.—12 species. (4.4%).

(5) Indomalaysian-Pacific element.—95 species. (35.2%).
(Including a number with Marianas-Philippines distribution).

(6) Paleotropical element.—22 species. (8.2%).

(7) Pantropical element.—39 species. (14.4%).

(8) (a) Obscure or doubtful.—12 species. (4.4%).
(b) Special distribution: Bonins-Marianas.—1 sp. (0.3%).

The distribution of the 56 species of ferns is as follows:

(1) Endemic element.—2 spp. (3.6%).

(2) Micronesian element—combined with

(3) Polynesian element.—4 species. (7.2%).

(4) Melanesian element.—1 species. (1.8%).

(5) Indomalaysian-Pacific element.—total—21 species. (37.8%).
(a) Philippines-Marianas—1 sp.
(b) Philippines-Sumatra-Marianas—1 sp.
(c) Philippines, Borneo, New Guinea—1 sp.
(d) Indomalaysian wide distrib.—15 spp.

(6) Paleotropical element.—18 spp. (32.4%).
(7) Pantropical element.—10 spp. (18%).

Combined distribution of Vascular Plants (58 ferns, 270 Angiosperms), total 328 spp.:

(1) Endemic element.—70 spp. (21.3%).
(2) Micronesian element.—16 spp. (5.2%).
(3) Polynesian element.—8 spp. (2.6%).
(4) Melanesian element.—13 spp. (4.4%).
(5) Indomalaysian-Pacific element.—113 spp. (34%).
(6) Paleotropical element.—40 spp. (12.2%).
(7) Pantropical element.—49 spp. (15.2%).
(8) Dubious element.—14 spp. (4.5%).

The native flora of 328 species is distributed in 86 families, of which 10 families are ferns and fern-allies (the Polypodiaceae taken "sensu lato"); 1 family of gymnosperms, the Cycadaceae; 16 families of monocots; and 59 families of dicots.

Families represented in native flora

Gymnosperms—1, Cycadaceae.

Monocotyledons: 16 fams.

Pandanaceae, Zannichelliaceae, Potamogetonaceae, Ruppiaceae, Hydrocharitaceae, Gramineae, Cyperaceae, Palmae, Araceae, Flagellariaceae, Commelinaceae, Philydraceae, Liliaceae, Hypoxidaceae, Dioscoreaceae, Orchidaceae. [doubtful: ? Zingiberaceae].

Dicotyledons: 59 fams.

Casuarinaceae, Piperaceae, Ulmaceae, Moraceae, Urticaceae, Olacaceae, Balanophoraceae, Polygonaceae, Amaranthaceae, Nyctaginaceae, Aizoaceae, Portulacaceae, Ceratophyllaceae, Menispermaceae, Annonaceae, Lauraceae, Hernandiaceae, Capparidaceae, Leguminosae, Rutaceae, Meliaceae, Simarubaceae, Euphorbiaceae, Anacardiaceae, Icacinaceae, Sapindaceae, Rhamnaceae, Tiliaceae, Malvaceae, Sterculiaceae, Theaceae, Guttiferae, Flacourtiaceae, Cucurbitaceae, Thymeleaceae, Lythraceae, Rhizophoraceae, Combretaceae, Lecythidaceae, Myrtaceae, Melastomaceae, Araliaceae, Umbelliferae, Sapotaceae, Myrsinaceae, Primulaceae, Loganiaceae, Gentianaceae, Apocynaceae, Asclepiadaceae, Convolvulaceae, Boraginaceae, Verbenaceae, Solanaceae, Scrophulariaceae, Lentibulariaceae, Rubiaceae, Goodeniaceae, Compositae.

Ferns—10 fams.

The endemic species, varieties, and forms of Guam (including those of the Marianas in general) are as follows:

Ferns: 2 spp., *Ceratopteris gaudichaudii* Brongn.,* *Thelypteris maemonensis* (Wagner & Grether) Stone.*

Monocots: *Pandanus fragrans* Gaud., *Potamogeton mariannensis* C. & S., *Digitaria mariannensis* Merrill, *Ischaemum longisetum* Merrill, *Digitaria stricta* Gaud., *Dimeria*

* Both of these are weakly distinct or dubious as endemics.

chloridiformis Gaud., *Dendrobium guamense* Ames, *Taeniophyllum mariannense* Schltr., *Saccolabium guamense* Ames, *Bulbophyllum guamense* Ames. (10 species).

Dicots: *Peperomia mariannensis* DC., *Piper guahamense* DC., *Artocarpus mariannensis* Trécul, *Ficus microcarpa* L. f. var. *saffordii* (Merrill) Corner, *Ficus prolixa* var. *subcordata* Corner, *Elatostema calcareum* Merr., *Elatostema stenophyllum* Merr., *Dendrocnide latifolia* (Gaud.) Chew, *Balanophora pentamera* v. T., *Tinospora homosepala* Diels, *Guamia mariannae* (Safford) Merrill, *Hernandia labyrinthica* Tuyama, *Capparis cordifolia* Lamk., *Canavalia megalantha* Merr., *Leucaena insularum* var. *guamensis* Fosb. & Stone, *Serianthes nelsonii* Merr., *Tephrosia mariana* DC., *Aglaia mariannensis* Merr., *Claoxylon marianum* M.-A., *Euphorbia gaudichaudii* Boissier, *Macaranga thompsonii* Merr., *Phyllanthus saffordii* Merr., *Maytenus thompsonii* (Merr.) Fosb., *Allophylus holophyllus* Radlk., *Elaeocarpus joga* Merr.,* *Heritiera longipetiolata* Kanehira, *Xylosma nelsonii* Merr., *Eugenia bryanii* Kanehira, *Eugenia palumbis* Merr., *Eugenia thompsonii* Merr., *Medinilla rosea* Gaud., *Discocalyx megacarpa* Merr., *Maesa* sp. nov., *Jasminum marianum* DC., *Alyxia torresiana* Gaud., *Cerbera dilatata* Markgraf, *Tabernaemontana rotensis* (Kanehira) Fosberg ex Stone, *Bleekeria mariannensis* (A. DC.) Koidzumi, *Dischidia puberula* Decaisne, *Ipomoea indica* f. *albiflora* Stone, *Solanum guamense* Merr., *Bikkia mariannensis* Brongniart,** *Canthium odoratum* var. *tinianense* (Kanehira) Fosberg, *Hedyotis albido-punctata* (Merr.) Fosb., *Hedyotis megalantha* Merr., *Hedyotis foetida* var. *mariannensis* (Merr.) Fosb., *Hedyotis laciniata* Kanehira, *Morinda umbellata* var. *glandulosa* (Merr.) Fosb., *Psychotria mariana* Bartl. ex DC., *Psychotria hombroniana* (Baillon) Fosberg, *Psychotria rotensis* Kanehira, *Timonius nitidus* (Bartl.) F.-Villar, [*Wedelia biflora* var. *canescens* (Gaud.) Fosb.—also Yap ?]. (45 species, 7 varieties, 1 forma).

Of the crop plants, at least 19 species are probably of pre-European aboriginal introduction: *Bambusa vulgaris, Coix lachryma-jobi, Oryza sativa, Saccharum officinarum, Cocos nucifera, Tacca leontopetaloides* (?), *Dioscorea alata, D. esculenta, Musa sapientum and M. paradisiaca, Curcuma domestica, Zingiber zerumbet, Maranta arundinacea, Pangium edule, Areca catechu, Colocasia esculenta, Cyrtosperma chamissonus, Artocarpus altilis, Piper betle.* To this may be added a few species possibly of aboriginal introduction, i. e. *Cananga odorata, Inocarpus fagiferus, Canna edulis, Citrus aurantifolia, Luffa acutangula, Momordica charantia, Ipomoea aquatica, Mangifera indica, Boehmeria tenacissima, Ficus tinctoria, Moringa oleifera.*

Some of the ornamental species may also be of aboriginal introduction. These are: *Adenanthera pavonina, Cordyline fruticosa, Acalypha wilkesiana, Codiaeum variegatum, Polyscias fruticosa, P. scutellaria, P. pinnata, Pseuderanthemum carruthersii.* The time of introduction of all of these could however have been after 1521.

A large number of the introduced plants are from Mexico, Central or South America, and may be traced to the Spanish galleon route from Acapulco, Mexico, to Guam, and on to Manila, Philippines. The long Spanish occupation and governance of the island ensured that many crops, ornamentals, and weeds were introduced from the vicinity of Acapulco and from around Manila.

Important crops of America origin include, these 20 species: *Zea mays, Annona muricata, A. reticulata, A. squamosa, Persea americana, Vanilla planifolia, Xanthosoma* spp., *Ananas comosus, Hevea brasiliensis, Manihot esculenta, Gossypium*

* Apparently also in Palau.

** Probably not distinct from *B. tetrandra*.

barbadense, *Ceiba pentandra*, *Carica papaya*, *Lagenaria siceraria*, *Psidium guajava*, *Manilkara achras*, *Ipomoea batatas*, *Capsicum annuum*, *Nicotiana tabacum*, *Solanum lycopersicum*.

Some of the weeds of undoubted or probable American origin are the following 42 species: *Sagittaria subulata*, *Cenchrus echinatus*, *Paspalum conjugatum*, *Paspalum ciliatifolium*, *P. fimbriatum*, *Pennisetum setosum*, *Cassia alata*, *C. occidentalis*, *C. sophora*, *C. tora*, *Acacia farnesiana*, *Crotalaria quinquefolia*, *Indigofera suffruticosa*, *Leucaena leucocephala*, *Mimosa pudica*, *Zornia diphylla*, *Tribulus cistoides*, *Euphorbia cyathophora*, *E. geniculata*, *E. glomerifera*, *Triumfetta semitriloba*, *Malachra capitata*, *M. fasciata*, *Asclepias curassavica*, *Ipomoea triloba*, *Stachytarpheta jamaicensis*, *S. indica*, *Hyptis capitata*, *H. mutabilis*, *H. spicigera*, *H. suaveolens*, *H. pectinata*, *Capsicum frutescens*, *Physalis angulata*, *P. lanceifolia*, *Hippobroma longiflora*, *Ageratum conyzoides*, *Elephantopus mollis*, *Conyza bonariensis*, *Synedrella nodiflora*, *Pseudelephantopus spicatus*, *Tridax procumbens*.

Further American species, some weedy, some abandoned after cultivation, in old fields of Guam are: *Amaranthus spinosus*, *Passiflora foetida*, *Jatropha curcas*, *Calopogonium mucunoides*, *Crotalaria mucronata*, *Mitracarpum hirtum*, *Heliotropium indicum*, *Ipomoea quamoclit*, *Blechum brownei*, *Chloris inflata*.

Therefore of the 150 species of weeds in Guam, about 52 species are of New World origin. The remainder are either of Old World origin, or are pantropical and of obscure or unknown origin.

Notes on the Vegetation of Guam

Guam is a small island; it is not presently a high one, but it very likely was about 1000–1500 ft. higher at the maximum in the days when its volcanic activity first ceased building mountains.* It has also been subject to alterations of height and of relative sealevel, with the result that coral-reef derivative rocks and soils occur now at the very summit areas of the island. At least four sealevels [ancient beaches] can be discerned.

There is no evidence that Guam has been connected by overland transitions to the remaining Mariana Islands, but for plant dispersal the islands have been close enough [not over 60 miles] so that no major obstacle to dispersal among the southern Marianas has ever existed.

Guam displays five major types of substrate for plant life, excluding the aquatic fresh and the marine. These are: basaltic laterite [in the past, also young lavas and ash]; riverine mud, chiefly derived from laterite; coral rock and its derivative clay soils; coral sand, derivative of coral rock by wave action, hence always therefore as beaches; and finally, mixtures of coral and laterite soils [argillaceous soils].

The coral rock and its derived soil supports a larger number of species than any of the other substrates. This can be viewed in 2 possible ways: (1) the coral rock+soil positively provides a better substrate for plant growth and at the same time provides more niches [via stronger microclimate differences, or varying

* Based on the premise that the average height achieved by volcanism in a given locality remains roughly the same from cone to cone, and can therefore be judged on the basis of extant live cones. In the Marianas, the live cone (Pagan) is about 3000' alt.

micronutitional differences], or (2) the laterite is negative in effect, i. e. *prevents* the growth of various plants.

One plausible hypothesis suggests that the laterite soils are more restrictive chiefly because of their tendency to become quickly waterlogged, and to stay thus for long periods. In contrast, the coral soils are well and rapidly drained by vertical percolation, and well aerated.

The coral substrates probably also provide a greater diversity of niches. For example; the various degrees of fragmentation, ranging from essentially solid, though porous and rather brittle, coralline rock, through in termediate stages to fine, alkaline, red clays, seldom of much thickness [up to a few inches] but rich in nutrients.

Finally the abundance of calcium, chiefly as carbonate, with the concomitant slightly to highly alkaline pH of the coralline substrate, provides a significant difference for plants.

It is therefore not surprising to find that the great majority of the endemic plants in Guam's flora are plants of the coral substrate. Only a few occur in other habitats [e. g. *Potamogeton mariannensis*, fresh water; *Pandanus fragrans* forma *savannarum* chiefly on laterite; *Hedyotis megalantha* on laterite]. A number of species which occur on both laterite and coral substrates have slightly different forms, e. g. *Pandanus*. The laterite substrates may however support species endemic in a slightly larger area, e. g. *Myrtella bennigseniana* (Marianas-West Carolines). The really marked and significant endemics, e. g. *Guamia* (Annon.), with 1 sp., *Aglaia mariannensis*, *Eugenia thompsonii*, *Hernandia labyrinthica*, *Heritiera longipetiolata*, etc., are all limestone plants. Even the few peculiar strand forms are chiefly on the hard limestone beach rocks, not on sand alone, i. e. *Leucaena insularum* var. *guamense*.

Heritiera longipetiolata is probably derived form *H. littoralis* and *Hernandia labyrinthica* from *H. sonora*. Both are examples, in my opinion, of speciation of inland endemics of limestone forest, from littoral or riverine species (*Hernandia sonora* prefers sandy coasts, while *Heritiera littoralis*, despite its name, is just as much a riverine species or a semi-mangrove type). It may be suggested that the obviously abrupt changes in sealevel, especially where the relative sealevel rose, (as is evident from the old, raised beaches) provided a means whereby the floating fruits or seeds of these (and various other) species could be dispersed well toward the interior and to a relatively distinct ecological habitat.

Not all cases, however, resulted in changes leading to endemism and distinctness. *Calophyllum inophyllum*, *Barringtonia asiatica*, *Barringtonia racemosa*, *Pandanus dubius*, and *Caesalpinia bonduc* may be cited as examples of species producing floating fruits or seeds which have not shown any trends toward distinctness.

In *Pandanus fragrans* we have an intermediate example, i. e., inland forms, sometimes with obvious, if rather trivial, unique characters, do occur.

Possibly *Canavalia megalantha* is a case parallel to the endemic *Heritiera* and *Hernandia*.

It is of interest to note that *Barringtonia asiatica* is a very common inland plant in Saipan, forming one of the two or three dominant canopy forming species there even on the island's summit, Mt. Tagpochau. Yet in Guam, this plant is seldom found much above sealevel except where it has been planted, and is common on rocky limestone coasts. I can offer no explanation of this difference,

since *Barringtonia* is almost certainly naturally dispersed and deliberate planting is rare and possibly of recent occurrence only.

Other species to be considered are *Bleekeria mariannensis* and *Cerbera dilatata*; it is possible that these two species originated from widespread littoral species, but if so, the latter are no longer found in the Marianas. *Cerbera manghas*, however, still occurs in Palau.

Safford states (1905) that the pandans in Guam do not occur on the outer beach, but this is not the case; I have often seen *P. dubius* only a few feet from the ocean or lagoon (as at Tumon Bay), and *P. fragrans* also, though less commonly. I have also noticed on many occasions the phalanges of both species washed up on beaches, though whether they originated in Guam or elsewhere it is not easy to tell; however, they appear to have originated from Marianas plants.

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