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NO. 273

FLORISTICS AND ECOLOGY OF WESTERN INDIAN OCEAN ISLANDS

EDITED BY

M.-H. SACHET, D. R. STODDART, AND F. R. FOSBERG

ISSUED BY

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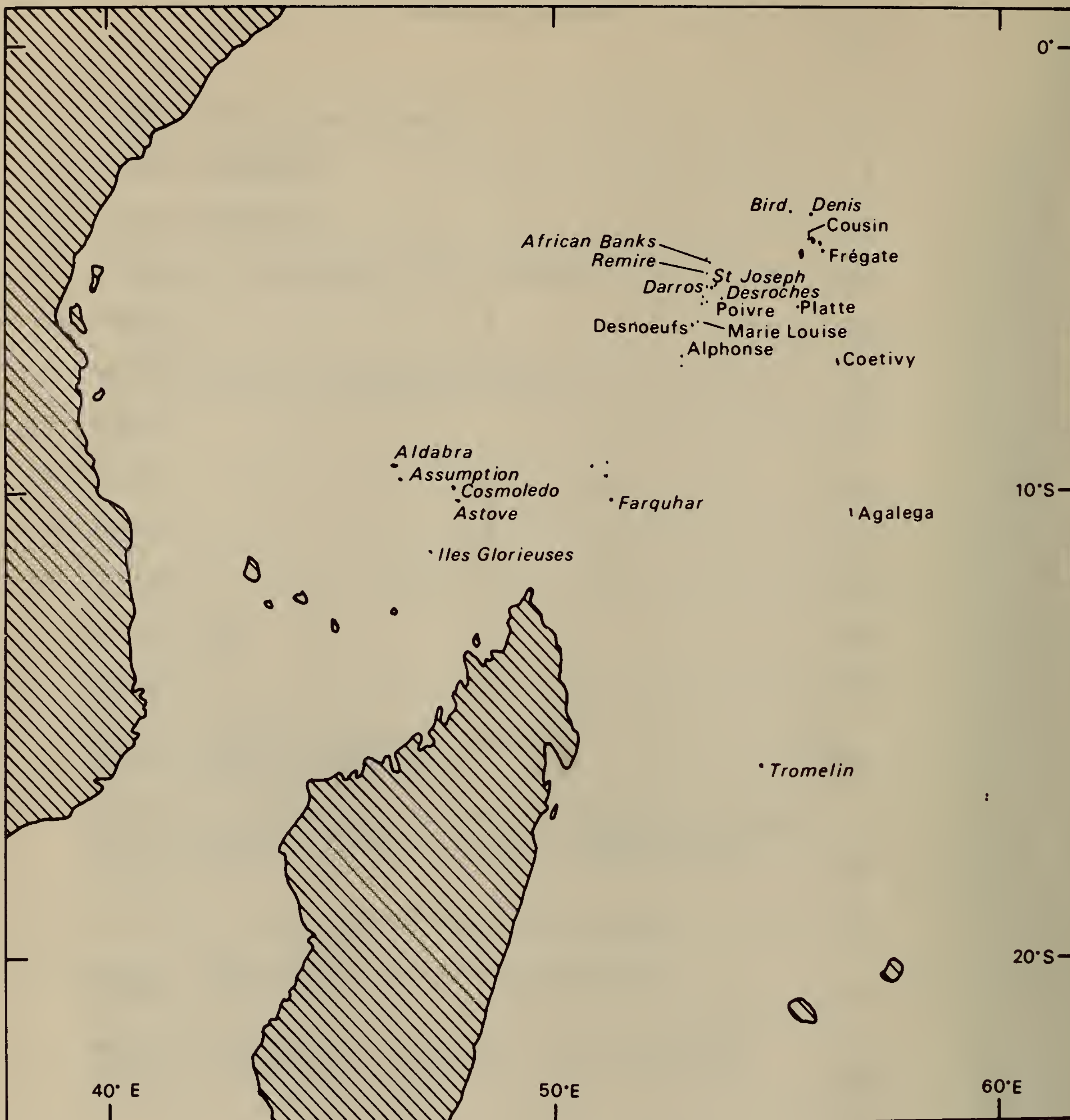

Figure 1. Western Indian Ocean islands. Islands named in Roman script are considered in this Bulletin, those in italic script have been treated in previous papers in this series.

FLORISTICS AND ECOLOGY OF WESTERN INDIAN OCEAN ISLANDS

1. INTRODUCTION

by D. R. Stoddart

At the time that the Royal Society of London and the Smithsonian Institution began studies of the marine and terrestrial ecology of western Indian Ocean coral reefs and islands, in 1966, this was one of the least known sectors of the world's reef seas. Only the sketchiest information was available for most of the islands between Madagascar and Seychelles (Stoddart 1967), and much of that dated from the early years of the century.

Since then, research has been concentrated at the Research Station built by the Royal Society at Aldabra Atoll in 1968-70, and operated since 1980 by the Seychelles Islands Foundation. The early summary accounts of Aldabra ecology (Stoddart, ed. 1967; Westoll and Stoddart, eds. 1971) have been greatly expanded, particularly with regard to the terrestrial fauna and flora (Stoddart and Westoll, eds. 1979). *The Flora of Aldabra and neighbouring islands* (Fosberg and Renvoize 1980) provides a critical account of the plants found on many of the western Indian Ocean coral islands as well as on the raised-reef islands of the Aldabra group itself, and replaces the earlier *Field Guide* of Wickens (1975). The origins and distributions of the western Indian Ocean island floras have been examined by Renvoize (1971, 1975, 1979), while on a smaller scale S. H. Hnatiuk (1979b) has applied island-biogeographic theory to the floras of small islets within the Aldabra lagoon. The role of dispersal mechanisms, germination and fertilisation has been studied at Aldabra by S. H. Hnatiuk (1978, 1979a), Wickens (1979a, 1979b) and Woodell (1979), though so far there have been few studies of other aspects of the land plants, such as genetics and physiology (Lewis 1975, R. J. Hnatiuk 1980).

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Much attention has also been given to vegetation studies at Aldabra. Fosberg's (1971) original classification of the vegetation has been examined by Hnatiuk and Merton (1979a, 1979b), and numerical techniques applied to the Mixed Scrub community by Newbery and Hill (1981). The mangroves have been studied by Macnae (1971), and the intertidal communities by Potts and Whitton (1980). Gillham (1977a, 1977b) has studied the effects of seabirds on vegetation, both at Aldabra and at Cosmoledo. Aldabra is, of course, the only remaining island in the western Indian Ocean to have retained its native population of Giant Tortoises, though many other islands had similar populations until about 150 years ago (Stoddart and Peake 1979). The effects of tortoise grazing on vegetation has been studied by R. H. Hnatiuk *et al.* (1976) and Merton *et al.* (1976). More recently Gibson and Phillipson (1983a, 1983b) have investigated primary productivity, with particular reference to tortoise grazing, while Gibson *et al.* (1983) have examined the response of vegetation to exclusion of tortoises in experimental plots.

Parallel with the Aldabra studies, every opportunity has been seized to expand our knowledge of other western Indian Ocean islands, both within and outside the Republic of Seychelles. In addition to data on land birds and seabirds, particular attention has been given to the flora, with the aim of establishing a basic knowledge of the distribution and composition of insular floras of vascular plants. In an earlier issue of the Bulletin, *Coral islands of the western Indian Ocean* (Stoddart, ed. 1970), floristic lists and much other information were presented for Assumption, Astove and Cosmoledo (elevated islands in the Aldabra group) (this information was revised in the *Flora of Aldabra*); Remire, Desroches and African Banks (coral islands in the Amirantes); and for Farquhar Atoll and Tromelin. Subsequently similar data have been provided for D'Arros and St Joseph in the northern Amirantes (Stoddart, Coe and Fosberg 1979), and for Bird and Denis Islands on the Seychelles Bank (Stoddart and Fosberg 1981).

In the present Bulletin, new information is presented on several more western Indian Ocean islands. These include the small granitic islands of Cousin and Frégate in the central Seychelles; the coral islands of Poivre, Marie-Louise, Desnoeufs and Alphonse in the southern Amirantes; the coral islands of Platte and Coetivy on the Seychelles Bank; and the two large isolated coral islands of Agelega. Figure 1 shows the location of these islands, and also of those previously examined in this series of island reports associated with the Royal Society, Smithsonian Institution, and Seychelles Islands Foundation research programme.

The final paper presents new information on rainfall variability on Aldabra itself, extending the analyses provided by Stoddart (1971), Stoddart and Mole (1977), Stoddart and Walsh (1979), Farrow (1971), and R. J. Hnatiuk (1979).

A substantial amount of floristic information is now available on the raised-reef and coral islands of the western Indian Ocean. A preliminary analysis of it has been made by Stoddart and Fosberg (in press), and a more substantial review, including the central and eastern Indian Ocean coral islands, is in preparation. It is, however, appropriate to note that information is still required on the flora and vegetation, as well as on other aspects of the terrestrial ecology, for islands such as St Pierre, Providence, Cerf, St Francois, Bijoutier, and the islands in the Mozambique Channel.

Acknowledgement

We thank the Department of Lands and Surveys, Mahe, Seychelles, for permission to base Figures 2, 4, and 7-12 on photomaps prepared by the Directorate of Overseas Surveys.

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2. NATURAL HISTORY OF COUSIN ISLAND

by F. R. Fosberg

Cousin Island is one of the relatively tiny and less well known of the Seychelles Archipelago. It was known to be the home of several of the rarer species of endemic land birds of the Seychelles, and to protect these from possible extermination, the International Council for Bird Preservation bought the island in January, 1968. It is now maintained as a sanctuary where all indigenous birds are given complete protection.

I was invited by Professor W. H. Thorpe, Chairman of the British Section of the Council, to visit the island and make a preliminary reconnaissance of the vegetation, to aid in handling any management problems that might arise. Fortunately it was possible to combine a visit to the Seychelles with an already-arranged trip to Ceylon, and through the courtesy and cooperation of the U. S. Air Force, to secure transportation to the Seychelles on the weekly amphibian plane that then serviced the Satellite Tracking Station on Mahê, largest island of the group. I wish to express the appreciation of the Smithsonian Institution, as well as my own gratitude for this indispensable help. I also wish to acknowledge the courtesy and helpfulness of the Pan-American Airways personnel and the others connected with this plane service and with the Satellite Tracking Station facilities, particularly Major Martin M. Manion and Capt. J. M. Smith, U.S.A.F., then commander and administrative officer of the Station. I wish, also, to thank Dr. S. Dillon Ripley, Secretary of the Smithsonian Institution, for suggesting that I accept Dr. Thorpe's invitation to visit the island to carry out this reconnaissance.

The vegetation map of Cousin Island, fig. 2, is adapted from the map by A. W. Diamond in the Cousin Island Nature Reserve Management Plan, and published by permission, for which I am grateful.

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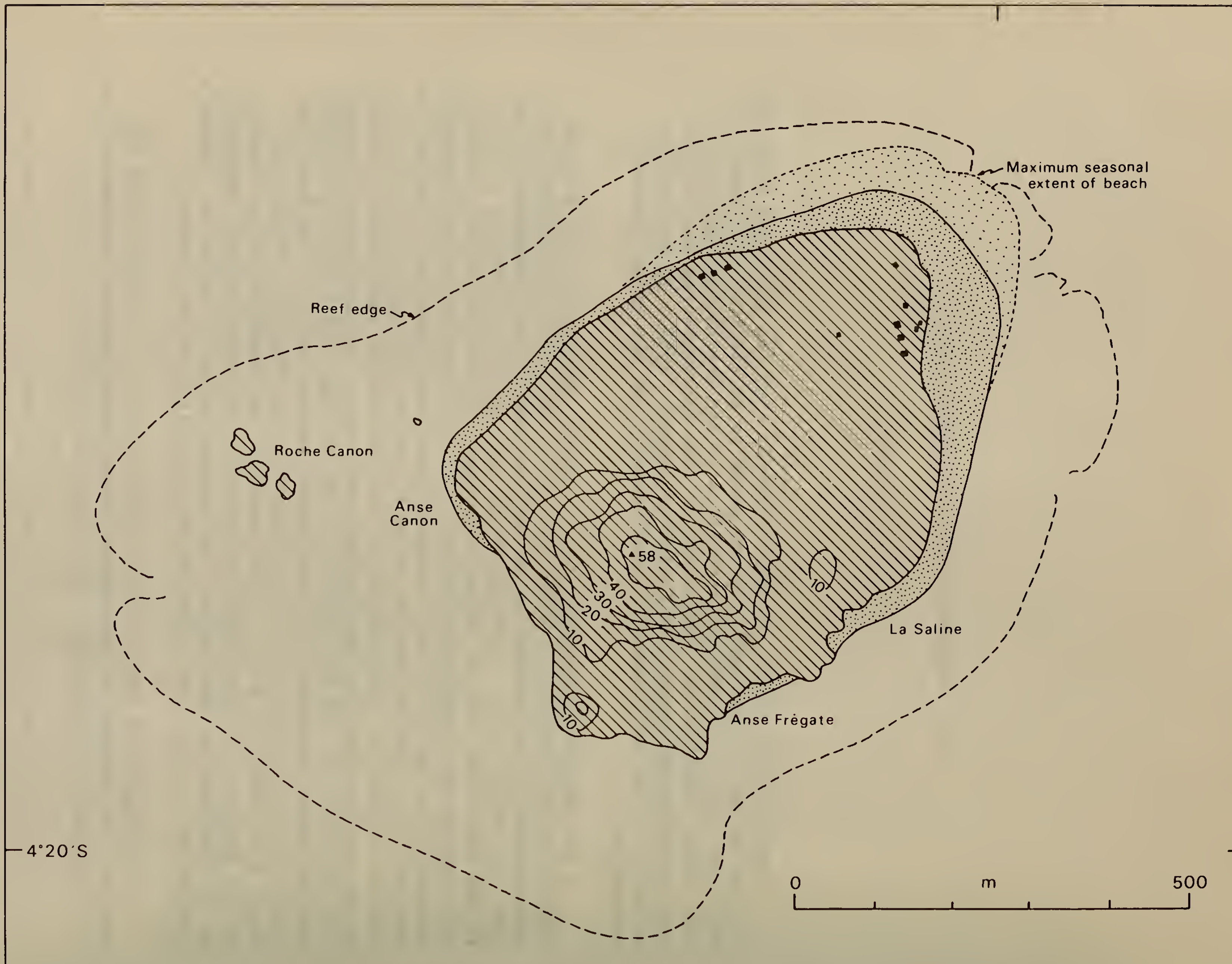

Figure 2. Cousin

My stay on Mahé, as well as travel to Cousin were enormously facilitated by a number of local residents of Victoria, Mahé, particularly Mr. J. F. G. Lionnet, then Director of the Department of Agriculture, Seychelles Govt., and his staff, especially Mr. S. M. Savy, Mr. Philippe Loustau-Lalanne, and Mr. R. M. Mason. Mr. Malcolm Penny, then resident ornithologist on the island, and his local staff, went to great pains to arrange my visit and make it comfortable, as well as introducing me to the island. Mr. Kantilal Jivan Shah, local intellectual and scientific enthusiast in Victoria, Mahé, extended hospitality and many courtesies.

I stayed on Cousin Island from noon, Jan. 21, 1970 to the morning of January 26, during which time I visited most parts of the island and collected 142 numbers of vascular plants, as well as 2 fungi.

This paper is a revised version of a report prepared for the International Council for Bird Preservation in 1970. The report was submitted to them in its original, preliminary form, especially lacking final identifications of a number of plant species, and has been in use by them since. Although much further work has been done on Cousin, especially by the series of managers stationed there by the ICBP, no further information has been made available to me, nor have any corrections or criticisms of the report been received. As the island is an important one for the survival of several endangered bird species, it seems desirable to publish this description of the island as it was in 1970, seen through the eyes of a non-ornithologist.

GEOLOGY AND GEOGRAPHY

Cousin is irregular in shape, roughly isodiametric, covers 68 acres and has an extreme elevation of 58 m. A little less than half is occupied by a granite outcrop, the remainder is flat and just above sea level, and is called locally the "plateau". The plateau has a surface of soft phosphatic sand-stone with superficial sand and humus accumulations up to a few cm deep, or deeper where cavities are filled. This surface has been artificially roughened by the local practice of digging large pits in the phosphatic rock for planting coconuts, with piles of broken cobbles between the pits.

Judging by the character of the rock, white particles in a brown matrix, and the present abundance of both young Pisonia trees and fish-eating birds, this phosphatic layer is unquestionably a beheaded Jemo soil (Fosberg 1954). The normal "mor" humus A-horizon has been largely lost by decomposition without renewal since the Pisonia forest was cleared and coconuts planted. The thickness of the phosphatic hard-pan layer here is striking. Holes excavated in it to a depth of one meter are common. It is not clear whether these penetrated through the layer, as they are partly filled with debris and no time was available to clean one out.

The granite hill is a ridge trending WNW-ESE. The slopes vary from a gentle smooth "glacis" (local name for bare smooth rock slopes) to ledges, crags and vertical cliffs. An unusual feature is the presence of obvious channel erosion, "lapies"-like or "rillenstein"-like fluting. This is not nearly so striking here, however as on nearby Cousine Island, or on certain cliffs on Silhouette Island, second highest of the Seychelles. On the summit ridge of this granite hill is some flat rock surface, broken by sharp ridges and monoliths.

At the north base of the granite hill, where it meets the phosphatic hard-pan layer, is an elongate depression extending across the island. In its central portion, near the well that supplies the drinking water for the island, this depression is deep enough to hold standing water and mud. Eastward toward the coast it becomes more abrupt, straight-sided. Westward it is more shallow and slopes in from both sides.

South of the granite hill around the coastal indentation called Anse Frégate is a much smaller flat area than that forming the north half of the island. Piggott (1968) implies that this has a Jemo soil, as has the north half, and Baker (1963) indicates both areas as phosphatic sandstone. Time was not available to check this adequately here, but certainly some phosphate is exposed. A depression containing a small mangrove swamp extends the length of this flat area, but not immediately against the base of the hill. On this south side the basal slopes of the hill are much more gentle, less abrupt than on the north side, although the upper slopes are steep and cliff-like. Along the beach of the eastern end of Anse Frégate is a conspicuous line of fossil beach-rock, reaching almost a meter higher than present beach level.

The "plateau" is partly lined, at the top of the beach, by a low sandy beach ridge, especially along the northwest and south and southeast sides. A broad sand flat forms a lobe projecting from the east side of the island and used as the landing, which is through the surf. The beach is very steep and falls off sharply into water several meters deep.

On the west side of Cousin rises a rugged clump of granite rocks, separated at high and medium tides from the island by about 100-150 m of water. At low spring tides a ridge of boulders is exposed, connecting the rocks with the shore. This is washed by waves from both directions. The rocks are called Roche Canon. They are of a hard granite similar to that on the island.

FAUNA

Birds are plentiful and very tame. Many fairy terns, _Gygis alba_, and occasional bos'n birds, _Phaëthon lepturus_, were nesting. Both noddies, _Anous stolidus_ and _Anous tenuirostris_, were present in some numbers, as well as sooty terns, _Sterna fuscata_.

Of shore birds only turnstones, _Arenaria interpres_, and whimbrels, _Numenius phaeopus_, were identified with any confidence. The Cape barn owl, _Tyto alba_, was seen several times. What appeared to be a dimorphic egret, _Egretta dimorpha_, was seen once along the north coast, but this identification is not certain.

Ground doves, Geopila striata, were present in considerable numbers. The local and the introduced Madagascar subspecies of Streptopilia picturata have hybridized, according to Malcolm Penny, and a hybrid swarm of individuals ranging from almost black, or dark gray, to rich brownish red on head and back has replaced the local Seychelles turtle-dove on the island.

Both the native Seychelles weaver, Foudia seychellarum, and the Madagascar "cardinal," Foudia madagascariensis, occur in numbers on the island, but without seeming to interfere with each other. They are extremely tame, freely entering houses and foraging without obvious fear of man. Several Seychelles brush warblers, Bebrornis seychellensis, occupied territories in and immediately around the house in which we stayed at the north-east corner of the island for the first day or two of our visit, being almost equally bold and familiar as the fodies. However, after several days of human presence in the house they had retired to working in trees and bushes some yards away and seldom approached the building.

Fortunately no rats seem to have reached the island. Information received from Malcolm Penny after my return from the island indicated the presence of feral rabbits.

Lizards are, next to the birds, the obvious vertebrates to be seen. Skinks (Mabuya spp.) occur in great numbers generally. Two or three species of gecko, a large gray one (Gehyra sp.?), a smaller gray one (young of large one?), and a smaller bright green one (Phelsuma madagascariensis) are frequently seen, the gray ones especially at night in the houses.

Insects are also plentiful. Both day- and night-flying mosquitoes are troublesome in the thick vegetation out of reach of the wind, and to some extent in the houses. "Blister beetles" are attracted to lights at night and may be a bother. A small species of ant occurs in great numbers. Termite nests of some size, cylindric, up to 0.5 m tall, are seen here and there.

ORIGINAL VEGETATION

As on all the Seychelles, as well as most islands everywhere, the vegetation of Cousin Island has been profoundly altered since the arrival of man. Sauer (1967) has drawn a partial picture of this history for the group as a whole. To the best of my knowledge no records exist of what the original vegetation of Cousin was like. Summerhayes, in his list of the flora of the Seychelles (1931), mentions only one species from Cousin. This, significantly, is Pisonia grandis.

The presence of a prominent and continuous bed of brown "Jemo" soil hardpan over the entire flat area of the island and the very common occurrence of small Pisonia grandis trees in the present vegetation, with what is known of the origin of the Jemo Soil Series (Fosberg 1954) make it possible to say with some confidence that the original vegetation of the flat area was solid Pisonia forest. In all likelihood this was a dense forest with a high continuous canopy, to as much as 30 m, with massive pale soft-wood trunks, possibly up to several m diameter; there was no undergrowth or ground vegetation, except in the peripheral zone on and just back of the beach ridges. On the beach ridges there may well have been a lower, dense thicket of Cordia subcordata, Guettarda speciosa, Morinda citrifolia, and possibly locally, Thespesia populnea, tangled with Canavalia cathartica, and lined, on the outside, by a dense fringe of Scaevola sericea and Suriana maritima. On the sand at the top of the beach was probably a mixture of Ipomoea pes-caprae, Sporobolus virginicus, Boerhavia repens, and possibly Lepturus repens.

The swampy area at Anse Frégate may well have been occupied by a mangrove swamp with Avicennia marina and Thespesia, as at present, but probably with much larger and better formed trees. Other mangrove species could possibly have been present.

Reconstruction of the possible original vegetation of the granite hill with any reliability is impossible on the basis of my present knowledge. On the basis of what is known of the original vegetation of the Seychelles as a whole it is probable that the hill was much more completely forested than at present. Areas now lacking soil may have reached this condition by continued cutting of trees and burning since the arrival of man. The Ficus species still present there in numbers, the Calophyllum inophyllum, and the Euphorbia pyrifolia and Phyllanthus casticum were certainly normal components of the lowland forest of granite areas, as still seen in the relict at La Réserve, on Silhouette. Pisonia and Morinda may well have also been components of this, as well as species no longer present.

In all likelihood the sparse vegetation at present on Roche Canon, of Sporobolus virginicus, Boerhavia repens, Ipomoea pes-caprae, Portulaca oleracea, and Achyranthes aspera may be relatively unchanged from that originally present. Two minor species, Acrostichum aureum, present in one deep crevice, and a small colony of Lagrezia oligomeroides, may have been there for a long time, or may be recent arrivals by wind or bird transport. White tailed tropic-birds now nest on the rocks.

One statement of interest can be made with assurance. The Pisonia forest which occupied the "plateau" was certainly the home of vast numbers of sea-birds. The thick layer of phosphatic rock covering this area could not have been formed otherwise. The present conspicuous but relatively small tern populations could not likely have brought about such massive phosphatization even over long periods of time.

EXISTING VEGETATION

A determining fact in the nature and pattern of the present vegetation of the island is that coconuts have been planted wherever it was possible that they might grow. They are now found over the entire flat area of the island except the beach ridges and the swampy ground at Anse

Frégate, and on the slopes of the hill wherever there is a substantial pocket of soil, almost to the summit. The more recent planting on the "plateau" has largely been in pits a meter or so deep dug in the phosphate rock.

It is not now known whether any effort was made to keep the undergrowth cleared, but it is probable that this was done to some extent on the "plateau", especially toward the east and north sides, as here the Morinda, Pisonia, Neisosperma and other tree saplings are not large. Fairly large understory trees of these species, as well as Calophyllum, and shrubs of Phyllanthus found toward the base of the granite hill suggest that there may have been less clearing out of brush in that area, at least in recent years.

The canopy of coconut crowns, while reasonably complete, is rather irregular and not dense. An understory of Morinda, Pisonia, Carica papaya, occasional Ficus nautarum, Calophyllum, Ricinus, Neisosperma, and, near the base of the hill, other species, is conspicuous and locally dense. The Carica is especially common and of all ages. Its fruit, while very small, is quite sweet and palatable. A dense herbaceous layer, 1 to even 2 meters tall is found throughout this forest. It includes Achyranthes aspera, Amaranthus dubius, Kalanchoe pinnata, Asystasia multiflora, Nephrolepis multiflora, and, in a local area of a few acres in the northeast part, Mirabilis jalapa. Along trails and near dwellings other species are common in the forest, such as Synedrella nodiflora, Cyperus kyllingia, Portulaca oleracea, Stenotaphrum micranthum, Digitaria spp., Eragrostis tenella var. insularis, Phyllanthus amarus, Euphorbia hirta, Acalypha indica, Vernonia cinerea, Eleusine indica, Cyperus ligularis, Turnera ulmifolia and others, mostly exotic weeds.

Along the north base of the hill, where a depression extends across the island, generally moist, and in places with mud or standing water, the forest is generally more luxuriant and many cultivated exotic species have been planted, mostly in small numbers. These include Mangifera indica, Annona squamosa, Annona muricata, Artocarpus altilis, Coffea arabica, Eugenia aquea, Manihot esculenta, Dioscorea alata, Moringa oleifera, Colocasia esculenta, Averrhoa bilimbi, Bambusa vulgaris, Musa sapientum, Persea americana, Citrus sp., Cucurbita moschata, Capsicum frutescens, Quisqualis indica and Alocasia macrorrhiza. Only the last three have shown much tendency to become naturalized and to spread. Certain weeds, in addition to those noted above, are found in this wet area. These include Panicum maximum, Cyperus polystachyos, Ludwigia octovalvis, Cyperus sp., Commelina diffusa, Panicum (Cyrtococcum) patens and Heliotropium indicum.

At its western end, this depression becomes broad and shallow and is covered by a forest of Pisonia, not, however, of very large trees. A similar forest, but much mixed with Morinda, Calophyllum and Carica, as well as some coconuts, is found near, but not at, the eastern end of the depression. The eastern end is occupied by a thicket of low Thespesia with a few Avicennia shrubs in the bottom of a shallow ravine where it reaches the back of the beach.

The mangrove depression at Anse Frégate is narrow at the east end and filled with a row of very bushy Avicennia. Westward it broadens and becomes dominated by Thespesia, likewise not very tall. The Thespesia, where growing in the wet area of the swamp, produces exposed arching roots which may possibly serve as pneumatophores. The pneumatophores of the Avicennia are the usual slender, vertical "upside-down roots", produced in numbers over an area of even broader radius than that of the crown of the tree. Around the margins of the depression are masses of the large, leathery fern Acrostichum aureum, up to 1.5 or even 2 m tall. Otherwise the only subordinate layer of vegetation is a locally prominent stand of Avicennia seedlings a few cm tall.

Back of the mangroves, in addition to coconuts, is an irregular thicket of Morinda, Pisonia and Scaevola, tangled with Canavalia and Ipomoea macrantha, with one small patch of Phyllanthus acidus.

Inside the beach ridges along most of the north and east coasts of the "plateau" and south of the mangrove at Anse Frégate is an open zone, under the coconuts, with very sparse undergrowth or none, only a few scattered shrubs of Morinda, Pisonia, Neisosperma and Carica, but with dense herbaceous growth varying from Achyranthes, Amaranthus and Asystasia a meter tall to a much lower mosaic of Boerhavia repens, Sporobolus virginicus, and Stenotaphrum dimidiatum, all in relatively pure stands, with local patches of Catharanthus roseus, Stachytarpheta jamaicensis, Abutilon indicum, Gossypium hirsutum, Dactyloctenium aegyptium, Panicum (Brachiaria) sp., and scattered individuals of Turnera ulmifolia, Datura metel, Ricinus communis, and Cassia occidentalis. The dense areas of Boerhavia repens are of interest in that where crowded, the Boerhavia instead of being very prostrate and elongate, has shorter ascending stems with fewer inflorescences and denser foliage. This zone is said to have resulted from the pasturing of hogs by the previous owner. It seems very likely to grow up soon to undergrowth similar to that farther inland in the coconut forest if all disturbance is removed.

On the beach ridge, which extends around the "plateau" with gaps only in and near the dwelling areas, is an interrupted row of giant old Casuarina trees, up to 30 m tall, buttressed at base, laying down a carpet of "needles" which locally seems to discourage, somewhat, the normal herbaceous layer. Between and under these is generally a "hedge" or low thicket of Scaevola and Suriana. Here and there are a very few fairly large Guettarda trees. Toward the west end, and especially in a fairly large gap in the Casuarina, the beach ridge is covered by a dense thicket, up to 4-5 m tall, of Cordia subcordata, Pisonia grandis and Scaevola sericea. A similar thicket, mainly Pisonia and some Scaevola occupies the south end of the beach ridge on the east coast. Here the Casuarina trees form a small grove, extending a few meters inland, rather than only a row at the top of the beach. The Casuarina is not reproducing itself except very locally where otherwise unvegetated beach sand, in full sun, supports stands of seedling Casuarina and/or Scaevola.

On the outer slopes of the beach ridges and outer edges of the sand flats where there are no ridges, Sporobolus virginicus, Boerhavia repens and *Ipomoea pes-caprae* tend to spread down onto the top of the beach, or onto berms or terraces formed on them. The rhizomes of *Sporobolus* growing toward the sea send up characteristic straight rows of shoots. The elongate stems of *Boerhavia* here spread in a very prostrate manner from root crowns. The *Ipomoea* forms loose mats which locally extend back onto the sand flats where the beach ridge is lacking.

A few trees, lacking elsewhere, such as *Hibiscus tiliaceus*, *Spondias purpurea* and *Barringtonia*, are planted around dwellings along these coasts.

The vegetation of the granite area is much more varied and locally diverse, and patterns are less obvious and are difficult to define. The species are predominantly indigenous and, with the exceptions of *Morinda citrifolia* and *Pisonia grandis*, among trees, and *Achyranthes aspera*, *Asystasia* sp., *Nephrolepis multiflora*, and *Ipomoea pes-caprae*, are not those which have much importance in the "plateau" vegetation.

The gentler lower slopes are mostly wooded with a low mixture of *Morinda* and *Pisonia*, with some *Ficus nautarum* and *Ficus* sp., *Calophyllum*, *Euphorbia pyrifolia* and *Phyllanthus casticum*, with, of course, planted *Cocos nucifera*. On the lower west slopes *Pandanus balfourii* is locally abundant or even dominant, and elsewhere *Calophyllum* may be dominant. A patch of *Fourcraea foetida* is found on a rather low gentle slope on the northwest corner of the hill. Locally *Passiflora foetida* is abundant, climbing in bushes. On the south side *Panicum* (*Cyrtococcum*) sp. is abundant in patches with *Asystasia*. In open scrub and forest there is frequently a dense ground layer of *Nephrolepis multiflora*.

The lower east slopes of the hill are gentle, and have scattered *Pisonia* and *Morinda*, but are mainly open and completely dominated by *Achyranthes*. The slopes end in alternating bare rock ridges and sandy coves. The coves have *Pisonia*, *Cocos*, and *Casuarina* trees and small sand flats or storm beaches covered by *Ipomoea pes-caprae*, *Achyranthes*, and *Asystasia*, with small clumps of herbs such as *Fimbristylis cymosa*, *Cleome viscosa* and *Cenchrus echinatus*. There is little *Scaevola* or *Suriana* here.

On the middle west slopes is an area dominated by planted *Eucalyptus camaldulensis*, reaching 20 or more meters in height. Elsewhere the middle slopes are either ledgy and jointed, and support an open growth of *Ficus nautarum*, *Morinda*, *Calophyllum*, and a very few small *Casuarina*, or they are smooth "glacis" or bare rock, with little soil except in crevices and pockets. Here are occasional *Euphorbia pyrifolia*. A few slopes on the north side are covered by a blanket of *Coleus subfrutectosus*. Sedges of several species occur in crevices and pockets. Clumps and patches of *Panicum maximum* are also found here, and *Nephrolepis multiflora* in crevices and accumulations of soil.

The higher slopes, where they are not steep, bare "glacis" or cliffs, have irregular clumps of *Ficus nautarum*, *Pandanus balfourii* and *Calophyllum*, with a herbaceous layer of *Asystasia* and *Nephrolepis*, or especially on steeper southwest slopes, a rather dense scrub of *Euphorbia pyrifolia*, with *Nephrolepis*.

Near the top of the hill, on the southwest side especially, are relatively flat areas covered by a tall dense scrub or scrub forest of *Euphorbia pyrifolia*, *Phyllanthus casticum*, *Ficus nautarum* and *Pandanus balfourii*, choked beneath with *Nephrolepis* up to 2 m deep. Here are the highest coconuts, a few small trees. Openings in this scrub are dominated by *Fimbristylis* cf. *consanguineus*.

The summit ridge, little higher than this flat area, has sparse vegetation, where any at all. Where some sand has accumulated in longitudinal grooves is, surprisingly, *Ipomoea pes-caprae*, with *Achyranthes*, a little *Cenchrus echinatus*, *Fimbristylis* spp., wisps of *Panicum maximum*, and scattered bushes of *Euphorbia pyrifolia*.

The vegetation of Roche Canon was mentioned above as possibly being in approximately its original condition. Most of the rocks are bare, but locally on the larger peak are thick masses of *Sporobolus virginicus*, and *Achyranthes aspera*, and lesser mats of *Boerhavia repens*. A little *Portulaca oleracea* grows around the edges of these mats, and also in sheltered spots on the smaller peak. Here it reaches a gigantic size, up to 0.7-0.8 m tall. On top of the smaller peak, in sheltered crevices, are a few plants of *Lagrezia oligomeroides*, possibly brought on the feet of seabirds from far-away Aldabra. Otherwise, except for a tiny tuft of *Acrostichum* in a deep crevice, the rocks are completely bare.

MANAGEMENT OF VEGETATION

As is well shown by the history of the Seychelles, vegetation can be profoundly changed by the activities of man. This has happened in the past to the vegetation of Cousin, resulting in the confused patterns described above.

All vegetation is intrinsically dynamic, that is, it constantly changes to some extent, even if left to itself. Long established natural vegetation tends to change only slowly or fluctuate about internal equilibria. This situation is altered, even naturally, by severe storms, volcanic eruptions, lightning fires, landslides, and other catastrophic events, as well as by changes in animal populations, and perhaps rarely, by plant diseases. Wherever man has gone he has accelerated change and upset existing equilibria, usually in a haphazard, unplanned and destructive manner. The result is that any vegetation that has been influenced by man tends to be in a state of relatively active change. Such change goes on, once the disturbance has been effected, regardless of what man does from then on. He can influence the direction of the change but he finds it difficult, if not impossible, to maintain precisely the status quo. Attempts to do so, if even moderately effective, require the expenditure of very considerable effort and constant attention. Guided change, on the other hand, may require relatively little effort, if it is in the direction of the existing trend in any situation. If the desired change is contrary to such trends, it may require large expenditures of effort indeed, and with no assurance of success.

Carrying out policies intended to influence, in whatever manner, the processes of change in vegetation is commonly called vegetation management. Hence, it is impossible to recommend any form of management until appropriate policies have been established to further the objectives of the Cousin Island Preserve. Certain alternatives may be discussed and possible consequences pointed out. It must be noted that my familiarity with Seychelles vegetation and the Seychelles environment is limited to what could be learned in two weeks, so any suggestions should be accepted with due caution.

Reasonable alternative management paths that might be followed fall roughly into four sorts. Granting effective protection from outside influences, they are (1) non-interference, allowing present trends to continue without active efforts to direct, accelerate, or retard change; (2) the deliberate introduction of additional plant species; (3) the deliberate elimination or reduction of species now present, presumably the exotics; (4) attempts to alter (or "ameliorate") in some manner the physical or biological environment. These will be discussed briefly in order.

1. As pointed out above, change in the vegetation is going on and will continue. Allowing present trends to continue is certainly the easiest and least expensive policy that could be adopted. It would be presumptuous to assume that I know what all of these trends are, or what their immediate or ultimate outcome will be. However, one or two things seem likely.

As suggested above, the relatively open zone around the "plateau" inside the beach ridge is very likely to grow up in a short time to resemble the thicker undergrowth farther inland. Since the _Casuarina_ does not seem to be reproducing very effectively, and since several windthrown trees were noticed, it is likely that over a period of many years the stately row of giant _Casuarina_ will be replaced by a few localized thickets or groves of this species and occasional isolated trees. The beach ridge hedge and thickets will likely become taller and, at least on the beach side, denser, and may occupy areas not now covered by woody plants. A strip of _Scaevola_ seedlings now to be seen in front of the resident scientist's house represents the initiation of such vegetation in one place where it is now absent.

It seems most likely that the understory in the coconut plantation on the "plateau" will in time thicken and greatly increase in height, eventually replacing the coconuts. The papaya, now so abundant, will disappear, except possibly around dwellings and along the more established paths. The ultimate result, a long time from now, will probably be the reestablishment of the _Pisonia_ forest that originally occupied the area. This course could be changed, over a very long time, by the development of a _Neisosperma_ forest, which, in the Central Pacific atolls, seems capable of replacing the _Pisonia_ forest completely. It is not known if this could happen in the western Indian Ocean. The former existence of extensive _Pisonia_ forests here suggests that such replacement is at least not inevitable. The replacement of the coconut forest by _Pisonia_ is contingent on continued complete harvest of the coconut crop, as at present. If the nuts are allowed to lie on the ground and germinate an impenetrable thicket of young coconut palms will result, probably crowding out everything else in time, unless one or other of the existing coconut pests reaches the island and alters the situation, which would be rather likely, sooner or later.

Change in the vegetation on the granite hill would seem to be rather slow. Soil is absent in many areas and thin in most others. The granite weathers very slowly, and humus breaks down rapidly under tropical conditions. The trend will doubtless be toward the spread of forest and the increase in stature and density of the forest now there, but the process will certainly be slow. Fire could set it back drastically. The presence of the Eucalyptus grove no doubt increases the probability of fire.

The composition of the vegetation in the depression at the north base of the granite hill will probably change rapidly, with some of the planted species dying out as a result of competition, the effects of scale insects and mealy bugs, or simple unsuitability in an increasingly densely forested environment. Which species will persist is hard to know, but at present three -- Quisqualis indica, Alocasia macrorrhiza and Capsicum frutescens seem to be on the increase, and Manihot esculenta, at least, seems on the way out.

2. There seems little use in discussing the introduction of additional species. There are a great many thousand available, and no one has any reliable information on theprobably consequences of introducing any of them. There is always a strong possibility that introduction of any species without its natural enemies will result in an uncontrolled increase, which is usually disastrous for some or many existing species. The end result is likely to be impoverishment, rather than enrichment of the habitat. However, it is likely that species will be introduced, either accidentally or deliberately. People seem to have a missionary zeal in this direction that is not influenced by reason, past bad experience, or good advice. One can only recommend against ill-considered introductions and hope the plants die if they are brought in.

3. The eventual elimination of at least certain of the exotics now present will probably be advisable. This should not be hasty or ill-considered. It should be undertaken only after a full understanding of the relationships of the birds to the plants in question is achieved. Elimination of any species should, also, only be considered after it is determined, possibly by experiment, what of the existing species present will fill the niche vacated.

The only species that I would venture to propose for elimination would be the Eucalyptus, and possibly the Cenchrus, and these only after a careful study of their role in the present situation.

These remarks do not, of course, apply to permitting the disappearance of species by natural causes. A species on its way out will likely go, unless a determined effort is made to save it. This should probably only be made if it should be found that one of the birds for which the Reserve was set up is dependent on the threatened plants.

4. Alterations of the habitat are likely to be both difficult and expensive if done rationally and carefully. Likewise the consequences are not fully predictable. Fertilization, the application of pesticides, changing drainage patterns, thinning of vegetation, selective reduction of a particular species, erecting wind-breaks are all possible alterations. There is no pressing reason to undertake any of these, and past experience elsewhere has shown that unanticipated results and side-effects are likely. It is suggested that only after the fullest consideration of all aspects, and for the most pressing reasons, should any such course be adopted.

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SYSTEMATIC LIST OF PLANTS

All collection numbers are Fosberg's. Plant names preceeded by an asterisk are those regarded as introduced by man into Cousin.

POLYPODIACEAE

Acrostichum aureum L.

Sparingly at edges of mangrove swamp at Anse Frĕgate (52090). One tiny clump in deep crack on Roche Canon (52080).

Nephrolepis multiflora (Roxb.) Jarrett

Very common to abundant everywhere except on beach ridges and sand flats. Especially abundant on granite slopes (52159).

Polypodium scolopendria Burm. f.

Rare, seen only in depression near well, on base of tree (52110), and on stone wall of tortoise pen (52097).

PANDANACEAE

Pandanus balfourii Martelli

Common on slopes and top of granite hill (52092, 52093).

GRAMINEAE

*Bambusa vulgaris Wendl.

Two clumps in depression near well (52106); undoubtedly planted.

*Cenchrus echinatus L.

Small colonies on top of granite hill (52160) and on beach at east end of granite hill (52188). Possibly brought by birds.

*Dactyloctenium ctenoides (Steud.) Bosser

Common generally except in densest forest, especially just back of beaches (52177).

Digitaria horizontalis Willd.

Here and there along paths in edges of forest (52066).

*Digitaria radicosa (Presl) Miq.

One patch seen at northeast corner of island near path (52175), and occasionally near dwellings (52101).

*Eleusine indica (L.) Gaertn.

Occasional clumps and patches along trails and near dwellings (52098).

Enteropogon sechellensis (Baker) Dur. & Schinz

General but not abundant in open places (52172).

*Eragrostis tenella (L.) Beauv.

Very rare, found once in path near dwelling on north coast (52167).

Eragrostis tenella var. *insularis* Hubb.

Occasional in and along paths (52095, 52176).

**Panicum maximum* Jacq.

Abundant in standing water in depression near well (52105), common here and there on granite hill, occasional elsewhere. Panicles used by local people to make brooms.

**Panicum (Brachiaria) miliformis* Presl

Common along trails and near dwellings, northeast part of island (52072).

Panicum (Cyrtococcum) patens L.

Abundant on lower slopes of granite hill, and especially at Anse Frégate (52050), occasional elsewhere.

Sporobolus virginicus (L.) Kunth

Abundant around all coasts, on rocks and sand flats, forming a dense sod (52032); on Roche Canon (52078) forming deep masses.

Stenotaphrum dimidiatum (L.) Brongn.

Locally abundant on sand flats along coasts (52033).

Stenotaphrum micranthum (Desv.) Hubb.

Common in small patches in coconut plantation on phosphate rock, especially along paths (52099).

CYPERACEAE

Bulbostylis barbata C.B.Cl.

Occasional in rock crevices and soil pockets on and near top of granite hill (52060, 52055, 52140).

Cyperus distans L.f.

In wet places, as in depression near well (52104).

Cyperus dubius Rottb.

Scattered generally, nowhere seen abundant (52062).

**Cyperus kyllingia* Endl.

Common in forest along paths (52061), sparingly elsewhere.

Cyperus ligularis L.

Generally but sparingly distributed principally in open and semi-open places (52119).

*_Cyperus polystachyos_ Rottb.

Very sparingly distributed, especially along paths (52087).

Cyperus polyphyllus Vahl

Generally but sparingly distributed in open and semi-open places (52058).

Fimbristylis cymosa R. Br.

One tiny colony back of beach at east end of granite hill (52186). A giant form.

Fimbristylis cf. _consanguineus_ Kunth

Common on and near top of granite hill in depressions and crevices in rock (52059, 52054).

PALMAE

*_Cocos nucifera_ L.

Planted everywhere where there is sufficient soil. The nuts are harvested as they fall.

ARACEAE

*_Alocasia macrorrhiza_ (L.) Schott

Naturalized abundantly in and near depression along the north base of granite hill (52181).

*_Colocasia esculenta_ (L.) Schott

Planted locally in mud of depression near well (52115).

COMMELINACEAE

*_Commelina diffusa_ Burm. f.

Very abundant in depression, north of granite hill (52118), also at Anse Frégate. Seldom seen flowering.

BROMELIACEAE

**Ananas comosus* (L.) Merr.

Solitary plants or small clumps at several places, as on granite slopes above well (52164).

LILIACEAE

**Crinum asiaticum* L.

Two clumps just back of beach near dwellings (52184), not flowering.

**Furcraea foetida* (L.) Haworth

Small patch on slopes near northwest base of granite hill (52135).

**Hymenocallis littoralis* (Jacq.) Salisb.

Several clumps in edges of forest near dwellings (52171), not flowering.

DIOSCORACEAE

**Dioscorea alata* L.

One vigorous plant in depression at foot of granite hill west of well (52126), not flowering.

MUSACEAE

**Musa sapientum* L.

Planted abundantly in depression at north base of granite hill (52108).

CASUARINACEAE

Casuarina equisetifolia L.

A single interrupted row of large old trees on beach ridges almost around the island (52168), locally in one or two places forming small groves. Reproducing in only one or two places on bare sand.

MORACEAE

**Artocarpus altilis* (Park.) Fosb.

Two small trees planted in depression at north base of granite hill (52133).

<u>Ficus avi-avi</u> Bl.

One small tree seen on east side of tortoise pen, northeast of well (52143), sterile.

<u>Ficus nautarum</u> Baker

Very common on granite hill (52142, 52154), occasional elsewhere.

<u>Ficus</u> aff. <u>thoningii</u> Bl.

Occasional to common on slopes of granite hill (52084, 52134), rare elsewhere, as at Anse Frégate.

NYCTAGINACEAE

<u>Boerhavia repens</u> L.

Very abundant everywhere on flats back of beaches (52145, 52146), occasional elsewhere at low elevations, also on Roche Canon (52077).

*<u>Mirabilis jalapa</u> L.

Very common in an area within the coconut plantation in from the north coast (52180).

<u>Pisonia grandis</u> R. Br.

Generally common, locally abundant on "plateau" (52063), extending somewhat up on the granite slopes. Undoubtedly formed solid forests over lowlands in pre-human time, judging by the extent of the phosphatic soil and hard-pan of the Jemo series.

AMARANTHACEAE

<u>Achyranthes aspera</u> L.

One of the most ubiquitous plants on the island, especially abundant back of beach ridges and in coconut plantation, but found generally at all elevations; an especially vigorous form of the species (52173).

*<u>Amaranthus dubius</u> Mart. ex Thell.

Found generally at low elevations, especially common near houses and paths (52034) but well distributed even in the dense coconut forest.

<u>Lagrezia oligomeroides</u> (C. H. Wright) Fosberg

One tiny colony on Roche Canon (52075), not seen elsewhere, nor is there any published record from the Seychelles. Very similar to, if not identical with, the plant common on Aldabra.

AIZOACEAE

Mollugo oppositifolia A. DC.

One small colony in dry depression at Anse Frĕgate near edge of mangrove swamp (52086).

PORTULACACEAE

Portulaca oleracea L.

Very generally distributed except in densest forest and on top of granite hill, especially abundant along paths (52120), very large plants on Roche Canon (52079).

ANNONACEAE

*Annona muricata L.

Several trees planted in depression at north base of granite hill, near well (52111).

*Annona squamosa L.

Commonly planted along depressions at north base of granite hill (52123), fruiting abundantly.

LAURACEAE

*Persea americana Mill.

One tree bearing fruit, planted near well in depression at north base of granite hill (52128).

CAPPARIDACEAE

*Cleome viscosa L.

A few dwarfed plants in crevices on summit of granite hill (52052) and a small colony back of beach at east end of granite hill (52185).

MORINGACEAE

*Moringa oleifera Lam.

One or two trees planted in depression at east base of granite hill (52131).

CRASSULACEAE

*_Kalanchoe pinnata_ (Lam.) Pers.

Very abundant almost everywhere in lowlands (52109), especially on old stone walls and in small openings in woods.

LEGUMINOSAE

*_Adenanthera pavonina_ L.

One tree on northwest slope of granite hill not far below top (52162).

Caesalpinia bonduc Roxb.

A single seedling at top of beach at east end of granite hill (52187), not seen elsewhere.

Canavalia cathartica Thou.

Very common, climbing in trees over most of western half of island (52138).

*_Cassia occidentalis_ L.

Common in open and semi-open places, especially near dwellings (52069).

*_Sesbania_ cf. _cannabina_ (Retz.) Roxb.

Common at Anse Frégate (52051), seen once or twice elsewhere near dwellings.

*_Vigna unguiculata_ (L.) Walp.

Planted in garden around dwelling (52100).

OXALIDACEAE

*_Averrhoa bilimbi_ L.

Several trees in depression at north base of granite hill (52112), fruiting.

RUTACEAE

*_Citrus aurantifolia_ (Christm.) Swingle

Seen but not collected on lower north slope of granite hill, rare.

*Citrus sinensis (L.) Osbeck

Oranges said to be present but not seen on this visit.

*Citrus "calamondin" ?

Occasional near well at base of north slope of granite hill (52124), fruit resembling a lime but not sour ("Bigaradier").

SURIANACEAE

Suriana maritima L.

Locally common on beach ridges (52065).

EUPHORBIACEAE

*Acalypha indica L.

Very common along trails and around dwellings (52070) in open and semi-shade.

*Euphorbia hirta L.

Common along paths (52122), around dwellings, and in open spots generally.

*Euphorbia prostrata Ait.

One small colony in path near dwelling (52148) at northeast corner of island.

Euphorbia pyrifolia Lam.

Common on granite hill, dominant in scrub near top (52056, 52053, 52136, 52155, 52156, 52157).

*Euphorbia thymifolia L.

Local in path along north coast near dwellings (52030).

*Manihot esculenta Crantz

One poor plant in depression at north base of granite hill, doubtless planted (52127).

*Phyllanthus acidus (L.) Skeels

A few trees at Anse Frégate (52089), well inland, large one probably planted, smaller ones spontaneous.

Phyllanthus amarus Schum. & Thonn.

Common along paths and in openings near dwellings (52082, 52121).

Phyllanthus casticum Willem.

Common on slopes of granite hill, very common near top, less so in coconut plantation not far from base of hill (52031, 52129, 52158).

**Ricinus communis* L.

Generally common in lowlands, especially near paths and in semi-open places (52165).

ANACARDIACEAE

**Mangifera indica* L.

Two or three trees planted near well in depression at north base of granite hill (52113).

**Spondias purpurea* L.

One tree at manager's house on east coast (52183).

MALVACEAE

**Abutilon indicum* (L.) Sweet

Local along path on north coast near dwellings (52068).

**Gossypium hirsutum* L.

Here and there along paths in semi-open areas, especially near dwellings along north coast (52073).

**Hibiscus tiliaceus* L.

One small clump near dwelling on north coast (52170).

**Sida acuta* Burm. f.

A few plants near dwellings on east coast (52094).

Thespesia populnea (L.) Sol. ex Correa

Abundant in and around mangrove swamp at Anse Frégate (52085) and at east end of depression at north base of granite hill; a form with rather large pyriform fruit.

GUTTIFERAE

Calophyllum inophyllum L.

Common on slopes of granite hill (52141), uncommon elsewhere.

TURNERACEAE

*Turnera ulmifolia L.

Common in edges of coconut plantation, especially near northeast corner of island (52035).

CARICACEAE

*Carica papaya L.

Abundant in coconut plantation, especially in more open areas (52096).

PASSIFLORACEAE

*Passiflora foetida L.

Common on lower slopes of granite hill (52083, 52151).

*Passiflora suberosa L.

Occasional in edges of coconut plantation, on back slopes of beach ridges, and on semi-open sand flats near coasts (52169).

CUCURBITACEAE

*Cucurbita moschata Duch.

Planted in and near depression at north base of granite hill (52163), also near dwellings.

*Momordica cf. charantia L.

Planted in garden at manager's house, trained up on trellis, large fruit hanging through trellis; not collected.

COMBRETACEAE

*Quisqualis indica L.

Well established in depression at north base of granite hill (52132).

*Terminalia catappa L.

One tree seen but not relocated, probably near well; possibly an error in identification.

LECYTHIDACEAE

*Barringtonia asiatica (L.) Kurz

One small tree at manager's house on east coast (52182).

MYRTACEAE

*Eucalyptus camaldulensis Dehnh.

Abundantly planted on middle slopes of west end of granite hill (52137, 52150).

*Eugenia aquea L.

One large tree planted at well, north base of granite hill (52114), fruiting freely.

ONAGRACEAE

*Ludwigia octovalvis (Jacq.) Raven

Common in standing water and mud in depression at north base of granite hill (52116).

UMBELLIFERAE

*Centella asiatica (L.) Urb.

One small colony near well, in depression at north base of granite hill (52107).

APOCYNACEAE

*Catharanthus roseus (L.) Don

Well established here and there in lowlands, especially in semi-open areas and groves back of beach ridges (52147).

Neisosperma oppositifolia (Lam.) Fosb. & Sachet

Occasional in lowlands, especially on flats just back of beach ridges (52067).

CONVOLVULACEAE

Ipomoea pes-caprae (L.) R. Br.

Common to abundant on beach ridges and sand flats along coast (52189), also on granite hill on open rock slopes and summit (52161), also on Roche Canon (52076). The form seems intermediate between ssp. pes-caprae and ssp. brasiliensis.

Ipomoea macrantha R. & S.

Common on south coast, at Anse Frégate (52049), and back of beaches at east end of granite hill.

Ipomoea cf. venosa R. & S.

Occasional on slopes of granite hill, on low granite area west of Anse Frégate (52091) and near dwelling inland from east coast (52103). A curious abnormal form with deeply lobed corolla was collected on the west slope of granite hill (52152).

BORAGINACEAE

Cordia subcordata Lam.

Common generally on beach ridges (52064).

*Heliotropium indicum L.

Very rare in wet depression near well at north base of granite hill (52117). This is an unusually glabrous form of this normally hirsute, widespread weedy species. There are various specimens from Indian Ocean localities intermediate in hairiness between this and the coarser more hirsute ordinary forms.

Tournefortia argentea L. f.

One small bush at top of beach on north coast (52174).

VERBENACEAE

Avicennia marina L.

Common in mangrove swamp at Anse Frégate (52048) and local at east end of depression at north base of granite hill.

*Stachytarpheta jamaicensis (L.) Vahl

Common back of beach ridges in semi-open areas and around dwellings (52074).

LABIATAE

Coleus subfrutectosus Summ.

Locally very abundant on lower north slopes of granite hill, completely covering some rock slopes (52057).

SOLANACEAE

Capsicum frutescens L.

Locally common in depression at north base of granite hill (52125), occasional elsewhere in lowlands along paths and near dwellings.

*_Datura metel_ L.

Common near dwellings, especially along east coast (52190).

*_Nicotiana tabacum_ L.

Two or three plants seen in garden near manager's house.

*_Solanum melongana_ L.

Sparingly planted in gardens and around dwellings (52144).

ACANTHACEAE

Asystasia multiflora Klotzsch

Very abundant generally (52153, 52166).

*_Justicia gendarussa_ Burm. f.

One tiny colony at Anse Frégate (52088).

RUBIACEAE

*_Coffea arabica_ L.

A few trees planted in depression at north base of granite hill (52130).

Guettarda speciosa L.

A very few scattered trees on beach ridges and flats behind beaches (52178).

*_Hedyotis corymbosa_ (L.) Lam.

Very local in paths, both on phosphate rock and on granite (52081, 52139).

Morinda citrifolia L.

Very common everywhere (52179), an important component of most woody vegetation.

GOODENIACEAE

Scaevola sericea Vahl

Locally abundant along beach ridges (52047), tending to form a tall hedge on ridge, or fringe seaward of other vegetation.

COMPOSITAE

*Synedrella nodiflora (L.) Gaertn.

Locally common along paths and near dwellings (52102).

*Vernonia cinerea (L.) Less.

Common along paths (52071), near dwellings and in open weedy places.

ADDENDUM TO SYSTEMATIC LIST

Information on changes in the flora has been provided from several Cousin Island Research Station scientific administrators' reports and from Technical Report No. 16, by G. M. and H. V. Bathe, since the above version of the plant list was prepared. The following species may be added to the list on the basis of these notes. I have not seen the specimens supporting these observations.

Lemna sp. (Lemnaceae)

Common in The Pond.

*Saccharum officinarum L. (Poaceae)

Planted in depression, N. E. base of Granite Hill.

*Haemanthus multiflorus Martyn (Liliaceae, s. l.)

Persisting around abandoned house back of N. shore.

*Peperomia pellucida (L.) H.B.K. (Piperaceae)

Found around paths on Parve Plateau[1]; said to be native but surely not, as this is an American species.

*Gliricidia sepium H.B.K. (Fabaceae)

Planted near house.

*Euphorbia tirucalli L. (Euphorbiaceae)

Near houses.

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[1] Apparently the "plateau," flat north half of island.

Hibiscus surattensis L. (Malvaceae)
(as H. swattensis, a name not listed in Index Kewensis).

Found in S. E. end of depression at base of Granite Hill.

Rhizophora mucronata Lam.

In coastal brackish water on south and east coasts.

Many miscellaneous notes on the vegetation occur in these reports. They should be collected together and summarized for publication after a period of years, as trends of change may be established.

In the account of the fauna, above, I inadvertently omitted mentioning the presence of five giant tortoises, presumably brought from Aldabra Island, confined in an enclosure surrounded by a low stone wall. I was not able to learn how long they had been there, but the enclosure was obviously not new. The tortoises seemed in good health but were not successfully breeding. The enclosure was located on the "plateau" between the dwellings and the depression at the foot of the granite hill.

Figure 3. Cousin: vegetation. From *Cousin Island Nature Reserve Management Plan 1975-79*, by A. W. Diamond (London: International Council for Bird Preservation [British Section]), Appendix 4. Key:

1. Tall herbs on flat sandy coast. Characteristic species *Passiflora suberosa, Boerhavia repens.*

2. Herbs on rocky coast. *Asystasia* sp., *Ipomoea pes-caprae.*

3. Open woodland regenerating through coastal tall herbs; intermediate between types 1 and 4.

4. Closed woodland on plateau, regenerating through coconut plantation. *Morinda citrifolia, Pisonia grandis, Phyllanthus casticum.*

5. Tall closed plateau woodland. Taller and more open (ground layer) than type 4. *Ficus nautarum* replaces *Phyllanthus casticum.*

6. Low-lying woodland near the coast, subject to tidal inundation. *Avicennia marina, Thespesia populnea, Ipomoea macrantha.*

7. Mature *Pisonia* forest. *Pisonia grandis,* some *Morinda citrifolia.*

8. *Eucalyptus* plantation. *Eucalyptus camaldulensis.*

9. Closed *Euphorbia* scrub. *Euphorbia pyrifolia, Nephrolepis multiflora.*

10. Tall herbs on the top and southwest slopes of the hill. *Nephrolepis multiflora.*

11. Herbs on the northeast slopes of the hill. *Cyperus polyphylla, Cyperus ligularis.*

12. Groves or individual trees of *Casuarina equisetifolia.*

13. *Ficus* grove. *Ficus nautarum, F. reflexa, F. avi-avi.*

14. Open *Pisonia* regenerating through dense *Asystasia* sp. under *Cocos nucifera.*

15. Very varied vegetation, almost entirely planted, in the depression at the foot of the hill; on deep soil, much of it under standing water according to rainfall. Not sampled.

16. Bamboo.

17. Not sampled.

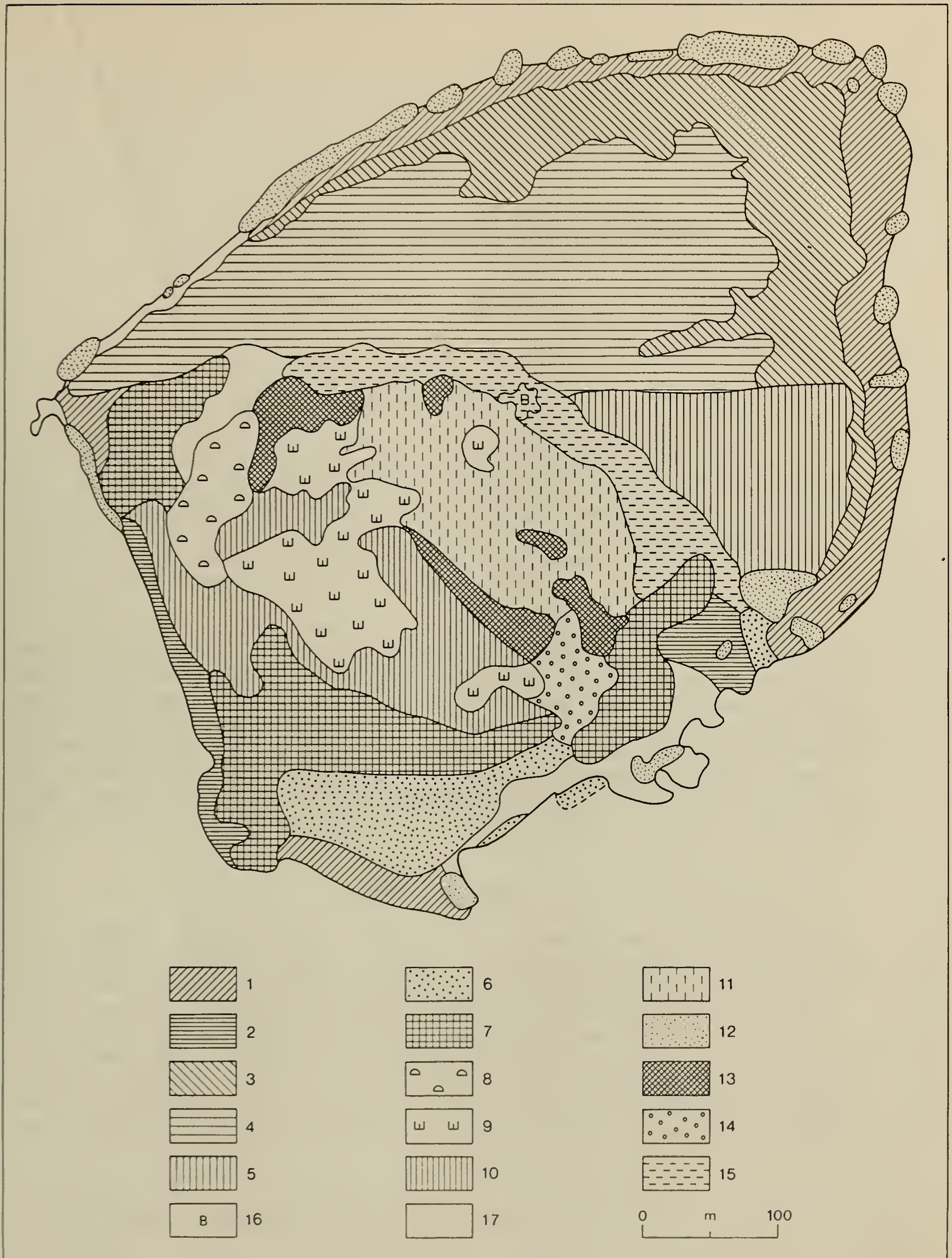

Figure 3. Cousin Island, vegetation types. Adapted, by permission, from map by A. W. Diamond.

3. VEGETATION OF FRÉGATE ISLAND, SEYCHELLES

by S. A. Robertson and D. M. Todd

Introduction

Frégate Island is the most easterly of the islands which comprise the Seychelles Group in the western Indian Ocean. It is one of the smaller islands in the group, and has been run as a private estate since the first permanent settlement was established early in the nineteenth century. All of the original vegetation has been cleared over the years so that a variety of crops could be planted, and the island's flora is now dominated by introduced species.

Ann Robertson made several visits to Frégate Island in 1978 to collect plants and was able to compile a preliminary list for the island which included those collected by Jeffrey in 1962 and Procter in 1972. David Todd spent some time on the island in 1981 and 1982, participating in an International Council for Bird Preservation project to study the Seychelles Magpie Robin and to eradicate feral cats, and was able to add to the plant list and to describe and map the vegetation types. We have combined our records and information to provide a brief history of the island and a fairly comprehensive plant list.

Frégate Island

Frégate (Figure 4a) is a low, rocky island of about 202 ha, rising to a height of 125 m above sea level. Its two hills are composed mainly of aplite, unlike the other granite islands of the group. Although aplite weathers rapidly to produce a deep and fertile, though bouldery, soil layer, large areas of bare rock remain on the island. In the north-east and the west are two areas of flat, low-lying land, locally called 'plateaux', which have a combined area of about 26 ha. On these coastal plateaux, there are rich, phosphatic soils of the Jemo series, which indicate that the island once supported large colonies of breeding

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Atoll Research Bulletin No. 273: 39-64, 1983.

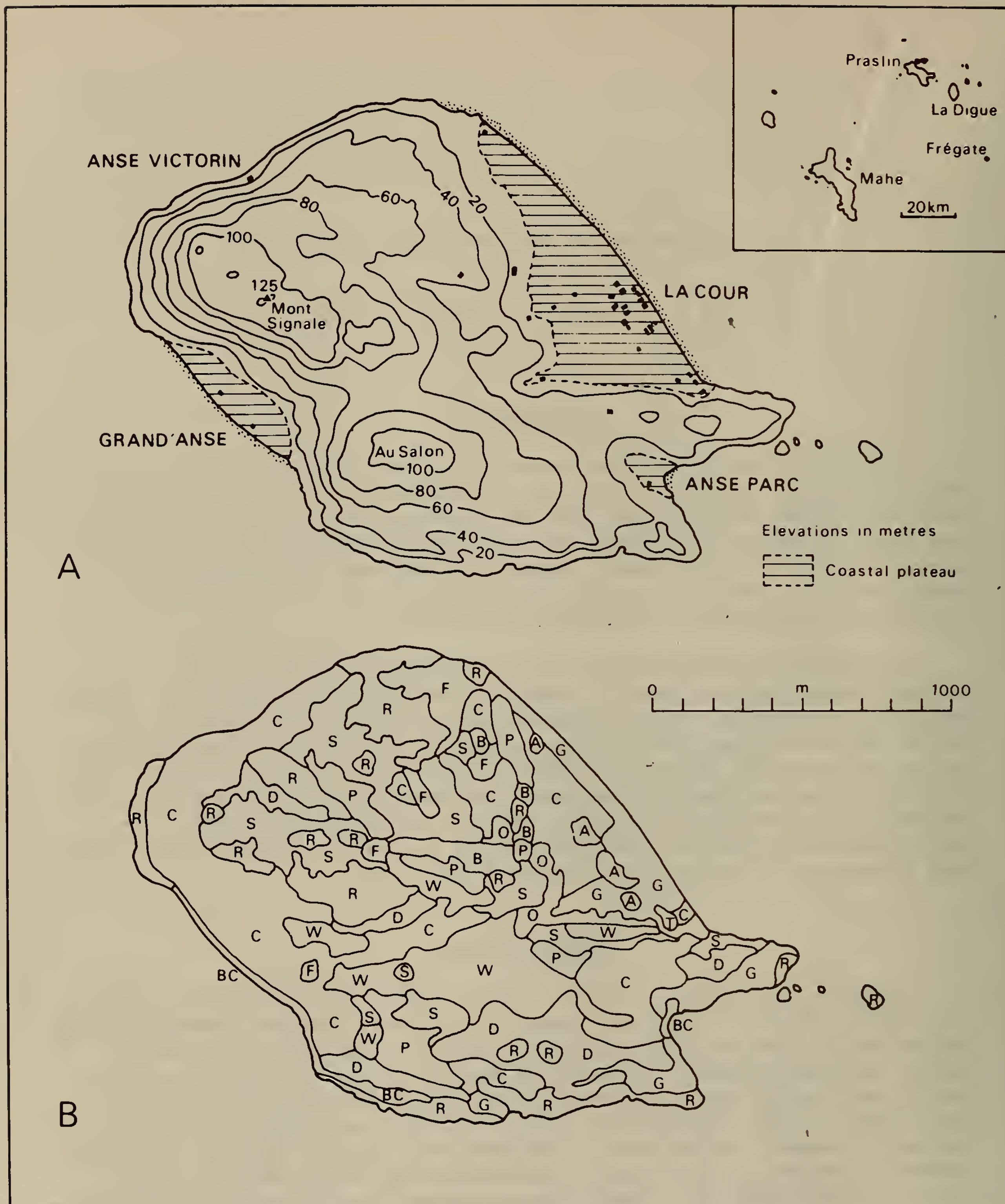

Figure 4. Frégate. A: topography. B: vegetation.

seabirds, while Shioya type soils are found behind the beach crests (Piggott, 1968). Even though Frégate experiences the same seasonal weather patterns as the other islands in the group, it attracts far less rain than the larger and higher islands. The limited records suggest that the rainfall is approximately 1250 mm per annum, about two-thirds of that in coastal areas of Mahé (Watson, 1978).

The early history of Frégate is very poorly documented. The island was apparently first settled by pirates early in the eighteenth century, but, though some of the stone walls and enclosures which they built still survive, they had abandoned the island before the French started to explore the group. In 1774, Lazare Picault, on his second voyage to the Seychelles from Mauritius, anchored off Frégate, but was unable to land. It was at this time that the island was given the name 'Ile aux Frégates', presumably after frigate birds seen in the vicinity. Apart from a brief period in 1801, when one of the Jacobin terrorists, who had been deported from France after an attempted assassination of Napoleon, and three slaves were marooned on Frégate (Lionnet, undated), the island remained uninhabited until 1813 at least. In that year, the island officially came into the ownership of the Savy family, although there is a reference to "Lieutenant Savy de Frégate" as early as 1785 (Fauvel, 1909). By 1851, the number of people resident on island had risen to 60, and subsequent census reports indicate that the population has since fluctuated, reaching a peak of 118 in 1947, before dropping to its present total of less than 25.

In 1787, Malavois, the Commandant of the Seychelles, described Frégate as being covered by timber trees of poor quality and lacking coconuts and other palms. However he did consider that the island might be suitable for the cultivation of rice and maize (Fauvel, 1909). There are no records of the early exploitation of the island, but by 1868, there were fields of rice and large mango trees, and bananas were grown. However, the major crop was sugar cane, and between 20,000 and 30,000 gallons of high-quality rum were produced each year. A few sheep were also kept on the island (Wright, 1868). A few years later, another visitor noted a flourishing vegetable garden and a number of Madagascar cattle in addition to the fields of sugar cane (Pike, 1872). Twenty years later, plantations of coconuts had been added to those of sugar cane (Guérard, 1891). Coconut palms have since been widely planted, even in the most marginal of habitats, and sugar cane has all but disappeared. Judging by their present abundance, cashew trees must also have been extensively cultivated at one time, while groves of citrus trees were established along the base of the hill behind the main plateau. The presence of a patch of cotton suggests that this too may have been grown commercially at some stage. More recently, efforts were made to establish a series of vanilla plantations, but they failed partly due to the presence of a fungal parasite. However, the sandragon trees planted to support the vanilla vines have thrived and now form a distinctive vegetation type. At present, the major crops are coconuts, from which copra is prepared, and, to a lesser extent, bananas and oranges. Cattle, pigs and chickens are kept on the plateaux.

Since the island was first settled, all of the indigenous vegetation has been cleared over the years to make way for man's crops. The result has been that an overwhelming proportion of the plant species now found on Frégate have been introduced by man, and that these species now dominate the vegetation. The disappearance of native plant species and the spread of introduced ones may have been helped by the presence of Javan Rusa Deer *Cervus timoriensis* (although these died out sometime in the 1950s), House Mice *Mus musculus,* and such birds as Indian Mynahs *Acridotheres tristis* and Madagascan Fodies *Foudia madagascariensis.*

Vegetation Types

The present vegetation of Frégate consists of a mosaic of different types dependent both on the nature of the underlying substrate and the period since the area was either last cleared or planted by man. There are few areas with what could be termed a climax vegetation. Because of this, it is almost always impossible to find clear boundaries between vegetation types. Despite this, thirteen vegetation types were recognised and are summarised below. Figure 4b indicates boundaries which are both subjective and approximate.

BC. Beach crest : hedges of *Scaevola sericea* survive along the tops of the beaches at Grand' Anse and Anse Parc, though the one on the main plateau at La Cour has been largely destroyed; with *Ipomoea pes-caprae* and *Sporobolus virginicus,* and in places *Casuarina equisetifolia, Guettarda speciosa* and *Colubrina asiatica.*

R. Rock : in the cracks and depressions in the large expanses of bare rock grow such plants as *Cyperus dubius, Panicum maximum, Pennisetum polystachyon, Furcraea foetida, Premna obtusifolia, Ficus benghalensis, F.nautarum, F.reflexa, Chrysobalanus icaco* and *Anacardium occidentale.*

G. Grassland : areas with a low growth of grasses, sedges and herbs with only occasional trees or shrubs; on the main plateau, a wide range of species including *Cynodon dactylon, Digitaria horizontalis, Lippia nodiflora, Sida* spp., *Stachytarpheta* spp., *Cassytha filiformis, Ipomoea obscura,* etc. are found; on the south coast in areas exposed to salt spray *Stenotaphrum dimidiatum* occurs with *Ipomoea pes-caprae* and some *Acrostichum aureum.*

F. Fatak grassland : areas dominated by *Panicum maximum* with occasional *Cocos nucifera* and other emergent trees, and in some areas a low growth of *Chrysobalanus icaco.*

D. *Chrysobalanus* scrub : *Chrysobalanus icaco* with a canopy at about 2 or 3 m with occasional emergent *Cocos nucifera, Anacardium occidentale* and *Ficus benghalensis.* The *Chrysobalanus* may have been planted to halt erosion.

S. Mixed scrub : areas with varying proportions of *Panicum maximum, Chrysobalanus icaco* and *Anacardium occidentale,* always with a very broken canopy often at less than 7 m, though with emergent species; with a wide range of other species including *Cocos nucifera, Cinnamomum zeylanicum, Strychnos spinosa, Asystasia gangetica, Citrus* spp., *Albizia lebbeck, Mangifera indica, Ficus benghalensis, Terminalia catappa* and *Furcraea foetida.*

W. Mixed woodland : areas with a higher and more complete canopy than 'S', usually with *Anacardium occidentale* as the dominant species, but including many other tree species such as *Ficus benghalensis, Cocos nucifera, Adenanthera pavonina, Albizia lebbeck, Hevea brasiliensis, Eucalyptus* sp., etc. Breaks in the canopy allow some growth of *Chrysobalanus icaco, Dracaena angustifolia, Nephrolepis biserrata* and *Polypodium scolopendria.*

C. Coconut plantation : areas with complete, or almost complete, canopy of *Cocos nucifera.* Where the canopy is incomplete, the undergrowth may resemble vegetation types 'G', 'F', 'D', or 'S'; in areas on the main plateau, the coconuts have been underplanted with *Musa* spp., *Carica papaya, Citrus* spp. and *Persea americana.*

O. Citrus plantation : areas planted with *Citrus* spp., most commonly *C.aurantium,* and including other species such as *Cinnamomum zeylanicum, Artocarpus heterophyllus* and *Jatropha curcas,* and where the canopy is broken, a ground flora resembling 'G'. A small area of *Coffea canephora* growing under *Albizia lebbeck* and *Cananga odorata* has been mapped with this type.

A. Breadfruit woodland : mature *Artocarpus altilis* growing on the main plateau, with occasional *Heritiera littoralis, Cocos nucifera, Calophyllum inophyllum* and *Mangifera indica,* with *Averrhoa bilimbi, Annona reticulata* and *Coffea canephora* around the fringes.

T. *Terminalia* woodland : small stands of *Terminalia catappa* growing at southern end of the main plateau with partial ground cover of *Maranta arundinacea.*

P. Sandragon woodland : even-aged stands of *Pterocarpus indica,* originally planted as supports for *Vanilla planifolia;* those on the pleateau include a few *Artocarpus altilis, Terminalia catappa* and *Thespesia populnea,* whereas those up the hill have occasional *Anacardium occidentale.* There is little or no ground cover.

B. Bamboo : *Bambusa vulgaris* grows down the course of the main seasonal stream on the island, with occasional *Ficus benghalensis, Mangifera indica* and *Albizia falcata.*

List of plants

Collectors' names and numbers in the following list refer to specimens deposited in the Herbarium of the Ministry of Agriculture, Mahe, Seychelles. Sight records by Robertson and Todd are also indicated. No attempt was made to record all the ornamental species growing around houses, but those found further afield have been included in the list. Commonly-used Creole and English names have also been given.

ACANTHACEAE

Asystasia gangetica (L.) T. Anders. — Manz Tou
Robertson 2681

AIZOACEAE

Glinus oppositifolius (L.) DC. — Gro Laverven
Todd 13

AGAVACEAE

Agave sisalana (Perr. ex Engl.) Drumm. & Prain — Lalwa, Sisal
Todd, sight

Dracaena angustifolia Bak. — Sandel
Robertson 2670

Furcraea foetida (L.) Haw. — Lalwa, Mauritius Hemp
Robertson 2656

AMARANTHACEAE

Achyranthes aspera L. — Serzan
Todd 44

Alternanthera sessilis (L.) R. Br. — Anbalaz, Bred Malabar
Procter 4158
Robertson 2467, 2715

Amaranthus dubius Mart. ex Thell. — Payater
Todd 15

Cyathula prostrata (L.) Bl.
Robertson 2689

ANACARDIACEAE

Anacardium occidentale L. Robertson 2666	Kazou, Cashew
Mangifera indica L. Robertson, sight Todd, sight	Mang, Mango
Spondias dulcis Park. Todd, sight	Frisiter, Golden Apple

ANNONACEAE

Annona muricata L. Todd, sight	Korosol, Soursop
Annona reticulata L. Robertson, sight Todd, sight	Ker-d-bef, Ox-heart
Annona squamosa L. Robertson, sight Todd, sight	Zat, Custard-Apple
Cananga odorata DC. Robertson, sight Todd, sight	Langila, Ylang-Ylang

APIACEAE (UMBELLIFERAE)

Centella asiatica (L.) Urb. Todd, sight	
Daucus carota L. Robertson, sight	Karot

APOCYNACEAE

Alstonia macrophylla Wall. Todd, sight	Bwa Zonn
Catharanthus roseus (L.) G. Don Todd, sight	Rozamer, Saponer, Madagascar Periwinkle
Plumeria acuminata Ait. Todd, sight	Prensipann, Frangipani
Plumeria rubra L. Todd, sight	Prensipann, Frangipani

ARACEAE

Alocasia macrorrhiza (L.) Schott — Vya
Todd, sight

Caladium bicolor (Dryand.) Vent.
Todd, sight

Colocasia esculenta (L.) Schott — Larouy, Cocoyam
Robertson, sight
Todd, sight

ARALIACEAE

Polyscias pinnata J. R. and G. Forst.
Todd 27

ARECACEAE (PALMAE)

Areca catechu L. — Koko Pak, Areca Palm
Robertson, sight
Todd, sight

Cocos nucifera L. — Kokȯ, Coconut Palm
Robertson, sight
Todd, sight

Lodoicea maldivica (J.F. Gm.) Pers. — Koko-d-Mer, Coco de Mer
Todd, sight

ASCLEPIADACEAE

Calotropis procera (Ait.) Ait.f.
Robertson 2731

Cryptostegia grandiflora R. Br.
Robertson 2732

Sarcostemma viminale R. Br. — Lyann san Fey
Robertson 2742

ASTERACEAE (COMPOSITAE)

Ageratum conyzoides L.
Todd 53

Emilia sonchifolia (L.) DC.
Robertson 2644

Melanthera biflora (L.) Willd.
Todd 58

Synedrella nodiflora (L.) Gaertn.
Robertson 2672

Vernonia cinerea (L.) Less. — Gerivit
Robertson 2676

BIGNONIACEAE

Tabebuia heterophylla (Lindl.) Miers — Kalis-d-pap
Todd, sight

BOMBACACEAE

Ceiba pentandra (L.) Gaertn. — Lawet, Kapok
Todd, sight

BORAGINACEAE

Heliotropium indicum L. — Lerb Papiyon
Procter 4248
Robertson 2735

Tournefortia argentea L.f. — Bwa Taba
Todd, sight

BRASSICACEAE (CRUCIFERAE)

Brassica chinensis L. — Sou-d-sinn
Todd, sight

Nasturtium officinale R. Br. — Kreson, Water Cress
Robertson, sight

BROMELIACEAE

Ananas comosus (L.) Merr. — Zanana, Pineapply
Robertson, sight
Todd, sight

CAPPARIDACEAE

Cleome viscosa (L.) DC. — Pisat-d-sinn
Todd 20

Cleome gynandra L.
 Jeffrey 1173
 Todd, sight

CARICACEAE

Carica papaya L. — Papay, Pawpaw
 Robertson, sight
 Todd, sight

CARYOPHYLLACEAE

Drymeria cordata (L.) Willd.
 Todd 14

CASUARINACEAE

Casuarina equisetifolia L. — Sed
 Robertson, sight
 Todd, sight

CHRYSOBALANACEAE

Chrysobalanus icaco L. — Prinn-d-frans, Coco-plum
 Robertson 2700

CLUSIACEAE (GUTTIFERAE)

Calophyllum inophyllum L. — Takamaka
 Todd sight

COMBRETACEAE

Lumnitzera racemosa Willd.
 Todd 37

Terminalia catappa L. — Badamye, Indian Almond
 Todd, sight

COMMELINACEAE

Commelina sp. — Lerb Koson
 Todd, sight

CONVOLVULACEAE

Ipomoea batatas (L.) Lam. — Patat, Sweet Potato
Robertson, sight

Ipomoea macrantha Roem. & Schultes — Gro Patat Koven
Todd, sight

Ipomoea obscura (L.) Ker-Gawl
Todd 10

Ipomoea pes-caprae L. — Patatran Rouz, Beach Morning Glory
Todd, sight

CUCURBITACEAE

Cucumis melo L. — Melon-d-frans, Melon
Robertson, sight
Todd, sight

Cucumis sativus L. — Kokn, Cucumber
Robertson, sight
Todd, sight

Cucurbita moschata (Duch. ex Lam.) Duch. ex Poir. — Ziromon, Pumpkin
Robertson, sight
Todd, sight

Trichosanthes cucumerina L. — Patol, Snake Gourd
Robertson, sight
Todd, sight

CYPERACEAE

Cyperus aromaticus (Ridl.) Mattf. and Kük. — Lerb Zonyon
Robertson 2683

Cyperus compressus L. — Lerb Zonyon
Procter 4213
Robertson 2729

Cyperus dubius Rottb. — Lerb Zonyon
Procter 4161
Robertson 2661

Cyperus kyllingia Endl.
Kyllinga monocephala Rottb.
Robertson 2699

Cyperus ligularis L. — Lerb Sent Mari
Procter 4175

Cyperus polystachyos (Rottb.) Beauv. — Lerb Zonyon
Robertson 2663

Cyperus rotundus L.
Robertson 2723

Fimbristylis complanata (Retz.) Link — Barb Anri
Robertson 2669

Fimbristylis dichotoma (L.) Vahl
Robertson 2695

Fimbristylis spathacea Rottb.
Procter 4151
Robertson 2643, 2725

Remirea maritima (L.) Aubl.
Robertson 2727

EBENACEAE

Diospyros discolor Willd. — Manbolo
Todd 23

EUPHORBIACEAE

Acalypha indica L. — Lerb Sat
Robertson 2716

Euphorbia hirta L. — Zan Rober
Robertson 2641

Euphorbia pyrifolia Lam. — Tangen, Bwa-dile
Jeffrey 1179
Robertson 2658

Euphorbia thymifolia L. — Trenas
Robertson 2724

Hevea brasiliensis Muell.-Arg. — Kaoutsou; Rubber
Todd, sight

Jatropha curcas L. — Piyondenn
Robertson 2711

Manihot esculenta Crantz — Manyok, Cassava
Robertson, sight
Todd, sight

Pedilanthus tithymaloides (L.) Poit. — Bwa Malgas
Todd, sight

Phyllanthus amarus Sch. & Thonn. — Kiraneli Blan
Robertson 2713

Phyllanthus urinaria L. — Kiraneli Rouz
Robertson 2714

FABACEAE (LEGUMINOSAE)

Abrus precatorius L. — Reglis
Robertson 2680

Acacia confusa Merr.
Procter 4172

Adenanthera pavonina L. — Lagati, Bead Tree
Todd, sight

Albizzia falcata (L.) Book. — Albizya
Todd, sight

Albizia lebbeck (L.) Benth. — Bwa Nwar
Robertson 2720

Caesalpinia bonduc (L.) Roxb.
Robertson 2738

Caesalpinia pulcherrima (L.) Swartz — Zegret, Pride of Barbados
Todd 24

Canavalia cathartica Thonn. — Pwa Maron
Robertson 2649

Canavalia rosea (Sw.) DC.
Jeffrey 1186

Cassia occidentalis L. — Kaspyant
Robertson 2692

Centrosema pubescens Benth.
Robertson 2744
Todd 31

Crotalaria pallida Ait.
Procter 4160
Todd 16

Crotalaria retusa L.
Robertson 2684

Delonix regia (Hook.) Raf. — Flanbwayan
Todd, sight

Desmodium canum (Gm.) Sch. & Thell. Pti Tref
Robertson 2660

Desmodium triflorum (L.) DC. Pti Tref
Robertson 2660

Indigofera suffruticosa Mill. Lendigo
Procter 4173
Robertson 2694

Leucaena leucocephala (Lam.) de Wit
Todd, sight

Mimosa pudica L. Sansib
Robertson 2698

Pithecellobium unguis-cati (L.) Benth. Kanpes
Todd 49

Pterocarpus indicus Willd. Sandragon
Robertson 2737

Sophora tomentosa L.
Robertson 2726

Tamarindus indica L. Tamaren, Tamrind
Todd, sight

Tephrosia noctiflora Boj. ex Baker
Jeffrey 1176
Procter 4159
Robertson 2673

Teramnus labialis (L.f.) Spreng.
Robertson 2647

GOODENIACEAE

Scaevola sericea Vahl Veloutye
Robertson 2653

HERNANDIACEAE

Hernandia sonora L. Bwa Blan
Robertson, sight
Todd, sight

LAMIACEAE (LABIATAE)

Coleus sp. — Grobon
Robertson 2675

Leucas lavandulifolia Sm.
Procter 4154
Robertson 2644

Ocimum basilicum L.
Todd, sight

LAURACEAE

Cassytha filiformis L. — Lyann san Fen
Robertson 2682

Cinnamomum zeylanicum Blume — Kanel, Cinnamon
Robertson 2667

Litsea glutinosa (Laur.) C. B. Rob. — Bwa Zwazo
Todd 21

Persea americana Mill. — Zavoka, Avocado
Robertson, sight
Todd, sight

LECYTHIDACEAE

Barringtonia asiatica (L.) Kurz — Bone Kare
Robertson, sight
Todd, sight

LILIACEAE (sensu lato)

Crinum amabile Ker-Gawl ? — Lis
Todd, sight

MALVACEAE

Abutilon indicum (L.) Sweet — Lerb Herison Blanc
Todd 26

Abutilon mauritianum (Jacq.) Medic
Procter 4156
Todd, sight

Gossypium hirsutum L. Todd 39	Koton, Cotton
Hibiscus abelmoschus L. Todd 2741	Zanbret
Hibiscus mutabilis L. Todd, sight	Biskis, Hibiscus
Hibiscus tiliaceus L. Todd, sight	Var, Tree Hibiscus
Sida acuta Burm.f. Robertson 2748, 2691	Lerb Dir
Sida pusilla Cav. Jeffrey 1180 Todd, sight	
Sida rhombifolia L. Robertson 2651, 2749	Lerb Dir
Sida stipulata Cav. Robertson 2747	Lerb Dir
Thespesia populnea (L.) Sol. ex Correa Todd, sight	Bwa-d-roz
Urena lobata L. Robertson 2650	

MARANTACEAE

Maranta arundinacea L. Todd 59	Larourout, Arrowroot

MELIACEAE

Melia azederach L. ? Robertson 2690	Lila
Swietenia macrophylla Jacq. Todd, sight	Mahogany
Xylocarpus granatum Koen. Todd, sight	Pasyans, Cinese Puzzle Nut

MORACEAE

Artocarpus altilis (Park.) Fosb. — Fri-a-pen, Breadfruit
Robertson, sight
Todd, sight

Artocarpus altilis (Park.) Fosb. var. — Rima, Breadfruit
Robertson, sight
Todd, sight

Artocarpus heterophyllus Lam. — Zak, Jackfruit
Todd, sight

Ficus avi-avi Bl.
Todd 28

Ficus benghalensis L. — Piltiplyan, Banyan
Robertson 2668

Ficus nautarum Bak. — Lafous Gran Fey
Todd, sight

Ficus reflexa Thunb. — Lafous Pti Fey
Robertson 2657

MORINGACEAE

Moringa oleifera Lam. — Bred Morong, Horse Radish Tree
Todd, sight

MUSACEAE

Musa spp. — Banann Sen Zak, Gabou, Minyon, Kare
Todd, sight

MYRTACEAE

Eucalyptus sp. — Kaliptis
Todd, sight

Eugenia javanica Lam. — Zamalak, Java Apple
Robertson, sight
Todd, sight

Eugenia malaccensis L. — Pom, Pomerac
Robertson, sight
Todd, sight

Psidium littorale Raddi — Gouyav (Rouz), Chinese Guava
Todd, sight

Psidium littorale Raddi var. *lucidum* Degener — Gouyav (Zonn)
Todd, sight

NYCTAGINACEAE

Boerhavia sp. — Patat Koven
Jeffrey 1181
Todd 32

Bougainvillea glabra Choisy — Vilya
Todd, sight

ONAGRACEAE

Ludwigia erecta (L.) Hara — Lerb Lamar
Robertson 2648

ORCHIDACEAE

Vanilla mexicana Mill. — Lavany, Vanilla
Todd, sight

OXALIDACEAE

Averrhoa bilimbi L. — Bilenbi
Robertson, sight
Rodd, sight

Oxalis corniculata L.
Robertson 2717

PANDANACEAE

Pandanus balfourii Martelli — Vakwa-d-rivyer
Todd, sight

Pandanus utilis Bory — Vakwa Sak
Todd, sight

PASSIFLORACEAE

Passiflora foetida L. — Pok-pok, Bonbon Plim
Robertson 2697

PEPEROMIACEAE

Peperomia pellucida (L.) HBK. — Lerb Glase
Jeffrey 1174
Todd 51

POACEAE (GRAMINEAE)

Axonopus compressus (L.) P. Beauv.
Robertson 2665

Bambusa vulgaris Schrad. — Banbou
Todd 11

Chloris barbata Sw.
Robertson 2739

Coix lachryma-jobi L. — Zob, Job's Tears
Todd 54

Cynodon dactylon (L.) Pers. — Gazon Sovaz
Procter 4157, 4250

Dactylcctenium ctenoides (Steud.) Bosser — Lerb Touloulou
Robertson 2722

Dendrocalamus giganteus Munro ? — Banbou Zean
Robertson 2749a
Todd 18

Digitaria horizontalis Willd.
Robertson 2685

Digitaria timorensis (Kunth.) Bal. — Gazon Lave
Procter 4170

Eleusine indica (L.) Gaertn. — Pat-d-poul
Robertson 2696

Enteropogon sechellensis (Bak.) Dur. and Schinz — Lerb Diri
Robertson 2466

Eragrostis ciliaris (L.) R. Br.
Procter 4169

Eragrostis tenella (L.) Beauv. var. *insularis* Hubb. — Lerb Touterel
Robertson 2743

Lepturus radicans (Steud.) Camus
Jeffrey 1182

Panicum brevifolium L. — Gazon banbou
Robertson 2640

Panicum maximum L. — Fatak
Jeffrey 1175
Robertson 2686

Panicum subquadriparum Trin.
Robertson 2719

Panicum sp. near *umbellatum* Trin.
Procter 4153
Robertson 2693

Paspalidium geminatum (Forsk.) Stapf
Procter 4174
Robertson 2645

Paspalum conjugatum Berg.
Robertson 2671

Paspalum scrobiculatum L.
Procter 4171
Robertson 2664

Pennisetum polystachyon (L.) Schult. — Ma Tant
Robertson 2688

Pennisetum purpureum Schum. — Lerb Letefan
Todd, sight

Saccharum officinarum L. — Kann, Sugar Cane
Todd, sight

Setaria barbata (Lam.) Kunth — Lerb Banbou
Procter 4162
Robertson 2642

Sporobolus virginicus (L.) Kunth
Procter 4150
Robertson 2740

Stenotaphrum dimidiatum (L.) Brongn.
Robertson 2679

Vetiveria zizaniodes (L.) Nash
Robertson 2734

POLYPODIACEAE (sensu lato)

Acrostichum aureum L. — Fouzer Manglye
Todd, sight

Nephrolepis biserrata (Swartz) Schott — Fouzer Taba
Robertson 2674

Pityrogramma calomelanos (L.) Link
Todd, 12, 19

Polypodium scolopendria Burm.f. — Kapiler
Todd 56

Vittaria ensiformis L.
Todd, sight

PORTULACACEAE

Portulaca oleracea L. — Kourpye
Robertson 2728

PSILOTACEAE

Psilotum complanatum Sw. — Pti Sed
Robertson 2745

RHAMNACEAE

Colubrina asiatica (L.) Brong. — Bwa Savan
Todd, sight

RUBIACEAE

Coffea canephora Pierre ex Fröhner — Kafe, Robusta Coffee
Robertson, sight
Todd, sight

Guettarda speciosa L. — Bwa Kase
Todd, sight

Hedyotis corymbosa L.
Jeffrey 1183
Procter 4166
Robertson 2736

Hedyotis macrophylla DC.
Jeffrey 1177
Todd 30

Mitracarpum verticillatum Vatke
Robertson 2662

Morinda citrifolia L. — Bwa Torti
Robertson 2659

RUTACEAE

Citrus aurantiifolia (Christm.) Swing. — Limon, Lime
Todd, sight

Citrus aurantium L. — Zoranz Mozambik, Bigarad, Gro Bogarad, Seville Orange
Todd, sight

Citrus hystrix DC — Kavava
Todd, sight

Citrus limon (L.) Burm.f. — Sitron, Lemon
Todd, sight

Citrus paradisi Macf. — Panplemous, Grapefruit
Todd, sight

Citrus reticulata Blanco — Mandarinn, Tangerine
Todd, sight

Citrus sinensis (L.) Osbeck — Zoranz Po Finn, Sweet Orange
Todd, sight

SAPINDACEAE

Cardiospermum halicacabum L.
Robertson 2468

SCROPHULARIACEAE

Scoparia dulcis L.
Robertson 2712

Striga asiatica L. — Lerb Dife, Lerb Diri
Procter 4163
Robertson 2733

SOLANACEAE

Capsicum annuum L. — Piman Salad, Sweet Pepper
Robertson, sight

Capsicum frutescens L. — Piman, Chillie
Todd, sight

Datura metel L. — Fler Pwazon
Robertson 2730

Physalis peruviana L. — Pok-pok
Todd, sight

Solanum indicum L. — Brenzel maron
Todd, sight

Solanum lycopersicum L. — Tomat, Pomdamou, Tomato
Robertson, sight
Todd, sight

Solanum melongena L. — Brenzel, Eggplant
Robertson, sight
Todd, sight

Solanum nigrum L. — Bred Marten
Procter 4149
Robertson 2718

STERCULIACEAE

Heritiera littoralis Ait. — Bwa-d-tab
Todd, sight

STRYCHNACEAE

Strychnos spinosa Lam. — Kalbasye
Robertson 2646

TILLIACEAE

Triumfetta rhomboidea Jacq.
Procter 4168
Robertson 2677

TURNERACEAE

Turnera ulmifolia L. — Koket
Robertson 2654

VERBENACEAE

Lippia nodiflora (L.) Michx.
Todd 47

Premna obtusifolia R. Br. — Bwa Siro
Robertson 2655

Stachytarpheta indica (L.) Vahl — Zepi Ble
Robertson 2678

Stachytarpheta jamaicensis (L.) Vahl — Zepi Ble
Robertson 2687

Tectona grandis L. — Tek, Teak
Todd, sight

Vitex trifolia L.
Todd, sight

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4. BIOLOGICAL HISTORY OF AGALEGA, WITH SPECIAL REFERENCE TO BIRDS AND OTHER LAND VERTEBRATES.

by A.S. Cheke and J.C. Lawley

Introduction

The twin islands of Agalega lie at 10°25'S, 56°40'E in the western Indian Ocean, about 560 km south of Mahé (Seychelles), 990 km north of Mauritius and 700 km east-north-east of Diego Suarez (Madagascar). They were discovered in 1509 by the Portuguese Diego Lopez de Sequiera (Scott 1961), and first appeared on a map in 1517, labelled Ilha do Gale (Fauvel 1909). Scott's book, *Limuria,* is the only comprehensive history of the exploration and settlement of Agalega, though the important compilation by Leduc (1848), and the books of Lionnet (1924) and Dussercle (1949) are also useful. Scott took pains to lay to rest various earlier theories as to the discoverer, discovery date, and origin of the islands' name. The often accepted association with 'Galego', nickname of the mariner João (=Juan) de Nova, appears to be invalidated, as the actual account of the discovery explains how the long low islands were nicknamed *Baixos do Gale* (Galiass Banks — a galiass being a long low sailing galley) (Scott, 1961).

After two centuries of obscurity, Agalega was rediscovered by the French ship *Rubis* in 1758 (Scott 1961). Fauvel (1909) credited the rediscovery to the *Charle* and the *Elisabeth* in 1742, but Scott considered their itinerary very doubtful). The islands became a dependency of the then Ile de France, and remain to this day part of the State of Mauritius. The island was colonised from Mauritius in 1808 (Scott 1961).

Agalega is currently run by the Outer Islands Corporation, a consortium of government and commercial interest, represented by a Manager, who apart from exploiting the copra, has administrative and judicial powers as government representative. There are however periodic visits by police and judicial officers three times a year when

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Atoll Research Bulletin No. 273: 65-108, 1983.

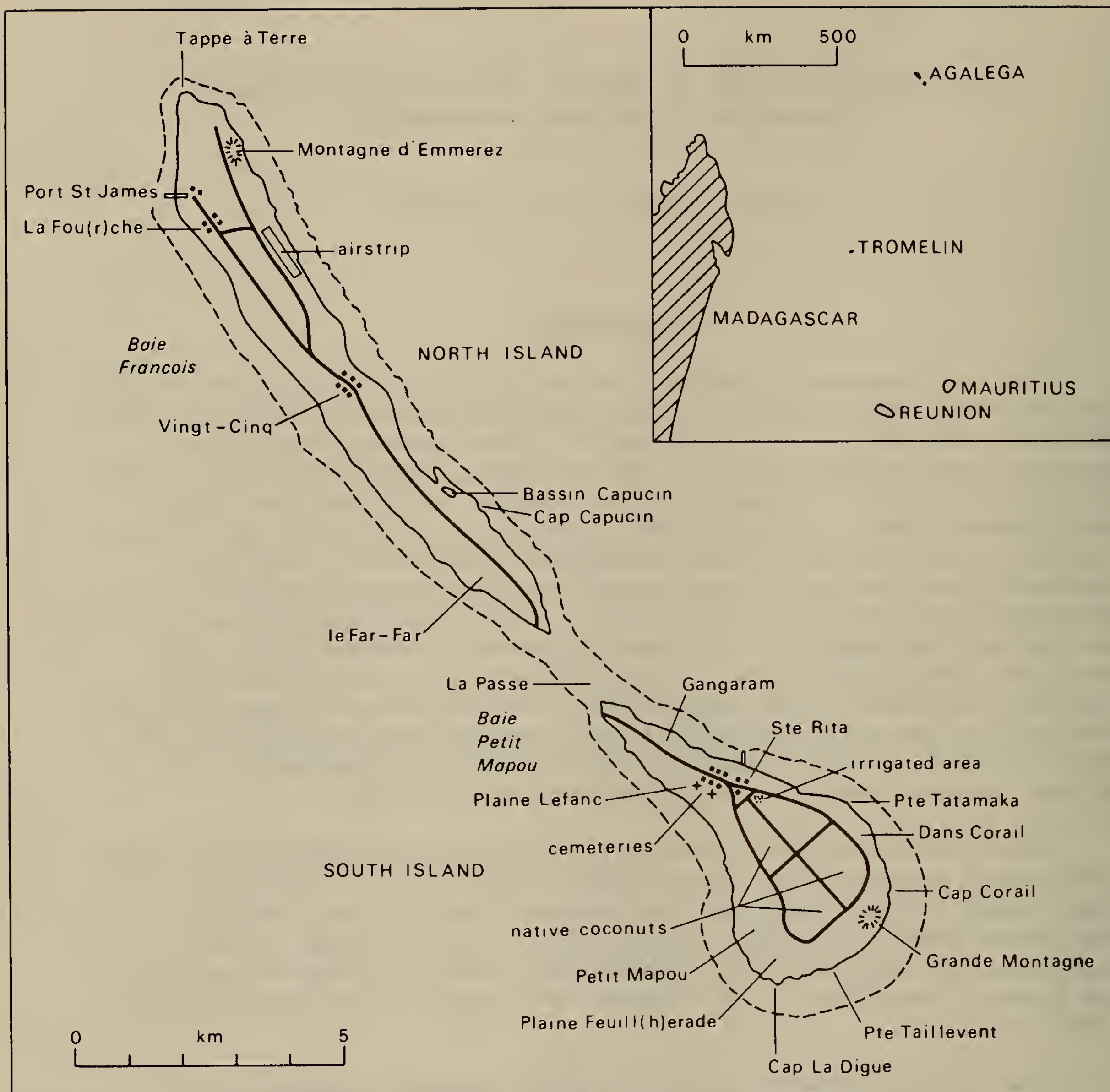

Figure 5. Agalega

the trading vessel *Mauritius* calls, and much is left over to await these visits. The only other visits are those of yachts sailing in the Indian Ocean. The human population, around 425 in 1961, had fallen to 200 by 1974 (*L'Express*, Mauritius, 7.7.74), and further to about 150 in 1978.

History of exploration and study

Of all the islands in the western Indian Ocean, Agalega has been the most neglected by scientists. There has never been a full geological survey, and neither the Percy Sladen Expeditions (early 1900s) nor any ship of the International Indian Ocean Expedition (1963-4) ever went there. The only bird list previously published dates from the 1830s (Leduc 1848; often reprinted, e.g. Watson, Zusi & Storer 1963), and likewise the only list of plants (Bojer 1835). Auguste Leduc's collections of molluscs and cryptogams remain the only significant ones from the islands (Poisson 1954, Montagne 1841). No adequate map exists, and no aerial photographs have been flown (search by Cheke in both the Mauritius Survey Department and the UK Ministry of Defence).

After the activity of the 1830s it was a century before the islands were again visited by a scientist, Rivaltz Dupont in 1934. Since then visits have been somewhat more frequent although very little has been published. The gaps can partly be filled from incidental observations by other, non-scientific, visitors; for such a little frequented island their contribution is substantial. All sources from which we have taken biological information are listed in Table 1.

Contact with Agalega was initially from Mauritius, and later also with the Seychelles (Scott 1961). It is not clear at what time connections with the latter became regular, but probably before 1830 to judge by the presence of a coco-de-mer (*Lodoicea*) nut on the Bojer-Leduc list (Leduc 1848; a collection of objects from Agalega: see below, under Birds, for dating). British naval vessels, on Indian Ocean patrols to prevent illegal slave trading in the Seychelles, called regularly in the early 1830s (Lionnet 1924, Scott 1961), and merchant captain F. Liénard was collecting in the Seychelles and Agalega in the 1830s (see *Rapports Annuels* and *Procés-Verbaux* of the Societé d'Histoire Naturelle de l'Île Maurice). There is no evidence of any direct contact at any time with Réunion or Madagascar, but the possibility that the islands were known to and used by 17th and 18th century pirates cannot be ruled out, though no traces have been reported.

In an earlier paper Cheke (1975) stated that he and John Procter were preparing for publication a review of the literature, a detailed description of the islands, and a survey of the present distribution of plants and animals. John Procter's death (*Oryx* 15:129 (1979)) has most unfortunately removed the detailed botanical element of this review: he was going to write up the flora in full, using the unpublished collections of Dupont, Mamet and Wiehé as well as his own specimens and notes. It is to be hoped that his MSS will be deposited in a place accessible to future students of Agalegan botany. We only intend here to give a very general survey of the vegetation and its history, while Fosberg *et al.* (this issue) have compiled a plant list to appear at the same time.

Scientific names used in this paper follow Fosberg *et al.* (this issue: plants), Morony, Bock & Farrand (1975: birds), Wermuth & Mertens (1977: Chelonians), Cheke (in press a: lizards) and Mamet (1978: insects). Local names are those recorded by us (but see Bailey 1971 and Cheke 1982a). We have throughout spelt the name of the islands' first colonist as he spelt it himself in his report (Rozemont 1809), not 'de Rosemond' as written by many other authors.

Geological History

Some notes on the structure and origin of Agalega have been published by Leduc (1841) and Dupont (1936), but there has been no formal survey. Leduc, who knew the island before man had seriously altered the vegetation, argued that the land surface had only been emerged some 600 years (i.e. since ca.1200-1250). He based his evidence primarily on the apparent age of trees and their distance from the shore — assuming the first seeds were washed up and each generation was able to move further inland only at a limited rate. Scott (1961) supported his view on the grounds that the Portuguese originally termed Agalega a bank (*baixos*) rather than an island, suggesting, according to him, that there may have been little or no vegetation in the early 1500s. Without stratigraphic evidence there seems no way of evaluating these theories, but one can confirm from its landform that Agalega is of relatively recent formation. The total absence of land birds before human colonisation (Rozemont 1809) suggests the same, as does the relatively undeveloped stage of the native vegetation (Bojer 1835).

Agalega (Figure 5) consists of two low-lying islands of consolidated coral debris (platin) separated by a 1.5 km coralliferous channel nearly dry at low tide. Figures for the size of the islands given the literature vary enormously. Those given here are taken by direct measurement from Admiralty Chart No.1881 (1969 printing), and are slightly larger than those previously quoted by Cheke (1975), which were taken from a derivative map. Lionnet (1924) claimed that the then current Admiralty Chart (No.2299) showed North Island as much too long and narrow, and himself gave a map showing a stouter shape, perhaps based on Bouffé (1913). Mamet (1978), without giving sources, gave in the text the total land area as 44 sq.km, over double the value we obtained from the current Admiralty Chart; likewise his figure for the maximum width of North Island is 2.4 km, as against 1.6 km; measurements taken from his map, however, agree with ours. Note that Renvoize (1975), in a paper comparing the floras of Indian Ocean coral islands, gave the land area as only 4 sq.km; his figure for the number of plants recorded was also too small by an order of magnitude.

On the chart North Island is long and narrow, 12.4 km by 1.6 km, while South Island is pear-shaped, measuring 6.6 km by 3.6 km. The

Table 1. Scientific studies at Agalega

Date	*Visitor and study*	*Reference*
1758	Island sighted by the *Rubis*, co-ordinates established.	Fauvel (1909, Dussercle (1949) Scott (1961)
1785	De Richery (on the *Maréchal de Castries*). Vegetation described from offshore.	Leduc (1848), Froberville (1848), Dussercle (1949)
1785-90	Ships sent in search of tortoises.	Froberville (1848), Dussercle (1949)
1790-1802	Unsuccessful attempts at settlement.	Leduc (1848), Dussercle (1949)
1808-9	Caillou (de) Rozemont. General observations; survey of coconuts and agricultural potential.	Rozemont (1809), Dussercle (1949)
1823, December	C.T. Hilsenberg. Brief botanical and zoological notes. Remarks on coconut cultivation.	Hilsenberg (1823)
1824	Anon. ('A.Lec...'). General remarks.	Anon (1828), Leduc (1848)
1824	Werner & C.T. Hoart. General remarks and agricultural observations. Also a map surveyed by Hoart.	Werner (1824); Toussaint & Adolphe (1956) for map details.
1827-1839	Auguste Leduc. Observations on vegetation, growth rates of trees; collections of birds, invertebrates, plants; notes on human ecology in the islands, etc.	Desjardins (1831), Leduc (1841), Montagne (1841), Leduc (1848), Lionnet (1924), Dussercle (1949), Poisson (1953), Scott (1961) etc.
1831, February	Capt. Trotter (on H.M.S. *Curlew*) collected an ibis.	Desjardins (1832)
1835, Apr.-Jun.	Wencelaus Bojer. Complete plant list. Notes on birds, game.	Bojer (1835), Bouton (1846), Vaughan (1958)[1]
1837, June	Capt. Laplace (on *l'Artémise*). General remarks.	Laplace (1841-54)
1838, June	C. Anderson. General remarks; birds, game agriculture.	Anderson (1838)

Table 1 continued:

1842	Capt. Liénard brought a living *tortue* to Mauritius.	Bouton (1846)
ca.1875	Feuillerhade. Collected birds' eggs.	Newton (1883)
1883	I. Dupont. General remarks.	Dupont (1883)
1889	A. Boucherat. General remarks; birds, game, agriculture.	Boucherat (1890)
1889-1903	G. Lionnet. General remarks; birds, game, coconut crabs, rats, agriculture (his book also contains more recent information from other sources; Dussercle (1948:51) gives Lionnet's dates).	Lionnet (1924)
1891, September	*Mathilde* wrecked; rats introduced.	Lionnet (1924), Dussercle (1949)
1893	Gabriel Lincoln. General remarks; birds, game.	Lincoln (1893), Lionnet (1924)
1912-13	G. Bouffé. Agriculture (his report contains the only reasonable map of the interior of the islands).	Bouffé (1913)
1934	Rivaltz Dupont. Topographical observations and general remarks. Plants collected (now in Mauritius Herbarium, Réduit).	Dupont (1936)
1935-48	Roger Dussercle. General remarks; birds, rats, agriculture.	Dussercle (1949)
1955, May	Raymond Mamet. Insects and plants collected (latter preserved in the Mauritius Herbarium).	Mamet (1978)
1955, September	Sir Robert Scott. General remarks, birds, game, agriculture.	Scott (1961)
1961	Octave Wiehe. Plants collected (in Mauritius Herbarium)	-

Table 1 continued:

1972, April	John Procter. Plants collected (duplicates are in the Mauritius Herbarium; location of main collection unknown). Probably also general faunal notes.	-
1974, June 8, 26-28	Anthony Cheke. Birds; lizards collected; general observations on vegetation and other fauna.	Cheke (1865, 1982a,b); This report.
1976, July 19-20	D.R. Stoddart and M.J. Coe. Geology and flora.	Fosberg, Sachet & Stoddart, this issue.
1978, November 5-6	Jonathan Lawley. Birds; lizards collected.	This report; Cheke 1982b

1. Bojer wrote numerous papers in which Agalegan plants are mentioned; see Vaughan (1958) for a full bibliography.

total land area is 21 sq.km (North Island: 11.7, South Island: 9.3; map tracings cut out and weighed).

The two islands are surrounded by a fringing reef enclosing a very narrow lagoon (25-100 m wide) with no natural passes. At the current landing place, Port St. James (North Island), the reef comes to within a few metres of the shore, and a pass has been blasted out. The size and structure of Agalega appears to be comparable with that of Coëtivy, 315 km to the north, discussed by Gardiner & Cooper (1907). Agelega appears however to be of younger formation than Coëtivy, which has a shallow shelf to the west and a broken fringing reef.

Inside the lagoon the islands are bounded throughout by a sandy beach about 20-30 m wide, a few feet higher above sea level than the interior, and vegetated on the inland side. At the south-east of South Island there are coastal dunes (Grande Montagne) rising to some 7 m or so in height, and higher ones (Montagne d'Emmerez; 15 m according to Dussercle (1949)) towards the north-east of North Island. Inland of the beach and dunes is very flat terrain composed of consolidated coral sand (platin) with a sandy surface, or, in certain areas, soil. Depressions fill with water during the rainy season, especially the large area in the centre of South Island where the coconuts (see below) are densest. Dupont (1936) considered this area to be below sea level. There is permanent water (brackish) at Bassin Capucin (North Island; Patel 1974) and (fresh) in the ditches surrounding the company's garden at Ste.Rita (South Island).

Superficial phosphate rock associated with *Pisonia grandis* occurs near the north end of North Island as a typical Jemo Series cemented layer. Guano has been intermittently exported from Agalega on a small scale. According to the *Annual Reports* of the Customs (later Customs and Excise) Department, Mauritius, this amounted to 4 tons in 1934, 350 tons in 1935, 385 tons in 1936, 235 tons in 1937, 366 tons in 1938, 50 tons in 1947 and 465 tons in 1952, a total of 1855 tons. Lincoln (1939) gave the following phosphate determinations, quoted by Hutchinson (1950, p. 294):

29.5% P_2O_5, of which 28.9% is soluble in neutral citrate and 74.5% in 2% HNO_3

25.8% P_2O_5, of which 27.6% is soluble in neutral citrate and 58.9% in 2% HNO_3

24.5% P_2O_5, of which 23.3% is soluble in neutral citrate and 63.6% in 2% HNO_3.

A sample of the cemented layer collected by D.R. Stoddart in 1976 has been analysed by X-ray fluorescence, and gives the following composition (Stoddart and Scoffin 1983, p. 370):

SiO	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	P_2O_5	Total
0.30	0.02	0.00	0.26	68.64	0.28	0.00	0.01	0.00	29.35	98.22

Climate

A meteorological station has been maintained on South Island for some years, and rainfall data are published in *Meteorological Observations and Climatic Summaries for Mauritius*. A scatter diagram of monthly rainfalls for the period 1947-1966 was provided by Stoddart (1971a), and this is revised with the addition of data for the years 1967-1971 in Figure 6. The average annual total for the 25 years of available data is 1706 mm, with extremes of 2458 mm in 1951 and 1290 mm in 1956 (Table 2). Most rain falls during the first part of the hot season (December-February) but it continues wet through May. Agalega is about at the southern limit of the Northwest Monsoon, experiencing variable but often northerly winds (bringing the rain) from November to April. During late May to October the drier Southeast Trades dominate the weather.

Agalega lies just within the zone of tropical storms; cyclones are irregular, but can be just as devastating as those further south. Although there was only one bad cyclone during the nineteenth century (in 1833: Lionnet 1924), there have been five severe storms since 1900, in 1911, 1922, 1933, 1950 and 1952 (Dussercle 1949, Scott 1961, *contra* Mamet 1978). In the period 1939-1970 three weaker storms also passed over the island and another eleven passed close by (Davy 1971).

For an account of the climate of Agalega, see Newnham (1949).

Vegetation and agriculture

The earliest account of the vegetation, given by de Richery on the *Maréchal de Castries* in 1785, described the island from close inshore: "the shores appeared to be covered with a lawn of attractive green; at a very short distance inland it was easy to distinguish a forest of coconut palms laden with nuts..." (Froberville 1848, Dussercle 1949; Cheke's translation). Rozemont (1809) spent eight months on the island when only a handful of unsuccessful attempts to settle had been made (Scott 1961) and had presumably not altered the vegetation. He described the vegetation as follows: "These islands appear at first sight to be covered in coconut palms, but they are in fact not so, except down the middle in a strip that follows their [the islands'] direction and which occupies only 3/4 of their length [Dussercle (1849) has "2/5"]. There exists in these islands only one kind of spongy wood, of the variety of *bois blanc* [*Hernandia sonora*]; it grows amongst the coconuts but not elsewhere. One also finds there a species of false *badamier* [?*Guettarda speciosa*; *badamier* is *Terminalia catappa*] which grow high enough but which do not become thick. All these trees are worthless wood and can only serve for making wattle huts. The other trees are *mapoux* [*Pisonia grandis*] and *veloutiers* [*Tournefortia argentea* and *Scaevola sericea*]. ... There is only one kind of grass, a nasty little Bermuda-grass ["*chiendent*"] which grows in the rainy season and which disappears completely when it is dry. The spiny Bermuda-grass [?*Stenotaphrum* sp.] that we have here (at the Isle of France [=Mauritius]) grows there too." (Rozemont 1809, Dussercle 1949; Cheke's translation).

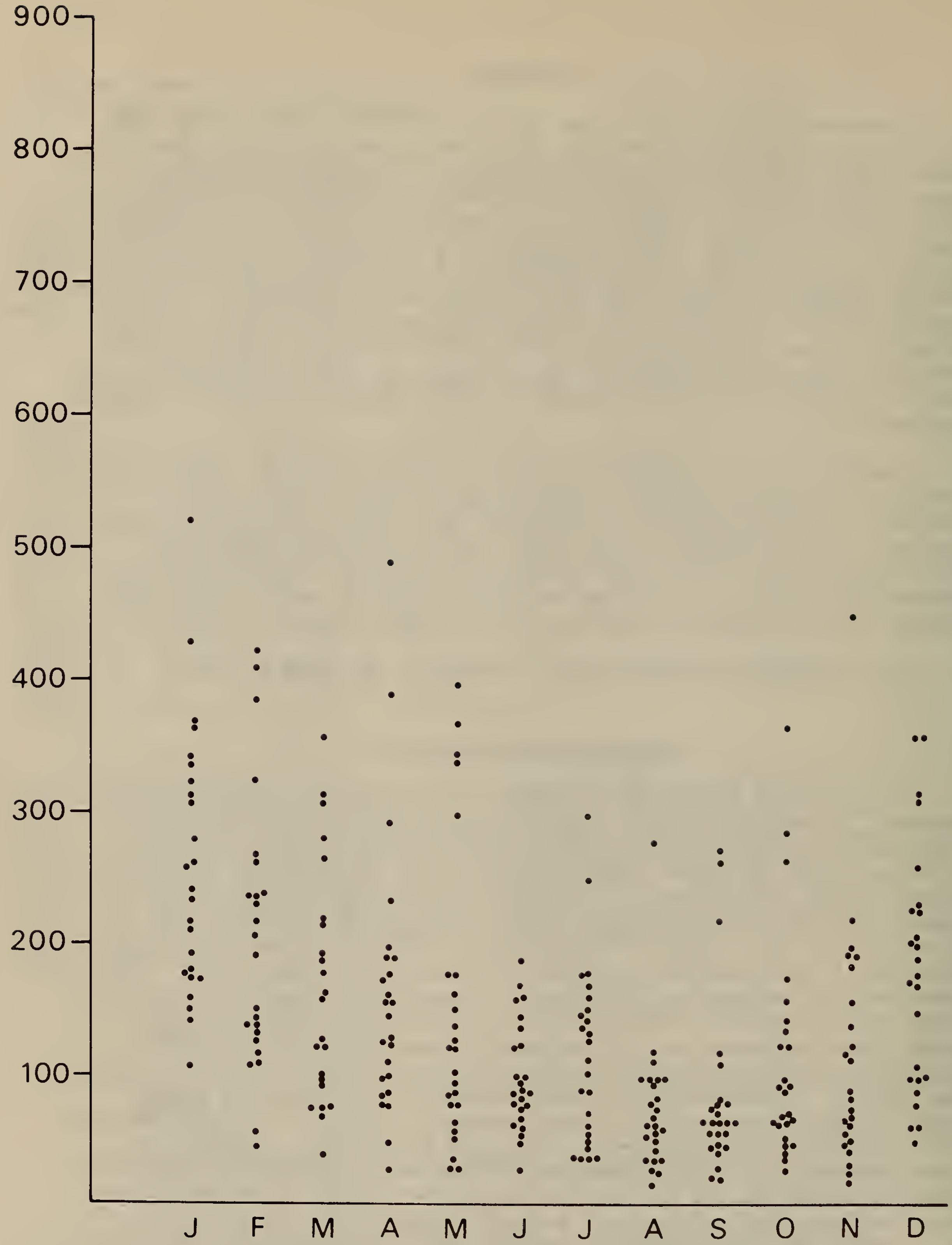

Figure 6. Monthly rainfall on Agalega 1957-1971

Table 2. Temperature and rainfall at Agalega

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average temperature °C[1]	27.3	27.3	27.6	27.5	26.9	25.7	25.0	24.9	25.3	25.9	26.6	27.1	26.4
Average rainfall mm	256	204	163	160	146	96	113	72	82	108	110	198	1706
Maximum rainfall	519	418	358	385	394	185	292	272	268	362	446	843	2458
Minimum rainfall	105	47	38	29	35	27	32	14	21	23	13	60	1290
Number of rainy days (>1 mm)[2]	17	17	15	14	13	13	15	12	11	12	12	15	166

[1] Data for 1951-1970 only; maximum and minimum figures not available

[2] Data for 1951-1970 only

Since there is no evidence of any landings prior to the 1780s, it seems most probable that coconuts are native, as is presumed for the Seychelles (Sauer 1967). The rest of the vegetation is typical of recently emerged low coral islands (e.g. Stoddart 1971b, Renvoize 1975), albeit depauperate in such typical species as *Pemphis acidula* and *Thespesia populnea*.

The botanist Charles Hilsenberg visited the island for two or three days in December 1823, but apart from coconuts, only mentions *Tournefortia, Scaevola, Suriana,* a *Cyperus* and a *Portulaca* in his account (Hilsenberg 1823).

The island was visited twice in 1824. One visitor (Anon 1828) reported 'wild lemon trees' and "those other palms which give birth to that remarkable fruit, representing the image of two thighs, and called 'Nois matoire' or coco-de-mer [*Lodoicea maldivica*]". Perhaps some nuts had been brought from the Seychelles and were growing. A coco-de-mer nut was included amongst products of the island sent to Bojer in 1831 (Leduc 1848, Lionnet 1924), but Bojer (1835) did not include the palm in his plant list. The other visitor, Werner (1824) from Mauritius, laid more emphasis on the shrubby vegetation than Rozemont, stressing that the "greatest part of the island is overrun with the *veloutier* [*Tournefortia*] and *manioc* [*Scaevola*] trees,[2] and which is the greatest source of fertility, for when it is required to plant a certain piece of ground with maize, these shrubs are cut down and burnt, which produces enough soil to have two or three crops from the same piece of land, after which it is allowed to remain for three years, when it will be fit to cultivate again." He continues: "The natural produce of the island is cocoa [sic] nuts, the trees run is [sic] a vein for nearly the whole length of the islands, in a kind of marsh.... The South island contains 2144 acres, and the coco plantation takes up nearly 1050 acres. The North island contains 4736 acres, but the vein of coco trees is so very irregular that no estimation could be formed as to the space of ground they covered. There is very little wood on the island, the only varieties are the *bois blanc* [*Hernandia*], Mango wood [?*bois mangue,* a term for *Ochna* sp. on Aldabra (C Gibson, pers. comm.) though this seems unlikely] and a little takamaka [*Calophyllum inophyllum*]".

Bojer's visit in 1835, the last by a botanist for 136 years, was very fruitful. In addition to general impressions, he compiled a list of about 150 plant species he found on the islands (Bojer 1835), of which some 30-35 appear to be native. Little had changed since 1824, apart from some progress in coconut planting and horiticulture. Among native plants of particular interest he noted the climbing fern *Stenochlaena tenuifolia* (known then as *brède Andingue,* and eaten),

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[2] 'manioc tree' is a translation (by Werner) of *bois manioc,* i.e., in Mauritius, *Scaevola*; '*manioc*' alone in Mauritian French would of course be cassava *Manihot utilissima,* but the context here clearly indicates *Scaevola*.

patches of *Suriana maritima* amongst the fringing band of *veloutier,* and large specimens of *Pisonia grandis.* Bojer's plant list was also reproduced in Leduc (1848) and Lionnet (1924), and his general remarks, in part, by Dussercle (1949).

Over the next century the main vegetation changes appear to have been the extension of coconut plantations at the expense of the *veloutier,* with clearance of species growing amongst the palms (e.g. *Pisonia* and *Hernandia*). Details of the expansion of plantations, made possible by digging holes for each nut in the platin, can be found in Bouffé (1913), Lionnet (1924) and Dussercle (1949). *Casuarina equisetifolia* (*filao*) was introduced by Leduc in 1828 (Leduc 1841), and was used for timber and as a windbreak for a long time thereafter. Dussercle (1949) noted the existence in 1948 of a belt of *Casuarina* almost all the way round the islands, and a large plantation at the south end of South Island. The cyclones of 1950 and 1952 apparently devastated the *Casuarina* (Scott 1961), and little attempt has been made since then to replant on any scale.

During the 19th century both cocoa *Theobroma cacoa* and citrus fruits *Citrus* spp. were developed as important crops, but were both eventually defeated by pests. Dupont (1883) reported nearly 4000 cocoa trees destroyed by 'borers', and Boucherat (1890) wrote of "the total destruction of the lemon and orange trees which grew on the island owing to the presence of a kind of insects known there by the name of "Pous Blancs" [*Icerya seychellarum*]"; this pest has since been controlled by the introduction of the ladybird *Rhodolia chermesina* (Mamet 1978).

Both islands are surrounded by a belt of *veloutier* growing on the upper part of the beach. The dominant species is *Scaevola sericea,* but there is some *Tournefortia, Suriana, Pisonia grandis* and rather more *Guettarda,* especially on the east coast of North Island. The crest of the dunes at the south end of South Island is largely vegetated with *Suriana,* with *Scaevola* to seaward.

North of the settlement at St. James there is a copse of *Hernandia sonora.* Around the same settlement are clumps of breadfruit *Artocarpus altilis,* and scattered *Calophyllum* and *Terminalia catappa.* The rest of North Island consists largely of coconut plantation with a ground layer of grass, *Kalanchoe pinnata* and the parasite *Cassytha filiformis* (*liane sans fin*). There are some areas more or less dominated by *Casuarina,* and individuals of this species, and also *Pisonia,* scattered throughout the coconuts. On the east side the belt of *Scaevola* is up to 200 m wide, though a long stretch between St. James and Vingt Cinq has been cleared to make an airstrip. Neither of us at the time of our visits was aware of the brackish pool Bassin Capucin, but the photograph in Patel (1974) shows it to be surrounded by grassy dunes with *Casuarina,* and to have mangroves *Rhizophora mucronata* growing in it. We saw no obvious trace of surviving native coconuts on North Island.

The vegetation of South Island is dominated by the large mass of native coconuts (*coco bon dieu*) growing at very high density in an oval depression in the centre of the island. This was dry at the time of Cheke's visit (June), but it floods in the rains, presumably forming a brackish swamp as the principal species in the ground layer is the mangrove fern *Acrostichum aureum*; also abundant is a thelypteroid fern that Cheke noted in 1974 as a *Cyclosorus*.

Around the central wild coconut area and to the north of it are coconut plantations, but towards the south of the island there are patches of *Casuarina* (in the east) and *Terminalia catappa* (south and west); *Casuarina* also lines the eastern beach north of Ste. Rita. There is an open grassy area inland of Grande Montagne in the South-east. One of the more remarkable characteristics of South Island (less marked on North Island) is the growth of normally epiphytic pteridophytes on the ground. *Langue de boeuf* (*Asplenium nidus*) is common under *Terminalia,* while *Psilotum nudum* is frequent on old stumps and tussocks in swampier areas. Under the native coconuts, and to a lesser extent outside them, are areas with an understorey of *Morinda citrifolia* (*bois torti*). The climbing fern *Stenochlaena tenuifolia* that so attracted Bojer still grows commonly in parts of South Island, especially in the southern part of the wild coconut patch. The area around the 'capital', Ste. Rita, is planted with a variety of exotic vegetation — vegetables in the company's garden, bananas *Musa* sp., *flamboyants Delonix regia,* breadfruit, papayas *Carica papaya,* cocoa *Theobroma cacao, Citrus* spp. etc. The nearby cemeteries are dominated by *Casuarina*.

Since the island was nationalised in 1975 the total population has declined to about 150, and human pressure on the environment as a whole has significantly diminished as a result. By 1978 many coconuts were being left unharvested, and allowed to run to seed in many areas. The irrigation scheme near Ste. Rita was completely neglected, and as a result there are now several acres of lush wetland. The area under *Casuarina* is expanding too, particularly on South Island where there are new large areas of untouched woodland.

Finally we should mention that the 'bois blanc' accidentally referred to by one of us earlier (Cheke 1975:42) as *Hibiscus tiliaceus* was of course in fact *Hernandia sonora,* though both species are probably present and are in fact recorded by Mamet (1978).

History and present status of land vertebrates and sea turtles

Reptiles

Geochelone gigantea Giant Tortoise; *torti*[3]

Stoddart & Peake (1979) cited Froberville (1848) as authority for the presence of "a few land tortoises there in 1785", and suggested they had been landed from a passing ship. In fact Froberville used the non-specific word 'tortue', and those actually found on the island (as opposed to what had been hoped for following de Richery's report) were almost certainly sea turtles. There is no unequivocal reference in the literature to land tortoises; the large living 'tortue' brought to Mauritius by Liénard in 1842 (Bouton 1846) was also no doubt a turtle.

In 1974 Cheke was told by an old *îlois* whose name he didn't obtain (but subsequently referred to as *Bonhom,* old man), that there had been a good number of tortoises present, but that "the Seychellois had eaten them", the last ones having survived until about 12 years previously. As Scott (1961) pointed out, all evils are blamed on "the Seychellois", so this explanation should not be taken too literally. Mr Paul Moulinié confirmed to Cheke the sometime presence of these animals, saying he thought they had been brought in some fifty years previously (i.e. ca. 1925); source stocks are available in the Seychelles and Mauritius. Bonhom said he never saw any young, so presumed they never bred successfully; this may have been due to feral cats and pigs. It is slightly odd that Dussercle (1949) made no mention of any tortoises.

Pelusios sp. Terrapin; *supap*

Terrapins, presumably of this genus, were reported to Cheke as occurring in pools and swamps. These animals are possibly native, but more likely to have been introduced from Diego Garcia or the Seychelles where three species have recently been recognised (Bour 1983).

Chelonia mydas Green Turtle; *torti*

Turtles seem never to have been particularly common. Rozemont (1809) commented that "the sea turtle is not very abundant there, the structure of these islands, surrounded everywhere by reefs, forming a barrier that they cannot cross" (Cheke's translation). Turtles are mentioned as occurring in small numbers by most subsequent writers. Dussercle (1949) wrote that they were decreasing due to human predation,

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[3]Creole names are given in the orthography used in Cheke (1982a) devised by Philip Baker for a dictionary of Mauritius Creole (in prep.). Names given were collected on the island unless bracketed: round brackets indicate a name taken from the Agalega literature, square brackets the presumed name (= usual Mauritius or Seychelles name).

though Scott (1961) reported that about two dozen were turned every year in the mid-1950s. Small numbers were still reported in 1974. Agalega's beaches are long enough, and the human population small enough, for turtles still to be able to land without necessarily being detected.

Eretmochelys imbricata Hawksbill Turtle; *care*

Lionnet (1924) and Dussercle (1949) are the only authors to mention hawksbills, the latter saying they were found "quite often" and used to make tortoiseshell trinkets.

Phelsuma borbonica agalegae Day Gecko; *lezar*

First described (Cheke 1975) as a new species, but later (Cheke 1982b) reduced to an endemic race of the Réunion day gecko. Hilsenberg (1823) was the only author to mention lizards. The geckos are abundant on coconut palms on both islands, up to five individuals per tree, the total population running into hundreds of thousands (Cheke 1975).

Gehyra mutilata House Gecko; *lezar (gri)*

Common, though much less so than the day gecko, on both islands; specimens collected by Cheke are deposited in the British Museum (Natural History). Occurs in houses and on palms and other trees. Eggs found by Cheke in June 1974 were laid cemented together in pairs under bark, in crevices etc. It was presumably introduced from Mauritius (Cheke in press, a).

[*Hemidactylus frenatus*] [House Gecko]

This species has not been recorded from Agalega, although its presence would be likely on biogeographical grounds (Cheke in press, a). Cheke saw and photographed a gecko on a tree on North Island which appeared to be this species, but the picture is not clear enough for a certain identification.

Birds

Agalega was a major seabird station in the 19th century, and most authors commented on the immense numbers of nesting birds, especially 'goelettes' (Sooty Terns). A list of birds by W. Bojer with notes on breeding etc. by A. Leduc was included in Leduc (1848) and reprinted by Lionnet (1924) and, less completely, by Gibson-Hill (1952) and Watson, Zusi & Storer (1963). As recently as 1978, Feare reported the status of boobies on Agalega as 'unknown', although the seabird colonies are known to have been destroyed deliberately by fire in 1943 (Dussercle 1949). Apparently after his seabird wardens had been threatened and birds massacred, the then manager, Volcy Monnier, set fire to the Plaine des Oiseaux (near Montagne d'Emmerez, North Island) to solve the problem once and for all — and succeeded, thus depriving the islanders of a traditional source of food. The eggs used also to be exported to

Mauritius (Scott 1961). The frigates and boobies probably disappeared before the 20th century (see systematic list).

Newton (1883) referred to seabird eggs collected in the 1870s by the then island manager M. Feuillherade, as representing "all well-known species". As he did not name them we do not know if frigates and boobies survived to this date. Newton also failed to specify the identities of the small birds which "had most undoubtedly been introduced by man's agency". These eggs are not included in the brothers Newton's collection preserved in Cambridge (Cheke, pers. obs.).

There appear to have been two phases in the introduction of land birds to Agalega: game birds, and Madagascar Turtle Doves (if not native), brought in by the first settlers, followed by passerines and Zebra Doves after August Leduc's arrival in 1827. In this context it should be noted that the original Bojer-Leduc bird list (Leduc 1848, Lionnet 1924) included a number of species that were overlooked by Jean Vinson when he transmitted it to Gibson-Hill (1952); these birds are likewise absent from Watson, Zusi & Storer (1963). These last two derivative references will not be cited further except to clear up certain confusions. Dupont (1883) reported that the management intended to introduce insectivorous birds "such as 'oiseaux blancs' [*Zosterops borbonica*], 'oiseaux bananes' [*Foudia rubra*], and 'oiseaux manioc' [*Z.chloronothos*]" to control pests; this appears never to have taken place.

The most notable existing member of the avifauna is the Glossy Ibis, occurring in the Indian Ocean otherwise only on Madagascar. The population is now very small and endangered (Cheke 1978).

Indian Ocean creole bird names and their origins are discussed at length in another paper (Checke 1982a).

Puffinus sp. Shearwater; *fuke*

Bonhom reported to Cheke that an all-dark 'fouquet' nested all over the island during the north wind (i.e. Nov.-April). This is presumably *Puffinus pacificus*. The only previous mention of a shearwater from the island is by Bouton (1846) listing some of the genera of birds given by Bojer to the Natural History Society of Mauritius. The list includes the genus '*Procellaria*'. It is strange that, if really common, such a notoriously edible bird (the chick) should not have been mentioned by Leduc or visitors to the island.

Phaethon rubricauda Red-tailed Tropic-bird; *payanke* [*ruz*]

Former breeder, referred to by Dussercle (1949) as present up to the destruction of the seabird colony in 1943. Leduc (1848, Lionnet 1924) gave laying dates as August and September, on sand under scrub (i.e. *veloutier*) by the sea; such a brief breeding season seems improbable in view of the very extended seasons found in Mauritius (Gill *et al*. 1970, Temple 1976) and the Seychelles (Prŷs-Jones & Peet 1980).

Mr Hervé Sylva reported to Cheke that his wife had once seen a *payanke*, and Lawley was likewise told of their occasional occurrence. The species could not be determined.

Sula sula Red-footed Booby; *fu*

Former breeder, evidently once numerous. Leduc (1848) described the ease with which 20 or 30 could be killed in a few minutes by attracting them to a handkerchief attached to a pole. There are no later records. 'Fous' were also noted by Rozemont (1809), anon.(1828) and Bojer (1835). Leduc (1848, Lionnet 1924) reported laying throughout the year: single eggs in crude nests on *Pisonia* (Bojer-Leduc list) or up "trees and coconut palms" (text). On Aldabra, at about the same latitude, breeding occurs throughout the year with peaks of laying in November, January, March and August-September (Diamond 1971).

There is an undated specimen presented to Bojer in the Naturhistorisches Museum in Vienna (H. Schifter *in litt.* to Cheke). It is erroneously cited as from Mauritius by Hartlaub (1877) on the basis of its current label. The accessions register, however, reveals that the original label stated it was from Agalega (photocopy transmitted by H. Schifter).

Bonhom reported to Cheke that a kind of *fu*, black all over with a white belly, was occasionally seen. This would appear to be the Brown Booby *S.leucogaster,* but dark phase *S.sula* and immature *S.dactylatra* cannot be ruled out.

Fregata sp. Frigate-bird; (*fregat*)

Former breeder, species undetermined. Recorded by Rozemont (1809), anon (1828), Bojer (1835) and Leduc (1848, Lionnet 1924), but not thereafter. Leduc stated that, like the Red-footed Booby, they nested throughout the year, laying one egg in *Pisonia* (Bojer-Leduc list) or "trees and coconut palms" (text); anon (1828) also referred to nests in coconuts. On Aldabra, although there are young in the nest throughout the year, laying is confined to the period June-December (Diamond 1971), and the pattern is similar at St. Brandon, the nearest colony to the South (Staub & Guého 1968).

Ducks; *Sarsel*

Bonhom reported to Cheke that *sarsel* were seen occasionally. These are likely to be either White-faced Tree Ducks *Dendrocygna viduata* or Garganey *Anas querquedula,* the two ducks which most regularly visit the Seychelles (C.J. Feare & R.P. Prŷs-Jones, pers. comm. to Cheke).

Ardeola ibis Cattle Egret; [*madam patoñ*]

Stated by Guérin (1940-53), writing in 1941, to be an occasional visitor to Agalega. This seems likely enough, although Guérin gave no supporting evidence, and no one mentioned Cattle Egrets to us as having been seen on the islands.

Butorides striatus Little Green Heron; *gas*

Recorded by Leduc (1848, Lionnet 1924) and Dussercle (1949). Leduc reported clutches of a single egg in bushes, and that the birds ate mice, small birds and also 'fished' on the shore. Bojer's specimens, examined by Desjardins in the 1830s, are mentioned by Oustalet (1897). The clutch size for this species in Mauritius (Staub 1976) and the Seychelles (Benson & Penny 1971, Penny 1974) is normally two or three, though often only one young is reared (Cheke, pers.obs., Benson & Penny, *loc.cit.*); Leduc may have assumed a single egg from observations of single chicks.

Not a very numerous bird today. In 1974 Cheke saw two birds on North Island, none on South Island; in 1978 Lawley saw several birds on South Island, particularly around the abandoned irrigation scheme, but none on North Island.

Heron sp.

An unnamed tall wading bird, apparently a large heron, was described to Cheke by Bonhom as an occasional visitor.

Plegadis falcinellus Glossy Ibis; *telinga, tarañga*

First recorded by Werner (1824) under the same name, *telinga,* as is current today. There is no information in the literature on numbers, until Scott (1961) reported an estimated 200 in 1950, with a decline by the time of his visit in 1955. Dussercle (1949) listed the ibis amongst other 'ordinaire' (i.e. everyday, common) birds, and it was clearly considered fairly numerous by Lincoln (1893). Guérin (1940-53), who appears to have had contacts on the islands, wrote in 1940 that ibises were "not numerous".

Leduc (1848, Lionnet 1924) reported laying in September and October in nests in bushes; by contrast Bonhom told Cheke that the birds nested up coconuts during the north wind — i.e. November onwards. Leduc gave the clutch as two; Bonhom three, rearing 2-3 young ("ugly, grey with a white head"). As many as three pairs are said to nest together in a single palm, building generally on an inflorescence, and constructed with fresh green coconut leaves. Lawley however found a presumed ibis nest 20 ft up in a mature *Casuarina*. It was roundish, messy and about 30 in. in diameter. It was constructed of tightly packed twigs and other material, and apparently virtually impenetrable from below by the local tree-climbing rats; the nest did not appear to be occupied. He was told by locals that they had seen similar nests deep in the casurina forest.

As far as we can determine only three specimens of the Agalega ibis have ever been collected; two by August Leduc for Bojer in 1830 (Desjardins 1831, Leduc 1848, Lionnet 1924), and one by Captain Trotter of H.M.S. *Curlew* the year after (Desjardins 1832). Two of these specimens formed part of the Desjardins museum in Port Louis, but have since vanished. The Glossy Ibises now in the Mauritius Institute (which took over the Desjardins Museum) were shot in Mauritius in the 1930s (Guérin 1940-53). As this population has presumably been isolated for a long time on Agalega it would be most interesting to examine birds at close hand to see if any differentiation has taken place.

The creole name *telinga* is not, as Dussercle (1949) asserted, a "Malagasy name for the black ibis", but an old creole name for Indians now known as Telegu (Cheke 1982a). The bird was no doubt named after the skin colour of the Indians, in the same way as the Common Noddy, *makwa,* was named after members of the Mozambican Maccoa (or Macoua) tribe (Cheke, *loc.cit.*).

The current status of the ibis, now confined to South Island, is precarious. Cheke saw a pair and isolated individuals in 1974, though five were seen together by Bonhom one morning during his visit, and a group of 12 had recently been seen. These groups were seen in the irrigated vegetable garden near Ste. Rita. On the basis of local reports Cheke estimated a maximum population of about 20 (Cheke 1978). In 1978 Lawley saw a total of eight birds, all in the area of open grassland in the south-east and was given reports of regular sightings around Ste. Rita (irrigated area and cemetery). The total population was again estimated as about 20.

Cheke was told in 1974 that the young were good to eat, and that eggs and young were shaken out of coconut trees. Lawley heard of birds(?adults) being killed by children. The reduced human population in recent years may have allowed the ibis numbers to stabilize somewhat, but the decline since the 1950s has been precipitous. Proper protection is clearly necessary if the populations's survival is to be assured (Cheke 1978).

Birds seen by Lawley were foraging on the surface on dry ground; Bonhom recported to Cheke that they fed on cockroaches and 'worms' (*ver*). The fondness for the irrigated area suggests that they also seek aquatic food.

[*Threskiornis aethiopica*] [Sacred Ibis]

Newton (1888), in error for the Glossy Ibis, listed '*Ibis bernieri*' the Madagascar race of the Sacred Ibis as occurring on Agalega; Guérin (1940-53) repeated the mistake, assuming that Newton had recorded the bird as an accidental visitor.

Margaroperdix madagascariensis Madagascar Partridge; *perdri* [*kay*]

'Perdrix' were first mentioned by Hilsenberg in 1823, though Hartlaub(1877) was the first to assign them to a particular species. He referred them, without citing any evidence, to the Madagascar Partridge. Carié (1904) supported Hartlaub's assertion, adding that in Mauritius the species was known as *Caille d Agaléga*. Later, the same author (Carié 1916) reported that cats, introduced to destroy rats (which had arrived in 1891 (Lionnet 1924)), had wiped out the partridges. Lionnet

(1924) attributed the loss of game animals to feral hunting dogs, released in 1897; by ca.1911 (see below, under *Paroaria,* for dating) partridges were said to be declining fast (Lionnet, 1924). The dogs were apparently later controlled by shooting, but evidently too late to save the game birds and hares.

We are unaware of any specimens existing to confirm that the partridge on Agalega was indeed *Margaroperdix,* though there is no reason to doubt Carié's identification. The stock presumably came from Mauritius, where the species, now extinct, was perhaps still common around 1820 (Cheke in press b).

Dussercle (1949) mentioned a 'recent' re-introduction of 'perdrix' to North Island subsequent to their extirpation by dogs [or cats?], but the species involved this time is more likely to have been *Francolinus pondicerianus,* the only partridge in Mauritius to survive the introduction of the mongoose *Herpestes edwardsii* (Carié 1916, Staub 1976). Scott (1961) reported 'partridges' around Montagne d'Emmerez (North Island) in 1955.

Cheke was told in 1974 by P. Moulinié and Bonhom that partridges still occurred on North Island, but neither of us saw or heard any, so their identity remains in doubt.

Gallus gallus Feral chicken; (*pul maroñ*)

Feral chickens were first noted by Hilsenberg (1823), and then by most authors up to and including Lincoln (1893). They may have been devastated by the feral dogs and cats around the turn of the century. Neither Lionnet (1924) nor Dussercle (1949) mentioned feral fowl, and Scott (1961) stated there were none in 1955.

One of the last birds Cheke saw on the island in 1974, in the copse north of St. James (North Island), was a cock that flushed at 150 yards and flew off. Such behaviour is hardly typical of domestic chickens. Unfortunately it was by then too late to ask the locals whether feral chickens were present.

Numida meleagris Guinea Fowl; (*peñtad*)

Guinea Fowl were first reported by Hilsenberg (1823); Lincoln (1893) was the last to do so. They presumably shared the fate of the partridges and chickens after the escape of hunting dogs in 1897. Earlier in the century they were always referred to as very abundant, Leduc (1848) allowing the islands' labourers to hunt Guinea Fowl (and wild chickens) but not the partridges and hares.

Reference to 'peacocks' by Boucherat (1885) and Lincoln (1893) seems likely to be due to a mistranslation into English of 'pintade'; both were Mauritians whose first language would have been French, not the English they used for preparing their reports. Lincoln, however, did also refer to 'Guinea fowls'.

Plover sp.

Bouton (1846) used the genus '*Aedicnemus*' (sic) for one of the bird species from Agalega presented by Bojer to the Natural History Society of Mauritius in 1844. This was presumably a plover, perhaps the Grey Plover *Pluvialis squatarola* or the Greater Sand Plover *Charadrius leschenaultii*; Desjardins, Bouton's predecessor as secretary of the Society, used the name '*Oedicnemus*' for the latter in 1832 (Oustalet 1897). Either species is to be expected, as both occur in Mauritius (Staub 1976) and the Seychelles (Penny 1974).

Numenius phaeopus — Whimbrel; *korbizo*

First mentioned by Werner (1824), and regarded by most subsequent visitors as a game bird of quality. Leduc (1848, Lionnet 1924), evidently unaware of the Whimbrel's migrations, remarked that he had been unable to find its nest and thus presumed it must be elsewhere than Agalega. As there is no mention of seasonality by visitors, it appears that birds are present throughout the year. Scott (1961) reported a flock of several hundred 'curlews' at the north point of North Island in September 1955.

As might be expected this Palaearctic species was scarce in June 1974 (Cheke), a few being seen on both islands, with a maximum of 12 in south South Island. By contrast in November 1978 the species was common on both islands both inland and near the shoreline (Lawley). More were seen singly amongst the trees in coconut plantations than anywhere else.

Arenaria interpres — Turnstone; *zalwet*

First mentioned in the Bojer-Leduc list, as '*Strepsilus*' (sic), *alouette* and *Tourne-pierre* (Leduc 1948, Lionnet 1924). 'Alouettes' or 'larks' are often mentioned by visitors, but the name could also apply to other species of small waders (Cheke 1982a). Bojer's specimens, examined by Desjardins in the 1830s, are mentioned by Oustalet (1897).

Scattered individuals and small groups seen both in June 1974 (Cheke) and November 1978 (Lawley), both inland and on the coast.

Calidris alba — Sanderling; *kavalye*

Cheke saw one on the airstrip (North Island). Children at Ste. Rita described a small white shorebird known as *kavalye* (='cavalier') that was presumably this species, though the name is applied in the Seychelles to the much larger Crab Plover *Dromas ardeola* (Penny 1974, Cheke in press, b).

[*Sterna anaethetus*] — [Bridled Tern]

Listed by Gibson-Hill (1952) and Watson, Zusi & Storer (1963), but not acceptable for reasons given below under *Anous tenuirostris*.

Sterna fuscata Sooty Tern; *golet, (yeye)*

Formerly bred in huge numbers. Lincoln (1893) referred to "acres of ground... covered with eggs and birds" and Lionnet (1924) said it was possible, during the season, to "collect thousands [of eggs] every day". Dussercle (1949) described the firing of the colony in 1943, since when the birds have never returned.

Leduc (1848, Lionnet 1924) described the breeding season as follows: "Birds of passage. They come and lay an egg on the sand in July and August, and leave again in February". This statement was accepted uncritically by Gibson-Hill (1952) and Watson, Zusi & Storer (1963), despite the known fact that the incubation and fledging period in the Sooty Tern is only three months and that nesting is highly synchronised (e.g. Feare 1976). Later authors reported laying in September-October (Lincoln 1893), extending to November (Lionnet 1924) — so I presume Leduc meant that the birds *arrived* in July or August *in order to lay, later,* an egg on the sand... This is in keeping with the total period of presence, and the stages of the breeding season at Aride Island in the Seychelles (Warman & Todd 1979), though the season apparently started four months later in the year at Agalega.

Sooty Terns were common offshore (South Island) in June 1974 (Cheke).

Anous stolidus Common or Brown Noddy; *(makwa), k'lek, maryan, mandria*

The only past mention is in Leduc (1848, Lionnet 1924) both in the 'Bojer-Leduc list' and in the text. The name 'maka' (list) or 'macoua' (text) is diagnostic for this species (Cheke in press, b), although the islanders no longer distinguish the two noddies today. Leduc reported laying in May and June in bushes (list) and "trees and coconut palms" (text). This noddy may have been less common than the *mariannes* (*A.tenuirostris*) which Bojer (1835) referred to as darkening the sky; his visit was in April and May (Vaughan 1958) before the Sooty Terns had returned. It is not clear to what extent the two noddies suffered from the destruction of the seabird colony, but none now nest on North Island.

The creole name *mandria* (=*mandreñ*) is unique to the oil islands[4] of Agalega and the Chagos (Cheke 1982a). The French *mandrin* means a mandrel, presumably recalled by the bird's long pointed beak.

Birds were seen flying inland in June 1974 (Cheke, South Island) but only offshore in November 1978 (Lawley). P. Moulinié told Cheke that they nested.

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[4] Agalega and the islands of the Chagos group are known in Mauritius as the 'oil islands' after their principal product, coconut oil. As they were much of the time controlled by the same company there was regular movement of people from one to the other (Scott 1961), hence the shared creole names.

A.tenuirostris Lesser or Black Noddy; *maryan, k'lek, mandria*

Details from Leduc (1848, Lionnet 1924) are the same as for the Common Noddy, but it is this species that Bojer (1835) claimed was in such numbers as to darken the sky.

Some confusion has arisen in the literature (Gibson-Hill 1952, Watson, Zusi & Storer 1963) because of Bojer's use of the scientific name '*Sterna antarctica*' for the 'marianne' in the 'Bojer-Leduc list' (Leduc 1848, Lionnet 1924). Gibson-Hill, followed by Watson *et al.*, assumed the species was the Bridled Tern *S.anaethetus antarctica;* had they known anything of Indian Ocean creole bird names they would have realised that 'marianne' could only refer to *Anous tenuirostris* (Cheke 1982a). Where Bojer got his name '*antarctica*' from we do not know; he left the 'maka', which Gibson-Hill interpreted correctly, as '*Sterna* species'. Guérin (1940-53) cited both Bridled Tern and Lesser Noddy for Agalega, but gave no sources.

In June 1974 Cheke saw birds flying inland on South Island and also a few sitting in the daytime on coconut fronds. P. Moulinié told Cheke they bred, and Cheke's observations confirm that this is likely. No birds were seen on North Island. Lawley did not record any Lesser Noddies in November 1978.

Gygis alba Fairy Tern; *gagari*, ("goelette blanche")

Mentioned only by Leduc (1848, Lionnet 1924), Dussercle (1949) and Scott (1961). Leduc noted laying in May and June: "no nest, place their egg on a branch". Some birds were incubating and others feeding young in late June 1974 (Cheke; South Island). Seasonal breeding seems unlikely given the all-year round breeding in the Seychelles (Penny 1974) and St. Brandon (Staub & Guého 1968), although there is a summer (Oct.-Dec.) peak in the latter islands. Not being colonial this species may not have suffered from the destruction of the seabird colony, but is likely to have experienced predation from tree-living rats *Rattus rattus* since their introduction in 1891 (see below).

The onomatopaeic creole name *gagari* is unique to the oil islands of Agalega and the Chagos (Cheke 1982a).

Fairy Terns were common on South Island in June 1974 (Cheke) and in November 1978 (Lawley). Neither of us saw any on North Island.

[*Columba livia*] [Feral pigeon; [*pizon̄*]]

The original Bojer-Leduc list (Leduc 1848, Lionnet 1924) includes at the end a few birds "not represented by specimens", amongst which was 'pigeon de voliere', i.e., presumably, this species. The suggestion is that they were feral, but this is not certain. There are no feral pigeons present today, nor were they mentioned by any nineteenth-century writer other than Leduc.

Streptopelia picturata Madagascar Turtle Dove; (*pizoñ*) *ramye*

'Pigeons', presumably this species, were noted by Hilsenberg (1823) and listed amongst the game of the island by many subsequent visitors. Boucherat (1885) used the term 'Dutch Pigeon'; the name *pigeon hollandais,* normally signifying *Alectroenas* spp., was sometimes used in Mauritius at that time for *Nesoenas mayeri,* also known as the *gros ramier* (Cheke 1982a), a bird somewhat resembling *S.picturata*. The impression from earlier visitors is that this dove was common in the nineteenth century, but Guérin (1940-53), writing in 1940, reported a subsequent population crash as follows:

"Madagascar Turtle Doves were very numerous at Agalega; a few years ago they nested in the coconut plantations which they enlivened by their plaintive and monotonous cooing. But following a cyclone which caused damage in the island [1933 ?], the number declined rapidly, and these birds have today become very rare. It has also been reported to me that the islanders, who appreciate the taste of their flesh, contributed substantially to their reduction, killing them with blows from sticks, profiting, for this act, the moment when the birds landed on lumps of pressed coconut (poonac) of which they are very fond" (Cheke translation). Presumably the storm-weakened and starving birds risked the proximity of men to reach food. The species has never recovered.

Assuming they were introduced, the doves on Agalega appear to have differentiated in the 160 or so years they have been there. Guérin (*loc.cit.*) described birds recently received from Agalega as "a little smaller than those in Mauritius, and having a slightly darker plumage" (Cheke translation). Cheke noted in 1974 that the birds were darker than Mauritian examples on the back, and had a more or less green (instead of purplish) gloss. The head was grey like the Mauritian birds (Malagasy race, *S.p.picturata*; Rountree et al. 1952) and unlike the Seychelles or Aldabra races (Penny 1974), whose head is dark, like the mantle. On the basis of this differentiation *Streptopelia picturata* might appear to be native to Agalega, though in view of Rozemont's (1809) categorical statement that in 1808 there were no landbirds present, it is more likely to be an introduction.

The turtle dove is scarce on Agalega today. Cheke saw only three or four during several hours wandering on North Island in 1974; Lawley saw none there in 1978. Neither of us say any on South Island, though P. Moulinié told Cheke that there were some there. This bird may be extinct or nearly so. Any seen by future visitors should be studied closely for plumage characteristics, and any dead ones found saved for study. The reasons for its failure to recover after the 1933 cyclone are unknown.

Geopelia striata Zebra Dove; *tutrel, turtrel*

The Zebra Dove is first mentioned, as 'tourterelle' in the full version of the Bojer-Leduc list (Leduc 1848, Lionnet 1924), and in Leduc's text. Leduc presumably arranged for this species, and the various passerines, to be introduced shortly after his arrival in 1827, as the list appears from internal evidence to date from before Bojer's visit in 1835. Bojer is known to have received a collection of birds from Leduc in 1830 (Desjardins 1831), and it is probably these which are catalogued in the subsequently famous list.

Zebra Doves are common today on both islands, shunning only the *Scaevola* thickets. They are conspicuous around the settlements and along tracks. Cheke saw a newly fledged juvenile on South Island on 27.6.74.

Apus sp. Swift

While aboard the *Mauritius* off St. James on 28 June 1974, waiting to sail, Cheke watched a swift fly over the ship and on southwards down the coast of North Island. It was noted as "a largish black swift with a white rump and forked tail; paler throat; belly a little paler than back". The tail shape sketched at the time (outer feathers incurved giving a barrel shape in silhouette) was immediately reminiscent of the East African *A.horus,* but not any other species familiar to the observer. On geographical grounds, Feare (1979) considered the bird more likely to be *A.pacificus,* but Brooke & Steyn (1979)argued that *A.horus* was in fact equally probable as it is a partial migrant, and many southern populations are on the move in June.

['Larks']

The 'larks' mentioned by Boucherat (1890), Lincoln (1893) and Scott (1961) are small waders. The creole name *zalwet,* or in local French *alouette,* is derived from metropolitan French *alouette de mer,* and never refers to *Alaudidae,* which do not occur in the Mascarenes, Seychelles or other small Indian Ocean islands (Penny 1974, Cheke 1982a).

Terpsiphone bourbonnensis Mascarene Paradise Flycatcher

Included, as 'gobe-mouches de l'île de France', complete with a page reference to Buffon (1770-86), in the full version of the Bojer-Leduc list (Leduc 1848, Lionnet 1924). Presumably introduced by Leduc from Mauritius ca.1827-30 (quite a feat!), but subsequently died out.

Zosterops chloronothus Mauritius Olive White-eye

Included in the full version of the Bojer-Leduc list (Leduc 1848, Lionnet 1924), in the same way as the flycatcher, with page reference to Buffon, and Buffon's name '*cherie* [sic, =*cheric*] ou oeil blanc'. Also presumably introduced from Mauritius and died out.

Paroaria coronata Red-crested Cardinal; *kon̄de* 'Cardinal du Brézil'

Cheke's discussions with the then (1974) managing director Paul Moulinié illustrate the danger of relying on hearsay to establish dates of biological events (cf. also the land tortoises, above). Moulinié said that this species had been deliberately introduced some "twenty years" before. The literature establishes however that they were certainly already present and common in 1948 (and probably 1935; Dussercle 1949) and indeed rather earlier, as Guérin (1940-53), writing in 1940, reported their introduction as "twenty or so years ago". Lionnet (1924) cited an unknown sea captain as 'recently' telling M Henri Robert "editor of the *Revue Agricole*" that no more 'cardinals du Brézil' were to be seen (not true, as it turned out). Robert was editor of a *Bulletin Agricole* from 1911-13 (Toussaint & Adolphe 1956), which was probably the date of this exchange (the *Revue Agricole* was suspended from 1902 to 1922, and Robert was never the editor (Toussaint & Adolphe, 1956)). Thus the birds were clearly established before 1911, a date somewhat anterior to 1954! Guérin (1940-53) supposed they had escaped from a cage on a ship passing Agalega. Whether they were introduced deliberately or not is impossible now to establish, but this species was certainly a popular cage-bird in the Mascarenes from at least 1855 onwards (to judge by the numbers offerred to the natural history museum in St. Denis (Réunion); Cheke, pers.obs. of the museum accessions register). Guérin (1940-53) ascribed to the bird the beneficial trait of eating unwelcome beetle larvae: *gons* parastising coconut palms and nuts, and *moutoucs* feeding on copra and poonac. P. Moulinié (pers.comm. to Cheke) reported that these birds had been exported as cage birds to Mauritius in the past, and that they were formerly common on both islands.

In 1974 there were only two birds surviving, living around the houses at Vingt-Cinq (North Island), and locals told Cheke that they bred occasionally, but that the fledged young always 'disappeared'. P. Moulinié (pers.comm. to Cheke) said there had been only two for six years (i.e. since 1968), but the people at Vingt-Cinq suggested there had been three adults and a juvenile more recently than that. There were still two birds at Vingt-Cinq in November 1978 (Lawley), which may or may not have been the same individuals as in 1974.

This unique wild population of this South American bird is clearly about to die out. One can only speculate as to why this bird was so successful for 40-50 years, but then failed; there was clearly no human persecution, and competition with other introduced seed-eaters seems unlikely as they seem to have been introduced about the same time.

Serinus mozambicus Yellow-fronted Canary; *sereñ*

Included in the full Bojer-Leduc list (Leduc 1848, Lionnet 1924) with a page reference to Buffon under the names "*Oiseau du Cap,* dit *serin de Mozambique* ou *Canari du Cap*". Presumably introduced by Leduc ca.1827-30. Not mentioned by any other author except Guérin (1940-53).

Common today on both islands, favouring especially areas of *Casuarina,* feeding on the seeds. Cheke also noted feeding on *Pisonia* seeds on North Island.

Estrilda astrild Waxbill; (*bengali*)

Said by Guérin (1940-53), writing in 1940, to have been introduced to Agalega where it had difficulty establishing itself. It presumably eventually failed, as it is no longer present today.

Padda oryzivora Java Sparrow; (*kalfat*)

Mentioned by a sea captain to Henri Robert (ca.1912) as amongst the species that had died out (Lionnet 1924). This is the only reference to the Java Sparrow on Agalega.

Passer domesticus House Sparrow; (*mwano*)

Also mentioned by the sea captain to Robert (Lionnet 1924); there was apparently at that time a single surviving male. This is the only reference to the presence of sparrows on Agalega.

Foudia madagascariensis Madagascar Fody or Cardinal; *kardinal*

Scott (1961) is the only visitor to mention *cardinals,* though Guérin (1940-53), writing in 1940, recorded the species from Agalega. It was presumably introduced relatively recently, probably in the late nineteenth century with the Java Sparrows and House Sparrows.

The Cardinal occurs today throughout both islands, but is commoner on North Island and is especially numerous in the extensive *Scaevola* thickets there (Cheke). Males were in breeding plumage in July 1974 (Cheke) and November 1978 (Lawley).

Acridotheres tristis Common Mynah; *marteñ*

Presumably introduced by Leduc, ca.1827-30, as it occurs in the full Bojer-Leduc list under the name martin (Leduc 1848, Lionnet 1924). It may have declined early this century, as a sea-captain reported to Henri Robert (ca. 1912) that mynahs were no longer to be seen (Lionnet 1924). Guérin (1940-53), writing in 1940, Dussercle (1949) and Scott (1961) considered mynahs common, so they evidently recovered fairly rapidly. The decline or disappearance of many birds around 1912 may have been due to the severe cyclone in 1911.

Mynahs are abundant today on both islands. Cheke saw a bird carrying nest material on 28.6.74.

Mammals

[Chiroptera; bats]

Cheke watched for, but failed to see, any bats; none have ever been recorded from the islands.

Lepus sp. Hare; *liev*

Hares were first reported by Hilsenberg (1823), presumably having been introduced as game animals by the first settlers, as there were none in 1808 (Rozemont 1809). They thrived (several authors) until 1897 when feral dogs attacked all game (Lionnet 1924); around 1912 they were said to be getting daily rarer (captain to Robert; Lionnet, 1924). Dussercle's account (1949) suggests that hares died out completely, and had to be re-introduced, and that this was done only on North Island. Scott (1961) reported hares in 1955 around Montagne d'Emmerez (North Island).

This species has presumably throughout been the Black-naped Hare *Lepus nigricollis,* the only species in Mauritius (Carié 1916, Cheke in press b). Rabbits are mentioned at one point in the text of Leduc (1848) by Saint-Elme Leduc, the editor, but this seems to have been a case of association, rabbits being thrown in as "rabbits and hares" generally go together in the European mind. There is no suggestion from August Leduc, nor from any visitors, that rabbits *Oryctolagus cuniculus* were ever established on the islands.

Cheke was told by P. Moulinié and Bonhom in 1974 that hares still existed on North Island. Neither of us saw any.

Mus sp. Mouse; (*ti lera*)

Leduc (1848) reported that mice were already present when he arrived (1827), and that they had resisted all efforts to control them (30,000 were killed in 18 months). The only other author to mention them as Laplace (1841-54). They presumably still survive, their depredations overshadowed by those of that later arrival, the rat. The species involved is no doubt *Mus musculus,* the only species in Mauritius (Carié 1916, Cheke in press b).

Rattus rattus Ship Rat; *lera*

Leduc (1848) reported that rats had been introduced in 1832, but that by 1834 they had been eradicated.

In 1891 the supply schooner *Mathilde* was wrecked on the reefs, and its rats colonised the islands (Lionnet 1924, Dussercle 1949), soon to cause havoc to the coconut plantations, up to 25-30% of the crop being lost (Dussercle, 1949). Rat-hunting developed into a major industry for children, up to 60,000 being killed per year for a bounty Dussercle (1949). They are still most abundant.

Dussercle (1949) reported rats living primarily in roofs and in the crowns of coconut palms, behaviour typical of *R. rattus*. There is no evidence that *R. norvegicus* is also present.

Canis domesticus Feral dog; *lisyeñ maroñ*

Reported as prevalent after imported hunting dogs hybridised with local mongrels in 1897, but said to have been eliminated by shooting (Lionnet 1924, Dussercle 1949). In 1974 P. Moulinié told Cheke that some existed on South Island.

Felis catus — Feral cat; *sat maron̄*

Cats were released in the 1890s in an attempt to control rats (Carié 1916, Lionnet, 1924). Feral cats were reported by Scott (1961) in 1955, but were not reported to us in the 1970s; this may have been an oversight.

Sus scrofa — Feral pig; *koson̄ maron̄*

Feral pigs were mentioned by Werner (1824) and Leduc (1848) but by no other author, despite the fact that, according to P. Moulinié (pers. comm. to Cheke) they are still common on both islands. Neither of us saw any.

Equus spp. — Horses and Donkeys; *suval* and (*burik*)

Although Leduc (1848) imported horses, it appears not to have been until later that feral herds developed. Both feral horses and donkeys are mentioned by Dussercle (1949), but only the former by Scott (1961; South Island only). Only a handful of horses survive today, on South Island.

A note on the coconut crab *Birgus latro*

While writing on Agalega it seems appropriate to clear up an error in the literature about the only other large land animal known from the islands, the Coconut Crab *Birgus latro*. Lionnet (1924) asserted that the crab was introduced in the mid-nineteenth century, on the grounds that it was not mentioned by Bojer (i.e. presumably, Bojer 1835). This view was followed by Dussercle (1949), who added speculative sources for the introduction. However Lionnet overlooked the fact that the Bojer-Leduc list of ca.1830 (Leduc 1848), reproduced in his own book, includes two specimens of *Birgus*, with a short comment by Leduc on their behaviour. Leduc (1848), elsewhere in the text, also states that "*Cipails* (*Birgus latro*), crabs and *Bernard l'ermite* [hermit crabs] are the only crustaceans which live on land" (Cheke translation). Although earlier visitors did not mention them (none mentioned crustaceans at all), there is no reason to suppose the crabs were not native; they would scarcely, as coconut predators, have been introduced deliberately (though admittedly good to eat), and accidental introduction seems unlikely. By the time Dussercle (1949) was writing, Coconut Crabs were scarce and declining, the author commenting in an aside on their culinary excellence. Since then they appear to have died out. Scott (1961) covering the fauna and the islanders' diet in some detail did not mention them, and nothing was heard of them in 1974 or 1978.

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Plate 1. The jetty, Port St James, North Island (A. S. Cheke)

Plate 2. The wreck of the Wajao, off Ste Rita, South Island. Note the *Casuarina* fringe along the shore; looking north. (A. S. Cheke)

Plate 3. The chapel, Ste Rita. Note the large old *Delonix regia* tree (A. S. Cheke)

Plate 4. Two Glossy Ibises *Plegadis falcinellus* on a coconut palm, Ste Rita (A. S. Cheke)

Plate 5. Glossy Ibis on open ground with *Scaevola* thicket behind, November 1978 (J. C. Lawley)

Plate 6. Red-crested Cardinal *Paroaris dominicana* in papaya tree, Vingt-Cinq, November 1978 (J. C. Lawley)

Plate 7. Male day-gecko *Phelsuma borbonica agalegae* on coconut palm trunk, North Island (A. S. Cheke)

Plate 8. Native coconuts, *Scaevola* understory and bare ground, southeast part of South Island, just inland from the coast (A. S. Cheke)

Plate 9. A relatively open patch of the native coconut area in the centre of South Island showing the ground layer of *Acrostichum aureum* and other ferns (A. S. Cheke)

Plate 10. Grande Montagne, South Island, showing *Suriana maritima* on the dunes and a broad belt of *Scaevola taccada* fringing the shore (A. S. Cheke)

Plate 11. *Asplenium nidus* growing on the ground, South Island

Plate 12. *Psilotum nudum* on a grass tussock amongst *Nephrolepis*, South Island (A. S. Cheke)

5. LIST OF THE RECORDED VASCULAR FLORA OF AGALEGA

by F. R. Fosberg, Marie-Hélène Sachet and D. R. Stoddart

Introduction

Agalega is the largest unelevated coral island in the western Indian Ocean (North Island 1170 ha, South Island 930 ha, total 2100 ha), and undoubtedly has the largest flora. However, it has not been, and is not at present, possible to offer any reliable information as to the size and composition of either indigenous or total flora. Until the visits by John Procter in April 1972 and Stoddart in August 1976, little serious collecting had been done there. Bojer collected material in 1835 but few of his specimens seem to be still extant. A systematic search in the herbaria at Paris and Kew would doubtless lead to the discovery of some of his specimens, but this would involve both much time and also a good knowledge of the flora of the region, to yield significant results. Collections made by Dupont in July 1934, by Mamet in May 1955 and by Wiehe in September 1961 are in the Herbarium of the Sugar Industry Research Institute in Mauritius. Stoddart listed these during a visit in 1969, and later Fosberg examined them, but these collections as a whole have not been determined critically. Procter's specimens in the Herbarium of the Ministry of Agriculture, Mahe, Seychelles, are more carefully named though without the benefit of reliably determined collections for comparison, and some identities are thus doubtful.

Except for scattered references to Agalega plants in the general systematic literature, knowledge of the flora has rested on a posthumously published list by Bojer (Bouton 1871), which was obviously not intended by him for publication. This was added to, somewhat, and republished by Capt. J. G. Lionnet in 1924. Both of these lists are so full of misidentifications, misspellings and invalidly published names, often unidentifiable, that it would have been much better if they had never been published and we could start with a somewhat cleaner slate.

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The present list is designed to account for the extant specimens and all names that we are aware of in published records, together with records cited by A.S. Cheke and J. Lawley in the previous paper and also listed separately by Cheke (pers.comm, 13 September 1980). Where the name or spelling given in a published record differs from that accepted here by us, the original spelling is given in parentheses after the record. Some of the spellings, especially those given by Lionnet, are so incorrect that it is doubtful what was intended. Where there is serious doubt, this is indicated by parenthetical notes. Our own doubful identifications are indicated by queries (?). Synonymy and published misidentifications are cross-referenced.

We are under no illusion, either that this is a complete list, that all names are correct, or that all the species listed are at present members of the flora. Ordinary cultivated vegetables, recorded by Bojer as grown in 1835, are retained in the list even though it is unlikely that many of them were raised with any success.

The present list is not to be regarded as adequate for phytogeographic use. To gather material for a reasonably complete list would require a visit of at least a week or two by a competent collector. Detailed descriptive notes on the vegetation would also be very desirable.

For records of algae, lichens, hepatics and mosses of Agalega, see Montagne (1841, 1844-1846 and 1856).

List of plants

ACANTHACEAE

Asystasia bojeriana Nees
**Stoddart 7262 (US) (S)

AMARANTHACEAE

Achyranthes aspera L. var. *mollis* (Moq.) Townsend
*Bojer 1835
Mamet in 1955 (MAU) (N)
Stoddart 7237 (US) (N)

Aerva sp.
Dupont in July 1934 (MAU)

Alternanthera sessilis L.
Stoddart 7271 (US) (S)

Amaranthus asperus (probably in error for *Achyranthes aspera* L., which see)
Bojer 1835
Lionnet 1924

+*Amaranthus oleraceus* L.
Bojer 1835
Lionnet 1924

+*Amaranthus tricolor* L.
Bojer 1835
Lionnet 1924

Celosia spathulata Bojer
Bojer 1835
Lionnet 1924

+*Gomphrena globosa* L.
Bojer 1835
Lionnet 1924 (as *Gomphryna globosa*)

ANACARDIACEAE

+*Mangifera indica* L.
Bojer 1835
Lionnet 1922, p. 54
Lionnet 1924
Mamet 1978, p. 105

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* Records culled from literature are listed with authors' names not underlined, and with name or spelling used by the author following in parentheses if different from that accepted by us. Bojer records are cited as 1835, when his list was compiled, rather than as 1871, when it was published. Comments on some of these records are added, in parentheses. Lionnet 1924 citations are from pp. 72-76.

** Specimens seen by us are cited with collector's name underlined, followed by his collection number, underlined, or by the year; then followed, in parentheses, by the standard symbols for the herbaria in which they are deposited. The symbol MAHE (for the herbarium of the Department of Agriculture, Victoria, Mahe, Seychelles) is not an official symbol in the Index Herbariorum, ed. 7. In second parentheses, N or S are used for North or South Island, Agalega, where this information is recorded.

+ Introduced species.

+*Spondias dulcis* Parkinson
Lionnet 1924 (as *Spondia dulcis*)

ANNONACEAE

+*Annona reticulata* L.
Bojer 1835 (as *Anona reticulata*)
Lionnet 1924 (as *Anona reticulata*)
Mamet 1978, p. 107

+*Anona squamosa* L.
Bojer 1835 (as *Anona squamosa*)
Lionnet 1924 (as *Anona squamosa*)
Mamet 1978, p. 102

APIACEAE (UMBELLIFER

+*Apium graveolens* L.
Bojer 1835
Lionnet 1924
Mamet 1978, p. 107

+*Apium petroselinum* L.
Bojer 1835 (as *Apium petroselium*)
Lionnet 1924

+*Daucus carota* L.
Bojer 1835
Lionnet 1924

APOCYNACEAE

+*Catharanthus roseus* (L.) G. Don
Bojer 1835 (as *Vinca rosea*)
Lionnet 1924 (as *Vinca rosea*)
Mamet 1978, p. 106 (as *Vinca rosea*)
Stoddart 7287 (US) (S)

Cerbera odollam Gaertn.
Cerbera manghas sensu auct. non L. (probably is *Cerbera odollam* as *C. manghas* is not found in the western Indian Ocean)
Bojer 1835 (as *Cerbera* sp.)
Lionnet 1924 (as *Cerbera* sp.)
Dupont in 1934 (MAU)
Mamet in 1955 (MAU (S: Le Jardin)

Neisosperma oppositifolia (Lam.) Fosberg & Sachet
Dupont AG/15 (MAU)
Mamet in 1955 (MAU) (S)

+Nerium oleander L.
Bojer 1835
Lionnet 1924
Stoddart, sight (N)

ARACEAE

Colocasia esculenta (L.) Schott
Bojer 1835 (as *Arum esculentum*)
Lionnet 1924 (as *Arum esculentum*)

Typhonodorum lindleyanum Schott
Mamet 1978, p. 99 (S)

ARECACEAE (PALMAE)

+Cocos nucifera L.
de Richery 1785
Rozemont 1809
Prior 1820
Moresby 1822
Hilsenberg 1823
Werner 1824
Bojer 1835
Unienville 1838
Froberville 1848
Lionnet 1924
Mamet 1978, p. 103
Cheke, sight (N, S)
Stoddart, sight (N, S)

+Lodoicea maldivica (Gmel.) Pers.
Anon. 1828
Leduc 1848
Lionnet 1924 (as drift seed?)

+Phoenix dactylifera L.
Bojer 1835 (as *Phoenix dactilifera*)
Lionnet 1922, p. 54; 1924
Mamet 1978, p. 106

+Phoenix sp.
Recorded by Mamet in 1955 as the host for *Asplenium* and *Psilotum* but not collected

ASCLEPIADACEAE

Tylophora laevigata Decne.
Cynanchum mauritianum Bojer ex Decne.
Bojer 1835 (as *Cynanchum mauritianum*)
Lionnet 1924 (as *Cynanchum mauritianum*)

ASTERACEAE (COMPOSITAE)

+*Ageratum conyzoides* L.?
Ageratum coeruleum Bojer (This name is sometimes applied to a Tropical American weed, but there is no reason to think it was ever in Agalega. Bojer probably had a bluish form of *A. conyzoides*)
Bojer 1835 (as *Ageratum coeruleum*)
Lionnet 1924 (as *Ageratum coeruleum*)

+*Bidens pilosa* L.
Stoddart 7246 (US) (N)

+*Bidens pinnata* Bojer
(No such name is recorded as validly published. Bojer possibly had *Bidens pilosa* or perhaps *Dahlia* or *Cosmos*, but there is no way to know which)
Bojer 1835
Lionnet 1924

+*Helianthus annuus* L.
Helianthus major Bojer (no such name has been validly published. Bojer possibly used it for cultivated large-headed *H. annuus*)
Bojer 1835 (as *Helianthus major*)
Lionnet 1924 (as *Helianthus major*)

+*Lactuca andivia* Bojer
(No such name validly published; perhaps the cultivated endive, *Cichorium endivia* L.)
Bojer 1835 (as *Lactuca andivia*)
Lionnet 1924 (as *Lactuca andivia*)

+*Lactuca indica* L.
Bojer 1835
Lionnet 1924

+*Lactuca oleracea* Bojer
(No such name validly published; probably *Lactuca sativa* L.)
Bojer 1835
Lionnet 1924

+*Sigesbeckia orientalis* L.
Bojer 1835 (as *Siegesbeckia orientalis*)
Lionnet 1924 (as *Siegesbeckia orientalis*)

+*Tithonia tegtioides* Bojer
(This name not validly published: could it be *Tithonia tegetiflora* Desf. from Mexico?)
Bojer 1835
Lionnet 1924 (as *Tagetes tageticides*)

+*Tridax procumbens* L.
Stoddart 7283 (US) (S)

+*Vernonia cinerea* (L.) Less.
Mamet in 1955 (MAU) (S)
Stoddart 7274 (US) (S)

BALSAMINACEAE

+*Impatiens balsamina* L.
Bojer 1835 (as *Balsamina hortensis*, an apparently unpublished name)
Lionnet 1924 (as *Balsamina hortensis*)

BIGNONIACEAE

+*Tabebuia heterophylla* (DC.) Britt.
Tabebuia pallida sensu auct. non Miers
Mamet in 1955 (MAU) (S)
Stoddart 7267 (US) (S)

BORAGINACEAE

Borrago indica L. see *Trichodesmia indica* (L.) R. Br.

Cordia subcordata Lam.
Bojer 1835
Mamet in 1955 (MAU) (S)
Stoddart 7240 (US) (N)

Tournefortia argentea L.f.
Hilsenberg 1823
Werner 1824
Bojer 1835
Lionnet 1924
Cheke, sight (N)
Mamet 1978 p. 102
Mamet in 1955 (MAU)(N, S)
Stoddart 7241 (US) (N), 7256 (US) (S)

Trichodesmia indica (L.) R. Br
Borago indica L.
Bojer 1835 (as *Borrago indica*)
Lionnet 1924 (as *Borrago indica*)

BRASSICACEAE (CRUCIFERAE)

+*Brassica chinensis* L.
Bojer 1835
Lionnet 1924

+*Brassica oleracea* L.
Bojer 1835
Lionnet 1924
Mamet 1978, p. 102

+*Brassica pe-tsai* Bailey
Mamet 1978, p. 102

+*Raphanus sativus* L.
Bojer 1835
Lionnet 1924

Sinapis pratensis Bojer
(We do not find that this name has been validly published: perhaps either *Sinapis arvensis* L. = *Brassica kaber* (DC.) Wheeler, or, more likely, *Brassica nigra* L.)
Bojer 1835
Lionnet 1924

BROMELIACEAE

+*Ananas comosus* (L.) Merr.
Bromelia ananas L.
Lionnet 1924, p. 76 (as *Bromelia ananas*)

CANNACEAE

+*Canna indica* L.
Bojer 1835
Lionnet 1924

+*Canna* sp.
Mamet 1978, p. 107

CAPPARIDACEAE

Cleome viscosa L.
Mamet in 1955 (MAU) (N)

+*Cleome gynandra* L.
Gynandropsis pentaphylla (L.) DC.
Bojer 1835 (as *Gynandropsis pentaphylla*)
Lionnet 1924 (as *Gynandropsis pentaphilla*)
Stoddart 7276 (US) (S)

CARICACEAE

+*Carica papaya* L.
Bojer 1835
Lionnet 1924
Mamet, 1978, p. 106
Cheke, sight (S: Ste Rita)
Stoddart 7270 (US) (S)

CASUARINACEAE

+*Casuarina equisetifolia* L.
Bojer 1835
Laplace 1837 (in Froberville 1848)
Leduc 1841 (stated to have been introduced in 1828)
Lionnet 1924
Cheke, sight (N, S)
Stoddart, sight (N, S)
Procter 4189 (MAHE) (S)

CELASTRACEAE

Celastrus nepalensis Steud: see *Pittosporum floribundum* W. & A. (Pittosporaceae)

CHENOPODIACEAE

+*Chenopodium graveolens* Willd.
Bojer 1835 (as *Chenapodium graveolens*)
Lionnet 1924 (as *Chenapodium graveolens*)

+*Spinacea oleracea* L.
Bojer 1835
Lionnet 1924

CHLOANTHACEAE (DICRASTYLIDACEAE)

Nesogenes prostrata Hemsl. (Marais 1980, p. 802, considers this an error in locality for Aldabra)
Radamaea prostrata Benth.
Baker 1877 (as *Radamaea prostrata*)
Justice Blackburn in 1863 (K); Kew negative 5385 held in MAU.

CLUSIACEAE (GUTTIFERAE)

Calophyllum inophyllum var. *takamaka* Fosberg
Werner 1824 (as Takamaka)
Bojer 1835
Lionnet 1924
Cheke, sight (N)
Mamet in 1955 (MAU) (S: Pte Takamaka)
Stoddart 7281 (US) (S), 7292 (US) (S); sight (N)

COMBRETACEAE

+*Terminalia catappa* L.
Bojer 1835
Lionnet 1924
Cheke, sight (S, N)
Mamet 1978, p. 102
Stoddart 7268 (US) (S); sight (N)

COMMELINACEAE

+*Commelina diffusa* Burm.f.
Dupont in 1934 (MAU)

CONVOLVULACEAE

+*Ipomoea batatas* (L.) Lam.
Bojer 1835 (as *Convolvulus batatas*)

Ipomoea macrantha R. and S.
Ipomoea glaberrima Bojer ex Hook.
Ipomoea tuba (Schl.) Don
Bojer 1835 (as *Ipomoea glaberima*)
Lionnet 1924 (as *Ipomoea glaberrima*)
Wiehe 1606 (MAU) (N)

Ipomoea maritima R. Br.: see *Ipomoea pes-caprae* (L.) R. Br. subsp. *pes-caprae*

Ipomoea pes-caprae (L.) R. Br. subsp. *pes-caprae*
Ipomoea maritima R. Br.
Bojer 1835 (as *Ipomoea maritima*)
Lionnet 1924 (as *Ypomoea maritima*)
Mamet 1978, p. 106
Stoddart 7258 (US) (S)

CRASSULACEAE

+*Kalanchoe pinnata* (Lam.) Pers.
Cheke, sight (N)
Stoddart 7243 (US) (S)

CUCURBITACEAE

+*Cucumis acutangulus* L.: see *Luffa acutangula* (L.) Roxb.

+*Cucumis melo* L.
Bojer 1835
Lionnet 1924
Stoddart 7272 (US) (S)

Cucumis muricatus Willd.: see *Cucumis sativus* L.

+*Cucumis sativus* L.
Cucumis muricatus Willd.
Bojer 1835 (as *Cucumis muricatus* and *C. sativus*)
Lionnet 1924 (as *Cucumis mauricatus* and *C. sativus*)

Cucurbita aurantia Willd.: see *Cucurbita pepo* L.

Cucurbita melopepo L.: see *Cucurbita pepo* L.

+*Cucurbita pepo* L.
Cucurbita aurantia Willd.
Cucurbita melopepo L.
Bojer 1835 (as *Cucurbita aurantia* Willd. and *C. melopepo* L.)
Lionnet 1924 (as *Cucurbita aurantia* Willd. and *C. melopepo* L.)

Cucurbita lagenaria L.: see *Lagenaria siceraria* (Mold.) Standl.

+*Lagenaria siceraria* (Mol.) Standl.
Cucurbita lagenaria L.
Bojer 1835 (as *Cucurbita lagenaria*)
Lionnet 1924 (as *Cucurbita lagenaria*)

+*Luffa acutangula* (L.) Roxb.
Cucurris acutangulus L.
Bojer 1835 (as *Cucumis acutangulus* L.)
Lionnet 1924 (as *Cucumis actuangulus*)

+*Sechium edule* (Jacq.) Sw.
Mamet 1978, p. 106

CYPERACEAE

Cyperus comosus Poir. (possibly this but this is one of three homonyms)
Bojer 1835
Lionnet 1924

+*Cyperus compressus* L.
Bojer 1835
Lionnet 1924

Cyperus galagensis C. B. Cl.
Bouton acc. C. B. Clarke 1883 (Bouton's specimen is the type)

Cyperus javanicus Houtt.
Mariscus pennatus (Lam.) Domin.
Mamet in 1955 (MAU) (N)
Wiehe in 1961 (MAU) (N)

Cyperus cf. *kyllingia* Endl.
Dupont AG/23 (MAU)

Cyperus ligularis L.
Mariscus glandulosus Bojer
Bojer 1835 (as *Mariscus glandulosus*)
Bouton, Blackburn acc. C. B. Clarke 1883
Lionnet 1924 (as *Mariscus glandulosus*)
Renvoize 1975
Mamet in 1955 (MAU) (N)
Wiehe 1605 (MAU) (N)
Stoddart 7248 (US) (N)

Cyperus platystachyus Griseb.: see *Cyperus tenuis* sw.

+*Cyperus polystachyos* Rottb.
Pycreus polystachyos (Rottb.) Beauv.
Renvoize 1975 (as *Pycreus polystachyos*)
Stoddart 7269 (US) (S), 7286 (US) (S)

Cyperus rotundus L.
Mamet 1978, p. 105

Cyperus tenuiflorus Rottb.
Blackburn acc. C. B. Clarke 1883

Cyperus triceps Endl.
Kyllinga triceps Bojer
Bojer 1835 (as *Killingia triceps*)
Lionnet 1924 (as *Kellengia triceps*)

Cyperus sp.
Hilsenberg 1823
Bojer 1835
Lionnet 1924

Cyperus tenuis Sw. (a highly improbable record)
  Cyperus platystachyus Griseb.
    Bojer 1935 (as *Cyperus platystachys*)

Fimbristylis cymosa R. Br.
  Fimbristylis obtusifolia Kunth
    Renvoize 1975 (as *Fimbristylis obtusifolia*)
    Mamet in 1955 (MAU)

Kyllinga triceps Bojer: see *Cyperus triceps* Endl.

Kyllinga sp.: see *Cyperus* sp.

Mariscus pennatus (Lam.) Domin: see *Cyperus javanicus* Houtt.

Mariscus glandulosus Bojer: see *Cyperus ligularis* L.

Pycreus polystachyos (Rottb.) Beauv.: see *Cyperus polystachyos* Rottb.

Scirpus grossus L.f.

    Bojer 1835 (as *Scirpus grossus*, but this species is not otherwise known from Africa or the Western Indian Ocean)
    Lionnet 1924

Scirpus sp.
    Bojer 1835
    Lionnet 1924

EUPHORBIACEAE

Acalypha indica L.
    Bojer 1835
    Lionnet 1924

+*Breynia disticha* Forst.
  Breynia nivosa (Bull.) small var. *roseo-picta* Hort.
    Mamet in 1955 (MAU)

Breynia nivosa (Bull.) Small var. *roseo-picta* Hort.: see *Breynia disticha* Forst.

+*Euphorbia hirta* L.
    Bojer 1835
    Lionnet 1924
    Stoddart 7245 (US) (N), 7289 (US) (S)

Euphorbia peplus L.
    Mamet 1978, p. 105 (N, S)

Euphorbia prostrata Ait.
    Mamet in 1955 (MAU) (S)

Euphorbia serpens Kunth
Euphorbia serpilifolia Bojer
Bojer 1835 (as *Euphorbia serpilifolia*)
Baker 1877
Lionnet 1924 (as *Euphorbia serpyllifolia*)

Euphorbia serpilifolia Bojer: see *Euphorbia serpens* Kunth

Euphorbia stoddarti Fosberg
Wiehe 1602 (MAU) (S)
(The records referred to *Euphorbia serpens* above may belong here)

+*Manihot esculenta* Crants
Bojer 1835 (as *Janipha manihot*)
Lionnet 1924 (as *Japnaphat manihot*)
Mamet 1978, p. 107 (as *Manihot utilissima* Pohl)
Stoddart, sight (N)

Kirganellia elegans Juss. ex Spreng.: see *Phyllanthus casticum* Willem.f.

Phyllanthus casticum Willem.f.
Phyllanthus elegans Wall. Cat. (nom. illegit.).
Kirganellia elegans Juss. ex Spreng.
Bojer 1835 (as *Kirganellia elegans*)
Lionnet 1924 (as *Kirganellia elegans*)

Phyllanthus maderaspatensis L.
Renvoize 1975
"Bouton" (G-DC). Muell.-Arg. 1866, in DC., *Prodr.* 15(2): 363.
Dupont AG/Z (MAU)
Mamet in 1955 (MAU) (N)
Wiehe 1601 (MAU) (N: Port St James)

Phyllanthus stipulata Bojer (probably *Phyllanthus stipulaceum* Bojer intended)
Bojer 1835 (as *Phyllanthus stipulata*)
Lionnet 1924 (as *Phyllanthus stipulatus*)

Phyllanthus sp.
Mamet 1978, p. 105
Mamet in 1955 (MAU)
Proctor 4188 (MAHE) (N)

+*Ricinus communis* L.
Bojer 1835
Lionnet 1924
Mamet 1978, p. 105
Stoddart 7282 (US) (S)

FABACEAE (LEGUMINOSAE)

Acacia farnesiana (L.) Willd.
  Acacia indica Desv.
    Bojer 1835 (as *Acacia indica*)
    Lionnet 1924 (as *Acacia indica*)

Acacia indica Desv.: see *Acacia farnesiana* (L.) Willd.

Afzelia bijuga (Coleb.) Gray: see *Intsia bijuga* (Coleb.) O. Kitze.

+*Albizia lebbeck* (L.) Benth.
    Bojer 1835 (as *Acacia lebeck*)
    Lionnet 1924 (as *Acacia lebeck*)
    Mamet 1978, p. 105 (as *Albizzia lebbeck*)

+*Arachis hypogaea* L.
    Bojer 1835
    Lionnet 1924

Caesalpinia bonduc (L.) Roxb.
    Stoddart 7261 (US) (S)

+*Cajanus cajan* (L.) Huth.
  Cajanus indicus Spreng.
    Bojer 1835 (as *Cajanus indicus*)
    Lionnet 1924 (as *Cajanus indicus*)

+*Cassia occidentalis* L.
    Bojer 1835
    Lionnet 1924 (as *Cassia accidentalis*)

+*Clitoria ternatea* L.
    Bojer 1835
    Lionnet 1924

+*Delonix regia* (Bojer) Raf.
    Mamet 1978, p. 102
    Cheke, sight (S: Ste Rita)
    Patel 1974, photograph (S)

+*Desmanthus virgatus* Willd.
    Mamet in 1955 (MAU) (S)

Dioclea jacquiniana DC.
  Dolichos ruber Jacq.
    Bojer 1835 (as *Dolichos ruber*)
    Lionnet 1924 (as *Dolichos ruber*)

Dolichos capensis L.: see *Vigna capensis* (L.) Walp.

+*Dolichos lablab* L.
Bojer 1835
Lionnet 1924 (as *Dolichos lablas*)

Dolichos ruber Jacq.: see *Dioclea jacquiniana* DC.

+*Erythrina variegata* var. *orientalis* (L.) Merr.
Erythrina corallodendron Bojer non L.
Erythrina indica L.
Bojer 1835 (as *Erythrina corallodendron*)
Mamet 1978, p. 106 (as *Erythrina indica*)
Stoddart 7266 (US) (S)

Erythrina corallodendron L.: see *Erythrina variegata* var. *orientalis* (L.) Merr.

Intsia bijuga (Coleb.) O. Ktze.
Tamarindus intsia Spreng.
Intsia madagascariensis Bl.
Afzelia bijuga (Coleb.) Gray
Bojer 1835 (as *Intsia madagascariensis*)
Bojer 1835 (as *Tamarindus indicus*)
Leduc 1844
Baker 1877 (as *Afzelia bijuga*)
Lionnet 1924 (as *Tamarindus intsia*)
Procter 4195 (MAHE) (N)

Intsia madagascariensis DC.: see *Intsia bijuga* (Coleb.) O. Ktze.

+*Lens culinaris* Medic.
Lens esculenta Moench
Ervum lens L.
Bojer 1835 (as *Ervum lens*)
Lionnet 1924 (as *Ervum lens*)

Leucaena leucocephala (Lam.) De Wit.
Bojer 1835 (as *Acacia leucocephala*)
Lionnet 1924 (as *Acacia leucocephala*)
Stoddart 7250 (US) (N)

+*Phaseolus vulgaris* L.
Bojer 1835
Lionnet 1924

+*Pisum sativum* L.
Bojer 1835
Lionnet 1924

+*Tamarindus indica* L.
Bojer 1835 (as *Tamarindus indicus*)
Lionnet 1924 (as *Tamarindus indicus*)
Mamet 1978, p. 107 (as *Tamarindus indicus*)

Tamarindus intsia Spreng.: see *Intsia bijuga* (Coleb.) O. Ktze.

Vigna capensis (L.) Walp.
Dolichos capensis L.
Bojer 1835 (as *Dolichos capensis*)
Lionnet 1924 (as *Dolichos capensis*)

GOODENIACEAE

Scaevola sericea Vahl
Scaevola taccada (Gaertn.) Roxb.
Scaevola koenigii Vahl
Scaevola frutescens auct. plus non Mill.
Hilsenberg 1823
Werner 1824
Bojer 1835 (as *Scoevola koenigii*)
Lionnet 1924(as *Scevola koenigii*)
Mamet in 1955 (MAU) (N, S) (as *Scaevola frutescens*)
Mamet 1978, p. 105 (as *Scaevola frutescens*)
Cheke, sight (N, S)
Stoddart 7239 (US) (N), 7280 (US) (S)

HERNANDIACEAE

Hernandia sonora L.
Hernandia ovigera sensu auct. non L.
Rozemont 1809 (as Bois blanc)
Werner 1824
Bojer 1835
Lionnet 1924
Cheke, sight (N)
Mamet 1978, p. 106
Mamet in 1955 (MAU) (S, N) (as *Hernandia ovigera* L.)
Stoddart 7230 (US) (N), 7234 (US) (N), 7278 (US) (S)

LAMIACEAE (LABIATAE)

+*Leonotis nepetaefolia* R. Br.
Mamet in 1955 (MAU) (S: Le Jardin)

Leucas sp.
Mamet in 1955 (MAU) (S)

+*Thymus hortensis* Bojer (not validly published name; possibly *Thymus vulgaris* L. was intended)
Bojer 1835

LAURACEAE

Cassytha filiformis L.
Bojer 1835
Lionnet 1924
Cheke, sight (N)
Dupont AG/15 (MAU)
Mamet in 1955 (MAU) with *Achyranthes aspera*
Stoddart 7244 (US) (S)

+*Persea americana* Mill.
Mamet 1978, p. 105

LECYTHIDACEAE

Barringtonia asiatica (L.) Kurz
Barringtonia speciosa Forst.
Bojer 1835 (as *Barringtonia speciosa*)
Lionnet 1924 (as *Barringtonia speciosa*)

LILIACEAE (sensu lato)

+*Agave americana* L.
Lionnet 1924, p. 76

+*Allium ascalonicum* L. but sensu auct. usually *Allium cepa* L., which see

+*Allium cepa* L.
Allium ascalonicum sensu auct. non L.
Bojer 1835
Lionnet 1924 (as *Allium ascolonicum* and as *Allium cepa*)

+*Allium porrum* L.
Bojer 1835
Lionnet 1924

+*Allium sativum* L.
Bojer 1835
Lionnet 1924

+*Asparagus officinalis* L.
Lionnet 1924, p. 76

Crinum cf. *augustum* Roxb.
Stoddart 7259 (US) (S)

Furcraea foetida (L.) Haw.
Lionnet 1924, p. 76 (as *Agave foetida*)

Zephyranthes sp.
Mamet 1978, p. 102

MALVACEAE

Abutilon cf. *indicum* (L.) Sweet
  Sida mauritiana Bojer
    Bojer 1835 (as *Sida mauritiana*)
    Lionnet 1924 (as *Sida mauritiana*)
    Mamet in 1955 (MAU) (S) (probably)

+*Gossypium hirsutum* L.
  Gossypium barbadense L.
    Moresby 1822 (as Cotton)
    Bojer 1835 (as *Gossypium barbadense*)
    Lionnet 1924 (as *Gossypium barbadense*)
    Mamet 1978, p. 102 (as *Gossypium barbadense*)
    Stoddart 7251 (US) (N)

+*Hibiscus esculentus* L.
    Bojer 1835
    Lionnet 1924 (as *Hibiscus esculentum*)
    Mamet 1978, p. 106

Hibiscus tiliaceus L.
    Mamet 1978, p. 104, 105

Malva borbonica Willd.: see *Malvastrum coromandelianum* (L.) Garcke

Malva communis Bojer (this name has not been validly published)
    Bojer 1835

+*Malvastrum coromandelianum* (L.) Garcke
  Malva borbonica Willd.
    Bojer 1835 (as *Malva borbonica*)
    Lionnet 1924 (as *Malva borbonica*)
    Leduc in 1839 (G)
    Mamet in 1955 (MAU) (S: Le Jardin)
    Procter 4178 (MAHE) (S)

Pavonia urens Cav.
    Lionnet 1924

+*Sida acuta* Burm. f.
    Stoddart 7273b (US) (S)

Sida mauritiana Bojer: see *Abutilon* cf. *indicum* (L.) Sweet

Sida parvifolia DC.
  Sida vescoana DC.
    Renvoize 1975
    Dupont AG/5 (MAU)
    Mamet in 1955 (MAU) (S)
    Wiehe 1604 (MAU) (N: Port St James)
    Procter 4194 (MAHE) (N), 4184 (MAHE) (S)

Sida pusilla Cav. (This is *Sida spinosa* L. according to *Index Kewensis*, but we do not know what plant Bojer had. Possibly should include *Sida parvifolia* DC.)
Bojer 1835
Bojer 1837
Lionnet 1924

+*Sida rhombifolia* L.
Stoddart 7273b (US) (S)

Sida sp.
Wiehe in 1961 (MAU) (N)
Mamet 1978, p. 105
Procter 4207 (MAHE) (S)

MARANTACEAE

+*Maranta arundinacea* L.
Bojer 1835
Lionnet 1924 (as *Maranta acoudinaces*)

MELIACEAE

+*Melia azedarach* L.
Stoddart 7279 (US) (S)

MORACEAE

+*Artocarpus altilis* (Park.) Fosb.
Lionnet 1922, p. 54 (as Breadfruit)
Cheke, sight (N: Port St James; S: Ste Rita)

Ficus terebrata Bojer (this name is regarded as a synonym of two Brazilian species, but we have no clue to what species Bojer may have applied it)
Bojer 1835
Lionnet 1924

MORINGACEAE

+*Moringa oleifera* Lam.
Hyperanthera moringa Vahl
Bojer 1835 (as *Hyperanthera moringa*)
Lionnet 1924 (as *Hyperanthera moringa*)

MUSACEAE

+*Musa paradisiaca* L.
Bojer 1835
Lionnet 1924
Stoddart, sight (N)

+*Musa pumila* Bojer (we can find no record of publication of this name. Perhaps *Musa nana* Lam. was intended)
Bojer 1835
Lionnet 1924

+*Musa sapientum* L.
Mamet 1978, p. 105
Cheke, sight

MYRTACEAE

Calyptranthes jambolana Willd.: see *Eugenia cuminii* L.

+*Eugenia aquea* Burm.f.
Mamet 1978, p. 105

+*Eugenia cuminii* L.
Calyptranthes jambolana Willd.
Bojer 1835 (as *Calyptranthes jambolana*)
Lionnet 1924 (as *Calyptranthes jambolana*)
Mamet 1978, p. 105 (as *Eugenia jambolana* Lam.)

+*Psidium guajava* L.
Psidium pommiferum L.
Bojer 1835 (as *Psidium pommiferum*)
Lionnet 1924 (as *Psidium pommiferum*)

Psidium pommiferum L.: see *Psidium guajava* L.

NYCTAGINACEAE

Boerhavia bulbosa Bojer (we have not found that this name has been validly published)
Bojer 1835
Lionnet 1924

Boerhavia diffusa L.: see *Boerhavia repens* L.

Boerhavia repens L.
Boerhavia diffusa sensu auct. non L.
Dupont in July 1934 (MAU)
Mamet in 1955 (MAU)
Wiehe in September 1961 (MAU) (N: Port St James)

+*Bougainvillea* sp.
Cheke, sight (S)

Calpidia macrophylla Bojer: see *Pisonia grandis* R. Br.

+*Mirabilis jalapa* L.
Bojer 1835

Pisonia grandis R. Br.
Calpidia macrophylla Bojer
Pisonia macrophylla (Bojer) Choisy
Rozemont 1809 (as Mapoux)
Bojer 1835 (as *Calpidia macrophylla*)
Choisy 1849 (as *Calpidia macrophylla*)
Baker 1877 (as *Pisonia macrophylla*)
Lionnet 1922, p. 37
Lionnet 1924 (as *Calpidia macrophylla*)
Renvoize 1975
Cheke, sight (N)
Mamet 1978, p. 106
Mamet in 1955 (MAU) (S)
Stoddart 7242 (US) (N)

OLEACEAE

+*Noronhia emarginata* Thou.
Lionnet 1924 (as *Nortronia chartaca*)
Dupont AG/11 (MAU)

ORCHIDACEAE

Disperis tripetaloides (Thou.) Lindl.
Dryopeia tripetaloides Thou.
Bojer 1835 (as *Dryopeia tripetaloides*)
Baker 1877 (as *Disperis tripetaloides*)
Lionnet 1924 (as *Dryopea tripetaloides*)

PANDANACEAE

+*Pandanus utilis* Bory?
Bojer 1835
Lionnet 1924

PAPAVERACEAE

+*Argemone mexicana* L.
Bojer 1835
Lionnet 1924

PASSIFLORACEAE

+*Passiflora suberosa* L.
Stoddart 7231 (US) (N), 7263 (US) (S)

PHYTOLACCACEAE

+*Rivina humilis* L.
Rivina laevis L.
Dupont AG/12 (MAU)
Mamet in 1955 (MAU) (N)
Stoddart 7238b (US) (N)

PITTOSPORACEAE

Pittosporum floribundum W. & A.
Celastrus nepalensis Steud.
Bojer 1835 (as *Celestrus nepalensis*)
Lionnet 1924 (as *Celestrus nepalensis*)

PLANTAGINACEAE

+*Plantago major* L.
Dupont AG/6 (MAU)

POACEAE (GRAMINEAE)

+*Cenchrus echinatus* L.
Dupont in 1943 (MAU)

+*Cenchrus mitis* Anderss.
Procter 4196 (MAHE) (N)

+*Coix lachryma-jobi* L.
Bojer 1835 (as *Coix lachrima jobis*)
Lionnet 1924 (as *Coix lachrima*)

Cynodon aristatum Bojer (we have found no valid publication of this name and do not know what Bojer had in mind, possibly a varient of the following species)
Bojer 1835
Lionnet 1924

+*Cynodon dactylon* Pers.
Bojer 1835
Lionnet 1924
Mamet 1978, 107

Dactyloctenium aegyptium (L.) Beauv. (more likely *Dactyloctenium ctenoides* (Steud.) Bosser)
Bojer 1835 (as *Dactyloctenium aegyptiacum*)
Lionnet 1924 (as *Dactyloctenium aegyptiacum*)
Mamet in 1955 (MAU) (S)

Dactyloctenium distachyum Bojer (This name does not seem to be validly published: see *Dactyloctenium pilosum* Stapf)

Dactyloctenium pilosum Stapf
Bojer 1835 (as *Dactyloctenium distachyum*)
Lionnet 1924 (as *Dactyloctenium distachyium*)
Renvoize 1975

Dactyloctenium sp.
Stoddart 7297 (US) (N)

Digitaria biformis Willd.: see *Digitaria bicornis* (Lam.) R. & S.

Digitaria bicornis (Lam.) R. & S.
Mamet in 1955 (MAU) (S)

Digitaria didactyla Willd.
Mamet 1978, p. 105

Digitaria sp.
Procter 4192 (MAU) (N)

+*Eleusine indica* (L.) Gaertn.
Bojer 1835 (as *Eulesine indica*)
Lionnet 1924
Dupont in 1934 (MAU)
Mamet in 1955 (MAU)

Eragrostis brizoides (L.f.) Schult.
Bojer 1835 (as *Megastachia brizoides*)
Lionnet 1924 (as *Megastachya brizoides*)

+*Eragrostis ciliaris* (L.) R. Br.
Bojer 1835 (as *Megastachia ciliaris*)
Lionnet 1924 (as *Megastachyia ciliaris*)
Dupont in 1934 (MAU)
Stoddart 7232 (US) (N)

+*Eragrostis tenella* (L.) Beauv.
Mamet in 1955 (MAU) (S)

Eragrostis sp.
Procter 4191 (MAHE) (N)

Lepturus repens (Forst.) R. Br.
Bojer 1835 (as *Rottbellia repens*)
Lionnet 1924 (as *Rottbellia repens*)

Megastachia Bojer (Invalidly published generic name: see *Eragrostis* Hort.)

Panicum maximum Jacq.
Mamet 1978, p. 106

Paspalum distichum L.
Procter 4203 (MAHE) (S) (Name supplied by Mrs A. Robertson)

Stenotaphrum dimidiatum Brongn.
Mamet 1978, p. 106

Stenotaphrum micranthum (Desv.) C. E. Hubb
Stenotaphrum subulatum Trim.
Hemsley (1919) citing Baker (1877) (as *Stenotaphrum subulatum*)
Procter 4186 (MAHE) (S) (Name supplied by Mrs A. Robertson)

+*Zea mays* L.
Werner 1824
Moresby 1822 in Horsburgh 1852, p. 171
Bojer 1835 (as *Zea mais*)
Lionnet 1924 (as *Zea mais*)
Mamet, 1978 (S, S)
Cheke, sight (S)

POLYPODIACEAE (FILICES) (sensu lato)

Acrostichum aureum L.
Dupont AG/24 (MAU)
Cheke, sight (S)

Asplenium nidus L.
Bojer 1835
Lionnet 1924
Cheke, sight (S)
Mamet in 1955 (MAU) (S)
Stoddart 7235 (US) (N)

Lomaria grandis Bojer: see *Stenochlaena tenuifolia* (Desv.) Moore

Nephrodium splendens Desv.: see *Nephrolepis biserrata* (Sw.) Schott

Nephrolepis biserrata (Sw.) Schott
Nephrodium splendens (Desv.)
Bojer 1835 (as *Nephrodium splendens*)
Lionnet 1924 (as *Nephrodium splendens*)
Renvoize 1975
Cheke, sight (S)
Dupont AG/21 (MAU)

Nephrolepis hirsutula (Forst.f.) Presl
Stoddart 7236 (US) (N)

Pteris tripartita Sw.
Bojer (K)

Stenochlaena tenuifolia (Desv.) Moore
Bojer 1835 (as *Lomaria grandis*)
Lionnet 1924 (as *Lomaria grandis*)
Cheke, sight (S)
Dupont AG/25 (MAU)

Thelypteris (*Cyclosorus*) sp., probably *Thelypteris interrupta* (Willd.) Iwatsuki
Cheke, sight, 1974 (S)

Polypodiaceae indet.
Dupont in 1934 (MAU)

PORTULACACEAE

Portulaca hispida Bojer (This name does not seem to be validly published; perhaps *Portulaca mauritiensis* was the plant in hand)
Bojer 1835
Lionnet 1924

Portulaca mauritiensis v. Poelln.
Portulaca pilosa sensu auct. non (L.) DC.
Bojer 1837 (as *Portulaca pilosa*)

+*Portulaca oleracea* L. var. *oleracea*
Bojer 1835
Lionnet 1924
Dupont AG/12 (MAU) (S)
Stoddart 7293 (US) (S), 7294 (US) (S)

Portulaca pilosa (L.) DC.: *Portulaca mauritiensis* v. Poelln.

Portulaca sp.
Hilsenberg 1823
Mamet in 1955 (MAU) (S)

PSILOTACEAE

Psilotum nudum (L.) Beauv.
Psilotum triquetrum Sw.
Bojer 1835
Lionnet 1924 (as *Philotum triquetrum*)
Cheke, sight record, 1974 (S)
Dupont AG/22 (MAU)
Mamet in 1955 (MAU) (S)

RHAMNACEAE

+*Ziziphus mauritiana* Lam.
  Zizyphus vulgaris Bojer
  Zizyphus jujuba sensu auct. non Lam.
    Bojer 1835 (as *Zizyphus vulgaris*)
    Lionnet 1924 (as *Zizyphus vulgaris*)
    Procter 4206 (MAHE) (S)
    Mamet 1978, p. 106

Zizyphus vulgaris Bojer: see *Ziziphus mauritiana* Lam.

RHIZOPHORACEAE

Rhizophora mucronata Lam.
    Wiehe in 1961, not collected, photograph only (MAU) (N)
    Patel in 1974, not collected, photograph only (MAU) (N: Bassin Capucin)

ROSACEAE

+*Rosa indica* L.
    Lionnet 1924, p. 76

RUBIACEAE

Guettarda speciosa L.
  Guettarda indica Bojer. This name was apparently never validly published.
    Bojer 1835 (as *Guettarda indica*)
    Bojer 1837
    Lionnet 1924 (as *Guettarda indica*)
    Renvoize 1975
    Cheke, sight (N)
    Bojer (K)
    Mamet in 1955 (MAU)
    Stoddart 7257 (US) (S)

Morinda citrifolia L.
    Bojer 1835
    Lionnet 1924
    Mamet 1936
    Mamet 1978, p. 105
    Cheke, sight (S)
    Mamet in 1955 (MAU) (S)
    Stoddart 7233 (US) (N), 7265 (US) (S)

RUTACEAE

+*Citrus aurantiifolia* (Christm.) Swingle
Mamet 1978, p. 105
Stoddart 7275 (US) (S)

+*Citrus aurantium* L.
Bojer 1835
Lionnet 1924 (as *Citreum aurantium*)
Mamet 1978, p. 105 (as *Citrus aurantium* var. *bigaradia* Loisel)

Citrus decumana L.: see *Citrus grandis* (L.) Osbeck

Citrus fusca Lour.: see *Citrus sinensis* (L.) Osbeck

+*Citrus grandis* (L.) Osbeck
Citrus decumana L.
Bojer 1835 (as *Citrus decumana*)
Lionnet 1924 (as *Citrium decumanum*)

+*Citrus limon* (L.) Burm f.
Citrus limonium Risso
Lionnet 1924 (as *Citreum limonium*)

+*Citrus medica* L.
Mamet 1978, p. 106

+*Citrus reticulata* Blanco
Citrus nobilis sensu auct. non Lour.
Lionnet 1924 (as *Citreum nobile*)

+*Citrus sinensis* (L.) Osbeck
Citrus fusca Lour
Bojer 1835 (as *Citrus fusca*)
Lionnet 1924 (as *Citreum fuscum*)

Evodia sp.
Dupont AG/8 (MAU)

SANTALACEAE

+*Santalum* sp.
Procter 4179 (MAHE) (S), 4180 (MAHE) (S)

SAPINDACEAE

Dodonaea viscosa L. var.
Dodonaea triquetra Wendl.
Dupont AG/10 (MAU)
Lionnet 1924 (as *Dodonaea triquetrum*)

+*Litchi chinensis* Sonner.
Lionnet 1922, p. 54 (as *Litchi sinensis*)

Cookilla punctata Lionnet
Lionnet 1924 (we are unable to find that this genus and species have ever been validly published, or to guess what plant Lionnet may have had in mind)

SCROPHULARIACEAE

Campuleia coccinea Hook.: see *Striga asiatica* (L) O. Ktze.

Striga asiatica (L.) O. Ktze.
Campuleia coccinea Hook.
Bojer 1835 (as *Campuleia coccinea*)
Lionnet 1924 (as *Campuleia coccinea*)
Mamet in 1955 (MAU) (N) (var. *hirsuta* Benth.)
Procter 4183 (MAHE) (S)
Stoddart 7229 (US) (N), 7284 (US) (S)

SOLANACEAE

+*Capsicum annuum* L.
Bojer 1835
Lionnet 1924 (as *Capsicum mammum*)
Mamet 1978, p. 106

+*Capsicum frutescens* L.
Bojer 1835
Lionnet 1924 (as *Capsicum frutiscens*)

+*Datura metel* L.
Stoddart 7260 (US) (S)

+*Datura stramonium* L. (Possibly really *Datura metal* but no specimen available)
Bojer 1835
Lionnet 1924

Lycopersicon esculentum Mill.: see *Solanum lycopersicum* L.

+*Nicotiana tabacum* L.
Bojer 1835

+*Solanum lycopersicum* L.
Lycopersicon esculentum Mill.
Bojer 1835 (as *Lycopersicum esculentum*)
Lionnet 1924 (as *Lycopersicum esculentum*)

+*Solanum melongena* L.
Bojer 1835
Mamet 1978, p. 107

+*Solanum nigrum* L.
Bojer 1835
Lionnet 1924
Stoddart 7238a (US) (N) (var. *americanum* Shulz)

+*Solanum tuberosum* L.
Bojer 1835
Lionnet 1924

STERCULIACEAE

Heritiera littoralis Ait.
Mamet in 1955 (MAU) (S: Le Jardin)

+*Melochia corchorifolia* L.
Lionnet 1924

+*Theobroma cacao* L.
Dupont 1883
Cheke, sight (S: Ste Rita)

+*Waltheria indica* L.
Mamet in 1955 (MAU) (S: Le Jardin)

SURIANACEAE

Suriana maritima L.
Hilsenger 1823
Bojer 1835
Lionnet 1922, p. 37; 1924
Cheke, sight (N, S)
Mamet in 1955 (MAU (N, S)
Stoddart 7254 (US) (N)

TILIACEAE

+*Corchorus aestuans* L.
Corchorus near *acutangulus*
Mamet in 1955 (MAU)(S: Le Jardin)

Triumfetta procumbens Forst.f.
Bojer 1835, 1837
Lionnet 1924
Renvoize 1975
Bojer (CGE)
Stoddart 7253 (US) (N)

Triumfetta sp.
Dupont in 1934 (MAU)
Mamet in 1955 (MAU) (S)

TURNERACEAE

+*Turnera ulmifolia* L.
Mamet in 1955 (MAU) (N)
Stoddart 7291 (US) (S), 7296 (US) (N)

URTICACEAE

Pipturus argenteus (Forst.f.)
Urtica alba sensu auct. non Bl.
Baker 1877
Bojer 1835 (as *Urtica alba*)
Lionnet 1924 (as *Urtica alba*)
Le Duc, Bouton, Skottsberg 1932
Renvoize 1975
Dupont in 1934 (MAU) (as Pipturus sp.)
Mamet in 1955 (MAU) (S)
Stoddart 7252 (US) (N)

Urtica alba sensu auct. non Nl.: see *Pipturus argenteus* (Forst.f.) Wedd.

Urticaceae? indet.
Mamet in 1955 (MAU) (S)

VERBENACEAE

+*Lantana camara* var. *aculeata* (L.) Mold.
Mamet 1978, p. 106 (as *Lantana* sp.)
Stoddart 7277 (US) (S)

+*Lippia nodiflora* (L.) Rich.?
Zapania stolonifera Bojer (apparently not validly published)
Bojer 1835 (as *Zapania stolonifera*)
Lionnet 1924 (as *Zanapia stolonifera*)

+*Stachytarpheta jamaicensis* (L.) Vahl
Stoddart 7290 (US) (S), 7295 (US) (N)

Zapania stolonifera Bojer: see *Lippia nodiflora* (L.) Rich.

VITIDACEAE

+*Vitis vinifera* L.
Bojer 1835
Lionnet 1924

ZINGIBERACEAE

+*Zingiber officinale* Roscoe
Bojer 1835 (as *Zinziber officinale*)
Lionnet 1924 (as *Zinziber officiale*)

+*Zingiber zerumbet* (L.) Roscoe
Bojer 1835 (as *Zinziber zerumbet*)
Lionnet 1924 (as *Zinziber zerumbet*)

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6. LIST OF PLANTS COLLECTED ON COETIVY ISLAND, SEYCHELLES

by S. A. Robertson and F. R. Fosberg

Introduction

A visit was made by Robertson to Coetivy Island from 27 February to 3 March 1980. During that time as many parts of the island as possible were visited and a plant collection was made. 99 species were collected and another 22 noted, including crops but not obvious garden ornamentals. Two sets were made, one of which is incorporated in the Herbarium of the Ministry of Agriculture, Mahe, Seychelles, and the other lodged with the Herbarium, Royal Botanic Gardens, Kew, England. The first author is indebted to the Director, Royal Botanic Gardens, and his staff, in particular Mr S. Renvoize, for verifying the identifications. Included in the list are those species noted as occurring on Coetivy by Renvoize (1975); these are indicated by the abbreviation R. Most of them derive from the collections made by Gwynne and Wood (1969). Fosberg has been responsible for checking the nomenclature used, which conforms to that in others of this series of papers. Where these names differ from those used by Robertson (in press), the latter are given as synonyms. Families in the list are arranged alphabetically.

Coetivy (Figure 7) is a large sand cay of about 900 ha, 9.8 km long and 1.6 km wide at its widest point, aligned approximately north-east/southwest. The fringing reef is narrow and the main pass and settlement are slightly south of the mid point of the west coast. Coetivy is about 250 km south-south-east of Mahe and was named after the Chevalier de Coetivy, who sighted it on 3 July 1771. It is run as a coconut plantation.

The island is hedged with the usual beach-crest thicket of *Scaevola sericea*. This varies in width around the island and is greatest on the eastern coast. The northern and eastern parts of the island have the best soils and are covered with tall dense old coconut palms with a lush undergrowth of *Nephrolepis biserrata, Pipturus argenteus* and germinating

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Atoll Research Bulletin No. 273: 143-156, 1983.

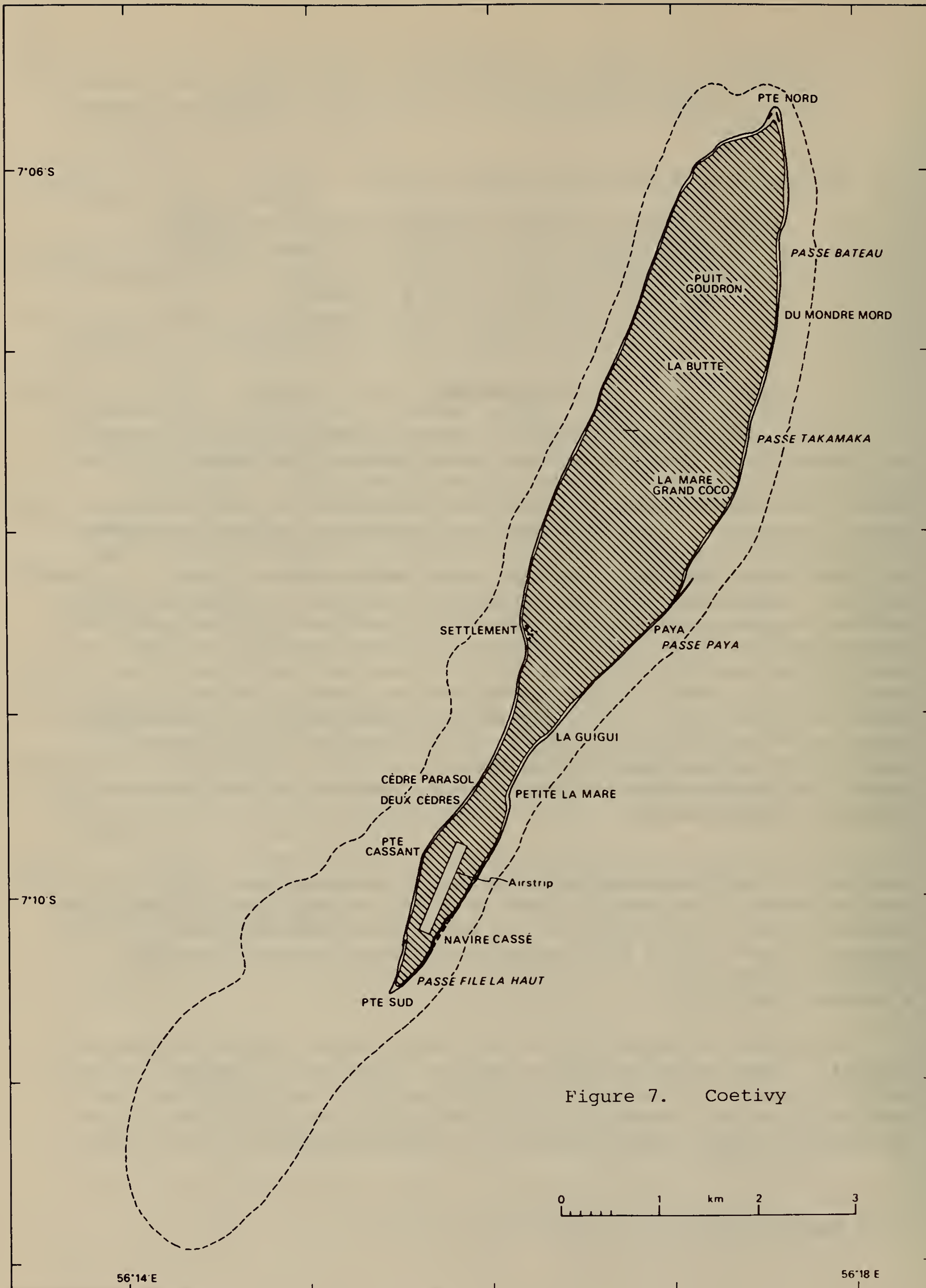

Figure 7. Coetivy

coconuts. The southern and western areas have very poor soil, almost pure sand, with stunted coconuts intermixed with *Scaevola sericea* and the ground sparsely covered with *Fimbristylis cymosa* and *Eragrostis subaequiglumis* tussocks. There were no planted coconuts south of the airstrip, and this area is thickly covered with *Scaevola sericea* and *Cordia subcordata* matted with *Cassytha filiformis* and *Canavalia cathartica*. There are several large dunes, up to 10 metres high, scattered over the island, and some fresh-water marshes, the largest being behind the settlement and reputed in island lore to be bottomless.

Plantations of exotic tree species such as *Tabebuia heterophylla, Neisosperma oppositifolia* and *Adenanthera pavonia* have been established in various parts of the island and have self-seeded successfully. *Casuarina equisetifolia* is, however, the most common tree after *Cocos nucifera*.

Of interest were the small herd of feral donkeys which graze the open areas, the frigate bird roosting colony in tall old coconut palms just south of La Butte (the large central dune), and the relative scarcity of land birds. Only Barred Ground Doves, partridges, egrets and migrant European Rollers were seen. There were no skinks but an abundance of grasshoppers, butterflies and day-flying moths.

The first author would like to thank the Government of Seychelles for permission to visit and collect on the island, and the island staff for their hospitality.

List of plants

ACANTHACEAE

Asystasia genetica (L.) T. Anders. ?
Robertson 3155, on imported pile of red soil at settlement

AGAVACEAE

Agave sisalana Perrine
Robertson, sight

Furcraea foetida (L.) Haw.
Robertson, sight

AMARANTHACEAE

Alternanthera sessilis R. Br.
Robertson 3095, marsh behind settlement; R

Amaranthus dubius Mart. ex Thell.
Robertson 3096, settlement

Achyranthes aspera L.
R; not seen by Robertson

ANNONACEAE

Annona squamosa L.
Robertson, sight

APOCYNACEAE

Catharanthus roseus (L.) G. Don
Robertson 3091, settlement

Neisosperma oppositifolia (Lam.) Fosb. & Sachet
Ochrosia oppositifolia (Lam.) K. Schum.
Robertson 3136, La Mare Gran Coco

ARACEAE

Alocasia macrorhiza (L.) G. Don
Robertson, sight

Colocasia esculenta (L.) Schott
Robertson, sight

ARECACEAE (PALMAE)

Cocos nucifera L.
Robertson, sight; over whole island

ASTERACEAE (COMPOSITAE)

Tridax procumbens L.
Robertson 3074, south of airstrip; R

Vernonia cinerea Less.
Robertson 3092, settlement; R

BIGNONIACEAE

Tabebuia heterophylla Britt.
Tabebuia pallida (Lindl.) Miers
Robertson 3153, central area, Chemin Barwills

BORAGINACEAE

Cordia subcordata Lam.
Robertson 3059, south of airstrip

Tournefortia argentea L.f.

Robertson 3182, eastern part on dune; R

CAMPANULACEAE

Hippobroma longiflora (L.) G. Don
Isotoma longiflora Presl
Robertson 3088, settlement; R

CAPPARIDACEAE

Cleome viscosa L.
Robertson, sight, settlement; R

CARICACEAE

Carica papaya L.
Robertson, sight

CASUARINACEAE

Casuarina equisetifolia L.
Robertson 3080, south of airstrip; R

CLUSIACEAE (GUTTIFERAE)

Calophyllum inophyllum L.
Robertson 3119, plantation in nothern part of island; R

COMBRETACEAE

Terminalia catappa L.
Robertson 3138, Chemin Le Parc; R

COMMELINACEAE

Commelina benghalensis L.
Robertson 3141, settlement

CONVOLVULACEAE

Ipomoea macrantha Roem. & Schultes
Robertson 3070, edge of airstrip; R

CRASSULACEAE

Kalanchoe pinnata (Lam.) Pers.
Bryophyllum pinnatum (Lam.) Oken
Robertson 3082, between airstrip and settlement; R

CUCURBITACEAE

Momordica charantia L.
Robertson, sight

Trichosanthes cucumerina L.
Robertson, sight

CYPERACEAE

Cyperus aromaticus (Ridl.) Mattf. & Kük.
Kyllinga polyphylla Willd. ex Kunth
Robertson 3100, behind settlement

Cyperus brevifolius (Rottb.) Hassk.
Kyllinga colorata (L.) Druce
Robertson 3106, marsh behind settlement

Cyperus cartilagineus (K. Schum.) Mattf. & Kük.
Kyllinga cartilaginea K. Schum.
R

Cyperus cristatus (Kunth.) Mattf. & Kük.
Kyllinga alba Nees
Robertson 3099, behind settlement

Cyperus dubius Rottb.
Mariscus dubius (Rottb.) Fisch.
Robertson 3079, north end of airstrip

Cyperus erectus (Schumacher) Mattf. & Kük.
Kyllinga erecta Schumacher
R

Cyperus kyllingia Endl.
Kyllinga nemoralis (Forst.) Dandy ex Hutch.
Robertson 3107, garden in settlement

Cyperus ligularis L.
Mariscus ligularis (L.) Urb.
Robertson 3055, south of airstrip

Cyperus maculatus Boeck.
Robertson 3086, behind settlement

Cyperus polystachyos Rottb.
Pycreus polystachyos (Rottb.) P. Beauv.
Robertson 3101, marsh behind settlement; R

Cyperus rotundus L.
Robertson 3104, settlement

Fimbristylis complanata (Retz.) Link
Robertson 3105, marsh behind settlement

Fimbristylis cymosa R. Br.
Robertson 3063, over whole island; R (as *F. dichotoma*)

DIOSCOREACEAE

Dioscorea alata L.
Robertson 3151, northern area

EUPHORBIACEAE

Acalypha indica L.
Robertson 3146, settlement

Euphorbia hirta L.
Robertson 3084, settlement

Euphorbia prostrata Ait. ?
Robertson 3147, settlement

Pedilanthus tithymaloides (L.) Poit.
Robertson 3118, settlement

Phyllanthus amarus Schum. & Thonn.
Robertson 3083, between airstrip and settlement

Phyllanthus maderaspatensis L.
Robertson 3087, settlement; R

FABACEAE (LEGUMINOSAE)

Abrus precatorius L.
Robertson 3157, in imported heap of red soil at settlement

Adenanthera pavonina L.
Robertson 3123, in old fruit garden in northern area

Caesalpinia bonduc (L.) Roxb.
Robertson 3133, near old house at Paya, east coast

Canavalia cathartica Thouars
Robertson 3060, south of airstrip

Cassia occidentalis L.
Robertson 3144, settlement

Delonix regia (Boj.) Raf.
Robertson 3126, in old fruit garden, northern part

Desmanthus virgatus (L.) Willd.
Robertson 3127, in old fruit garden, northern part

Desmodium triflorum DC.
Robertson 3156, on imported heap of red soil at settlement

Leucaena leucocephala (Lam.) de Wit
Robertson 3132, near old house at Paya, east coast

Mimosa pudica L.
Robertson 3158, on imported heap of red soil at settlement

Pithecellobium unguis-cati Benth.
Robertson 3143, settlement

Tamarindus indica L.
Robertson 3150, in old fruit garden, northern part

Vigna unguiculata (L) Walp.
Robertson, sight

GOODENIACEAE

Scaevola sericea Vahl
Robertson 3069, beach crest thicket; R (as *S. taccada*)

HERNANDIACEAE

Hernandia sonora L.
Hernandia nymphaeifolia (Presl) Kubitzki
Robertson 3057, south of airstrip; R (as *H. peltata*)

LAMIACEAE (LABIATAE)

Leonotis nepetaefolia (L.) R. Br.
Robertson 3130, settlement

Ocimum basilicum L.
Robertson, sight

LAURACEAE

Cassytha filiformis L.
Robertson 3064, south of airstrip; R

LECYTHIDACEAE

Barringtonia asiatica (L.) Kurz
Robertson 3103, settlement; R

LILIACEAE (sensu lato)

Crinum macowanii Baker
Robertson 3131, settlement

Yucca sp.
Robertson, sight; ornamental

MALVACEAE

Gossypium hirsutum L.
Robertson 3117, settlement

Malvastrum coromandelianum (L.) Garcke
Robertson 3125, northern lush part near path

Sida pusilla Cav.
Robertson 3077, south of airstrip; R (as *S. parvifolia*

Sida stipulata Cav.
Robertson 3159, settlement

MORACEAE

Artocarpus altilis (Park.) Fosb.
Robertson, sight

Ficus benghalensis L.
Robertson 3120, northern part near old fruit garden

MORINGACEAE

Moringa oleifera Lam.
Robertson, sight

MUSACEAE

Musa spp.
Robertson, sight

NYCTAGINACEAE

Boerhavia repens L.
Robertson 3061, south of airstrip

Mirabilis jalapa L.
Robertson 3129, settlement

ORCHIDACEAE

Vanilla mexicana Miller
Robertson, sight

OXALIDACEAE

Averrhoa bilimbi L.
Robertson, sight

PANDANACEAE

Pandanus utilis Bory
Robertson 3108, behind settlement

PAPAVERACEAE

Argemone mexicana L.
Robertson 3140, settlement

PASSIFLORACEAE

Passiflora suberosa L.
Robertson 3090, behind settlement; R

POACEAE (GRAMINEAE)

Cenchrus echinatus L.
Robertson, 3128, settlement

Cynodon dactylon (L.) Pers.
Robertson 3089, settlement

Dactyloctenium ctenoides (Steud.) Bosser
Dactyloctenium pilosum Stapf.
Robertson 3058, 3065, 3139, southern part on paths; very variable;

Digitaria didactylia Willd.
Robertson 3097, settlement

Digitaria setigera Roth
Robertson 3066, south of airstrip

Eleusine indica (L.) Gaertn.
Robertson 3122, northern lush part on path

Eragrostis ciliaris (L.) R. Br.
Robertson 3071, south of airstrip

Eragrostis subaequiglumis Renv.
Robertson 3072, 3073, common all over the island on poor soil

Eragrostis tenella (L.) P. Beauv.
Robertson 3078, 3112, northern end of airstrip and in north of island; R

Lepturus repens (G. Forst.) R. Br.
Robertson 3054, sand spit at south end of island; R

Panicum maximum Jacq.
Robertson, sight, settlement garden

Panicum subquadriparum Trin.
Brachiaria subquadripara (Trin.) Hitchc.
Robertson 3154, La Mare Gran Coco

Stenotaphrum dimidiatum (L.) Brongn.
Robertson 3085, behind settlement; R

Stenotaphrum micranthum (Desf.) Hubb.
Robertson 3134, La Mare Gran Coco

POLYPODIACEAE (sensu lato)

Acrostichum aureum L.
Robertson 3110, marsh behind settlement; R

Asplenium nidus L.
Robertson 3115, northern area; R

Nephrolepis biserrata (Swartz) Schott
Robertson 3109, behind settlement; R

Polypodium scolopendria Burm.f.
Robertson 3102, behind settlement; R

Pteris tripartita Sw.
Robertson 3135, La Mare Gran Coco; R

PORTULACACEAE

Portulaca oleracea L.
Robertson 3137, east coast north of Paya; R

POTAMOGETONACEAE

Halodule uninervis (Forssk.) Aschers.
R; not seen by Robertson

PSILOTACEAE

Psilotum nudum (L.) Beauv.
Robertson 3094, behind settlement; R

RUBIACEAE

Guettarda speciosa L.
RObertson 3113, north part of island

Morinda citrifolia L.
Robertson 3098, between airstrip and settlement; R

RUTACEAE

Citrus aurantiifolia (Christm.) Swingle
Robertson, sight

SAPINDACEAE

Dodonaea viscosa Jacq.
Robertson 3116, west side of island north of settlement, near old house

SCROPHULARIACEAE

Striga asiatica (L.) Kuntze
Robertson 3062, south of airstrip; R

SOLANACEAE

Datura metel L.
Robertson 3142, settlement

Physalis micrantha Link
Robertson 3145, settlement

Solanum melongena L.
Robertson, sight

Solanum nigrum L.
Robertson 3093, settlement

STERCULIACEAE

Heritiera littoralis Dryand.
Robertson 3149, marsh behind settlement

SURIANACEAE

Suriana maritima L.
Robertson 3067, south of airstrip; R

TILIACEAE

Triumfetta procumbens Forssk.
Robertson 3056, beach crest at south end of island; R

TURNERACEAE

Turnera ulmifolia L.
Robertson 3068, south of airstrip; R

URTICACEAE

Pilea microphylla (L.) Liebm.
Robertson 3121, north part near old fruit garden

Pipturus argenteus (Forssk.) Wedd.
Robertson 3114, north part of island; R

VERBENACEAE

Lantana camara L.
Robertson 3124, north part near old fruit garden

Lippia nodiflora (L.) Rich.
Robertson 3075, south of airstrip; R

Stachytarpheta jamaicensis (L.) Vahl
Robertson 3081, between airstrip and settlement; R

Stachytarpheta urticaefolia Sims
Robertson 3111, settlement

References

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Renvoize, S. A. 1975. A floristic analysis of the western Indian Ocean coral islands. *Kew Bull.* 30, 133-152.

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7. LIST OF PLANTS COLLECTED ON PLATTE ISLAND, SEYCHELLES

by S. A. Robertson and F. R. Fosberg

Introduction

On 26 February 1980 a visit was made to Platte Island, Seychelles, by the first author, and during the three hours spent there as many plant species were collected as possible. No crop plants or obvious garden ornamentals were taken. Two sets of plants were collected, one of which is incorporated in the Herbarium, Ministry of Agriculture, Mahe, Seychelles, and the other lodged with the Herbarium, Royal Botanic Gardens, Kew, England. The first author is indebted to the Director, Royal Botanic Gardens, and his staff, in particular Mr S. Renvoize, for verifying the identifications. Families in the following list have been arranged alphabetically. The names used have been checked by Fosberg and conform to the usage of others in this series of papers. There the names adopted here differ from those used by Robertson (in press), the latter are given as synonyms.

Platte (Figure 8) is a small sand cay, aptly named, about 125 km south of Mahe, surrounded by an extensive fringing reef. It is about 65 ha in extent and is run as a coconut plantation. There is a small settlement on the west coast with the manager's house and a few guest cottages to the northwest. There is a serviceable grass airstrip aligned southeast/northwest and approximately 900 m long.

The vegetation pattern is similar to that of other sand cays in the Seychelles, with beach crest colonisers *Ipomoea pes-caprae* and *Sporobolus virginicus* backed by a thicket of *Scaevola sericea* and *Guettarda speciosa* which extends slightly into the coconut plantation. A mixture of herbs and small shrubs forms an undergrowth of varying density beneath the palms. The list of plants is certainly incomplete but there are some surprising gaps in it, notably *Stenotaphrum dimidiatum, Morinda citrifolia, Asystasia gangetica* and *Triumfetta procumbens,* all of which are found in the Amirantes to the west and on

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Atoll Research Bulletin No. 273: 157-164, 1983.

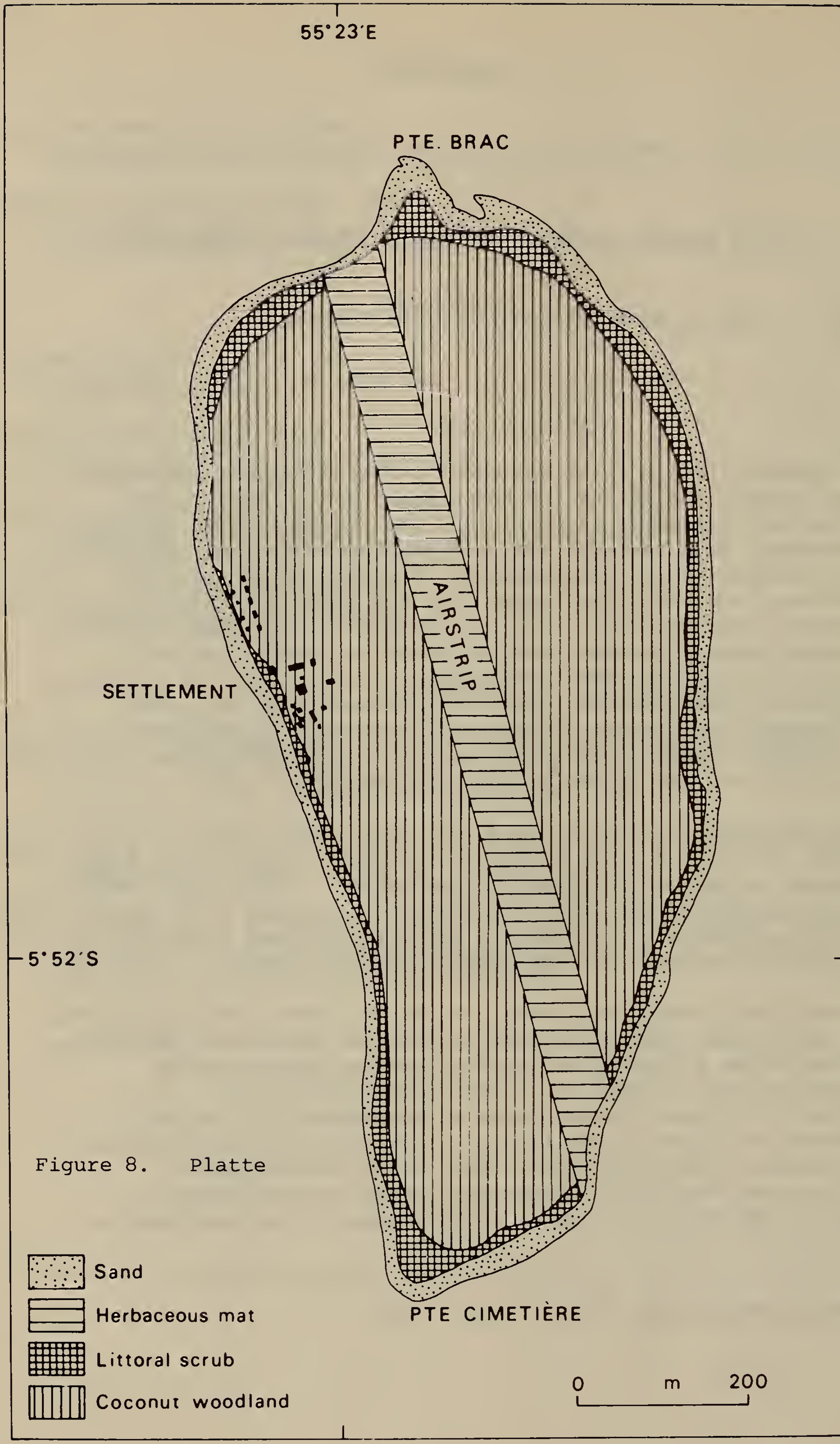

Figure 8. Platte

Coetivy to the south. As far as we are aware this is the first plant collection made from this island.

The first author would like to thank Mr G. Savy for permission to visit Platte and collect plants there, and the Government of Seychelles for assistance in reaching the island.

List of plants

AMARANTHACEAE

Achyranthes aspera L.
Robertson 3021

Amaranthus dubius Mart. ex Thell.
Robertson 3012

APOCYNACEAE

Catharanthus roseus (L.) G. Don
Robertson 3010

ARECACEAE (PALMAE)

Cocos nucifera L.
Robertson, sight

BORAGINACEAE

Cordia subcordata Lam.
Robertson 3050

Tournefortia argentea L.f.
Robertson 3032

CARYOPHYLLACEAE

Drymaria cordata (L.) Roem. and Schultes
Robertson 2998

CASUARINACEAE

Casuarina equisetifolia L.
Robertson 3007

COMPOSITAE

Vernonia cinerea Less.
Robertson 3045

CONVOLVULACEAE

Ipomoea macrantha Roem. & Schultes
Robertson 3036

Ipomoea pes-caprae (L.) R. Br.
Robertson 3029

CRASSULACEAE

Kalanchoe pinnata (Lam.) Pers.
Bryophyllum pinnatum (Lam.) Oken
Robertson 3038

CYPERACEAE

Cyperus dubius Rott.
Mariscus dubius (Rottb.) Fisch.
Robertson 3047

Cyperus kyllingia Endl.
Kyllingia nemoralis (Forst.) Dandy ex Hutch.
Robertson 2999

Cyperus ligularis L.
Mariscus ligularis (L.) Urb.
Robertson 3041

Fimbristylis cymosa R. Br.
Robertson 3019

EUPHORBIACEAE

Acalypha indica L.
Robertson 3044

Eurphorbia hirta L.
Robertson 3048

Euphorbia prostrata Ait. ?
Robertson 3011

Pedilanthus tithymaloides (L.) Poit.
Robertson 3041

Phyllanthus amarus Schum. & Thonn.
Robertson 3000

Phyllanthus maderaspatensis L.
Robertson 3026

FABACEAE (LEGUMINOSAE)

Cassia occidentalis L.
Robertson 3008

Leucaena leucocephala (Lam.) de Wit
Robertson 3005

GOODENIACEAE

Scaevola sericea Vahl
Robertson 3053

HERNANDIACEAE

Hernandia sonora L.
Hernandia nymphaeifolia (Presl) Kubitzki
Robertson 3034

LAURACEAE

Cassytha filiformis L.
Robertson 3006

LILIACEAE (sensu lato)

Haemanthus multiflorus Martyn ssp. *multiflorus*
Scadoxus multiflorus (Martyn) Raf.
Robertson 3053

MALVACEAE

Hibiscus tiliaceus L.
Robertson 3003

Sida acuta Burm.f.
Robertson 3009

Sida pusilla Cav.
Robertson 3017

Sida stipulata Cav.
Robertson 3014

NYCTAGINACEAE

Boerhavia repens L.
Robertson 3035

PASSIFLORACEAE

Passiflora suberosa L.
Robertson 3042

POACEAE (GRAMINEAE)

Cynodon dactylon (L.) Pers.
Robertson 3002

Dactyloctenium ctenoides (Steud.) Bosser
Robertson 3037

Digitaria setigera Rotn.
Robertson 3013

Eleusine indica (L.) Gaertn.
Robertson 3016

Eragrostis subaequiglumis Renv.
Robertson 3018

Lepturus repens (G. Forst.) R. Br.
Robertson 3025

Sporobolus virginicus (L.) Kunth
Robertson 3028

Stenotaphrum micranthum (Desf.) C. E. Hubb.
Robertson 3027

POLYPODIACEAE (sensu lato)

Nephrolepis biserrata (Swartz) Schott
Robertson 3023

Polypodium scolopendria (Burm.f.) Copel.
Microsorium scolopendria (Burm.f.) Copel.
Robertson 3022

PORTULACACEAE

Portulaca oleracea L.
Robertson 3033

PSILOTACEAE

Psilotum nudum (L.) Beauv.
Robertson 3020

RHAMNACEAE

Colubrina asiatica L.
Robertson 3004

RUBIACEAE

Guettarda speciosa L.
Robertson 3039

SCROPHULARIACEAE

Striga asiatica (L.) Kuntze
Robertson 3031

SOLANACEAE

Datura metel L.
Robertson 3043

Solanum nigrum L.
Robertson 3015

SURIANACEAE

Suriana maritima L.
Robertson 3030

TURNERACEAE

Turnera ulmifolia L.
Robertson 3046

URTICACEAE

Laportea aestuans (L.) Chew
Robertson 3040

Pipturus argenteus (Forst.) Wedd.
Robertson 3024

VERBENACEAE

Lippia nodiflora (L.) Rich.
Robertson 3001

Stachytarpheta jamaicensis (L.) Vahl
Robertson 3049

Reference

Robertson, S. A. In press. *The flowering plants of Seychelles: an annotated check list, including Gymnosperms, with line drawings.* St Louis: Missouri Botanical Garden.

8. LIST OF PLANTS OF POIVRE ISLAND, AMIRANTES

by S. A. Robertson and F. R. Fosberg

Introduction

A visit was made to Poivre by the first author on the 26 and 27 October 1976, and during these two days as many parts of the two islands (Figure 9) were visited as possible and a plant collection made. 58 specimens were collected and another 26 noted, including crop plants and some garden ornamentals. Two sets were made, one of which was incorporated in the Herbarium of the Ministry of Agriculture, Mahe, Seychelles, and the other lodged with the Herbarium, Royal Botanic Gardens, Kew, U.K. The first author is indebted to the Director, Royal Botanic Gardens, and his staff, in particular Mr S. Renvoize, for verifying the identifications. Noted in the list are those species given as occurring on Poivre by Piggott (1969).

Poivre, named after the famous Pierre Poivre, is part of the Amirantes, 240 km from Mahe, and consists of two islands, Poivre itself (110 ha) and South Island or Ile du Sud (135 ha), with an encircling reef formation. Piggott (1969) gives a good account of the islands as he found them on 26-30 October 1960, with comments on the morphology, soils, ecology and agriculture. Sixteen years later the islands were much as he described them, with the important difference that, the ownership having changed, the agriculture had been greatly improved, with replanting of coconuts, use of fertilisers, more crops being grown, and cattle and pigs kept. There had also been some involvement with tourism.

The first author would like to thank the owners of Poivre, and the managers, Mr F. Huala and Mr A. Bonnelame, for their great assistance and hospitality during the visit.

In the following list families are arranged alphabetically. The names used have been checked by Fosberg and conform to the usage of other papers in this series of papers. Where the names adopted here

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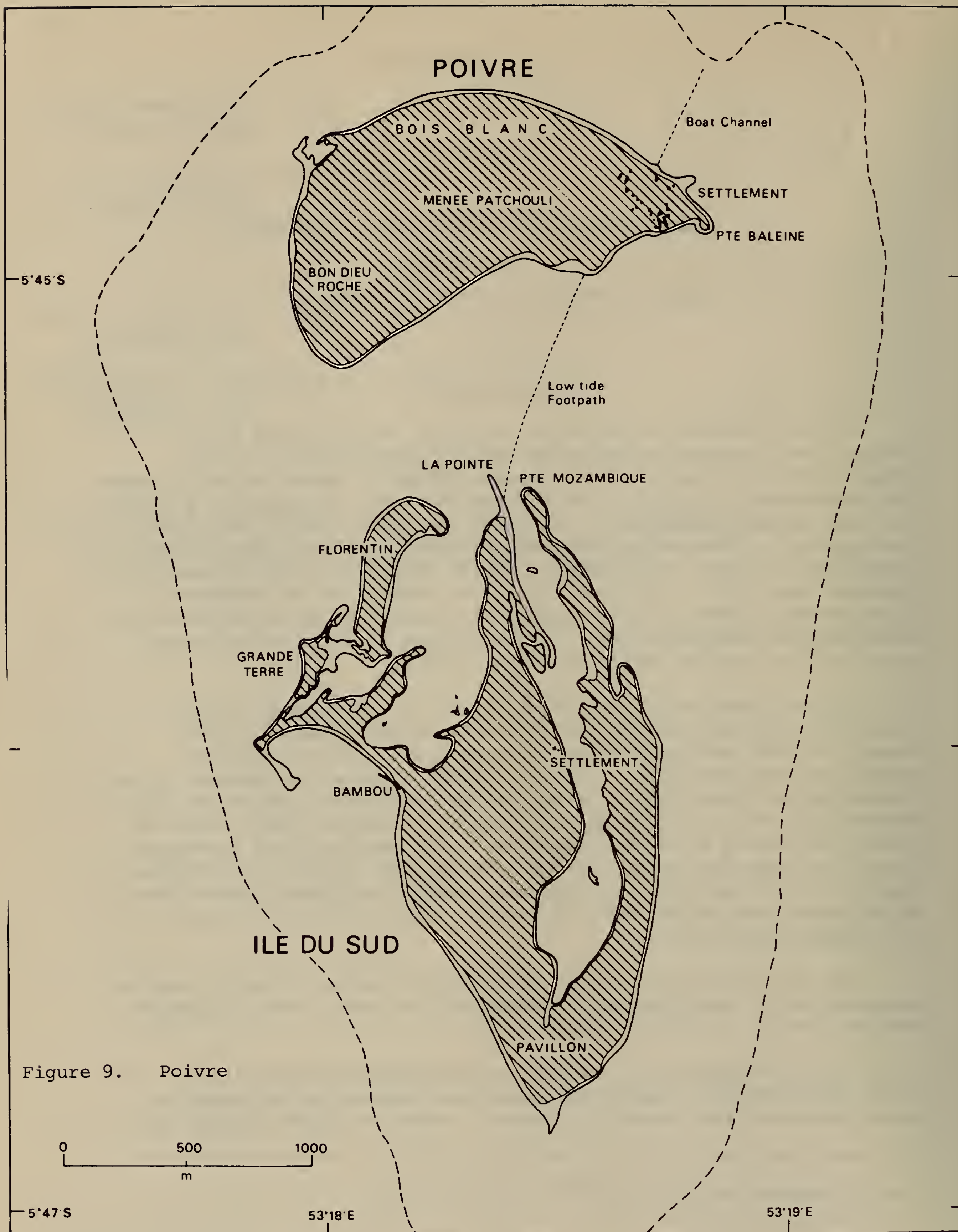

Figure 9. Poivre

differ from those used by Robertson (in press), the latter are given as synonyms.

List of plants

AGAVACEAE

Furcreae foetida (L.) Haw
Robertson, sight

AMARANTHACEAE

Achyranthes aspera L.
Robertson 2344

Amaranthus dubius Thell.
Robertson 2363

ANACARDIACEAE

Spondias dulcis Parkinson
Spondias cytherea Sonn.
Robertson, sight

ANNONACEAE

Annona squamosa L.
Robertson, sight

APOCYNACEAE

Catharanthus roseus (L.) G. Don
Robertson 2335

Plumeria rubra L.
Robertson, sight

ARACEAE

Alocasia macrorrhiza (L.) G. Don ?
Robertson, sight

ARECACEAE (PALMAE)

Cocos nucifera L.
Robertson, sight

BORAGINACEAE

Cordia subcordata Lam.
Robertson, sight

Heliotropium indicum L.
Robertson 2329

Tournefortia argentea L.f.
Piggott, sight; Robertson 2353

CAPPARIDACEAE

Cleome gynandra L.
Robertson 2364

CARICACEAE

Carica papaya L.
Piggott, sight; Robertson, sight

CASUARINACEAE

Casuarina equisetifolia L.
Piggott, sight; Robertson 2384

CLUSIACEAE (GUTTIFERAE)

Calophyllum inophyllum L.
Robertson, sight

COMBRETACEAE

Terminalia catappa L.
Robertson, sight

COMMELINACEAE

Commelina longifolia Lam.
Robertson 2365

COMPOSITAE

Bidens pilosa L.
Robertson 2389

Synedrella nodiflora (L.) Gaertn.
Robertson 2338

Tridax procumbens L.
Robertson 2346

Vernonia cinerea (L.) Less.
Robertson 2374

CONVOLVULACEAE

Ipomoea pes-caprae (L.) R. Br.
Robertson 2341

CRASSULACEAE

Kalanchoe pinnata (Lam.) Pers.
Bryophyllum pinnatum (Pers.) S. Kurz
Robertson 2350

CUCURBITACEAE

Cucurbita moschata (Duch. ex Lam.) Duch ex Poir.
Robertson, sight

Momordica charantia L.
Robertson 2373

CYPERACEAE

Cyperus brevifolius (Rottb.) Hassk.
Kyllinga colorata (L.) Druce
Robertson 2372

Cyperus cristatus (Kunth) Mattf. & Kük.
Kyllinga alba Nees
Robertson 2349

Cyperus dubius Rottb.
Mariscus dubius (Rottb.) Fischer
Robertson 2370

Cyperus ligularis L.
  Mariscus ligularis (L.) Urb.
    Robertson 2340

Fimbristylis cymosa R. Br.
    Robertson 2386

EUPHORBIACEAE

Acalypha indica L.
    Robertson 2380

Codiaeum variegatum (L.) Blume
    Robertson, sight

Euphorbia cyathophora Murr.
    Robertson 2356

Euphorbia hirta L.
    Robertson 2382

Euphorbia prostrata Ait. ?
    Robertson 2376

Manihot esculenta Crantz
    Robertson, sight

Pedilanthus tithymaloides (L.) Poit.
    Robertson, sight

Phyllanthus amarus Schum. & Thonn.
    Robertson 2345

Phyllanthus maderaspatensis L.
    Robertson 2352

FABACEAE (LEGUMINOSAE)

Adenanthera pavonina L.
    Robertson, sight

Albizia lebbeck (L.) Benth.
    Robertson 2375

Canavalia cathartica Thouars ?
    Robertson, sight

Cassia occidentalis L.
    Robertson 2366

Desmodium incanum DC.
Desmodium canum (J.F. Gmel.) Schinz & Thell.
Robertson 2367

Leucaena leucocephala (Lam.) de Wit
Robertson 2330

Pithecellobium unguis-cati (L.) Benth.
Robertson, sight

GOODENIACEAE

Scaevola sericea Vahl
Piggott, sight; Robertson 2334

HERNANDIACEAE

Hernandia sonora L.
Hernandia nymphaeifolia (Presl.) Kubitski
Piggott, sight; Robertson 2383

LAURACEAE

Cassytha filiformis L.
Robertson, sight

LILIACEAE (sensu lato)

Zephyranthes rosea Lindl.
Robertson, sight

LYTHRACEAE

Pemphis acidula Forst.
Piggott, sight; Robertson 2385

MALVACEAE

Gossypium hirsutum L.
Robertson, sight

Sida acuta Burm. f.
Robertson 2361, 2362

Sida pusilla Cav.
Robertson 2354

MORACEAE

Artocarpus altilis (Park.) Fosb.
Robertson, sight

Ficus benghalensis L.
Robertson, sight

MORINGACEAE

Moringa oleifera Lam.
Robertson, sight

MUSACEAE

Musa spp.
Robertson, sight

NYCTAGINACEAE

Bougainvillea spectabilis Willd.
Robertson, sight

PASSIFLORACEAE

Passiflora suberosa L.
Robertson 2381

POACEAE (GRAMINEAE)

Cenchrus echinatus L.
Robertson, sight

Dactyloctenium ctenoides (Steud.) Bosser
Robertson 2331, 2368

Digitaria horizontalis Willd.
Robertson 2371

Eleusine indica (L.) Gaertn.
Robertson 2332, 2360

Eragrostis subaequiglumis Renvoize
Robertson 2379

Eragrostis tenella (L.) P. Beauv.
Robertson 2347

Lepturus repens (G. Forst.) R. Br.
Robertson 2333

Panicum maximum L.
Robertson, sight

Stenotaphrum dimidiatum (L.) Brongn.
Piggott, sight; Robertson 2377

POLYPODIACEAE (sensu lato)

Asplenium nidus L.
Piggott, sight

Nephrolepis biserrata (Swartz) Schott
Robertson 2351

PORTULACACEAE

Portulaca oleracea L.
Robertson 2339

PSILOTACEAE

Psilotum nudum (L.) Beauv.
Robertson 2342

RHIZOPHORACEAE

Rhizophora mucronata Lam.
Robertson 2359 Piggott, sight

RUBIACEAE

Guettarda speciosa L.
Robertson 2357

Morinda citrifolia L.
Robertson 2387

RUTACEAE

Citrus spp.
Robertson, sight

SCROPHULARIACEAE

Striga asiatica (L.) Kuntze
Robertson 2348

SOLANACEAE

Datura metel L.
Robertson 2336

SURIANACEAE

Suriana maritima L.
Robertson 2358

TILLIACEAE

Triumfetta procumbens Forst.f.
Robertson 2388

TURNERACEAE

Turnera ulmifolia L.
Robertson 2355

URTICACEAE

Laportea aestuans (L.) Chew
Robertson 2337

Pilea microphylla (L.) Leibm.
Robertson 2343

VERBENACEAE

Lippia nodiflora (L.) Rich.
Robertson 2378

Stachytarpheta jamaicensis (L.) Vahl
Robertson 2369

References

Piggott, C. J. 1969. *A report on a visit to the Outer Islands of Seychelles between October and November 1960*. Tolworth: Directorate of Overseas Surveys, Land Resources Division, vi, 122 pp.

Robertson, S. A. In press. *The flowering plants of Seychelles: an annotated check list, including Gymnosperms, with line drawings*. St Lous: Missouri Botanical Garden.

9. LIST OF PLANTS COLLECTED ON ALPHONSE ISLAND, AMIRANTES

by I. A. D. Robertson, S. A. Robertson and F. R. Fosberg

Introduction

On 28 May 1979 Ian Robertson visited Alphonse to investigate the coconut pest situation, and during this visit made a collection of plants. These were given numbers in Mrs Ann Robertson's series and have been deposited in the Herbarium, Ministry of Agriculture, Mahe, Seychelles, or in the Herbarium, Royal Botanic Gardens, Kew. The first author would like to thank the owners of Alphonse for permission to collect. Fosberg has been responsible for checking the nomenclature used, which conforms to that in others of this series of papers. Where the names used differ from those given by Robertson (in press), the latter are given as synonyms. Mrs Robertson thanks the Director and staff of the Royal Botanic Gardens, Kew, for assistance with the identifications.

Alphonse Island (Figure 10) is a sand cay on the northeast rim of an atoll in the southern Amirantes. It has an area of 172 ha.

List of plants

AGAVACEAE

Agave sisalana (Perr. ex Engelmann) Drumm. and Prain
Robertson 2876

Furcraea foetida (L.) Haw.
Robertson 2842

Atoll Research Bulletin No. 273: 177-184, 1983.

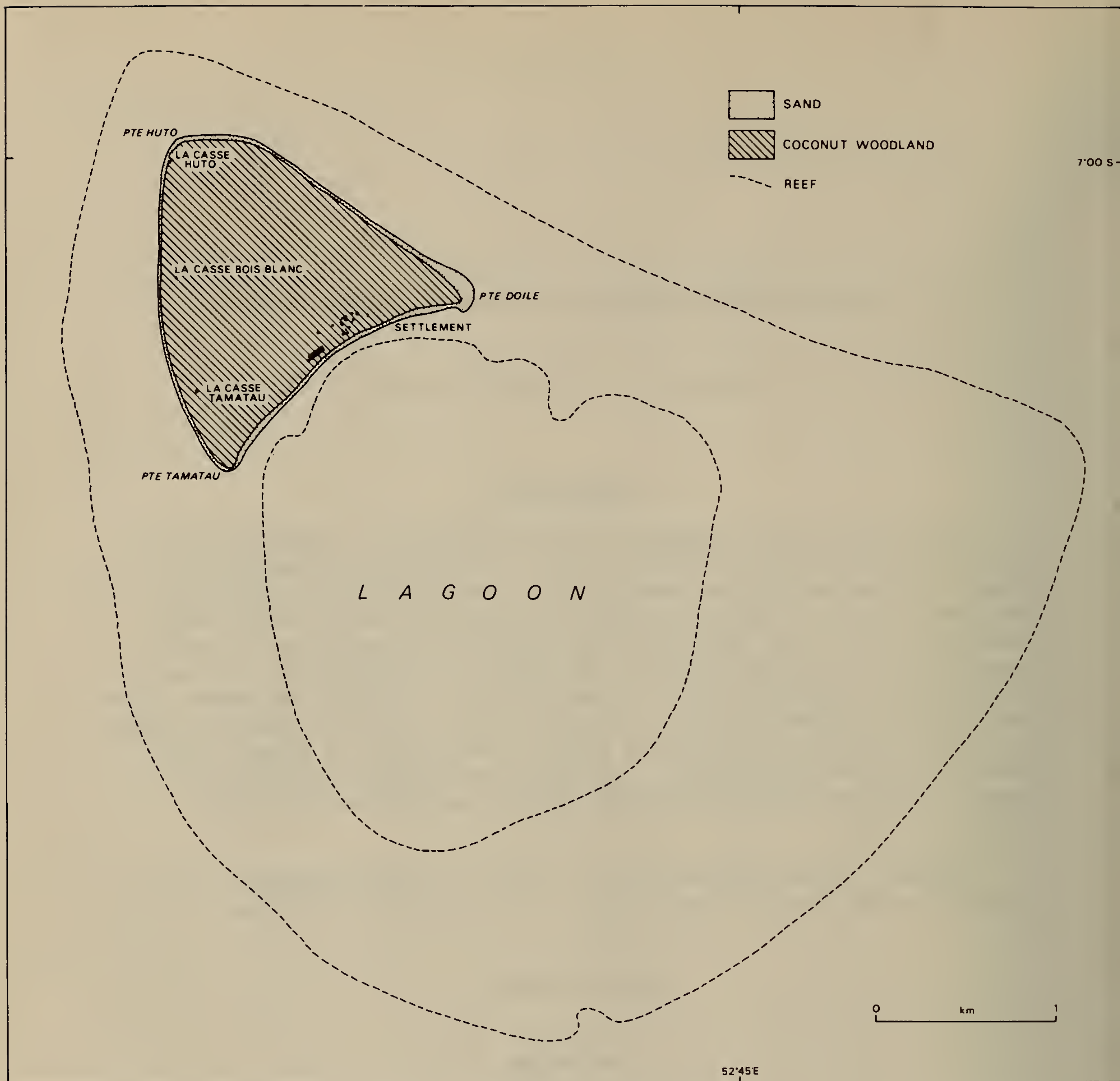

Figure 10. Alphonse

AMARANTHACEAE

Achyranthes aspera L.
Robertson 2866

APOCYNACEAE

Catharanthus roseus (L.) G. Don
Robertson 2829

Neisosperma oppositifolia (Lam.) Fosb. & Sachet
Ochrosia oppositifolia (Lam.) Schum.
Robertson 2840

ARACEAE

Alocasia macrorrhiza (L.) G. Don
Robertson 2889

ARECACEAE (PALMAE)

Cocus nucifera L.
Robertson, sight

ASTERACEAE (COMPOSITAE)

Vernonia cinerea (L.) Less.
Robertson 2849

BORAGINACEAE

Cordia subcordata Lam.
Robertson 2857

Tournefortia argentea L.f.
Robertson 2845

CARICACEAE

Carica papaya L.
Robertson 2824

CASUARINACEAE

Casuarina equisetifolia L.
Robertson 2848

CONVOLVULACEAE

Ipomoea macrantha Roem. & Schultes
Robertson 2823

Ipomoea pes-caprae (L.) R. Br.
Robertson 2850

Ipomoea sp.
Robertson 2825

CRASSULACEAE

Kalanchoe pinnata (Lam.) Pers.
Bryophyllum pinnatum (Pers.) Kurz
Robertson 2863

CYPERACEAE

Cyperus aromaticus (Ridl.) Mattf. & Kük.
Kyllinga polyphylla Willd. ex Kunth
Robertson 2890

Cyperus dubius Rottb.
Mariscus dubius (Rottb.) Fischer
Robertson 2887

Cyperus kyllingia Endl.
Kyllinga monocephala Rottb.
Robertson 2886

Cyperus ligularis L.
Mariscus ligularis (L.) Urb.
Robertson 2878

Cyperus rotundus L.
Robertson 2879

Fimbristylis cymosa R. Br.
Robertson 2881

EUPHORBIACEAE

Acalypha indica L.
Robertson 2853

Euphorbia hirta L.
Robertson 2826

Euphorbia prostrata Ait. ?
Robertson 2862

Phyllanthus amarus Schum. & Thonn.
Robertson 2852

Phyllanthus maderaspatensis L.
Robertson 2837

Ricinus communis L.
Robertson 2835

FABACEAE (LEGUMINOSAE)

Adenanthera pavonina L.
Robertson 2841

Cassia occidentalis L.
Robertson 2828

Erythrina variegata L.
Robertson 2838

Sesbania sericea (Willd.) Link
Robertson 2832

GOODENIACEAE

Scaevola sericea Vahl.
Scaevola taccada (Gaertn.) Roxb.
Robertson 2877

HERNANDIACEAE

Hernandia sonora L.
Hernandia nymphaeifolia (Presl) Kubitzki
Robertson 2827

LAURACEAE

Cassytha filiformis L.
Robertson 2873

LECYTHIDACEAE

Barringtonia asiatica (L.) Kurz
Robertson 2834

MALVACEAE

Gossypium hirsutum L.
Robertson 2830

Sida pusilla Cav. ?
Robertson 2839

Sida stipulata Cav.
Robertson 2844

MORACEAE

Ficus nautarum Bak.
Robertson 2858

MORINGACEAE

Moringa oleifera Lam.
Robertson 2888

NYCTAGINACEAE

Boerhavia repens L.
Robertson 2869

PASSIFLORACEAE

Passiflora suberosa L.
Robertson 2831

POACEAE (GRAMINEAE)

Dactyloctenium ctenoides (Steud.) Bosser
Robertson 2843, 2847

Eleusine indica (L.) Gaertn.
Robertson 2860

Eragrostis subaequiglumis Renvoize
Robertson 2882

Lepturus repens (G. Forst.) R. Br.
Robertson 2872

Panicum subquadriparum Trin.
Brachiaria subquadripara (Trin.) Hitchc.
Robertson 2885

Stenotaphrum dimidiatum (L.) Brongn.
Robertson 2867

Stenotaphrum micranthum (Desv.) Hubb.
Robertson 2871

POLYPODIACEAE (sensu lato)

Nephrolepis biserrata (Swartz) Schott
Robertson 2868

Polypodium scolopendria (Burm.f.) Copel.
Microsorium scolopendria (Burm.f.) Copel
Robertson 2865

RUBIACEAE

Guettarda speciosa L.
Robertson 2851

Morinda citrifolia L.
Robertson 2875

SCROPHULARIACEAE

Striga asiatica (L.) Kuntze
Robertson 2859

SURIANACEAE

Suriana maritima L.
Robertson 2846

TILIACEAE

Triumfetta procumbens Forst.f.
Robertson 2864

Triumfetta rhomboides Jacq.
Robertson 2833

TURNERACEAE

Turnera ulmifolia L.
Robertson 2854

URTICACEAE

Laportea aestuans (L.) Chew
Robertson 2874

Pilea microphylla (L.) Leibm.
Robertson 2861

Pipturus argenteus (Forst.) Wedd.
Robertson 2836

VERBENACEAE

Lippia nodiflora (L.) Rich.
Robertson 2870

Stachytarpheta jamaicensis (L.) Vahl
Robertson 2856

Stachytarpheta urticaefolia Sims
Robertson 2855

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10. ECOLOGY OF MARIE-LOUISE, AMIRANTES ISLANDS

by J. R. Wilson

Introduction

Marie-Louise (6°11'S, 53°08'E) lies at the southern end of the Amirantes 13 km from its nearest neighbour, Desnoeufs, and 280 km southwest of the granitic Seychelles. The island is rougly oval (Figure 11) with a long north-south axis, has a maximum elevation of 9 m although more generally 5-6 m, and an area of 52.6 ha. It is permanently inhabited with a population of c.15 agricultural workers and fishermen based in a small settlement on the west coast above the beach and opposite the only safe anchorage. Perhaps because of its isolation and the difficulty of landing the general natural history of Marie-Louse remains undescribed and the observations presented here, made on 14-15 June 1979 and 10-11 July 1980, are intended to fill this gap.

Geology and soils

The island is believed to be an uplifted cay with calcareous sandstones, overlying and interbedded with gravels, dipping outwards from the centre (Baker 1963, Piggott 1968, 1969). The rock is less well developed in the south which is considered to be of more recent origin. Jemo soils have formed, with a layer of guano above the sandstones which have become phosphatised, but the unconsolidated material has been stripped away and the rock is now exposed over ca 75% of the island surface. Shioya soils occur around the island perimeter. A broad beach is present in the north-west whilst the southern part of the island is generally bounded by low cliffs, giving way to rubbly storm beaches in the east and north.

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Figure 11. Marie-Louise

Vegetation

Five major vegetation types can be distinguished on the basis of subjective assessment of structure and species content.

Coconut grove community

Cocos nucifera has been planted over the greater part of the island into pits dug through the underlying phosphatic sandstone. Scattered *Hernandia sonora* trees are common throughout the grove which forms a closed canopy at about 12 m. *Morinda citrifolia* and *Carica papaya* are generally abundant in the understory and *Ricinus communis* is locally common. There is a dense and varied ground flora in which *Tridax procumbens, Boerhavia* sp., *Stachytarpheta jamaicensis* and *Passiflora suberosa* are widespread and conspicuous. Towards the airstrip trace in the north and the *Scaevola* thicket in the south the coconuts are more sparse and the canopy becomes more open with a greater proportion of *Hernandia, Morinda* and other trees. These conditions favour *Ricinus* and *Gossypium hirsutum.*

Herb community of open areas

The airstrip trace and an open area to the south of the settlement have been cleared and part of the airstrip is used seasonally for maize cultivation. A dense herb layer develops in which *Tridax* and *Stachytarpheta* are dominant and *Gossypium* forms dense patches.

West facing coastal hedge

The west coast is fringed with tall *Scaevola sericea* and *Tournefortia argentea* with occasional *Casuarina equisetifolia*. *Lepturus repens* and *Boerhavia* sp. underlie the hedge and, to the north of settlement, form a sparse cover on the beach crest. To the south of the beach, *Scaevola* thicket with some *Tournefortia* reaches the edge of the low cliffs, fronted only by a narrow and discontinuous band of low herbs including *Fimbristylis cymosa, Sida parvifolia, Passiflora, Tridax, Boerhavia, Euphorbia prostrata* and *Dactyloctenium* sp.

East facing coastal hedge

The coastal hedge on the east coast is dominated by *Scaevola* which extends back to form a dense thicket (see below). *Guettarda speciosa* is common in the north, with some *Tournefortia*. *Ipomoea macrantha, I.pes-caprae* and *Lepturus* are also present. Further south the *Scaevola* is lower and is mixed with occasional stunted *Tournefortia* and *Casuarina*. A thin and discontinuous band of herbs is found on the cliff edge, dominated by *Fimbristylis* and *Cyperus ligularis* whilst *Sida* and *Stenotaphrum micranthum* are also present. *Euphorbia prostrata* grows on the unstable surface of the cliff face.

Scaevola thicket

The *Scaevola* of the beach hedge extends back to form a dense thicket from the north east, where it has been partially cut for the airstrip, to the south where it extends right across to the west coast. The thicket reaches a height of 4 m and there is a sparse understorey grasses and herbs.

List of plants

65 species of vascular plants were noted, excluding those under cultivation. The following are all sight records, although specimens were retained for identification in Mahe if a positive identification could not be made at the time. The names used here have been checked by F. R. Fosberg, and conform to those in others of this series of reports.

ACANTHACEAE

Asystasia genetica (L.) T Anders.
(Probably *A. multiflora* Klotzsch or *A. bojeriana* Nees)
Patchily distributed but dominant where present in the coconut grove.

AGAVACEAE

Furcraea foetida (L.) Haworth
Patches, probably originally planted but now abandoned, are found at both ends of the airstrip trace and behind the beach hedge to the south of the settlement.

AMARANTHACEAE

Achyranthes aspera L.
Frequent in the coconut grove and in cleared areas; also occurring under the beach hedge of the northwest coast.

Amaranthus dubius Mart. ex Thell.
Common around the settlement and in the coconut grove.

APOCYNACEAE

Catharanthus roseus (L.) G. Don
Frequent in the coconut grove and cleared areas. Only the white-flowering variety occurs.

Neisosperma oppositifolia (Lam.) Fosb. & Sachet
Frequent within the coconut grove and present in the *Scaevola* thicket.

ARACEAE

Alocasia macrorrhiza (L.) G. Don
Occasional throughout the coconut grove.

ARECACEAE (PALMAE)

Cocos nucifera L.
The dominant species of the coconut grove. Scattered palms are also found within the *Scaevola* thicket but are poor.

ASCLEPIADACEAE

Tylophora asthmatica Wight & Arn.
Recorded by Piggott (1969) as the predominant species in the coconut grove, but not recorded in 1979 and 1980.

ASTERACEAE (COMPOSITAE)

Bidens pilosa L.
Infrequent in the coconut grove.

Tridax procumbens L.
Widespread, being common in the coconut grove and co-dominant with *Stachytarpheta* in cleared areas. It also occurs on the cliff edge of the southwest coast.

BORAGINACEAE

Cordia subcordata Lam.
Present in the coconut grove where palms are thinly distributed, particularly adjacent to the airstrip trace.

Tournefortia argentea L.f.
Common in the coastal hedge on the northern part of the island, but less frequent in the south.

CAPPARIDACEAE

Cleome gynandra L.
Found only around the settlement, on paths and on heaps of guano brought from Desnoeufs.

CARICACEAE

Carica papaya L.

Very common in the coconut grove, forming an open understorey ca. 3 m tall under the palms.

CASUARINACEAE

Casuarina equisetifolia L.

Tall trees along the west coast, and a small grove at the cemetery in the north. Scattered individuals grow along the east coast and particularly behind the *Scaevola* thicket on the edge of the coconut grove.

CLUSIACEAE (GUTTIFERAE)

Calophyllum inophyllum L.

A single tree was located on the inland margin of the *Scaevola* thicket on the east side of the island.

COMMELINACEAE

Commelina benghalensis L.

Present under the coconut grove but patchily distributed.

CONVOLVULACEAE

Ipomoea batatas (L.) Lam. ?

A single plant in the coconut grove, scrambling over blocks of phosphatic limestone rubble.

Ipomoea macrantha Roem. & Schultes

Present in the beach hedge on the north coast and in margins of the coconut grove on the east side of the island.

Ipomoea pes-caprae (L.) R. Br.

Present in the cleared areas but most common on the seaward edge of the coastal hedge on the north and east.

CRASSULACEAE

Kalanchoe pinnata (Lam.) Pers.

Frequent but patchily distributed within the coconut grove.

CUCURBITACEAE

Cucurbita moschata (Duch. ex Lam.) Poir
Cultivated around settlement and occasional in the herb layer of the coconut grove.

CYPERACEAE

Cyperus dubius Rottb.
Common in the coconut grove, particularly along paths.

Cyperus ligularis L.
Present as scattered tussocks in the cleared areas but most frequent on the cliff top of the east coast.

Fimbristylis cymosa R. Br.
Dominant on the edge of cliffs on the southeast and southwest coasts.

EUPHORBIACEAE

Acalypha indica L.
Common in the coconut grove, and also present in open areas and under the *Scaevola* thicket.

Euphorbia hirta L.
Abundant in the coconut grove and in open areas.

Euphorbia prostrata Ait.?
Common along paths and in the coconut grove. It also occurs in sparsely vegetated areas and along the cliff edges.

Pedilanthus tithymaloides (L.) Poit.
Two patches were found, one within the settlement and one by the wells in the coconut grove.

Phyllanthus amarus Schum. & Thonn.
Common in the coconut grove, especially along paths, and present in cleared areas.

Phyllanthus sp.
Frequent in the coconut grove; also occurring in open areas.

Ricinus communis L.
Frequent within the coconut grove, becoming more common in open areas.

FABACEAE (LEGUMINOSAE)

Cassia occidentalis L.
Scattered plants within the coconut grove.

Leucaena leucocephala (Lam.) de Wit.
Frequent as scattered bushes under the coconut grove. Tall *Leucaena* dominate a small area to the south of the settlement adjacent to the *Scaevola* thicket.

Sesbania sericea (Willd.) Link ?
Two specimens were found within the coconut grove.

Vigna sp. ?
Uncommon in the coconut grove: only two specimens found.

GOODENIACEAE

Scaevola sericea Vahl
Found around the perimeter of the island where it dominates the coastal hedge and forms a dense thicket covering the whole southern portion of the island. Scattered inliers occur on the margins of the coconut grove and in cleared areas.

HERNANDIACEAE

Hernandia sonora L.
Trees up to 12 m tall are common in the coconut grove, but less frequent in the *Scaevola* thicket.

LECYTHIDACEAE

Barringtonia asiatica (L.) Kurz
Two specimens found, one in the settlement and one in the coconut grove.

LYTHRACEAE

Pemphis acidula Forst.
Described by Baker (1963) as covering the southeast part of the island, presumably in error for *Scaevola*.

MALVACEAE

Abutilon indicum (L.) Sweet ?
Uncommon; found within the coconut grove and in open areas.

Gossypium hirsutum L.
Present in the coconut grove but more common in the cleared areas.

Hibiscus tiliaceus L.
Only one specimen found, on the edge of the airstrip trace.

Sida pusilla Cav.
Found throughout the island, being common in the coconut grove and open areas, frequent along the coast, and present under the *Scaevola* thicket.

Sida sp.
Common in the coconut grove.

MORINGACEAE

Moringa oleifera Lam.
A number of trees have been planted round the settlement.

MUSACEAE

Musa sapientum L.
One patch, within the coconut grove.

NYCTAGINACEAE

Boerhavia spp.
Found throughout the island, being abundant under the coconut grove and in open areas. It occurs along the west coast and under the *Scaevola* thicket, but is not common on the east coast. A white-flowering form predominates, but the pink-flowering type (*B. repens* L. ?) is infrequently found in the coconut grove.

Mirabilis jalapa L.
Frequent around the settlement but uncommon in the coconut grove.

PASSIFLORACEAE

Passiflora suberosa L.
Abundant in the coconut grove, both on the ground and ascending into the bushes. It is also common in open areas, and occurs along both southeast and southwest coasts.

POACEAE (GRAMINEAE)

Dactyloctenium ctenoides (Steud.) Bosser
Sparsely distributed in the coconut grove. Dead grass in the open areas and on the south and east coasts suggests that this species is more abundant at other times of the year.

Digitaria setigera Roth.
Frequent in the coconut grove and present in cleared areas.

Eleusine indica (L.) Gaertn. ?
Frequent in the coconut grove, and also present in open areas and under *Scaevola* thicket.

Eragrostis subaequiglumis Renvoize
Common in the coconut grove where ground cover is sparse, and especially along paths. Also occurs in cleared areas.

Lepturus repens (G. Forst.) R. Br.
Found on the coast around the entire island, and also growing in the *Scaevola* thicket.

Panicum maximum Jacq.
Planted in the settlement and also found in isolated patches within the coconut grove.

Stenotaphrum dimidiatum (L.) Brongn.
Present on the east coast.

PORTULACACEAE

Portulaca oleracea L.
Present in the coconut grove, especially along paths, and infrequent on the east coast.

RUBIACEAE

Guettarda speciosa L.
Common in the coastal hedge of the northeast but not recorded elsewhere.

Morinda citrifolia L.
Very common as low bushes or trees in the coconut grove. Also occurs as scattered bushes in the open areas and in the *Scaevola* thicket.

SOLANACEAE

Capsicum frutescens L.
Three bushes, probably planted, are found in the coconut grove.

Datura metel L.
Present as scattered plants in the coconut grove.

Solanum nigrum L.
Infrequent in the coconut grove.

TURNERACEAE

Turnera ulmifolia L.
Frequent in the coconut grove.

URTICACEAE

Laportea aestuans (L.) Chew
Frequent in the coconut grove.

VERBENACEAE

Lippia nodiflora (L.) Rich
Dominant in one small area close to the settlement, but not recorded elsewhere.

Stachytarpheta jamaicensis (L.) Vahl
Common in the coconut grove and generally co-dominant with *Tridax* in the cleared areas.

Vertebrate fauna

Reptiles

?Gehyra mutilata

A noctural light brown gecko, common in the settlement buildings.

Phelsuma madagascariensis

Common in the coconut grove and beach hedge.

Chelonia mydas Green turtle

A small number are said to breed on Marie-Louise, where suitable beaches extend from settlement to the northern point. One set of pits was found by settlement in 1979 and several traces of earlier visits were evident around the northern point by the cemetary. Two sets of pits were found in 1980, one several months old and one recent. Both were by the cemetary.

Eretmochelys imbricata Hawksbill turtle

Around 15 females are said to land on the island each year between October and February.

Both turtle species are taken whenever opportunity arises.

Birds

Puffinus l'herminieri Audubon's Shearwater

Not seen. Said to occur although not to breed (O. Souris, pers comm.).

Puffinus pacificus Wedge-tailed Shearwater

Two small colonies of c.45 burrows each were found on the east coast and at Point Fouquet, the southernmost tip of the island. Both colonies were situated in open ground on the cliff edge and although no birds were seen some burrows appeared to be in use.

Sula leucogaster Brown Booby

An adult plumaged bird roosted in coastal *Casuarina* on the night of 19 July 1980. An unidentified immature booby passed over the island on the evening of 14 June 1979.

Fregata sp. Frigatebirds

Three immature frigates passed over the island in the evening of 19 July 1980. It was not established if Marie-Louise is used as a roost although this is most likely.

Bubulcus ibis Cattle Egret

Three birds were seen on the airstrip in 1980. The population appears to be small.

Gallus gallus Feral chicken

A number of chickens have gone wild and range through the coconut grove. Their wariness and willingness to fly distinguishes them from the domesticated birds.

Pluvialis squatarola Grey Plover

Present, foraging on the airstrip trace and on the east coast.

Arenaria interpres Turnstone

Common throughout the island and on the coast. The manner in which birds freely perched in dead bushes where ground cover was dense was remarkable.

Sterna anaethetus Bridled Tern

Several hundred birds roost in the *Casuarina* of the west coast but it was not established if breeding took place.

Sterna fuscata Sooty Tern

Sooty terns regularly pass over the island but do not land.

Gygis alba White Tern

Common throughout the island and all stages of breeding observed. The population was estimated at several thousand pairs.

Anous tenuirostris Lesser Noddy

Common, several thousands being estimated as present. Breeding was noted in casuarinas behind the *Scaevola* thicket on the east coast and roosting birds were found throughout the coconut grove.

Anous stolidus Common Noddy

Common, breeding in coconuts throughout the island. With roosting birds, the population was estimated to be in the region of several thousand birds.

Passer domesticus House Sparrow

Common around the settlement but not in the coconut grove. A nest was under construction in the eave of a house in July 1980.

Foudia madagascariensis Madagascar Fody

Very common in the coconut grove and in feeding flocks on the airstrip trace.

Introduced "grey partridge" and quail were recorded as uncommon in 1955 (Ridley and Percy 1958) but neither species, the precise identification of which is uncertain, was seen in 1979 or 1980. Both have probably died out.

Mammals

Mus sp. (*?musculus*) Mouse

Mice are common but there are no rats.

Sus scrofulus Feral pig

A number of feral pigs occur, one being seen in the coconut grove in dense cover. They are extremely wary.

Tursiops truncatus Bottle-nosed Dolphin

Dolphins were seen off settlement beach on both visits.

Land use history

Marie-Louise is government-owned but has been leased and permanently settled since the late 19th century. The first major activity was the exploitation of guano and the island had two co-lessees in 1905 with a total population of 86. One lessee handled the guano extraction and at least 3500 tons were exported in late 1905 alone (Tonnet 1906). By 1906 it was reported that economically workable deposits were exhausted although an estimated 3000 tons remained in 1963 of which 1500 tons could be taken for local use without damaging agricultural potential (Baker 1963). In fact guano has been imported in recent years for agricultural purposes from Desnoeufs.

The second lessee in 1905 was responsible for agricultural development. 800 coconuts and the *Casuarina* on the west coast had already been planted and effort was maintained as holes were dug through the sandstone for further plantings. The wells sunk from chambers excavated under the sandstone beds also probably date from this period. Following the exhaustion of the guano, agriculture and fishing became the sole activities supporting a population of about 20. Sixty years later, Piggott (1969) commented that the estate was neglected and it remained in much the same condition in 1979-80 although pigs, poultry, vegetables, maize, tortoiseshell and saltfish were produced for island use and to augment copra exports. The airstrip trace in the north-east was cut some 10-15 years ago but the work was not completed.

The Island Development Company took the lease of Marie-Louise in 1981 and, given the emphasis placed by government on outer island development and the influx of resources and expertise under the new management, agricultural activity is expected to be intensified in future.

Discussion

The Du Roslan expedition, passing by in 1771 and giving Marie-Louise its name, described the island as well wooded (Fauvel 1908) and the present vegetation is a product of a century of human activity superimposed upon the effects of differing soils and degree of exposure to wind and wind-borne salt. The activity with the most far-reaching ecological impact must have been the guano exploitation involving the removal of any vegetation growing on it and the virtual loss of all top soil, and in 1905 this formerly wooded island was clothed only in small bushes and young coconuts (Tonnet 1906). The subsequent development of the vegetation has been controlled by management as an agricultural plantation.

The flora of Marie-Louise is now unremarkable and, of the 66 plant species noted, 34 are generally considered to be introductions to the Seychelles as cash crops, vegetables, ornamentals, for medicinal purposes or as weeds. This is an over-simplification as some native species are weedy or widely planted and may not have formed part of the original Marie-Louise flora whilst others are of uncertain status but, despite these difficulties in categorisation, a rough analysis of the provenance of the flora can be made:

Vegetation type	*No.native species*	*No.introduced species*	*total*	*% introduced species*
All types	31	34	65	51.5
Coconut grove	24	33	57	58
Cleared areas	9	12	21	57
Coastal hedge,W.	9	3	12	25
Coastal hedge,E.	13	2	15	13
Scaevola thicket	7	1	8	12

If the proportion of introduced species can be taken as an indicator of habitat disturbance, it is evident that the coastal hedge and *Scaevola* thicket have been altered least despite the presence of pits dug under the latter, suggesting cutting back in an effort to increase coconut production. It is likely then that the hedge and thicket are essentially persistent features of the original vegetation although there has been some invasion by hardy weeds, particularly on the more sheltered west coast.

It is also certain that the coastal hedge and its inland extension as *Scaevola* thicket is vital in protecting the coconut grove and, before that, the forest noted in 18th century. This forest must have consisted at least of *Hernandia, Barringtonia, Neisosperma, Morinda* and *Cordia,* and probably of other species incapable of withstanding the combined effects of removal of the guano in which they grew and the subsequent repeated coppicing practiced as an adjunct to coconut cultivation. That the forest was not more widespread is suggested by the difficulty with which native trees establish themselves within the *Scaevola* thicket even though all species concerned are capable of growth in its soils. The critical factor appears to be exposure to salt spray.

The seabirds are perhaps the most interesting ecological feature of the island. Despite the comments of Ridley and Percy (1958) who did not consider Marie-Louise to be a seabird island from the egg cropping viewpoint and recorded Lesser and Common Noddies as breeding in small numbers only, the island actually supports one of the largest concentrations of tree nesting terns in the Amirantes even though the greater number may only roost rather than breed. This population complements the similar concentrations of ground nesting and tunnelling sea-birds in the other southern Amirante Islands of Desnoeufs, Boudeuse and Etoile. The two noddies are taken for food by the island inhabitants but it is highly unlikely that this activity has any marked effect on the tern populations and only the small colonies of wedge-tailed shearwaters can be considered to be at risk through direct human predation. The important factors maintaining the number of birds on Marie-Louise are the absence of rats and the presence of the coconut grove which provides breeding and roosting sites and would continue to do so even under more intensive management. As already suggested, the existence of the coconut grove is dependant upon the shelter of the beach hedge and *Scaevola* thicket.

There is no real conflict between agricultural development and wildlife conservation interests on Marie-Louise. Indeed, the well-being of the coconut grove is to the advantage of all and the undesirability of the introduction of rats is generally accepted. However, the critical importance of the integrity of the coastal vegetation must be stressed. The removal or reduction of coastal hedge or *Scaevola* thicket to free land for agriculture without the establishment of some other adequate screen such as a *Casuarina* belt would be counter-productive on Marie-Louise and also considerably diminish the species and habitat diversity among the southern Amirantes.

Acknowledgements

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11. ECOLOGY OF DESNOEUFS, AMIRANTES ISLANDS

by J. R. Wilson

Introduction

Desnoeufs (6°14's, 53°02'E) is the southernmost of the Amirantes. It is situated 13 km from its nearest neighbour, Marie-Louise, and 290 km from Mahe in the granitic Seychelles. It is roughly circular (Figure 12) with an area of 39.7 ha and a maximum elevation of 4 m on its slightly raised perimeter. There is one safe landing on the beach in the north behind which a number of huts have been erected to house a workforce of around 30 men stationed on the island each year from May to August to collect seabird eggs. A reserve of 16.6 ha has been established on the western side.

Desnoeufs has received several visits by scientists over the past 25 years. Percy and Ridley (1958) described the natural history in detail and there have been a series of subsequent censuses of the sooty tern colony (Feare 1976, Percy and Ridley 1966, Procter 1970). The geology and soils have also been examined (Baker 1963, Piggott 1968) with particular emphasis on the guano deposits. The observations presented here were made during two visits to the island, during 15-24 June 1979 and 18 July-1 August 1980.

Geology and soils

The island is believed to be an uplifted cay in which sandstone, originally formed as beach rock, spreads outwards in concentric rings from a centre approximately 100 m in diameter (Piggott 1968, 1969). Beachrock formation continues on the shore whilst the older sandstones inland have become phosphatised to varying degrees and on parts of the south coast fragments of this dark brown phosphatised material have been reincorporated in the more recent beds. Unconsolidated calcareous gravels and sands underlie the rock.

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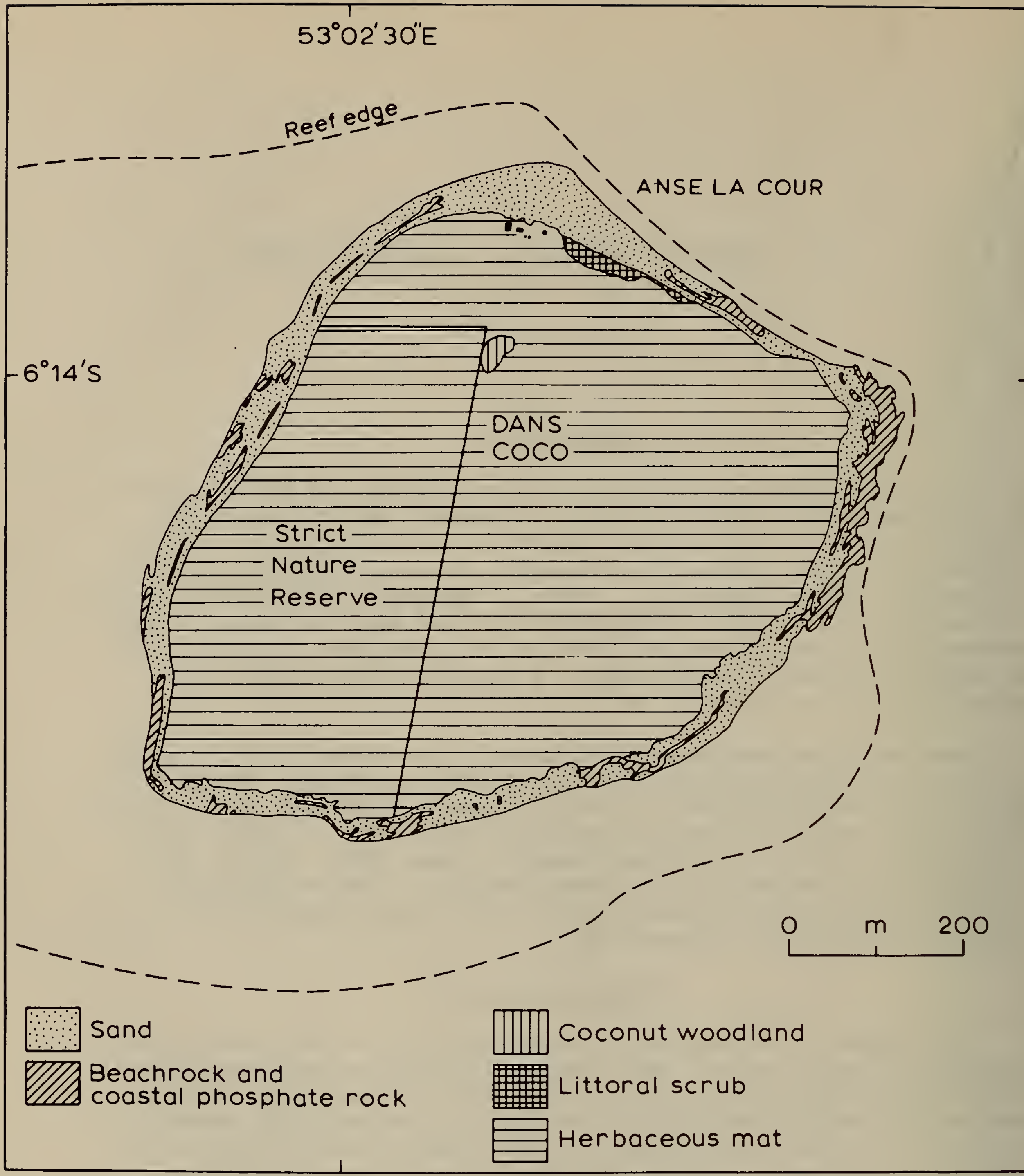

Figure 12. Desnoeufs

The soils are formed from guano and wind-blown sand. Baker (1963) estimated that the average depth of guano was approximately 20 cms but it is not evenly distributed and rock is widely exposed. The guano is the type for the Desnoeufs series soil (Piggott 1968), a richly phosphatic dark brown humus overlying the partially phosphatised sandstone and principally derived from material imported by seabirds with little contribution from the underlying rock. A structureless pink skin occurs on the surface of occupied and abandoned booby colonies.

Windblown sand forms low dunes which are best developed on the northeast and southwest coats whilst on the northwest and southeast, the coasts facing directly into the two prevailing winds, the sands extend further inland and are thinly spread. Farquhar Series soils develop. Typically these consist of a shallow organic horizon grading through to pure sand at about 30 cms (Piggott 1968) but on Desnoeufs they have a particularly high phosphatic content and the organic material is mixed to greater depth because of extensive burrowing by wedge-tailed shearwaters.

Vegetation

The island is generally cothed in coarse herbage although there is a small coconut grove, a single *Hibiscus* tree and a short stretch of coastal hedge. Eight vegetation communities were distinguishable on the basis of structure and species content but it was evident that considerable seasonal changes took place and that the herb communities described here were transient. During the wetter northwest monsoon when the sooty terns are absent the ground vegetation is aid to be luxuriant (O. Souris, pers. comm.) but it dies back over the south east trades between April and September under the combined effects of drought, exposure to salt spray, trampling by seabirds and accumulation of fresh droppings. The vegetation was considerably more open and community boundaries less distinct in late July 1980 than was the case in June 1979 and it has been assumed that these changes are essentially similar each year.

Beach crest community

A discontinuous cover of prostrate species including *Lepturus repens, Portulaca oleracea, Stenotaphrum micranthum, Sida parvifolia, Euphorbia prostrata* and *Boerhavia* sp. occurs on the beach crest. In June the community is generally confined to a strip ca 1 m wide although extending several metres inland in more exposed sites on the south coast. Later in the year it partially spreads into the area opened up by the reduction in cover of the dune community.

Dune community

In June the vegetation of the Farquhar Series soils is dominated by *Stenotaphrum.* To the north it forms a dense sward, also containing *Phyllanthus amarus* and *Passiflora suberosa,* whilst in the south the thinner soils bear a shorter, sparser *Stenotaphrum* sward mixed with *Portulaca, Sida* and *Boerhavia.* Later the *Stenotaphrum* tends to die back and *Boerhavia* becomes dominant or co-dominant. *Sida* and *Portulaca* remain common.

Dactyloctenium dominated transitional community

Behind the coastal ridge in the north and east lies a belt of soil transitional between the Farquhar and Desnoeufs Series. In June the area is dominated by withering *Dactyloctenium* sp. with scattered *Stenotaphrum, Stachytarpheta jamaicensis, Sida, Cleome gynandra, Portulaca* and *Boerhavia*. As the *Dactyloctenium* dies and becomes matted, *Stachytarpheta* and *Boerhavia* become more frequent.

South coast transitional community

A more floristically diverse variant of the dune community occurs inland along the south coast where the sand mixes with guano. *Stenotophrum* is dominant and *Stachytarpheta* common in June but in July the *Stenotaphrum* dies back and *Boerhavia* and *Portulaca* become co-dominant.

Coastal hedge

A narrow, dense hedge of *Scaevola sericea* about 75 m long occurs along the least exposed section of the north coast. It is interrupted by the settlement buildings.

Sheltered mixed herb community

A mixed herb community grows behind the coastal hedge and extends c.100 m beyond it towards the east. Constituent species include *Phyllanthus amarus, Acalypha indica, Abutilon* sp., *Solanum nigrum, Amaranthus dubius, Stachytarpheta, Datura metel, Catharanthus roseus* and *Dactyloctenium*. These species were all present in June 1979, forming a dense sward up to 75 cm tall. *Phyllanthus* and *Dactyloctenium* were absent in July 1980 and the community was more open with the eastern extension, formerly dominated by *Stachytarpheta*, partially cleared allowing *Amaranthus* to persist and *Portulaca* to become dominant.

Coconut grove

A small coconut grove is found in the centre of the island. In 1979 it sheltered a similar community, with the addition of *Eleusine indica, Colubrina asiatica* and *Alocasia macrorrhiza*, to that found behind the coastal hedge but had been cleared in July 1980. Nevertheless the constituent species of the 1979 flora remained as scattered individuals.

Desnoeufs Soil community

This is not a homogenous vegetation type but a mosaic, the composition of which is seemingly determined by previous concentrations of seabirds, their present distribution, and the clearing activities of the egg collectors. In June 1979 *Stachytarpheta, Cyperus ligularis,* *Portulaca* and *Amaranthus* all occurred in monospecific blocks or in mixed communities with occasional *Dactyloctenium, Solanum, Boerhavia* and *Cleome*. These latter species generally grew where the guano was mixed with sand or in small pockets of soil in loose sandstone blocks but *Abutilon, Sesbania* and *Datura* were scattered throughout the area. In July 1980 the vegetation was more open whilst a definite difference had developed between the reserve and the cropped area. The reserve, now densely occupied by breeding sooty terns, was dominated by open *Portulaca* with scattered *Cyperus* and *Boerhavia*. · Occasional bushes of *Sesbania* and *Datura* were present but *Amaranthus* persisted only in areas with few nesting birds. *Stachytarpheta* dominated the area by the reserve boundary. In the cropped area *Stachytarpheta* was generally dominant whilst *Boerhavia* and *Portulaca* were common and *Cyperus* formed dense mono-specific blocks. Where the *Stachytarpheta* had been uprooted by egg-collectors, *Portulaca* sparsely covered the open ground.

A single *Hibiscus tiliaceus* tree forms a unique element in the Desnoeufs Soil vegetation mosaic.

List of plants

30 species of vascular plants were recorded after exhaustive search. The following are all sight records, although specimens were retained for verification in Mahe if a positive identification could not be made at the time. The names used here have been checked by F. R. Fosberg, and conform to those in others of this series of reports.

AMARANTHACEAE

Amaranthus dubius Mart. ex Thell.

Dominant or co-dominant with *Portulaca* on Desnoeufs soil, particularly within the reserve, but also found behind the coastal hedge and within the coconut grove. Apparently dies back earlier than *Portulaca*.

APOCYNACEAE

Catharanthus roseus (L.) G. Don

Common behind the beach hedge, in the coconut grove, and in sandy soils behind the dunes of the north coast. Only the white-flowering variety is found.

Neisosperma oppositifolia (Lam.) Fosb. and Sachet

The coastal hedge contains a single shrub which is healthy and fruiting but grows no higher than the surrounding *Scaevola*.

ARACEAE

Alocasia macrorhiza (L.) G. Don

Several yellowed specimens grow in pits on the fringe of the coconut grove.

ARECACEAE (PALMAE)

Cocos nucifera L.

About 30 planted trees form the grove in the centre of the island, and a small number of nuts sprout around the coast.

CAPPARIDACEAE

Cleome gynandra L.

Present behind the dunes on transitional soils or on the Desnoeufs soils proper. In June most frequent as a seedling or dying mature plants in the southern half of the island. Very few seedlings and no mature plants were located in July 1980.

CARICACEAE

Carica papaya L.

Several small plants were found in 1979 growing from seed thrown out from the camp into the lee of the coastal hedge. None remained in July 1980.

CONVOLVULACEAE

Ipomoea macrantha Roem. & Schultes

One plant was found on the dunes of the west coast in 1979 but was not present in the following year.

CYPERACEAE

Cyperus ligularis L.

Two large patches grow on the southwest and northeast of the island on Desnoeufs soil. Isolated tussocks occur elsewhere on the guano but are thinly distributed.

EUPHORBIACEAE

Acalypha indica L.

Frequent under and behind the beach hedge and within the coconut grove.

Euphorbia prostrata Ait. ?
Common on the beach-crest community and on the dunes wherever vegetation cover is discontinuous.

Phyllanthus amarus Schum. & Thonn.
Occasional in the north coast dune community but more frequent in the sheltered mixed herb community and among the coconuts.

FABACEAE (LEGUMINOSAE)

Sesbania sp. probably *sericea* (Willd.) Link
Isolated plants or groups of plants widely scattered over the central part of the island. In June 1979 most were dying back and in July 1980 only ten with living shoots remained.

GOODENIACEAE

Scaevola sericea Vahl
Limited to the coastal hedge on the north coast.

MALVACEAE

Abutilon indicum (L.) Sweet ?
Frequent in the Desnoeufs Soil community, the coconut grove, behind the beach hedge, and in 1980 on the edge of the dunes of the northwest coast. Most plants were dead, even in June.

Sida pusilla Cav.
Common within the dune community and on the beach crest.

Hibiscus tiliaceus L.
A single large tree grows on the Desnoeufs Soil near the centre of the island.

NYCTAGINACEAE

Boerhavia sp.
A white-flowered, fleshy trailing herb, most common on sandy soils around the perimeter of the island but well represented inland by July.

PASSIFLORACEAE

Passiflora suberosa L.
In 1979 two or three vigorous plants scrambled over *Stenotaphrum* in one small area of the dunes on the northwest coast. The following year these plants had spread to cover an area of about 3000 sq metres, and a single specimen was also located on the northeast coast.

POACEAE (GRAMINEAE)

Dactyloctenium ctenoides (Steud.) Bosser

Occurs primarily as a dominant species behind the dunes on transitional soils on the northeast and east sides of the island, but it is also present in the coconut grove and in the dunes of the west coast. Apparently dies back early during the southeast trades.

Eleusine indica (L.) Gaertn.

Most frequent behind the beach hedge and within the coconut grove, but in 1979 occasionally found elsewhere immediately behind the dunes.

Lepturus repens R. Br.

Found in small isolated patches as a primary coloniser of the beach crest, occasionally extending into the dune community behind.

Stenotaphrum micranthum (Desv.) Hubb.

In June *Stenotaphrum* dominates soils around the island perimeter and also inland where isolated patches of windblown sand overlie the phosphatic sandstone. By July it has generally died back but scattered plants still persist.

PORTULACACEAE

Portulaca oleracea L.

Found throughout the island in open areas but apparently suppressed by denser vegetation. It flourishes in those areas with the densest Sooty Tern concentrations, where it is generally dominant or co-dominant with *Amaranthus*.

RHAMNACEAE

Colubrina asiatica (L.) Brongn.

A dense and flourishing mass of bushes with several outliers grows in the coconut grove.

SOLANACEAE

Datura metel L.

Frequent in the coconut grove and in the sheltered mixed herb community but less common elsewhere on Desnoeufs Soil and absent from Farquhar Series soils.

Nicotiana tabacum L.

A single plant was found in the beach hedge in July 1980.

Solanum nigrum L.

Locally common throughout the Desnoeufs Soil area in June, but limited by July to the coconut grove and the shelter of the coastal hedge.

VERBENACEAE

Stachytarpheta jamaicensis (L.) Vahl

The most conspicuous herb on the island, occurring throughout the area of Desnoeufs Soil in dense monospecific patches or dominating in mixed communities, and also growing in soils transitional with the Farquhar Series.

ZYGOPHYLLACEAE

Tribulus cistoides L.

One localised patch consisting of less than ten plants was found in 1979 in the south coast transitional community. Several plants were pulled out by the egg collectors although seed had already been dropped. The site could not be relocated in 1980.

Vertebrate fauna

Reptiles

Hemidactylus sp. (?*frenatus*)

A brown nocturnal gecko common in the camp buildings and also found in the coconut grove under blocks of sandstone.

?*Gehyra mutilata*

A number of paler, more translucent geckos were seen on the camp buildings in 1980 although they were not recorded in 1979. No specimens were collected and the identification is tentative.

Chelonia mydas Green Turtle

Pits dug by nesting green turtles were divided into three categories according to age. Those that were eroded, partially infilled and invaded by vegetation were estimated as being older than 6 months, those with vegetation starting to invade and with surfaces smoothed to stable gradients were classed as 1-6 months old and those uninvaded by vegetation and with unstable surfaces were considered recent. Groups of pits of similar age were taken to be the result of one visit by a female. On this basis the traces of 48 visits over the past six months remained evident in mid-June 1979 and 5 more landings, probably the efforts of 2 females, took place between 14 and 24 June. Allowing for 4 landings per female in which pits were excavated deep enough to remain evident during our visit, a conservative estimate of 13 females using Desnoeufs over the first half of 1979 is obtained. Peak nesting probably takes place from May-September but laying also occurs at other times of year (Frazier 1976) and simple doubling of the estimate for the first six months gives an extremely rough estimate of an annual breeding population of 26 females. However, no recent pits were found in July 1980 and there were very few pits in the 1-6 months age class, suggesting that the number of breeding animals can vary considerably from year to year.

Three sandy beaches lacking rock barriers or unnegotiable sand cliffs are present in June/July of which the longest is in the north (c.350 m) where the camp is situated. The remaining two are pocket beaches of 40 and 50 m length in the south east but one is steeply sloping and shingly with no evidence of nesting. However, the distribution of traces of breeding attempts does indicate that sand movements, by obliterating obstacles, allow nesting at some time or another over c.1150 m of shoreline including extensions of the three beaches mentioned above and two additional pocket beaches in the south west. Such sand movements are usually associated with the change in direction of the prevailing wind from the south-east trades to the north-west monsoon and this evidence supports the suggestion of prolonged and probable year-round breeding.

Eretmochelys imbricata Hawksbill Turtle

A turtle seen immediately offshore in 1979 was tentatively identified as this species.

Birds

Puffinus l'herminieri Audubon's Shearwater

A small number were regularly seen at night in the coconut grove where burrows were made by clearing natural holes in the sandstone of soil and debris. No more than 5 birds were noted on any one night in 1979 and 3 in 1980.

Puffinus pacificus Wedge-tailed Shearwater

Several thousand pairs used the island at night in June 1979 and July 1980. Burrows were distributed around the entire perimeter of the island but were densest in the deeper sandy soils on the north east and south west coasts. Any natural or man-made break in the phosphatic sandstone further inland was also exploited and it is possible that the population approaches the maximum the island can support. Breeding is said to occur from November to February whilst June and July is a period of burrow excavation and pairing. Remarkably, the birds may be seen on the ground in the open throughout the day although numbers increase from mid-afternoon onwards.

Sula dactylatra Masked Booby

There are two colonies on the island, one inland in the south western quadrant and a smaller colony in the dunes of the south west coast. 18 nests were found in June 1979 with a maximum count of 45 birds whilst 8 nests and a maximum of 31 birds were noted in July 1980.

On 14 June 1979 the dune colony consisted of 5 nests each with 2 eggs and the inland colony contained 9 nests, one with a clutch of

3 eggs and the remainder with 2. By 18 June the dune colony had increased by 1 nest and the inland colony by 3. A number of eggs hatched in the inland colony on 17 and 18 June by which time it consisted of 6 nests with 2 eggs, 4 with 1 egg and 1 chick, 1 with 2 eggs and 1 chick and 1 with a single chick. On 24 June 1980 the inland colony consisted of 6 nests of which 1 contained 1 egg, 2 contained 2 eggs, 1 held 1 egg and 1 chick, 1 held 2 chicks and 1 contained a single large downy chick (Van Swelm pers.comm.). On 27 July 3 nests were closely brooded and 3 contained single large downy chicks whilst the dune colony consisted of 2 nests of which one was closely brooded and the second contained a large chick.

A regurgitation was recovered from one chick, consisting of 2 semi-digested fish c.20 cm in length.

Sula leucogaster Brown Booby

The maximum number of brown boobies recorded in 1979 was 10, whilst that in 1980 was 8 although an immature bird not included in this count was seen on several occasions. Two nests were located in 1979 of which one contained an egg. A third nest was under construction and all three were within 25 m of one another. A large downy chick was present in July 1980. Loafing brown boobies frequented the vicinity of their nests, both masked booby colonies and a rocky headland on the south coast.

Sula sula Red footed Booby

An adult bird was noted in June 1979 and an immature in July 1980. Both birds roosted overnight in the *Hibiscus*.

Fregata spp. Frigate birds

Immature birds passed over the island each evening in both years and although only one roosting bird was seen in 1979, up to 15 regularly spent the night in the coconuts in July 1980. The species could not generally be determined but a male Greater Frigate (*Fregata minor*) was present in June 1980 (Van Swelm pers.comm) and two Lesser Frigates (*Fregata ariel*) were seen in July.

Bubulcus ibis Cattle Egret

Counts of roosting and foraging birds in 1979 gave a population estimate of 35 individuals and comparable numbers were present the following year. Approximately 20 disused nests were found in the *Hibiscus* in June 1979 and 21 pulli were found in June 1980 (Van Swelm pers.comm.). The birds forage over the entire island except the sea-shore and the contents of 26 pellets showed the prey to be primarily insects although 5 pellets also contained egg membranes and one included unidentified bones. Maggots have been recorded from the stomach of a Desnoeufs bird (Chong-Seng, pers.comm.) and an egret was seen taking a tern chick in July 1980. A small bounty is given for egrets because of their predatory habits and all 21 pulli were destroyed in 1980.

Pluvialis squatarola Grey Plover

Two birds were seen in 1979 and 5 in 1980. All were in non-breeding plumage and foraged exclusively on the shore.

Arenaria interpres Turnstone

Common, foraging on rocky shores and inland in small groups. 213 were counted in one roosting flock in 1979 and comparable numbers were present in 1980. Many birds bore bold facial patterning although none were in full breeding plumage. Turnstone preyed upon unattended sooty tern eggs and approached masked booby eggs if these were exposed after disturbance.

Calidris alba Sanderling

One bird was noted in 1979 and two in 1980. Sanderlings freely associated with turnstone, foraging inland as well as on the shore.

Calidris ferruginea Curlew Sandpiper

A single bird was recorded in 1980, accompanying turnstones and foraging inland.

Tringa nebularia Greenshank

Two birds were present in July 1980, foraging on the shore.

Limosa lapponica Bar-tailed Godwit

Two birds were noted in July 1980, foraging primarily inland but roosting with turnstones on the shore.

Numenius phaeopus Whimbrel

A single whimbrel was seen on the beach on 27 July 1980.

Gallus gallus Feral chicken

Frequently seen in the vicinity of the coconut grove and *Hibiscus*. Chickens were taken sparingly in 1979 but jealously guarded in 1980 although they were suspected of predating seabird eggs.

Thalasseus bergii Crested Tern

Three subadults and one adult were present in June 1979 while 6 were noted in June 1980 (Van Swelm, pers.comm.). Eight subadults were noted on 23 July but numbers rose rapidly thereafter and 28 birds of all ages were seen at the end of the month. The Crested Terns generally foraged in the surf line but also took tern chicks. In both years juveniles were seen unsuccessfully begging from adult birds.

Sterna fuscata Sooty Tern

The massive sooty tern colony is the most remarkable feature of Desnoeufs. Estimates of numbers were derived from egg counts along transects in the reserve and from the daily egg collection over the remainder of the island. The method is described in detail elsewhere (Wilson and Chong-Seng 1979), the only difference between years being that the counts were made in the reserve at the time of peak breeding activity in 1980 but 15 days beforehand in 1979. The 1980 estimate of peak attendance was 769,000 pairs on 11-13 July whilst that for 1979 was 1,195,000 pairs on 3 July. This latter figure relied upon a projection from counts in mid-June and assumed a maximum laying density of 5 nests/sq m throughout the *Stenotaphrum*-free part of the reserve, but, although maximum densities of 4.5 nests/sq m were reached in 1980, the average over the whole reserve was only 2.4 nests/sq m. The number reported at the close of the 1979 season was therefore probably an over-estimate and the actual figure is better taken as lying between 844,800 and 1,195,000 pairs.

The estimates are of the maximum number of breeding pairs based on the island at any one time and are not measures of the total number of pairs which used the island during the entire breeding season. Such an estimate would be complicated by inter-colony movement of breeding birds and was not attempted.

Squid and flying fish up to 12 cm body length, small shrimp-like crustaceans and siphonophores (?*Porpita* sp.) were found amonst the Sooty Tern colony and were assumed to be food items.

The Sooty Terns did not lay on the dunes where Wedge-tailed Shearwaters were common although they were present up to the beach crest on hard substrates. Numbers were generally low in areas dominated by *Stachytarpheta* and *Cyperus ligularis* and no laying took place under the coconut grove. Large numbers of eggs were lost in July 1980 when shallow pools formed after heavy rain. Once these pools dried out the open areas were swiftly recolonised.

Sterna anaethetus Bridled Tern

Two pairs of breeding bridled terns were located in the cropped part of the island in 1980. Both had lain beneath cairns.

Anous stolidus Common Noddy

Common noddies bred throughout the island in both years, forming small colonies in rocky areas around the perimeter of the island and, further inland, on cairns, boulder piles, heaps of herbage uprooted by the egg collectors and in coconut crowns. Noddy nests were counted at the same time as those of the sooty terns and 8400 breeding pairs were estimated in the reserve in July 1980. Assuming the same density throughout the island the breeding population is in the region of 20,000 pairs. One chick was found in mid-June 1979, suggesting laying had begin in mid-May. Eggs and chicks were present in July 1980 but the ages of the oldest chicks indicated onset of laying at the beginning of June.

Anous tenuirostris Lesser Noddy

Single birds roosted in the coconuts on the nights of 18 June 1979 and 22 July 1980.

Gygis alba White Tern

Two birds were seen offshore on 24 July 1980 and a single bird flew over the island on 26 July.

Foudia madagascariensis Madagascar Fody

A small flock frequented the coconut grove and mixed herb community behind settlement with maximum counts of 6 birds in 1979 and 16 in 1980.

Mammals

Mus sp. (?*musculus*) House Mouse

Mice were common in the camp and consumed eggs held for shipment but their distribution over the island as a whole was not ascertained.

Oryctolagus cuniculus Rabbit

Rabbits were released on Desnoeufs prior to 1900 (Percy and Ridley 1958) and were common in 1979/1980 ranging over the whole island although most frequently around the coconut grove from which they emerged to forage at dusk. At least 20 were taken for food in 1979 and probably more in 1980.

Tursiops spp Dolphins

Schools of dolphins up to 75 strong were commonly sighted offshore. Bottle-nosed dolphins (*Tursiops truncatus*) were definitely present but a second species, smaller and more greyish with a proportionately more slender bill and narrow dorsal fin, was also common and may have been predominant in some groups.

Land use

Desnoeufs is government owned but given out on a single lease with Marie-Louise. It has been held by a succession of private individuals and companies and has been most recently taken over, in 1981, by the Island Development Company.

Guano

The island was first sighted in 1771 by the Du Roslan expedition but remained uninhabited until it was permanently settled for the exploitation of guano towards the end of the 19th century (Percy and Ridley 1958). This activity ceased around 1910 although the deposits are the largest remaining in Seychelles (Baker 1963). Small shipments of several tons each are still occasionally taken to Marie-Louise for agricultural purposes.

Agriculture

In the first decade of the 20th century Marie-Louise had two lessees of which one developed the agricultural potential of the island in the wake of the guano exploitation (Wilson in prep.) and it is probable that the same system was applied to Desnoeufs although with less success. About 30 coconuts had been planted in 1900 (Ridley and Percy 1958) and rows of pits bear evidence of considerable effort to create a coconut plantation over the entire island whilst the deep wells, substantial turtle pond and remains of paved cart-tracks probably also date from this period. About 300 pigs were free-ranged between 1900 and 1910, subsisting on herbage and eggs, and pigs have occasionally been released outside the birds-egg season since then but not as common practice (O. Souris, pers.comm.). The coconuts are not considered worth collecting but tobacco is sometimes grown over the north-west monsoon and is said to be very successful. Chickens and rabbits are primarily taken for use by Marie-Louise inhabitants but are also shipped to the granitic islands in small numbers.

Seabirds

The seasonal seabird egg collection, taking place between mid-May and early August, is the major commercial activity on the island. This operation has been described elsewhere (Percy and Ridley 1958, Feare 1976) and continues on the same lines with three recent modifications; the close season has been discontinued in favour of establishment of the 16.6 ha reserve, the crates (used as a basic measure of the annual crop) have been reduced in size to take 400 rather than 750 eggs and Department of Agriculture staff monitor the collection on the island each year. 1,037,600 eggs left Desnoeufs in 1979 and 723,700 in 1980, both figures including ca 10% sent as gifts by the lessee or labourers and not reaching the open market but excluding the consumption on the island itself, estimated to be one crate per day.

Shearwater chicks are cropped annually during February and early March and around 2000, said to be half the total number available, are taken each year for shipment to the granitic Seychelles. It is strongly suspected that both frigates and noddies are taken for food from time to time.

Turtles

Green turtles are captured whenever the opportunity presents itself. Although some animals may have been exported from Desnoeufs in the past all are now consumed on the island. Desnoeufs is generally deserted during the north-west monsoon when breeding hawksbills might be expected.

Discussion

Ecology

Both Marie-Louise and Desnoeufs were described by the Du Roslan expedition in 1771 as being well-wooded and it would be remarkable if these two neighbouring islands of similar geology and comparable size were markedly different in ecology in their pristine condition, although Desnoeufs could have harboured ground-nesting seabirds on its coasts or in clearings inland. The differences today between bleak, open Desnoeufs and Marie-Louise with its overgrown coconut plantations and *Scaevola* thickets must therefore be primarily due to a difference in land-use practice. Certainly the known history of human activity on Desnoeufs and the fact that 40% of its flora is introduced, including the dominant *Stachytarpheta*, suggests profound modification despite the assertion that it is the "the only example of a virtually untouched island in the [Amirantes] group" (Piggott 1963).

It is most probable that the early management of Desnoeufs and Marie-Louise was run on identical lines. At the turn of the century birds' eggs were not an important article of commerce, as the free-ranging of pigs to feed on eggs suggests, and both islands were exploited for guano before being planted up with young coconuts. The difference between the two must have its source here, for the Marie-Louise plantation was successful whilst that on Desnoeufs was not. The likely explanation is that stripping of the vegetation to exploit the guano included, on Desnoeufs, the destruction of the coastal shelter thus allowing salt-laden wind to severely retard regeneration of woody vegetation over the entire island. The open space thus formed would favour expansion of any existing sooty tern colony, creating conditions even less suitable for regeneration and the open vegetation type would be perpetuated after the establishment of birds egg cropping by the practice of annual extensive clearance of ground cover to promote mamximum nesting density in the colony. Thus the predominance of ground-nesting seabirds is itself an artifact, having replaced a largely arboreal breeding avifauna. Under any circumstances Desnoeufs stands as an example of the extreme and often unexpected alteration which can be imposed upon an island ecosystem in a relatively short time-span, in this case around a century, by human management.

The records of the natural history of Desnoeufs collected by Percy and Ridley (1958) and continued by subsequent visitors also gives indication of the turnover of species which is to be expected on the island. It is known that *Cassytha filiformis* had been lost and *Stachytarpheta* established in the early part of the 20th century. *Carica, Tribulus* and *Ipomoea macrantha* were all recorded in 1979 but not the following year whilst *Nicotina* made a perhaps temporary appearance and the marked increase in *Passiflora* may signify expansion of a recent coloniser. Among the birds, Green-backed Heron (*Butorides striatus*) and Lesser Noddy bred in 1955 (Percy and Ridley 1958) but not 1979/80 although the Lesser Noddy still roosts. Crab Plover (*Dromas ardeola*), Great Sand Plover (*Charadrius leschenaultii*) and Mascarene Martin (*Phedina borbonica*) may also be added to the bird list as migrants or vagrants.

Percy and Ridley (1958) remarked upon the crickets in their tent yet made no mention of mice; any comment now on nocturnal nuisances would not make this omission, suggesting the mice too are recent colonists as may be the second gecko species. A continual flux in species composition of the island biota is evident.

Conservation

The conservation value of Desnoeufs lies entirely in its seabirds. The Sooty Tern colony is one of the largest in the world whilst, although their breeding populations are not the most substantial in the Seychelles, the boobies are of note in view of their general decline in the region (Feare 1978). Most importantly, the management of Desnoeufs is directed towards maintenance of its wildlife for economic gain in a durable system coordinating commerce and conservation and, whatever feelings one may hold regarding the trade in birds' eggs, there is no doubt that the disparate interests marshalled behind maintaining the productivity of the Sooty Tern colony act in the general favour of wildlife conservation both on Desnoeufs and, by example and association, elsewhere in Seychelles.

The main means by which conservation is effected is through the establishment of the 16.6 ha reserve in partial response to the most recent recommendations on the management of the egg collection (Feare 1976). The breeding seabirds in the reserve, which include the boobies, remain totally unmolested whilst all eggs laid in the remaining 23.1 ha of the island are taken for as long as it is profitable to do so and at least two Ministry of Agriculture staff are present on the island throughout the collection to ensure the reserve is not violated, to monitor the egg crop and to gather the information from which annual breeding populations may be calculated.

By and large this system works well and the reserve is respected, for although the two wardens may have difficulty in asserting authority when living in isolation with up to 30 egg collectors, the purpose of the reserve in maintaining egg production is generally understood. Potential for problems arise more where the need for control is less well appreciated and the degree of protection which can be afforded to female green turtles and to noddy terns is limited, particularly when the condition of the landing prevents fishing to vary the egg dominated diet of the island workers. However, with noddies at least it is highly unlikely that the limited depredations which take place have an appreciable effect on overall numbers.

These shortcomings apart, the conservation management of the island during the cropping season is fair given the circumstances under which it operates and its essential feature is that it works. The Sooty Tern population has been consistently estimated at between 1.2 and 1.75 million pairs over the past 25 years (Feare 1976, Percy and Ridley 1958, 1966, Procter 1970) with peak laying in June. The 1979 and 1980 seasons were both late and poorly attended, regular occurrences which, taken in conjunction with possible differences in counting technique between observers, do not allow the low census results of these latter years to be taken as evidence of overcropping.

The landing beach is unusable from late August until the north west monsoon has set in and over this period the island provides totally safe conditions for boobies to rear chicks and for turtles to breed. From mid-October to late May however, the island is unwardened and accessible to boats fishing in the area or from Marie-Louise. Given the traffic in the Amirantes it is quite possible that such visits are frequent although individually of short duration and, in the absence of permanent occupation, the beaches should still provide relatively safe breeding for the small number of turtles that frequent them, thus assisting in maintaining the eagerly sought-after turtle population among the islands. The boobies are more at risk. In 1955 Desnoeufs supportes some 20 Brown Boobies and, between 1955 and 1965, 100-450 pairs of Masked Booby, yet by 1974 only 4 Brown and 21 Masked Booby pairs bred, reduced further in 1976 to 3 Brown and 17 Masked Booby nests (Feare 1978). The observations presented here suggest that the rate of decline, attributed to human predation, is slowing but reports of destruction of boobies continue with both visits by fishermen and oil pollution being blamed. Permanent wardening is not feasible and control over such activity impossible to exert unless there is a fundamental change in attitude towards these birds. Until such time as this might be effected, the only boobies likely to reared successfully on Desnoeufs are those hatched and fledged between May and October, making the recovery of the island population unlikely.

Of other species, the Wedge-tailed Shearwater population appears to be maintaining its numbers and descriptions by Percy and Ridley for 1955 and 1966 apply equally well today despite their recommendation to increase cropping (Percy and Ridley 1966). The Cattle Egrets also seem capable of withstanding the intense persecution recommended by Percy and Ridley and carried out by successive island managers.

The pattern of human activity on Desnoeufs is now well established in a generally satisfactory manner and, whilst further refinement of both wildlife conservation and of the birds' egg trade is desirable and expected, the future management of the island is likely to continue on the same lines as long as care is taken not to increase the crop beyond the sustainable yield of the tern population and that the commerce is maintained.

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12. SPATIAL AND TEMPORAL VARIABILITY OF RAINFALL ON ALDABRA ATOLL

by D. R. Stoddart

Introduction

In spite of the existence of substantial amounts of information on atoll climates in both the Indian and Pacific Oceans, remarkably little attention has been paid to the possible existence of climatic variations within individual atolls. There is a presumption that because of pervasive marine influences, small area, and negligible elevation above the sea, atoll land areas have a sufficiently homogeneous climatic regime (neglecting the effect of different vegetation types on micro-climate) that a single recording station will give an adequate characterisation of atoll-wide conditions. Three observations at least raise doubts about this proposition. One is the generally recognised distinctiveness of windward and leeward situations on atolls in the Trade Wind belts. A second is the sharply limited incidence of individual rainfall events, often generated by single cumulus clouds of smaller-than-atoll size, especially in equatorial regions. A third, known for centuries, is the coincidence of cumulus development with atoll locations.

Rainfall variability on atolls

A study of intra-atoll rainfall variability was made at Enewetak Atoll, Marshall Islands, in 1957-58. The raw data were published by Blumenstock and Rex (1960) but no analysis appeared. The daily observations show wide variability between stations (e.g. 5.28 mm on 13 November 1957 at Enewetak Island compared with 0.06 mm on Engebi Island 38 km away), with some individual monthly totals varying between stations by a factor of up to 2. Nevertheless, over a 5 month period (December 1957-April 1958) the total rainfall at three stations (Enewetak Island, Parry Island, Engebi Island) varied by less than 5 per cent. and over an 11 month period (September 1957-August 1958) total

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rainfall at two of the stations (Enewetak Island and Parry Island, 9 km apart) varied by only 6 per cent.

Longer-term records are available for two stations 5.5 km apart on the western rim of Canton Atoll, Phoenix Islands, for which monthly and annual rainfall data are available for the 16 years 1948-1962 and 1966. Individual monthly totals frequently differ between the two stations by more than 40 per cent (maximum 71 per cent). Few annual totals differ by more than 20 per cent, however, and the annual means for the 16 years of record differ by only 5.5 per cent. Overall there is a correlation greater than 0.9 between all pairs of both monthly and annual records.

Rainfall on Aldabra Atoll

Aldabra Atoll (46°20'E, 9°24'S) is located in the dry southwestern sector of the tropical Indian Ocean (Stoddart 1971). It is a slightly elevated atoll, with a land area of 155 sq km, enclosing a lagoon of similar area, with a limestone rim that reaches a maximum altitude of 8 m and with coastal dunes reaching 15 m above sea level. In consequence of a high tidal range, large areas of the lagoon floor are emersed during low spring tides. The atoll is affected by strong and persistent Southeast Trade winds between April and November, and by weaker and less constant Northwest Monsoon winds for the rest of the year. For all these reasons it might be expected that if climatic differences were to be found on land areas of atolls, they would be exhibited on Aldabra.

A Meteorological Station was established at the Settlement on Ile Picard, on the western side of the atoll, in September 1967. It was subsequently relocated at the Royal Society Aldabra Research Station, 1 km to the south, in 1970. Initially a single daily synoptic observation was made at 0900 hours (GMT +3), but in January 1975 the Station was upgraded to World Weather Watch standards, jointly staffed by the U.K. Meteorological Office, Bracknell, England, and the Royal Society. Three-hourly synoptic observations and daily rainfall records are available from this date. Before 1967 rainfall had been measured at the Settlement by the atoll manager between June 1949 and June 1953 (only one complete year of record: 1192 mm in 1950), and again in 1958 and 1959 (very low figures of 381 and 349 mm). These earlier monthly data are listed by Stoddart and Mole (1977), but because of their dubious reliability they are not considered further here.

Table 1 lists the monthly and annual rainfalls at the Meteorological Station for the 15 years 1968-1982. The mean annual total is 1089 mm, with a minimum of 547 and a maximum of 1467 mm. The scatter diagram of monthly rainfalls in Figure 13 shows the great variability of rainfall at a single site from year to year, and the annual histograms in Figure 14 show the variability in seasonal incidence from year to year. Though the Aldabra record is too short for analysis, it seems likely that the annual totals show substantial cyclical fluctuations from decade to decade, as identified for the granitic Seychelles

(Stoddart and Walsh 1979). There high rainfalls occurred before 1905, between 1923 and 1937, and since 1959, with markedly lower rainfalls during 1905-1922 and 1938-58. The changes are of the order of 500 mm, or 20 per cent, between each period, and all are statistically significant at the 99 per cent confidence level.

Local rainfall variability on Aldabra

Since active research began on Aldabra there has been speculation about the possibility of systematic climatic differences existing between different parts of the atoll. Farrow (1971, 85) discussed these, and provided daily rainfall data for the period 24 September-17 October 1968 at the Meteorological Station and at Passe Houareau (Middle Camp). These indicated day-to-day variability comparable to that already described at Enewetak, though totals were similar over the period of record. Subsequently J. Frazier maintained rainfall records for a total of 221 days between June 1969 and June 1970 at Dune Jean-Louis on the south coast. The total rainfall at the Meteorological Station over this period was 70.5 per cent of that recorded at Dune Jean-Louis, and the number of rain-days 69.5 per cent. Correlation of daily rainfall totals between the two stations was only 0.35, though the mean rainfall per rain-day was very similar. Rain at that period thus fell on more days on the windward than on the leeward coasts (Stoddart and Mole 1977, Table 15).

A systematic effort to study local rainfall variability on Aldabra began in 1973. Between April 1973 and November 1977 thirteen recording stations were established at sites around the atoll (Table 2, Figure 15). They consisted of a plastic 1-gallon container, firmly anchored in soil or rock, with a plastic receiving cylinder. At Middle Camp, however, a standard metal Bradford gauge was installed from the beginning, and similar gauges supplied by the U.K. Meteorological Office replaced the plastic containers at all other sites during 1976-77. To minimise evaporation a small quantity of oil was placed in the gauge to form a film on the water surface; the initial use of coconut oil for this purpose was discontinued because of its attraction to coconut crabs *Birgus latro*. The plastic gauges had to be frequently replaced in the early days on account of being chewed by coconut crabs or deteriorating in sunlight. Ants and rats proved troublesome at some sites. On one occasion the date of a reading was lost when the data card was chewed by a goat.

The gauges were emptied and contents recorded whenever field workers visited the sites. Heavily-used camp sites such as Middle Camp and Cinq Cases thus generated large numbers of closely-spaced records (252 and 161 respectively, with mean time intervals of 12.7 and 19.5 days), but other more remote sites were visited less frequently. On some occasions the capacity of the gauge was less than the amount of rainfall between readings and the gauge overflowed; to some extent, therefore, the data will under-estimate actual rainfall. The frequency of recording declined during 1980-81, and records ceased to be maintained during December 1981-January 1982.

In addition to the main sites a further gauge was installed for a short period adjacent to the main Meteorological Station, to provide a check on the reliability of the method. This site is identified as Station.

The data available thus comprise a series of readings at irregular, variable and non-synchronous times. They were compiled onto standard record cards on site, periodically transcribed at the Aldabra Research Station, and one set of cards returned to London with a duplicate set maintained on the atoll; two cards were lost in this process. A preliminary analysis of records for eight of the sites for periods up to February 1975 has been given by Hnatiuk (1979, 32).

For each station the data of both date of observation and rainfall were then tabulated in cumulative form from an arbitrary origin on 1 January 1973. For stations with gaps in the record new cumulations were started when the record was resumed. Daily cumulative values for each station for the period of record were then generated using a program(INTERPOL),by linear interpolation between each successive pair of records. The interpolated cumulative totals corresponding to the last day of each month for the period of record were used to derive rainfall totals for all months. These were summed to give annual figures. While these calculated monthly totals cannot obviously be equal to actual monthly rainfalls because of the infrequency of the original observations, they do nevertheless provide a basis for comparison both between stations at any time and between months at any station.

Results

Calculated annual totals for all local stations, together with actual annual records at the Meteorological Station, are given in Table 3 and Figure 16. These show substantial differences between successive years at each locality, and also between different sites in the same year. That the temporal variablity is real is indicated by the fact that over the period of this study the annual totals at the Meteorological Station itself varied from 826 to 1467 mm. The differences in annual means between sites is of the same order (minimum of 1098 mm at Middle Camp and maximum of 1567 mm at Anse Var). The level of annual variability is detailed in Table 4 (percentage difference between annual totals at each station and the mean at that station), Table 5 (percentage difference between annual totals at each station and the total for that year at the Meteorological Station), and Table 6 (percentage difference between annual totals at each station and the 15-year mean [1089 mm] at the Meteorological Station). Inspection of these tables shows that the level and distribution of percentage variability in time is very similar to that for variability in space. Tables 7-20 give the interpolated monthly figures and annual totals for each of the sites, together with means based on data for completed calendar years of record. Figure 17 gives histograms of mean monthly rainfall at each station.

These data clearly demonstrate the variability of rainfall in both space and time, as revealed by a monthly sampling interval, thus confirming the earlier inferences from the Enewetak and Canton data. The spatial dimension of rainfall events is thus smaller than the atoll dimension, and the occurrence of rainfall across the atoll is in general non-synchronised. These generalisations will not, however, necessarily hold when the atoll is affected by large-scale regional disturbances such as cyclones.

It is of particular interest to ascertain whether over longer time-scales the average conditions vary systematically with location. Inspection of the data suggest that they do. If we group together the stations on the northwest side of the atoll (Anse Mais, Bassin Lebine, Anse Var, Polymnie and Gionnet, with 31 individual annual totals altogether) the mean of all annual totals is 1340 mm. That for the south coast stations (Cinq Cases, Anse Takamaka, Dune Jean-Louis, Dune d'Messe, with 24 annual totals) is 1203 mm. That for the northeastern area (Anse Malabar, Middle Camp: 13 annual totals) is 1137 mm. The mean of all annual totals for all stations (92) is 1228 mm.

Conclusion

Whether these regional differences would be sustained by longer-term records is an open question, but as they stand at present they point to interesting geomorphological and ecological consequences. In his study of a long series of hourly observations, June 1949 to February 1959, at Enewetak Atoll, Lavoie (1963, iv) concluded that 'the atoll influence upon cloud or precipitation over the atoll itself is hardly detectable and probably insignificant'. However he did not have available rainfall data (other than occurrence or non-occurrence) for quantitative analysis. If Lavoie's conclusion can be taken to imply spatial heterogeneity of rainfall over the ocean irrespective of the presence of an atoll, then it is compatible with the Aldabra data. If, however, it is interpreted to mean that the atoll itself has a homogeneous rainfall environment at least up to time-scales of a decade and spatial scales of 30-40 km, then as a generalization it needs re-examination. It would be of great interest to examine rainfall characteristics on other atolls with large compact land masses (e.g. Christmas Island, Pacific Ocean) as well as those with small and scattered islets. Without the benefit of an active research programme, however, as on Aldabra, such a study could only feasibly be carried out using automatic recording equipment.

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Table 1. Monthly and annual rainfall at Aldabra 1968-1982

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1968	11.9	28.0	133.0	72.4	21.0	38.0	69.5	14.8	9.7	7.3	56.5	85.0	547.1
1969	153.4	147.2	151.5	393.5	176.3	36.8	38.7	14.3	18.5	11.8	54.9	56.8	1253.7
1970	47.5	85.2	139.6	210.5	31.7	29.5	33.7	25.7	7.3	20.9	12.7	56.0	700.3
1971	244.5	57.4	285.9	192.5	34.7	65.9	14.3	19.1	8.6	6.0	89.6	201.8	1220.3
1972	224.5	15.0	112.2	162.2	28.2	100.3	54.6	75.1	4.2	12.7	25.6	240.2	1054.8
1973	261.0	286.8	262.8	56.7	57.1	47.7	81.3	25.2	21.8	33.7	9.2	77.6	1220.9
1974	290.6	114.5	380.8	346.4	50.4	29.4	52.2	31.8	1.9	1.1	19.4	148.9	1467.4
1975	131.4	162.8	111.1	166.7	76.7	41.4	16.1	14.9	14.5	2.9	91.7	136.2	965.8
1976	358.4	177.4	260.9	87.2	66.6	64.4	65.5	35.1	4.7	0	16.7	104.4	1241.3
1977	262.4	116.3	255.7	240.8	132.3	89.5	82.2	26.9	5.0	37.0	63.5	120.8	1432.4
1978	254.0	139.2	339.0	18.0	54.8	48.1	135.4	23.2	8.7	16.9	191.6	234.4	1463.3
1979	233.6	108.6	105.2	67.8	116.8	51.4	61.4	32.6	19.4	0.1	52.3	278.5	1127.7
1980	82.1	151.9	120.8	184.9	19.1	66.1	16.6	40.0	10.0	1.6	9.5	123.1	825.7
1981	143.5	52.9	238.1	17.8	94.5	26.2	22.1	24.3	12.1	8.6	10.8	339.6	990.5
1982	83.0	43.0	125.0	130.0	73.0	103.0	12.9	17.2	40.9	47.5	110.4	34.6	820.5
Mean	185.5	112.4	201.4	156.5	68.9	55.8	50.4	28.0	12.5	13.9	54.3	149.2	1088.8

Table 2. Local rainfall stations at Aldabra Atoll

Locality	Grid reference	Gauge installed[1]	Final record
Station	050 090	13 February 1975 (10 March 1977)	3 December 1981
Bassin Lebine	067 100	9 November 1976 (15 April 1977)	26 December 1981
Anse Var	070 100	18 August 1976 (11 May 1977)	28 December 1981
Polymnie	106 126	9 November 1973 (1 June 1977)	29 December 1981
Gionnet	139 125	15 April 1974 (9 February 1977)	29 December 1981
Anse Malabar	253 128	21 April 1974 (23 September 1977)	14 January 1982
Middle Camp	314 119	5 April 1973 (5 April 1973)	13 January 1982
Airstrip Trace	374 083	16 November 1977 (16 November 1977)	12 January 1982
Cinq Cases	398 058	1 June 1973 (3 August 1977)	11 January 1982
Anse Takamaka	346 035	28 February 1974	17 December 1977
Dune Jean-Louis	260 035	30 June 1973 (23 March 1977)	27 January 1982
Dune d'Messe	189 013	29 April 1973 (16 September 1977)	27 January 1982
Anse Mais	069 043	3 July 1973 (17 September 1976)	11 December 1981
Ile Esprit	105 061	27 June 1976 (31 August 1977)	29 December 1981

[1]Date in parentheses is that of the installation of a standard Bradford gauge.

Table 3. Annual rainfall at different localities at Aldabra Atoll 1974-1982

Locality	1974	1975	1976	1977	1978	1979	1980	1981	No. of years	Mean
Meteorological Station	1467	966	1241	1432	1463	1128	826	991	8[1]	1189
Station	-	-	-	-	-	1125	777	-	2	951
Bassin Lebine	-	-	-	1877	1682	1367	1047	978	5	1390
Anse Var	-	-	-	1538	2070	1411	1250	-	4	1567
Polymnie	1908	1443	1635	906	1439	1355	1000	919	8	1326
Gionnet	-	1338	2208	1656	1371	1418	1036	1107	8	1448
Anse Malabar	-	-	1217	-	1552	1129	1179	917	5	1199
Middle Camp	1235	1150	1201	921	1541	989	1070	679	8	1098
Airstrip Trace	-	-	-	-	1593	1092	1180	913	4	1195
Cinq Cases	1332	1690	1217	1355	1308	1085	1065	792	8	1231
Anse Takamaka	-	1442	1241	-	-	-	-	-	2	1342
Dune Jean-Louis	990	1029	-	1469	1443	997	1084	863	7	1125
Dune d'Messe	-	852	1129	2391	1398	947	900	855	7	1210
Anse Mais	-	1106	1416	2073	1401	1064	1033	-	6	1349
Ile Esprit	-	-	-	1196	1564	1029	955	960	6	1141
Number of stations[2]	4	8	8	10	12	12	11	10		
Mean[2]	1366	1256	1408	1538	1530	1145	1070	898		1284

[1] Total length of record 15 years and overall mean 1089 mm.

[2] Excluding Meteorological Station.

Table 4. Percentage difference between annual rainfall at each station and the mean annual rainfall at that station

Locality	1974	1975	1976	1977	1978	1979	1980	1981
Station	-	-	-	-	-	+18.3	-18.3	-
Anse Var	-	-	-	-1.9	+32.1	-10.0	-20.2	-
Polymnie	+43.9	+8.8	+23.3	-31.7	+8.5	+2.2	-24.6	-30.7
Gionnet	-	-7.6	+52.5	+14.4	-5.3	-2.1	-28.4	-23.5
Anse Malabar	-	-	+1.5	-	+29.4	+5.8	-1.7	-23.5
Middle Camp	+12.5	+4.7	+9.4	-16.1	+40.3	-9.9	-2.6	-38.2
Airstrip Trace	-	-	-	-	+33.3	-8.6	-1.3	-23.6
Cinq Cases	+8.2	+37.3	-1.1	+10.1	+6.3	-11.9	-13.5	-35.7
Anse Takamaka	-	+7.5	-7.5	-	-	-	-	-
Dune Jean-Louis	-12.0	-8.5	-	+30.6	+28.3	-11.4	-3.6	-23.3
Dune d'Messe	-	-29.6	-6.7	+97.6	+15.5	-21.7	-25.6	-29.3
Anse Mais	-	-18.0	+5.0	+53.7	+3.9	-21.1	-23.4	-23.4
Ile Esprit	-	-	-	+4.8	+37.1	-9.8	-16.3	-15.9

Table 5. Percentage difference between individual local and Meteorological Station rainfalls for each year

Locality	1974	1975	1976	1977	1978	1979	1980	1981
Station	-	-	-	-	-	-0.3	-5.9	-
Anse Var	-	-	-	+7.4	+41.5	+25.1	+51.3	-
Polymnie	+30.1	+49.4	+31.7	-36.7	-1.6	+20.1	+21.1	-7.3
Gionnet	-	+38.5	+77.9	+15.6	-6.3	+25.7	+25.4	+11.7
Anse Malabar	-	-	-1.9	-	+6.1	+0.1	+42.7	-7.5
Middle Camp	-15.8	+19.0	-3.2	-35.7	+5.3	-12.3	+29.5	-31.5
Airstrip Trace	-	-	-	-	+8.9	-3.2	+42.9	-7.9
Cinq Cases	-9.2	+74.9	-1.9	-5.4	-10.6	-3.8	+28.9	-20.1
Anse Takamaka	-	+49.3	0	-	-	-	-	-
Dune Jean-Louis	-32.5	+6.5	-	+2.6	-1.4	-11.6	+31.2	-12.9
Dune d'Messe	-	-11.8	-9.0	+67.0	-4.4	-16.0	+9.0	-13.7
Anse Mais	-	+14.5	+14.1	+44.8	-4.2	-5.7	+25.1	-
Ile Esprit	-	-	-	-16.5	+6.9	-8.8	+15.6	-3.1

Table 6. Percentage difference between the annual rainfall at each locality and the 15-year mean annual rainfall at the Meteorological Station

Locality	1974	1975	1976	1977	1978	1979	1980	1981
Meteorological Station	+34.7	-11.3	+14.0	+31.5	+34.3	+3.6	-24.2	-9.0
Station	-	-	-	-	-	+3.3	-28.7	-
Bassin Lebine	-	-	-	+73.4	+54.5	+25.5	-3.8	-10.2
Anse Var	-	-	-	+41.2	+90.1	+29.6	+14.8	-
Polymnie	+75.2	+32.5	+50.1	-16.8	+32.1	+24.4	-8.2	-15.6
Gionnet	-	+22.9	+102.8	+52.1	+25.9	+30.2	-4.9	+1.7
Anse Malabar	-	-	+11.8	-	+42.5	+3.7	+8.3	-15.8
Middle Camp	+13.4	+5.6	+10.3	-15.4	+41.5	-9.2	-1.7	-37.6
Airstrip Trace	-	-	-	-	+46.3	+0.3	+8.4	-16.2
Cinq Cases	+22.3	+55.2	+11.8	+24.4	+20.1	-0.4	-2.2	-27.3
Anse Takamaka	-	+32.4	+14.0	-	-	-	-	-
Dune Jean-Louis	-9.1	-5.5	-	+34.9	+32.5	-8.4	-0.5	-20.8
Dune d'Messe	-	-21.8	+3.7	+119.6	+28.4	-13.0	-17.4	-21.5
Anse Mais	-	+1.6	+30.0	+90.4	+28.7	-2.3	-5.1	-
Ile Esprit	-	-	-	+9.8	+43.6	-5.5	-12.3	-11.8

Table 7. Monthly rainfall at Station, Ile Picard

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1975	-	-	123	140	77	38	14	3	2	76	72	74	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	168	105	102	63	31	25	21	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	260	100	108	105	77	50	62	27	17	0	50	269	1125
1980	87	143	112	144	63	64	21	27	27	28	27	34	777
1981	130	56	185	158	91	57	26	13	13	1	9	-	-

Table 8. Monthly rainfall at Bassin Lebine, Ile Picard

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1976	-	-	-	-	-	-	-	-	-	-	-	182	-
1977	260	338	470	310	90	91	28	20	16	35	35	184	1877
1978	245	216	235	202	60	44	200	30	13	8	177	252	1682
1979	306	150	165	114	98	94	69	33	28	11	124	175	1367
1980	104	140	173	186	86	57	37	37	35	37	35	120	1047
1981	172	60	108	71	59	45	32	30	7	19	240	135	978
Mean[1]	217	181	230	177	79	66	73	30	20	22	122	173	1390

[1]Complete years only

Table 9. Monthly rainfall at Anse Var, Ile Picard

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1976	-	-	-	-	-	-	-	-	1	7	23	110	-
1977	154	384	198	155	134	111	57	24	7	9	98	207	1538
1978	766	114	449	30	45	74	180	28	6	3	211	164	2070
1979	350	122	311	103	85	54	49	30	21	1	93	192	1411
1980	66	314	314	129	94	73	56	56	33	43	41	31	1250
1981	21	19	21	21	21	25	15	0	0	34	23	282	482
Mean[1]	423	207	319	96	88	80	95	27	11	4	134	188	1673

[1]1977-1979; frequency of readings after May 1980 too low for records to be reliable

Table 10. Monthly rainfall at Polymnie, Ile Polymnie

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1973	-	-	-	-	-	-	-	-	-	-	-	110	-
1974	320	368	405	551	44	52	60	12	0	0	0	96	1908
1975	331	355	196	192	63	42	7	6	4	6	114	127	1443
1976	288	234	513	87	31	162	117	10	2	7	91	93	1635
1977	104	94	104	74	82	85	48	35	14	33	79	154	906
1978	183	120	442	39	43	69	195	15	2	8	93	230	1439
1979	388	183	164	123	101	82	53	34	18	19	142	48	1355
1980	102	88	138	217	111	38	39	39	24	3	70	131	1000
1981	155	140	73	114	82	74	41	25	28	33	15	289	919
Mean[1]	234	198	254	175	70	76	70	21	12	14	76	146	1326

[1]Complete years only

Table 11. Monthly rainfall at Gionnet, Ile Malabar

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1974	-	-	-	-	-	-	-	-	-	-	11	249	-
1975	445	319	144	150	66	48	17	4	2	5	33	105	1338
1976	286	263	841	193	32	167	188	14	12	13	21	178	2208
1977	333	119	124	111	110	143	246	123	8	50	121	168	1656
1978	131	145	417	25	63	59	141	43	15	9	93	230	1371
1979	325	226	152	137	94	75	77	49	16	15	98	154	1418
1980	86	77	145	206	87	55	51	32	18	19	122	138	1036
1981	174	162	74	115	104	87	27	32	19	20	41	252	1107
Mean[1]	254	187	271	134	79	91	107	42	13	19	76	175	1448

[1]Complete years only

Table 12. Monthly rainfall at Anse Malabar, Ile Malabar

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1975	-	-	124	94	78	36	8	8	5	3	49	88	-
1976	218	200	279	97	45	111	95	30	5	4	3	130	1217
1977	116	127	69	-	-	-	-	10	12	23	61	166	-
1978	154	131	439	62	165	151	94	35	13	11	182	115	1552
1979	219	180	171	43	143	55	56	51	34	14	40	123	1129
1980	126	110	122	258	156	37	38	38	37	38	49	170	1179
1981	170	72	69	66	69	66	26	46	16	128	93	96	917
Mean[1]	177	139	216	105	116	84	62	40	21	39	73	127	1199

[1]Complete years only

Table 13. Monthly rainfall at Middle Camp, Ile Malabar

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1973	-	-	-	-	13	15	40	44	16	4	25	121	-
1974	384	97	226	300	29	24	17	29	0	0	0	129	1235
1975	257	244	167	93	81	34	18	11	9	12	56	168	1150
1976	288	135	318	59	47	67	72	29	1	4	21	160	1201
1977	192	86	110	124	109	83	55	18	6	4	37	97	921
1978	265	294	335	109	54	25	118	14	2	0	151	174	1541
1979	207	139	165	52	93	30	36	30	47	4	57	129	989
1980	136	125	151	173	107	69	40	31	10	77	74	77	1070
1981	77	58	63	61	63	61	9	8	16	7	128	128	679
Mean[1]	226	147	192	121	73	49	46	21	11	14	66	133	1098

[1]Complete years only

Table 14. Monthly rainfall at Airstrip Trace, Grande Terre

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977	-	-	-	-	-	-	-	-	-	-	-	169	-
1978	353	171	341	51	132	65	125	29	11	22	165	128	1593
1979	302	135	143	47	114	50	52	45	15	5	33	151	1092
1980	177	156	168	162	101	80	42	37	36	37	54	130	1180
1981	130	74	72	70	72	70	58	24	14	148	89	92	913
Mean[1]	241	134	181	83	105	53	69	34	19	53	85	125	1195

[1]Complete years only

Table 15. Monthly rainfall at Cinq Cases, Grande Terre

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1973	-	-	-	-	-	-	119	79	28	7	30	167	-
1974	280	125	439	133	43	60	110	46	22	6	1	67	1332
1975	501	453	147	338	55	36	13	6	11	14	29	87	1690
1976	138	125	484	74	77	105	92	7	0	1	26	88	1217
1977	183	86	195	120	131	180	186	45	19	20	39	151	1355
1978	190	226	295	33	50	115	34	31	7	10	160	157	1308
1979	307	121	128	47	125	45	66	26	20	12	23	165	1085
1980	182	156	170	162	100	30	27	20	15	16	41	146	1065
1981	146	60	53	52	53	52	45	31	11	128	79	82	792
Mean[1]	241	169	239	120	79	78	72	27	13	26	50	118	1231

[1]Complete years only

Table 16. Monthly rainfall at Anse Takamaka, Grande Terre

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1974	-	-	189	460	84	0	0	0	0	0	0	300	-
1975	284	248	274	266	180	31	4	7	5	9	41	93	1442
1976	288	154	171	165	171	165	107	11	9	0	0	0	1241
1977	67	78	98	115	189	140	60	140	101	117	113	-	-
Mean[1]	286	201	223	216	176	98	56	9	7	5	21	47	1342

[1]Complete years only

Table 17. Monthly rainfall at Dune Jean-Louis, Grande Terre

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1973	-	-	-	-	-	-	-	56	38	39	112	193	-
1974	188	63	215	186	17	53	30	44	1	0	6	187	990
1975	193	187	188	151	105	29	6	16	10	15	41	88	1029
1976	-	-	-	-	-	-	-	-	4	0	58	120	-
1977	360	207	242	143	101	89	54	19	23	26	59	146	1469
1978	287	136	354	33	68	34	100	18	2	7	158	246	1443
1979	222	128	94	56	103	68	70	48	20	5	15	168	997
1980	147	184	109	106	66	54	72	37	20	81	102	106	1084
1981	104	87	124	76	63	61	45	36	24	95	73	75	863
Mean[1]	214	142	189	107	75	55	54	31	14	33	65	145	1125

[1]Complete years only

Table 18. Monthly rainfall at Dune d'Messe, Grande Terre

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1975	139	130	144	139	123	25	2	6	9	12	42	81	852
1976	358	231	177	78	49	19	70	60	2	16	25	44	1129
1977	437	252	130	346	330	230	236	123	48	47	104	108	2391
1978	146	245	385	33	44	94	71	39	7	3	163	168	1398
1979	251	150	96	60	79	47	48	36	10	8	34	128	947
1980	178	91	101	98	101	67	53	29	16	27	68	71	900
1981	109	123	137	73	57	55	26	25	99	51	49	51	855
Mean	231	175	167	118	112	77	72	45	27	23	69	93	1210

Table 19. Monthly rainfall at Anse Mais, Grande Terre

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1975	230	167	180	123	76	2	11	6	10	7	102	192	1106
1976	404	124	299	109	23	8	8	274	9	4	28	126	1416
1977	588	200	498	241	136	80	66	36	13	68	74	73	2073
1978	278	116	311	51	35	50	129	68	37	77	106	143	1401
1979	200	122	98	96	92	54	74	31	9	2	89	197	1064
1980	88	130	164	149	119	114	43	34	18	4	26	144	1033
1981	104	68	168	40	77	31	26	50	19	18	43	-	-
Mean[1]	298	143	258	128	80	51	55	75	16	27	71	146	1349

[1]Complete years only

Table 20. Monthly rainfall at Ile Esprit

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1976	-	-	-	-	-	-	111	34	2	10	103	107	-
1977	145	204	191	132	143	124	52	33	8	32	35	97	1196
1978	182	210	270	200	55	221	18	17	4	83	92	212	1564
1979	209	144	139	80	61	64	66	34	10	14	50	158	1029
1980	287	213	108	26	27	26	27	27	30	62	60	62	955
1981	98	112	125	121	54	50	33	18	16	17	21	295	960
Mean[1]	184	177	167	112	68	97	39	26	14	42	52	165	1141

[1]Complete years only

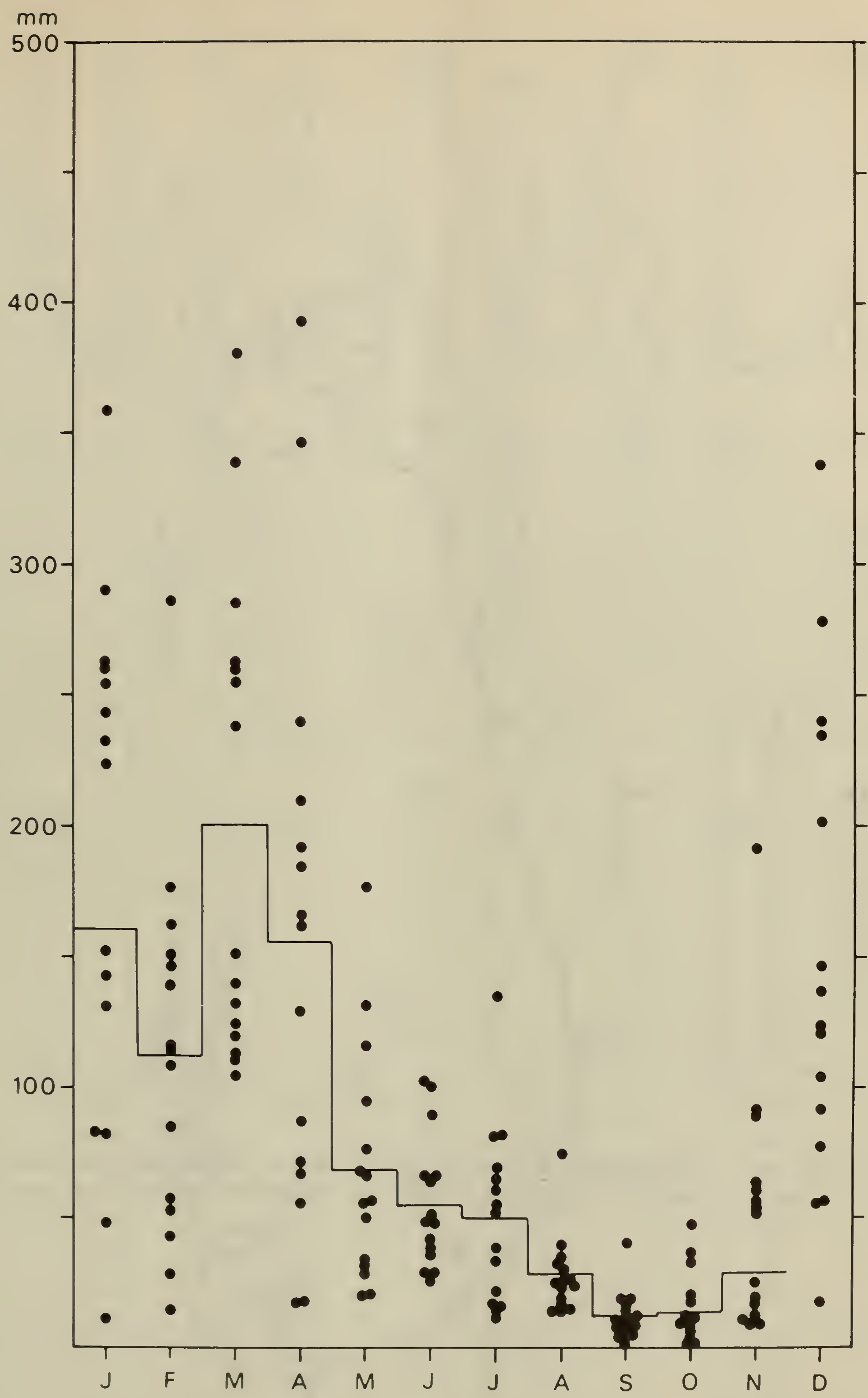

Figure 13. Monthly rainfall on Aldabra 1968-1982 (Meteorological Station data)

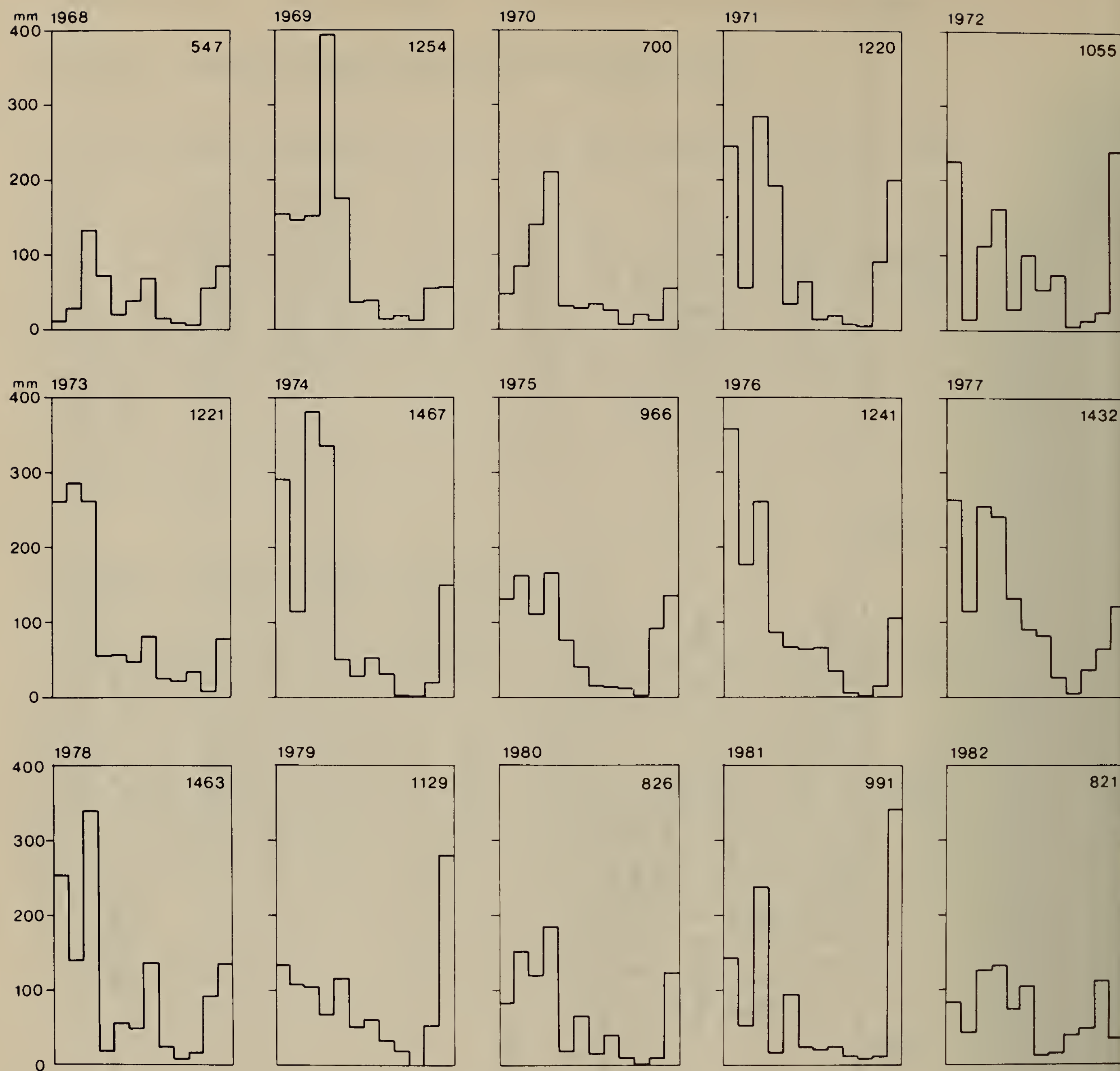

Figure 14. Histograms of monthly distribution of rainfall for each year of record at Aldabra, 1968-1982 (Meteorological Station data)

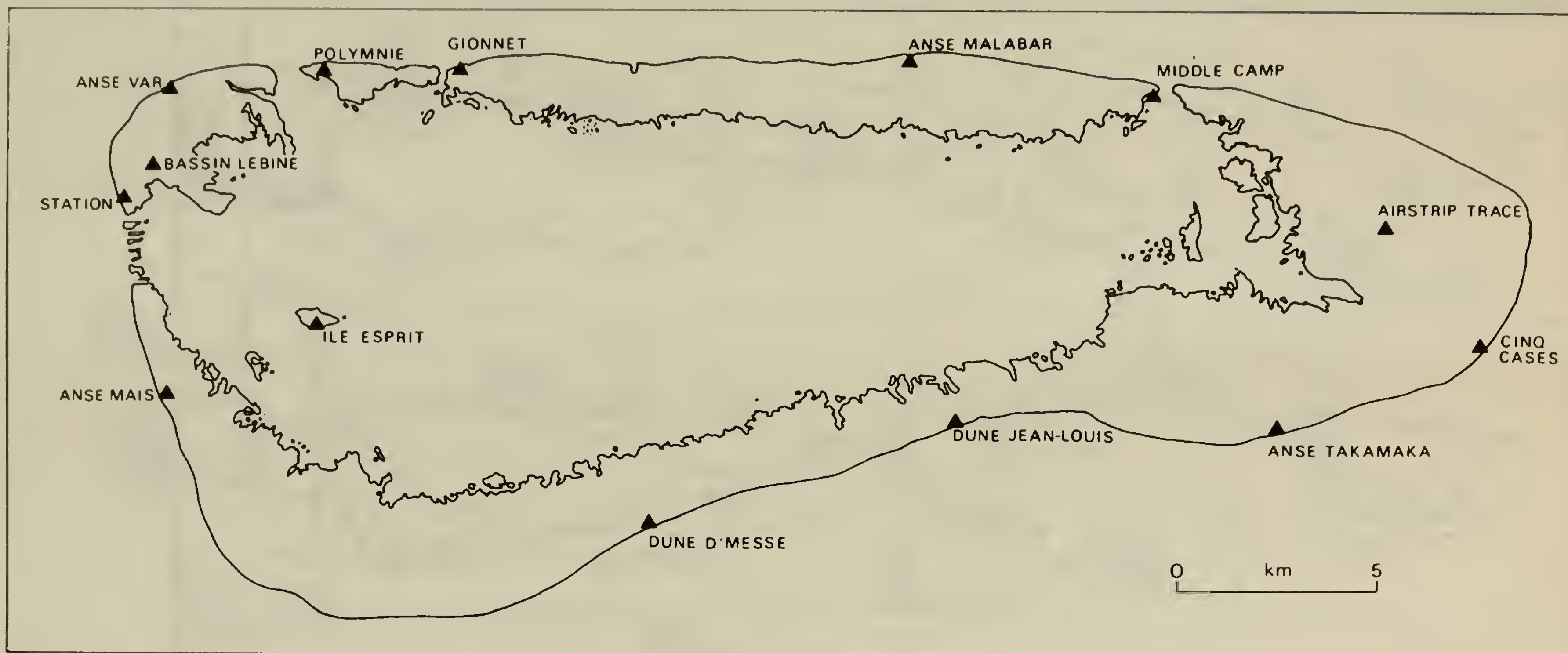

Figure 15. Location of local rainfall stations at Aldabra

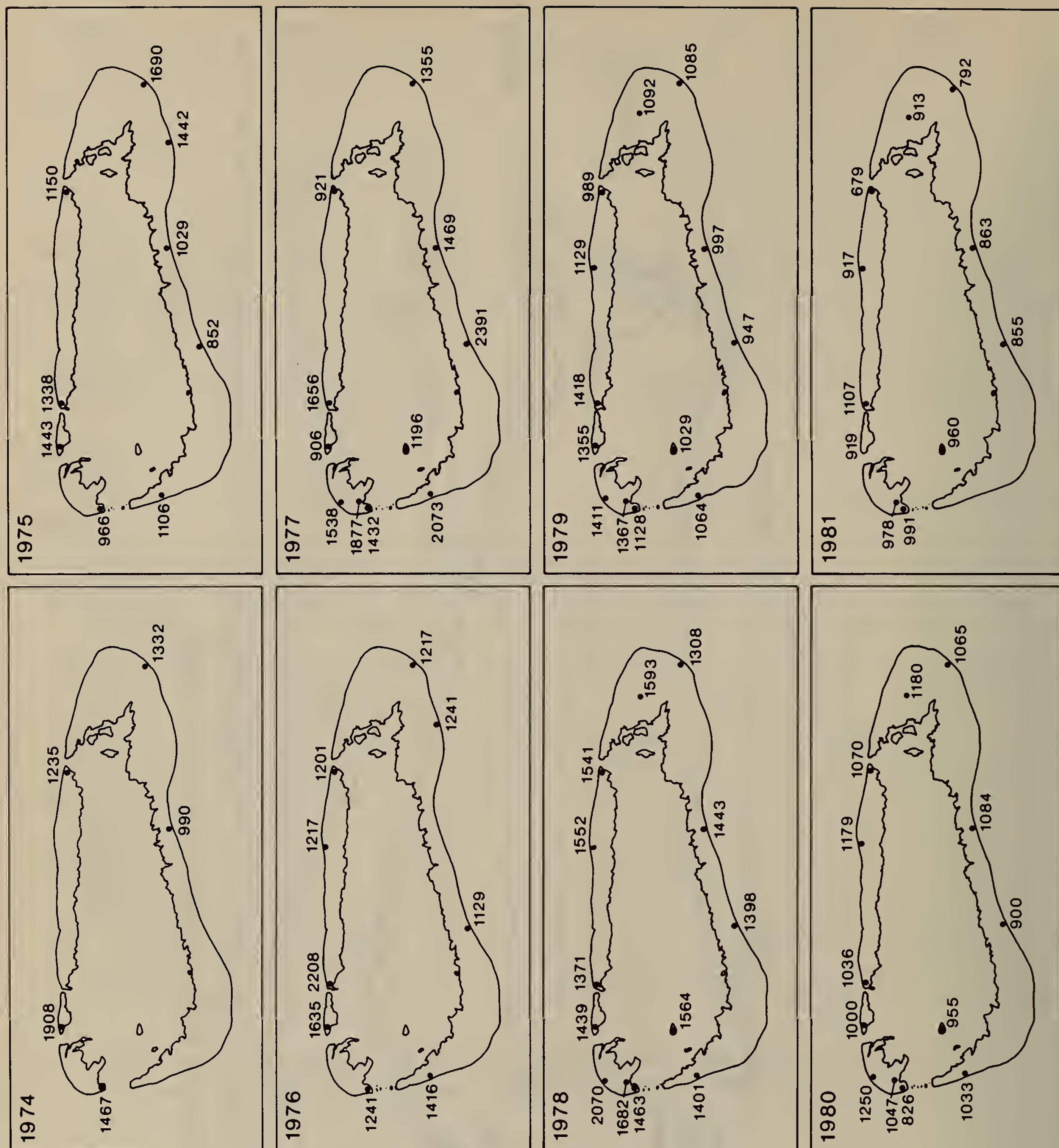

Figure 16. Annual rainfall totals at recording stations on Aldabra, 1974-1981

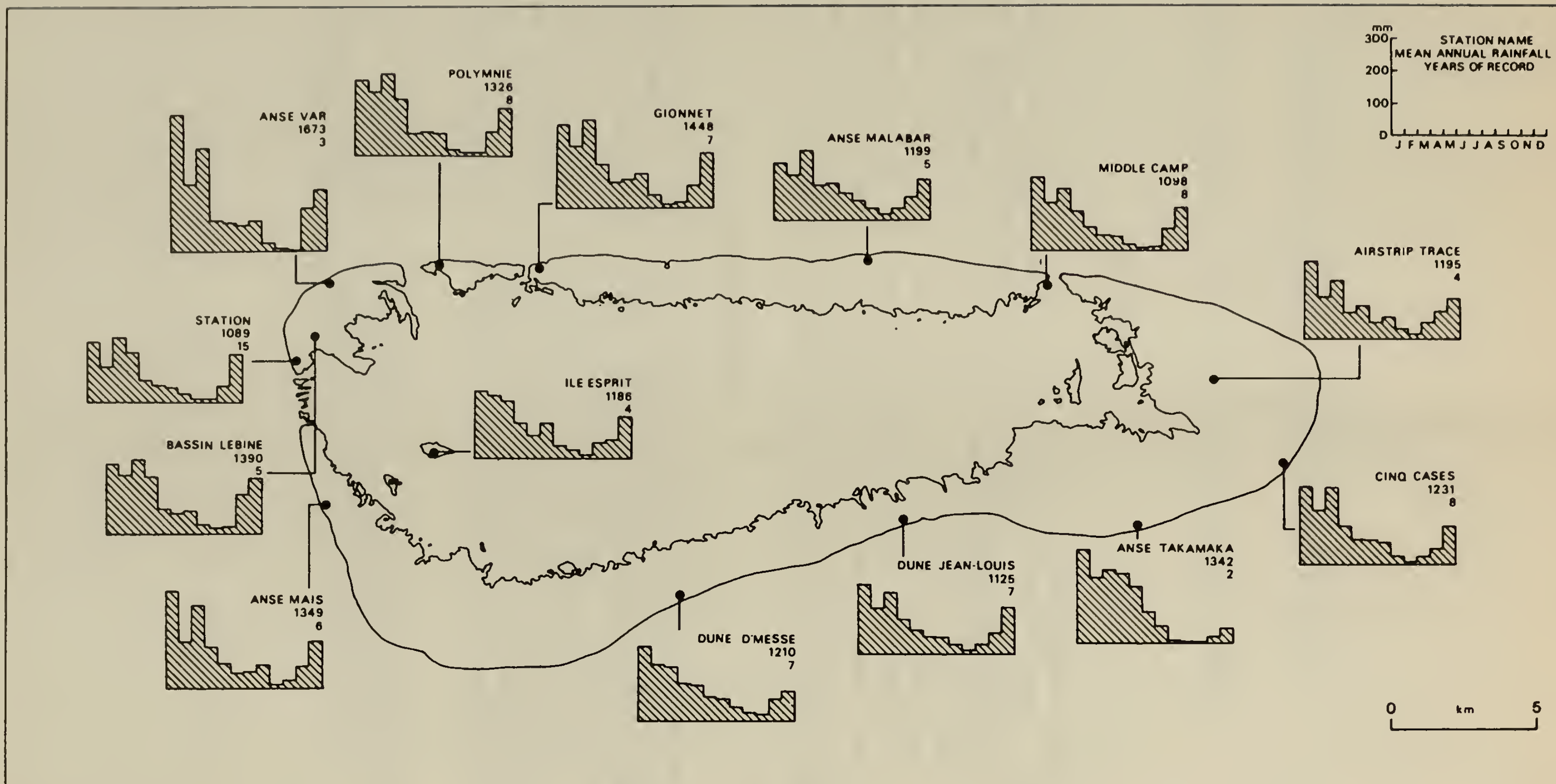

Figure 17. Monthly distribution of rainfall at local recording stations on Aldabra

13. THE GOAT AND THE COCCID: INTERACTIONS BETWEEN TWO INTRODUCED HERBIVORES AND THE VEGETATION OF ALDABRA ATOLL

by Margaret S. Gould, M. Garry Hill and David McC. Newbery

Abstract

Feeding preferences of two introduced, taxonomically remote herbivores were examined on Aldabra Atoll, in the western Indian Ocean. Both the feral goats (*Capra hircus*) and the coccids (*Icerya seychellarum*) exhibited clear preferences as to which plant species were fed upon, and these preferences overlapped to some extent. Although the individual actions of goats and coccids did not contribute directly to plant mortality, the combined effect of these two herbivores may be enough to jeopardize the survival of preferred, susceptible plant species, and thus may alter community structure on the atoll. When given a choice, a captive goat preferred coccid-infested vegetation to uninfested vegetation.

Introduction

Interactions between herbivores of very different taxonomic orders have been seldom investigated, though their importance is often suspected in many ecosystems. Situations rarely arise in which their effects can be separated from many other environmental interactions. We present here an unusual example of such an interaction which may generally be more common than previously realized. This paper summarizes our knowledge of the feeding preferences of two taxonomically remote but extremely important herbivores on the atoll of Aldabra and discusses their combined impact on the island ecosystem.

Aldabra is a large, raised coral atoll in the western Indian Ocean (46°20'E, 9°24'S). Its geology and ecology have been extensively reported elsewhere (e.g., Westoll & Stoddart, 1971; Braithwaite *et al.*, 1973; Gould & Swingland, 1980; Hill & Newberry, 1980).

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The only introduced vertebrate herbivore on the atoll has been and still is the feral goat (Capra hircus L.). Although the precise history of the population is uncertain, it probably originated from introductions in the late 19th century (Stoddart, 1981; Gould & Swingland, 1980). Gould (1979) and Gould & Swingland (1980) have described the population dynamics and behavioral ecology of the goats and their interactions with the atoll's major native herbivore, the giant tortoise (Geochelone gigantea Schweiger).

The most abundant invertebrate herbivore on Aldabra is a phloem-feeding insect, the coccid Icerya seychellarum Westwood (Homoptera; Margarodidae). From the time of its first report in 1968, the population rose to epidemic proportions on the atoll in the mid-1970's and has now (1979-82) fallen to a stable, low level (Hill & Newbery, 1980; Newbery, unpublished). The origins of the infestation are uncertain, although accidental introduction on fruit or plant stock is the most likely explanation (Hill & Newbery, 1982). Newbery (1980a, b) found that this coccid could reduce substantially the growth of highly susceptible tree species, but it seems that infestation caused little direct tree mortality (Hill & Newbery, 1980).

Methods

Experiment 1: General vegetation preferences of goats

Experiments on the feeding preferences of goats were conducted from January to May 1977, in a 4m x 4 m mangrove-pole enclosure at the eastern end of Malabar Island, Aldabra. A goat was captured at night, placed in the enclosure and allowed the following day to become accustomed to its confinement, the presence of an observer, and the experimental routine. Data collected from the second day on were used in the analysis. At dawn each day, five forage bundles were hung inside the enclosure at head height for the goat and spaced so that the animal had to take at least several steps to move from one bundle to another. The positions of the bundles were randomized daily. Each bundle was composed of one of five plant species known from direct field observations (Gould, 1979) to be preferred browse species for the goats: Capparis cartilaginea Decne, Pemphis acidula Forst., Phyllanthus casticum Willemet f., Polysphaeria multiflora Hiern, and Sideroxylon inerme L.. An effort was made to have all five bundles approximately the same size each day. Beginning weights of the bundles ranged from 275 to 2280 g over the course of the experiments. The experimental animal was observed continuously throughout the day until dark when the remnants of the bundles were removed from the enclosure. During the day, the cumulative time spent feeding at each species bundle was recorded. Each experiment lasted 2-4 days and three replicate goats were used: a mature male, a mature female, and an immature (sub-adult) male.

Experiment 2: Goat preference for Icerya-infested versus Icerya-free vegetation

To determine if feeding preferences were influenced by the presence of coccids on some of the vegetation, a captive goat was allowed to choose between infested and uninfested food bundles. Using the same experimental set-up as in the first experiment, two small (25-80 g) bundles, one with Icerya-infested Sideroxylon and the other with Icerya-free Sideroxylon, were hung in the enclosure for two minutes, then removed. Only Sideroxylon inerme was used for this experiment since Experiment 1 had shown that it was the goat's most preferred browse species. The time spent feeding at and the amount eaten from each of the two bundles were recorded during the two minutes. The experiment was repeated 32 times with the same goat, the immature male. The position of the bundles was reversed on successive trials to remove any positional bias.

Field studies on Icerya feeding preferences

Feeding preferences of Icerya were recorded in surveys of the Aldabra vegetation 1976-1978. The abundance of Icerya on 52 common plant species at 79 sites was assessed using a subjective five-point scale (0 = no Icerya present, to 4 = Icerya infestation devastating). The median score for each plant species over the whole atoll may be considered a comparative measure of Icerya preference (Hill & Newbery, 1980).

Results

Experiment 1 and Icerya feeding preferences

Sideroxylon inerme was by far the most preferred food source for both the feral goats and the coccids (Table 1). Agreement between the goat and coccid rankings of the other four species is less clear, especially since the goats showed individual variation. Capparis cartilaginea, however, was least preferred by the goats overall and was not utilized at all by coccids. Polysphaeria multiflora on the other hand had a fairly high preference rank with Icerya (11th out of 52 species in 1978), but was a low choice for two of the goats.

Experiment 2

The Icerya-infested bundles of Sideroxylon were preferred significantly to the uninfested bundles both in terms of the time spent feeding at each and the percentage (by weight) of available forage eaten (Table 2).

Discussion

The ranking of plant species obtained in Experiment 1 does not match the frequency of consumption of those same species observed in the field. For example, captive goats preferentially consumed much Sideroxylon and relatively little Capparis. Yet in field observations made at the eastern end of Malabar Island during the same time of year, Capparis was the most frequently observed browse species and Sideroxylon ranked third (Gould, 1979; Gould & Swingland, 1980). This discrepancy is most likely explained by differences in availability of browse species in the field versus in the enclosure. In the enclosure, all five species were readily and equally available, and the consumption pattern of the goats was an accurate reflection of their preferences. Yet in the field under natural conditions, much more of the low, shrubby Capparis was available to the goats than was the tree-form Sideroxylon with its established browse lines (Gould, 1979). There was also a high procurement cost (in terms of time, energy and risk of injury from browsing on hind-legs) associated with trying to feed on Sideroxylon in the field (Gould & Swingland, 1980).

In detailed studies of Icerya on Aldabra, Newbery (1980a, b) has shown that heavy infestations of this species can reduce the growth rate of two host plant species (Scaevola sericea Vahl, and Euphorbia pyrifolia Lam.) by approximately 50%. The long term effect of this level of infestation upon the survival of these plant species and upon the structure of the plant community is not yet known. Those species which are preferred by both invertebrate and vertebrate herbivores will be subject to even greater levels of stress.

Sideroxylon inerme is an important component of most scrub communities on Aldabra (Hnatiuk & Merton 1979; Newbery & Hill, 1981). Many of the mature trees of this species have clearly defined goat browse lines and are often badly infested with Icerya. In addition, on those parts of the atoll where goat densities are greatest (e.g., the eastern end of Malabar Island) seedling Sideroxylon are rare and restricted to areas of deeply dissected coral limestone inaccessible to goats (Gould & Swingland 1980). The combined impact of goats and Icerya may well have a serious effect upon the competitive ability and survival of Sideroxylon, at least on some parts of the atoll.

Experiment 2 showed that Icerya-infested Sideroxylon was consumed preferentially to uninfested Sideroxylon. This is encouraging, as one pest (the goat) will thereby eat the other (the coccid). However, since the foliage is also consumed in the process, the net result is of dubious benefit to the vegetation. The reason for the preference is unclear, though a likely explanation is that the goat is attracted by honeydew, the sweet excrement characteristic of phloem-feeding insects such as Icerya.

The results suggest that two herbivores of widely differing taxa demonstrate strong feeding preferences which overlap to some degree. The cumulative effect of such taxa being introduced into island ecosystems such as Aldabra may be far reaching, and is likely to affect plant community structure significantly in years to come. Furthermore, successive accidental introductions of herbivores are likely to have an accelerating influence upon plant community changes if certain plant species are typically more susceptible to a wide range of herbivores.

Future research aimed at quantifying the susceptibility of plants to a wide range of herbivores would be of interest, particularly with regard to islands such as Aldabra which have a high degree of endemism (Renvoize, 1971). It has been postulated that plants evolving on islands in the absence of strong herbivore pressure are more likely to lack

Table 1. Daily mean feeding time (minutes) of goats, median abundance of *Icerya* (Hill and Newbery, 1980), and relative preference ranks for five plant species. Numbers in parentheses for *Icerya* = preference ranks among the 52 plant species examined for *Icerya* infestation.

	Goat #1		Goat #2		Goat #3		Goat Totals		*Icerya* infestation median score		
	feeding time	rank	feeding time	rank	feeding time	rank	feeding time	rank	1976/1977	1978	rank
Sideroxylon inerme	52.5 (49%)	1	30.5 (57%)	1	62.8 (61%)	1	145.8 (55%)	1	0.60 (12)	1.35 (5)	1
Pemphis acidula	27.2 (25%)	2	11.6 (22%)	2	16.2 (16%)	3	55.0 (21%)	2	0.01 (31)	0.05 (24)	3
Phyllanthus casticum	15.6 (14%)	3	0.2	4	16.8 (16%)	2	32.6 (12%)	3	0	0	=4
Polysphaeria multiflora	4.7 (4%)	5	11.0 (21%)	3	7.2 (7%)	4	22.9 (9%)	4	0.59 (14)	0.43 (11)	2
Capparis cartilaginea	7.7 (7%)	4	0	5	0.7 (1%)	5	8.4 (3%)	5	0	0	=4

chemical defenses against herbivore attack (Levin, 1976). If this is true, it is endemic plant taxa such as Sideroxylon inerme (endemic ssp. cryptophlebia (Baker) Hemsley) which are most at risk from introduced herbivores.

Table 2. Chi-square test of time (seconds) spent feeding on infested and uninfested Sideroxylon bundles, plus test for equality of two percentages (Sokal & Rohlf, 1969) based on the grams (g) eaten of each.

Bundles	time	χ^2	g eaten	g not eaten	p(of being eaten)	t_s
Coccid infested	1683		711	679	0.5115	
		14.66*				9.55**
Uninfested	1468		451	903	0.3331	

* = $p < 0.005$

** = $p < 0.001$

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NATURAL HISTORY OF MOPELIA ATOLL, SOCIETY ISLANDS

BY

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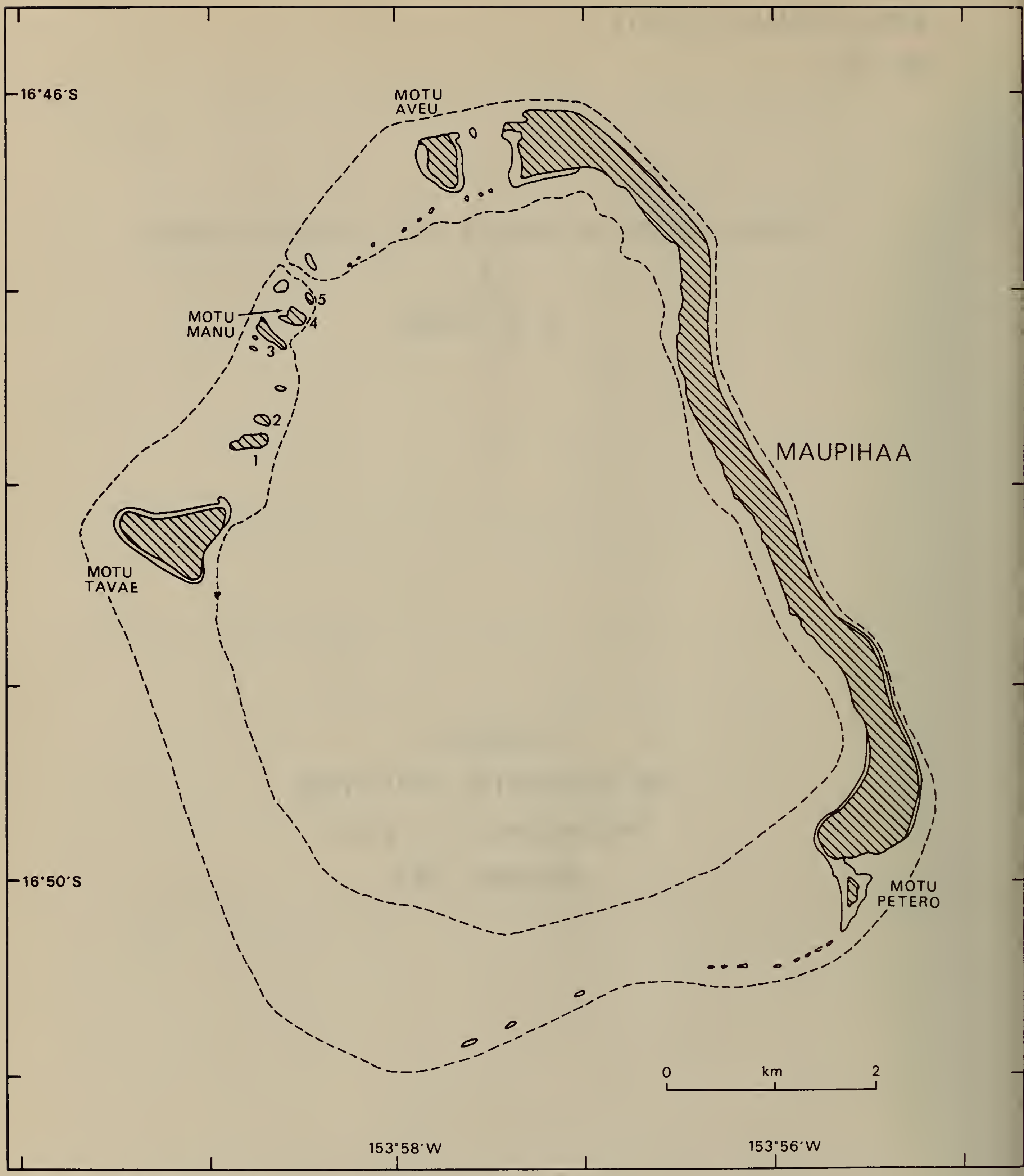

Fig. 1. Mopelia (Maupihaa) Atoll. (Adapted from Guilcher et al., 1969, by permission).

NATURAL HISTORY OF MOPELIA ATOLL, SOCIETY ISLANDS

BY

M.-H. SACHET

INTRODUCTION

The archipelago of the Society Islands, in the South Pacific, includes principally high volcanic islands, with fringing or barrier reefs, but also a number of outlying atolls: Tetiaroa, due north of Tahiti, Tupai or Motu-Iti, north-northwest of Bora-Bora and, at the west end of the volcanic chain, Maupihaa or Mopelia, Scilly or Fenua Ura or Manuae, and Bellingshausen (often spelled Bellinghausen) or Motu One. The latter (15°48'S, 154°32'W) is quite small, about 5 km in diameter, and there is no opening in its triangular reef. Scilly is larger (about 15 km NNW-SSE) with several islets on the east side, and a great reef awash at the western end. There is only a small boat passage across the southwest reef, and it is a fearful thing to watch a whale-boat threading its way through it up-current, as water on a falling tide runs out of the lagoon. Mopelia (16°46'S, 153°58'W) is intermediate in size between the other two, about 8 km in diameter, and has a narrow pass through the NW reef. Its size and its pass were two of the reasons why it was chosen as the site of their studies by a group of French geographers during the summer of 1963 (Guilcher 1965, Guilcher et al., 1969). I was in Tahiti on my way to the Marquesas Islands when their group was assembling, and was so fortunate as to join their well-organized expedition for the visit to Mopelia. For this opportunity I am very grateful to the principal investigators, Professors A. Guilcher, L. Berthois and F. Doumenge, as well as to the many persons who provided logistic and other support for their work, and whose contributions are acknowledged in Professor Guilcher's papers. I planned to study the vegetation and make collections, as complete as possible, of the land flora, with observations on other aspects of land ecology as time and circumstances permitted.

The aims of the expedition itself were to study the morphology of the reefs, as well as the sediments and circulation of the lagoon. Preliminary papers have been published by Berthois and Guilcher followed by an extensive report (Guilcher et al., 1969). Here only a sketch of the geology and geography will be included, considered as substratum and environment so to speak for the plant life.

HISTORY

Mopelia was discovered by Captain Wallis July 30, 1767 (Hawkesworth 1: 492, 1773) who described it as follows: "We ... could find no anchorage, the whole island being surrounded by breakers. We saw smoke in two places, but no inhabitants. A few cocoa-nut trees were growing on the lee-part of it, and I called it LORD'S HOW'S [HOWE'S] ISLAND. It is about ten miles long, and four broad, and lies in latitude 16°48'S. longitude, by observation 154°13'W." Later that day, he saw more low islands, and next day examined them and named them Scilly. Bellingshausen was discovered and so named by Kotzebue in March 1824 during his second voyage through the Pacific (Kotzebue, 1830: 255). He had missed the other two atolls.

On his second voyage, Captain Cook sailed by Mopelia of which he writes (1961, p. 430) in his entry for Monday June 6, 1774: "At 11 AM Saw How Island discovered by Captain Wallis which at Noon extended from west to NW distant one League, it is one of those low reef isle's of about 4 Leagues in circuit, the Most land lies on the NE part, the reef extends a good way to the SW and West and hath upon it some little islets. I think Captain Wallis found on the NW side a Channell in within the reef, but whether of a depth sufficient for Shiping or no I know not. The Inhabitants of Uliethea [Raiatea] speak of an uninhabited Isle which they call Mopeha lying to the west to which they go at certain Seasons for Turtle, perhaps this may be the Very Same. Captain Wallis saw upon it Smoaks, signs of inhabitants or people we saw none. Lt. 16°48', Longitude 154°18' West." Forster's account of the same visit (1777, 1: 161) describes it thus: "It is very low, consisting of coral ledges, which enclose a lagoon ... Several birds, called boobies, were seen in the neighbourhood of this little isle, which was to appearance uninhabited."

Turtles and birds were still in evidence when Mopelia's best-known visitor and resident, Count Felix von Luckner, arrived, July 29, 1917 with his famous raider, the Seeadler, originally an American clipper. The orchids, birds of paradise and glow-worms with which von Luckner has been accused of adorning Mopelia (Eggleston 1953: 107-108) were in reality provided by Lowell Thomas (1927: 225) in his fanciful translation of the count's works. In point of fact, von Luckner's description of Mopelia is factual and his attempt to describe the gorgeous play of colors in an atoll lagoon as good as any. His book includes photos of the reef and of the coconut plantation, and a sketch map. The Sea Devil's luck, however, was to run out here when, on Aug. 2, 1917, a great wave lifted his ship onto the reef (the exact sequence of events is disputed by Jourdain, 1973 and Clifford, 1977) and after camping on the atoll for three weeks, he left with 5 others in one of the lifeboats. Two weeks later, the rest of the crew seized the French schooner La Lutèce and escaped, her own crew and the Seeadler's prisoners remaining on Mopelia until rescued early in October together with the 3 Tahitians who had been collecting turtles on the atoll. Von Luckner revisited the site of the wreck in 1938, but could not land (1951: 334). He died in Sweden in 1966 at age 84. During the 1950's the remains of the Seeadler were still conspicuous just south of the pass, and in 1956 Ralph Varady (1958) could still find some on the reef and in the copra workers' village. In 1963, only a few rusted remnants were visible.

Whether Mopelia ever had a permanent population is not known. According to Cook it was in 1774 a dependency of Raiatea, visited at intervals to collect turtles. At the time of the Seeadler wreck, the atoll had been leased to a Papeete company, Grand, Miller et Cie, whose 3 employees were making copra and raising pigs and chickens as well as collecting turtles.

Later, Mopelia was leased, with its two neighbors, to the Compagnie française de Tahiti and entirely planted to coconut palms, and contract personnel from the Society, later from the Austral, Islands, were installed to make copra and visited every few months by schooner. In 1963, the "village" included close to 40 persons including many children, together with a Polynesian weather observer and his family. In 1960 Pierre Vérin (1961) started some archeological surveys on Mopelia and located ancient sites and some fish hooks.

Other than casual visits described in popular books (Eggleston, Varady) and Vérin's work, the only account of Mopelia is that of Papy (1954-1956) who made a brief visit in the late 1940's and published the first botanical study of the atoll. No collections, however, survive (Papy, personal communication 1964), so that those of 1963 appear to be the only ones available. A member of the Whitney South Sea Expedition of the American Museum of Natural History (New York), Ernest H. Quayle, visited two of the three western atolls in Dec. 1921-Jan. 1922 on the "Curieuse". His destination was really Scilly, and there he spent most of his time, observing and preserving birds, and also collecting plants which I have seen in the Bishop Museum and other herbaria. Scilly was then something of a dependency of Mopelia, and the little "Pastime" commuted between the two. Quayle landed on Mopelia on Dec. 18 for 3 days, but collected no plants. None of his observations were ever published, although the leader of the Expedition, Rollo Beck, wrote a number of popular articles in Natural History as well as papers on birds. The American Museum of Natural History, Division of Birds, however, holds typed and bound copies of the notebooks of Quayle, Beck and others, and has been most generous in making them available to me and to others, for which many thanks.

According to Thibault (personal communication, 1974), Mopelia was later visited by other ornithologists, D. Blackstone in 1972 and himself on Oct. 5 and 6, 1973.

Marine molluscs were studied and collected on Mopelia's reef and lagoon by Harald Rehder, on April 27, 1973. He later also examined Scilly and Bellingshausen (personal communication).

CLIMATE

A weather station was established on Mopelia after World War II, and moved in 1958 from the lagoon shore, where the coconut plantation interfered with visibility and wind observations, to the ocean side where the instruments find a more open situation. This is at the north tip of the main islet. There exist now almost continuous records for about 30 years. Data are published monthly, and yearly summaries issued by the Service Météorologique of French Polynesia. These and other sources (d'Hauteserre, 1960) were used in the following brief description of climatic conditions. The help of Bryce G. Decker and F. R. Fosberg in summarizing the data is gratefully acknowledged.

Winds and storms: Mopelia can be described as a moist, rather hot and not very windy atoll. It is in the tradewind region, with prevailing winds from the two eastern quadrants, those from the NE occurring more than one-half of the time. A minor component, usually less than 10% in a year, is from the western quadrants. Calm weather prevails between 10 and 30% of observations for most years.

Wind speeds are preponderantly between 2 and 7 meters per second, in some exceptional years up to 20% between 7 and 14 m/sec, usually much less. The arrows of the wind roses of the U. S. Navy Pilot charts are usually for Beaufort strength 3 (4.4 m/sec) or 4 (6.7 m/sec), but indicate 1% gales (over Beaufort 8 or 16.9 m/sec) 1% of the time for the ocean square 10-20°S, 150-160° W.

Hurricanes (= typhoons, cyclones) are uncommon in SE Polynesia, especially so in the west of the area, but strong winds and storm waves can affect coral atolls. Hurricane Emma (Feb.-March 1970) passed closer to Mopelia than most storms. In April 1977, hurricane Robert, passing within 200 km SW of Mopelia on the 19th, brought heavy rains, strong winds and rough seas throughout the Society Islands. Tropical depression Diana (16-20 Feb. 1978) passed very near Mopelia bringing record rains (676 mm for the month) and cutting down copra production on Scilly and Mopelia. One of the hurricanes of the extraordinary 1983 season, Rewa (Reva), at one point was headed west in the direction of Mopelia and the other two western atolls. The people on them (19 on Mopelia) were picked up by ships (March 11), but returned the next day after Rewa abruptly changed course just north of Tupai and turned SE.

Temperatures: Mopelia has an equable tropical maritime temperature regime in which temperatures change more between day and night (5° range in June, 6.2 in Dec. & Jan.) than from season to season. They range in absolute from 20° C to about 35° C but average 24 to 28° C, with a mean temperature for the warmest month, March, of 27.6 and for the coolest, August, of 25.5 (= annual range of 2.1°).

Rainfall: Precipitation ranges, annually, between 909 (1972) and 2519 mm (1979), with a mean of 1823 mm (1953-1980). Two-thirds of the rainfall occurs during the warmest season November-April, the wettest month being December (average 268 mm) and the driest July (62 mm). There can be great variation from year to year with record rainfall in January 1965 of 693 mm and record low in July 1963 of 0. There are usually 10-20 or more rainy days per month, with an absolute 24 hours maximum in December 1971 of 211 mm, and 155 mm, September 1969, for the dry season. Absolute minimum in wet season, March 1962 and November 1961 both with 20 mm.

Other factors: Factors which change little over the year include relative humidity, sea level atmospheric pressure, and sunshine and cloudiness. Relative humidity shows a mean daily value of 80% every month of the year with mean daily maxima between 86 (August) and 90 (January, February) and absolute daily maxima of 100 for all months; mean daily minima 66 (September) to 71 (February), absolute recorded minima, 55 (March) and 36 (August). Atmospheric pressure at sea level changes very little throughout the year, except for the minima which may indicate the passage of major storms. For instance, during the stormy weather of December 1971, a low of 995.6 mb was recorded at Mopelia. Sunshine and cloudiness: In the mean, the sky is about 1/2 obscured by clouds at all standard hours of observations, but the sun is completely obscured all day only about 11 days per year. Visibility is estimated by observers to be equal or superior to 20 km on 340 days of the year.

GEOGRAPHICAL SETTING

Mopelia is a small atoll, somewhat trapezoidal, with the corners corresponding fairly well to the points of the compass, the N-E and W-S sides being longer than the other two. The reef is continuous except for the narrow pass located about half-way between the west and north corners. It is narrowest along the NE side of the atoll, where its surface is covered by a continuous strip of dry land, the main islet. The south tip of this strip, just beyond the E corner of the atoll is prolonged by a small sandy islet, Petero. Near the north tip of the main islet, and separated from it by a shallow bay, is Aveu islet, at the north corner of the reef. There is another larger islet, Tavae, at the west corner of the atoll, and between it and the pass a number of very small islets are scattered on the lagoon side of the W-N reef. For our present purposes, the larger ones are numbered 1 to 5, no. 4 being labelled Motu Manu on the chart and no. 5 lining the pass. There is no dry land, except perhaps for some patches of rock to be discussed below, on the W-S and S-E parts of the reef, and they were not examined by me.

The most striking aspect, as one approaches Mopelia from the east, is the occurrence on the reef flat, like a sidewalk above a street, of a higher rock surface which, from a distance, seems very regular in height, one meter or more above the reef flat. This would appear to be an older reef surface, planed and locally dissected. Where it touches on the islets, it becomes an important type of substratum for land plants. It is broken into patches of varying sizes, the largest of which stretch between the main islet and Aveu, lining the oceanward side of both islets, and along both sides of the pass. Similar, but more scattered patches are strung along the S-E reef flat, and what seems to be the same rock forms patches at the south tip of Petero islet and beyond, and along the ocean side of the main islet at the east corner of the atoll.

The lagoon of Mopelia is rather deep, locally reaching 40 meters. It was studied in detail and mapped by Guilcher et al. (1969). Some coral patches come up very close to the surface of the water. As in coral island lagoons everywhere, the color of the water varies with the depth, the bright blue of the southern part locally gives way to shallower green areas, passing to very pale as the shores are approached. The lagoon shores of the islets are almost everywhere sandy. There is a patch of incipient beachrock on the lagoon shore of Tavae islet, but it barely emerges. Some rocky shores occur on the main islet forming small points jutting into the lagoon.

SUBSTRATUM

On an atoll such as Mopelia, the whole above-water land area is formed of organic limestone, skeletons and fragments of tests of marine animals and plants. This material may be solid fossil reef with corals in position of growth, with interstices and openings filled in with clastic fragments, still loose or cemented, or lithified into breccias or conglomerates. Much of the islet sediment forms unconsolidated piles of debris, the texture of the organic fragments ranging from sand to pebbles, cobbles and small boulders in variously sorted or unsorted mixtures, and either water-worn and rounded or angular and sharp.

The bare surfaces, whether lithified or loose, are generally blackened by endolithic blue-green algae, which are said to contribute to weathering by disintegration and subsequent solution of the rock surfaces. Wherever loose sand is not densely covered by vegetation the surface centimeter or so is caked, stuck together by a mass of blue-green algae of several kinds to form a friable, or when wet, gelatinous, crust, also of a dark, usually gray color.

Around much of the periphery of the land area a platform or ledge of island conglomerate is exposed, protruding from beneath the mass of unconsolidated material, and locally extending across the reef to form patches and blocks on the reef flat. Such a platform possibly extends across all or most of the islets, underlying the loose overburden or soil. It was not possible to investigate this by digging or boring test holes in the time available.

Along the seaward windward coast is a broad low beach ridge of clastic material, mostly coarse in texture, with some sand and much shingle thrown up against it as beaches.

On atolls generally, and strikingly so on Mopelia, there is very little soil formation. Generally some humus accumulates in the surface, darkening it. In coarse sediments this humus tends to fill the interstices and form a matrix which contains quantities of plant roots, and undoubtedly nourishes the plants.

Inland the soil tends to be sandy, mixed with larger coral fragments. Here, where humus would normally accumulate to form good soil for plant growth, periodic clearing of undergrowth and burning of trash, coconut leaves, and litter, keeps what little humus could be expected from building up in any quantities. The surface layers are darkened, but with low organic content, grayish to "milk-chocolate" color, soon changing downward to pale coral sand and gravel. This soil profile, called the "Shioya Soil Series" in Micronesia, is notoriously deficient in certain minor but essential nutrients, judging by analyses of Shioya samples from the Marshall Islands. This is most likely the case on Mopelia, too.

In the tropics generally, litter of leaves and other plant debris decomposes very rapidly and even good soils tend to be rather thin. In atolls, under some trees, the litter remains for some time and is especially noticeable in pure stands of Tournefortia, Guettarda, Suriana and especially Pandanus. Very thin layers of discolored "soil" occur under the litter.

In one or two places, especially in the interior of Motu Manu, are small areas of phosphatic soil, such as is called the Jemo Series in Micronesia, found under Pisonia groves inhabited, at least formerly, by large numbers of sea-birds. The soil profile includes, under leaf litter, often stained with guano, a top layer of acid raw humus of partly decomposed Pisonia leaves and twigs, then a layer of crumbly or sub-lithified coral sand altered or partly altered to calcium phosphate, brown with white speckles and light in weight, this overlying unaltered coral sand. Areas of the "Jemo" phosphatic layer may exist elsewhere on the atoll, marking the sites of former Pisonia groves, but very difficult to distinguish, when exposed and weathered, from ordinary coral rock.

Normally differences in soil are indicated, at least roughly, by differences in vegetation. Here on Mopelia most such indications are eliminated by the conversion of the land to coconut plantation. However, Pisonia groves, when relatively pure stands, may indicate "Jemo" phosphate. Suriana almost surely indicates sand or loose gravel, while Pemphis almost as reliably indicates consolidated limestone rock.

One more thing should be mentioned. In places, if holes are dug in the interior unconsolidated areas, buried soil profiles are encountered, indicated by darkened horizons covered with lighter, fresher sediments. These apparently originate when severe storm-waves carry large amounts of beach sediments into the interior, spreading unweathered layers on top of a developed soil. This phenomenon is common on many atolls, and shows up in some profiles on Mopelia. Animal activity also creates some mixing and turning over of the soil. Earthworms occur on atolls, but in very small numbers, and most of the disturbance of land surfaces results from the burrowing of land crabs, and locally probably coconut crabs, as observed on Motu Aveu where fairly large holes, exposing "milk chocolate" soil, were common under Tournefortia trees, and where soil layers became mixed when the holes collapsed.

LAND VEGETATION

The overriding characteristic of the vegetation of Mopelia is that most of it, especially inland, is very profoundly disturbed, coconut palms having been planted everywhere. In 1963 the only traces reminiscent of what the original inland vegetation may have been like could be found at the southern end of the main islet and on Tavae islet. Unfortunately, the latter, by far the most interesting part of the atoll, could only be examined on 2 short visits when boat transportation was available. From these areas, it appears that the atoll must have been originally covered by a tall mesophytic forest consisting of a locally varying mixture of a few species. There may have been a lower story of saplings, smaller trees and tall shrubs, and in the ground cover mostly shade-loving ferns. This forest would be comparable to that in the central or southern Marshall Islands, though perhaps not as luxuriant as that known in the southernmost (and wettest) of these atolls, as could be expected from a comparison of rainfall data.

The shore vegetation of Mopelia has undoubtedly been much less affected by human intervention than the inland forest, but it is also less characteristic of a particular atoll or group of atolls because it is less influenced by the variables in the substratum and the climate (mostly rainfall), the effects upon it of winds and salt-spray being pre-eminent.

The principal plant communities may be described in general terms, and local variants discussed in a more detailed account of the various parts of the atoll.

Ocean shores: Except on the most arid atolls, the ridges of sand or coral rubble that rise on the ocean shores, especially to windward, usually support a scrub of salt- and drought-resistant shrubs about 2-3 meters in maximum height. This is a relatively constant type, with minor local variations in stature and species composition, throughout the Indo-Pacific tropics on atolls and barrier reef islets, with a similar but floristically different vegetation on Caribbean and Gulf of Mexico coral islands. In the Pacific atolls, this strip of scrub, which has been especially well described in the Marshall Islands, includes *Scaevola sericea* as a principal component, together with *Tournefortia argentea* and *Suriana maritima* and various other species in smaller amounts. On Mopelia on the windward seaward side, that is, along the long N-E main islet, this typical scrub is well developed. Where the *Scaevola*, *Suriana* and *Tournefortia* are rather open, there are locally creeping woody vines of the widespread Indo-Pacific *Triumfetta procumbens* and scattered clumps or spreading shrubs of *Timonius polygamus* (Rubiaceae) endemic to South Polynesia. Like *Scaevola* it has shiny bright green leaves very resistant to winds and salt-spray. On the seaward slopes of the beach-ridges, this marginal scrub generally forms a very even cover, with prostrate, scattered *Scaevola* and *Timonius* at the top of the beach, becoming closed, denser and taller landward with a very smooth profile resulting from wind-shearing by the prevailing trades laden with salt-spray. In fact, this scrub belt forms a sort of wind-break against the worst of winds and salt effects and behind it more mesophytic and taller vegetation may occur. So it is on Mopelia where immediately behind this scrub, on the top or on the landward slope of the ridges, there is a strip with taller Scaevola and much Guettarda speciosa laced with the orange stringy stems of the parasite Cassytha filiformis.

On more leeward shores, the beach ridges are less high, and slope very gently toward the intertidal reef flat, forming a beach of small gravel or sand. On such slightly sloping surfaces typical atoll vegetation consists of scattered clumps of herbaceous salt-resistant species, or spreading prostrate herbs or small woody plants. On Mopelia this type is well developed on the ocean side of Tavae islet where it includes mainly tufts of Lepturus repens, small depressed plants of Portulaca and, somewhat more inland, Heliotropium anomalum. These pioneer species may also occur in pockets of sand or small gravel on rocky pavements. Immediately behind this zone of scattered herbs rises a strip of low forest, often of pure Tournefortia argentea with much leaf litter beneath.

The rocky platforms lining some of the islet shores are occupied by Pemphis acidula, forming low prostrate mat-like shrubs or large densely branching trees in a pure stand, with every possible intermediate aspect.

Lagoon shores: The vegetation of these shores is more variable, as are the shores themselves. In the case of an immense lagoon, such as some in the Tuamotus, the vegetation may be much exposed to the weather and a scrub fringe similar to that on the ocean side may protect the inland forest. This does not occur on Mopelia. On the less disturbed smaller islets (on Tavae), the lagoon and channel edges of the vegetated land bear forest of Tournefortia, Guettarda, with some Pandanus and Pisonia, or scrub forest or tall scrub of the same species (on bird islands, Aveu, Petero). Along most of the main islet, the lagoon shore is very narrow and the coconut plantation extends to the edge of the water in many places.

Mangrove vegetation and sea grass beds are quite lacking.

Vegetation inland: On very small islets such as the bird islets and Petero, the strand scrub forest "fills" the whole land area, with some coconut palms in the middle; elsewhere, except for traces of the original forest, the coconut plantation covers the whole interior with undergrowth in various stages of clearing and regrowth.

There are no marshy areas and no taro swamps, which is not surprising on a small atoll where there may never have been a permanent aboriginal population. The only other aspect of the vegetation consists of the few poor gardens and planted shrubs and trees of the village and the Station, with their cortege of introduced weeds.

In his study of the land vegetation of the Society Islands, Papy (1956: 182-183) gave a generalized section from ocean to lagoon of the southern end of the main islet of Mopelia: 1. sandy beach with Lepturus repens, 2. scrub of Scaevola and Pemphis and on the beach crest Heliotropium, 3. forest of Tournefortia, Guettarda and Pandanus with lianas and ferns, 4. forest of Pisonia with Boerhavia tetrandra, and 5. scrub of Scaevola and Pemphis. Like many other observers, Papy thought that Pisonia favored a soil richer in organic matter and guano, when in reality, this type of soil forms under the Pisonia.

Description of islets:

Motu Aveu: This is a land area about 0.6 km long and a half or third as wide, oriented transversally on the north reef of the atoll, a half km or less west of the NW end of the main islet. The north (ocean) side is a wide strip of elevated reef rock, densely covered by tall Pemphis scrub which gets shorter northward toward the sea, where the reef rock is separated by erosion into a number of remnants of various sizes, the larger covered by Pemphis. The sandy, larger part of the islet is planted to coconuts, but on the west side along the width of the reef are numerous Tournefortia trees and some Cordia subcordata.

Islets on NW reef, between pass and Motu Tavae: A half-dozen remnants of the older slightly elevated reef platform, with sand and gravel accumulations, plus many small rocks are scattered SW of the pass. Their vegetation is very impoverished, but richer on the larger islets. The species present are obviously those that can stand exposure to sun, wind and salt-spray, with accumulated guano and other effects of roosting and nesting sea-birds. Pemphis acidula scrub is the most obvious and frequent component of the vegetation mosaics, found on otherwise bare rock or rock with a thin cover of sand, even on some tiny rock remnants. Where the accumulation of sand and gravel is thicker, Pemphis may be wholly or partly replaced by other species such as Tournefortia argentea, Scaevola sericea, and, on larger islets, Pisonia grandis. On the one or two largest islets, a few coconut palms are planted and Portulaca, Boerhavia, Lepturus, and Achyranthes are common. On Motu Manu, itself, is a Pisonia grove with a raw-humus layer and phosphatized limestone debris.

Motu Tavae: This triangular wooded islet, about 1 km on its long side, is situated at the westernmost point of the atoll reef. It is, mostly, an accumulation of coral sand and gravel, lined along the north shore by old, much eroded and pitted, slightly elevated "fossil" beachrock. The lagoon shore, a gently sloping sandy beach, shows some incipient beach rock, locally still soft, but passing to the older, higher beds northward. At the western extremity the beach rock is lined then replaced with an exposure of eroded conglomerate reef platform, slightly above sea-level, extending out westward to a line of platform remnants near the reef-edge. On some of the platform rock at the western point of the island there is Pemphis scrub, with a few outlying Pemphis bushes on rock surfaces.

Most of the islet surface is covered by a forest, locally very dense, of large Tournefortia, Guettarda, Pisonia, Cordia, Hibiscus tiliaceus, Pandanus tectorius and Morinda trees with sparse patches of coconut palms here and there, connected by paths for gathering nuts for copra making. The ground cover, especially in openings, includes Portulaca, Boerhavia, Thuarea, Achyranthes and Polypodium and other ferns. Around the edges of this forest is an interrupted fringe of small Suriana and Tournefortia with Lepturus on sand at top of beach. In openings and thin places in the forest Scaevola, Suriana, and Timonius are common, with Polypodium, Asplenium, Lepidium, and Ipomoea macrantha. Near the west end is a thin sand and gravel area just back of the shore with Lepturus and Heliotropium anomalum, and several bushes of Ximenia americana in edges of forest. Around a copra shed and house is an opening with semi-weedy vegetation of Cyperus, Triumfetta, Vigna marina, Euphorbia hirta and planted Hibiscus tiliaceus. The latter species, somewhat inland, forms tangled jungle-like patches.

Motu Tavae in 1963 was the least altered by man of all the non-rocky land on Mopelia.

Mopihaa (Mopelia) or Main Islet: The principal land area on Mopelia Atoll is a long, narrow strip of land, about 8-9 x 0.3-0.5 km, lying on the east reef of the atoll. It is essentially a deposit of coral gravel and sand lying on a reef platform surface slightly elevated to about 1 m above low tide level. This platform extends out from under the loose deposits of the islet at various places around the periphery, especially around the two ends, which form slight hooks, following the curves in the reef (see map). Along the east side, especially, a beach ridge of sand to mostly coarse gravel and cobbles has been thrown up by wave action.

Keeping in mind the profound disturbance of the original vegetation and the resulting likelihood of rapid change in aspect if the character of human interference varies, we can distinguish the following vegetation types along the ocean shores. This is the least disturbed vegetation on Mopelia and it reflects well the variation in exposure and substratum. On the windward (N and N-E) side, that is, the ocean shore of the main islet, there is hardly any sandy substratum. At the Meteorological Station (ocean shore opposite the village) which served as expedition base camp, the cobble beach ridge is topped by a dense strip of tangled Scaevola bushes about 1-1.5 m high with stunted Tournefortia trees rising above them. The oceanward slope of the ridge has a very open scrub of prostrate Scaevola, with some very long branches, almost like runners, and isolated small (a meter at most) Tournefortia plants, many of them rather leafless. Scattered small plants of Suriana maritima are also present. Much of the white cobble ground is exposed. The slope passes to pebbles and eventually to a beach of coarse sand, but is then bare of plants except for a gray to black crust of algae identified by Jan Newhouse as Calothrix confervicola, Phormidium submembranaceum and Anacystis montana. Farther south-east where the island juts somewhat into the ocean, the cobble ridge is highest, perhaps 3 m above the level of the reef, and the fringe of shore vegetation better developed. There is a wide strip of Scaevola shrubs, up to 2 m tall, and of Suriana, the profile illustrating beautifully the wind-shearing effect of the prevailing trades. Oceanward, the strip passes smoothly to lower, then prostrate plants of Scaevola mixed with scattered ones of Timonius polygamus with 4- or 5-pointed corollas and round purple berries. This plant was described from the Tuamotus, where it is very abundant.

The open prostrate scrub on the upper slope of the cobble ridge includes also scattered plants of Tournefortia under a meter in height, and often leafless, and, especially where a little sand fills a hollow, the long spreading branches of prostrate Triumfetta procumbens. There are no herbaceous plants in the vegetation fringe of the windward shore. Along the southern half of the main islet the beach ridge is narrower, lower and of smaller cobbles and pebbles, and passes more rapidly to a beach of coarse sand. There the strip of vegetation is almost pure tall Suriana, 2 or more meters in height, with a carpet of its small golden-brown leaves covering the ground.

On the outer parts, where the rock platform protrudes from beneath the sand and gravel, the vegetation almost abruptly changes to a scrub forest or scrub of small-leafed, intricately branched Pemphis acidula, varying in places with exposure down to a creeping, mat-like dwarf scrub. In large parts of the periphery, both on seaward and lagoonward sides, the Pemphis vegetation, often reaching tree-size, is the first impression beneath the coconut forest, that the visitor gets on approaching the island. Pemphis resembles Suriana in appearance, but the leaves are stiffer, grayer green, the twigs are stiff and harsh, and the flowers are white instead of yellow.

In some areas, especially toward the south end, where the coconut palms are either sparse or absent, inward from the beach ridge, a scrub forest of Tournefortia occurs, occasionally of sizeable trees. On the lagoon side, where the beach ridge is absent, this Tournefortia forest may be found on the shore, or directly back of the Pemphis. It may in places be mixed with, or replaced by Guettarda, Pandanus, Morinda, and Pisonia, with some rather tall (2 m) Scaevola, in varying mixtures. With this and into the coconut plantation Timonius may be found in an open shrub layer. All may be tangled with extensive vines of Ipomoea macrantha bearing large white flowers.

Where the lagoon shore is of sand and lacks protruding old reef platform, the vegetation immediately along the shore may be a tall fringe of Suriana, sometimes hard to distinguish at a distance from Pemphis except that it is likely to be greener.

Inland, between the lagoon-coast vegetation just described and the seaward beach ridge, the entire flat, gravelly, and sandy area the full length of the islet has been converted to coconut plantation. This is theoretically kept clear of all vegetation except an open to continuous herbaceous layer of Stenotaphrum, Eragrostis, Lepturus, Tacca, Polypodium, and in less dense areas, other, mostly weedy, herbs. Actually, one observes different areas in all stages of regrowth of woody species including most of those mentioned above except Pemphis, Suriana, and Tournefortia, which thrive better along the coast. The luxuriance of the woody regrowth depends largely on how long the area has remained uncleared. A few large trees, especially Guettarda, are apparently purposely left standing in the plantation, but not many.

None of the vegetation except the Pemphis which grows on bare limestone rock can be said to be undisturbed, or natural in any accepted sense of the word. Disturbance is continuous and all vegetation may be regarded as pioneer or successional.

The village of the plantation workers is located at the north end of the main islet, in a bend of the lagoon shore. Almost directly opposite, across the land strip and just inland from the ocean beach ridge is the Meteorological Station, in a fenced yard. Both sites are shaded by planted and other trees, including Casuarina, Hibiscus, Calophyllum, and the various households tend little gardens. None of these appeared particularly flourishing in 1963. In spite of soil brought from Tahiti, the substratum seemed very poor and the plants unhealthy. They were perhaps also overly shaded by coconut palms. It must be remembered also that the people came from the Austral Islands, where conditions are quite different.

In addition to species included in the list of plants below, I noted the following: a red-flowered Hibiscus rosa-sinensis or a hybrid ornamental, sweet potatoes said to be of 2 varieties, a Capsicum with erect red fruit, 2 sickly tomato plants, small manioc plants (Manihot esculenta), a seedling mango (Mangifera indica) and avocado (Persea americana), and a tiny "mape" (Inocarpus edulis), "ti" (Cordyline fruticosa), Pedilanthus tithymaloides. None of these plants seemed likely to survive long, although a few belong to species which can grow on atolls with care. Other vegetables had been tried but had died. I was told that many Calophyllum trees had been knocked down, as well as some "miro" (Thespesia populnea), a species which I did not find anywhere.

Motu Petero: This is a tiny patch of sand and gravel, with an extension east and south of reef-platform, cut at its edges by erosion into small remnants. On this rock is a low dense cover of Pemphis scrub. Inside the Pemphis zone on the east and south is an expanse of sand with Suriana scrub. On the main body of the islet are a few planted Cocos with Tournefortia, Pisonia and Guettarda, forming a small patch of forest, with a fringe of small Tournefortia and Suriana around its west and north sides.

Between the S tip of the Main islet and Petero, and inside the protective barrier formed by older reef-rock remnants, stretches a low muddy flat usually free of water, in places somewhat elastic underfoot and covered with a putty-like layer of cyanophyceae ranging in color from dirty yellow to orange-brown and green below. When drier, this area feels sandier and the blackish crust of algae forms lumpy masses or curls in scaly patterns. Guilcher et al. (1969: 45) have compared this area to a small "sebkha" or desert drying salt hard pan. Here I collected Schizothrix calcicola and Calothrix confervicola (det. Jan Newhouse).

Of the slightly elevated reef remnants strung along the reef edge from Petero islet westward to the southernmost of the atoll, the last one, investigated by Guilcher et al. had a vegetation of Pemphis, Portulaca and Lepturus (personal communication).

MARINE VEGETATION AND FLORA

Observations made by the geographers on the role of algae in the formation of the Mopelia reefs were reported by Guilcher, Denizot and Berthois (1966) and repeated in Guilcher et al. (1969: 31). The authors consider that the pink outer reef crest is essentially veneered and cemented by Porolithon onkodes, rather smooth or only slightly undulating, and P. craspedium, more irregular or convoluted in surface, and found in slightly quieter situations. The Porolithon spp. become thicker when they overhang or even bridge over the edges of surge channels. The role of other algae in the reef flat is also described.

I made only a few casual observations and collections of marine algae as I walked across shallow reef flats from motu to motu. On the reef flat, around Motu Aveu, I noticed bouquets of Halimeda sp. on sandy substratum. Halimeda micronesica (det. Roy Tsuda) was collected under rocks on the reef near the Meteorological Station, as was Turbinaria ornata. Large pebbles on the reef were encrusted with a red alga (Cruoriopsis sp.?).

Obviously much work is needed on the marine flora of Mopelia, as indeed on the fauna.

FAUNA

Because nothing has been published as yet on the fauna of Mopelia, except for notes on the birds (Thibault, 1974; Holyoak, 1974), I will mention briefly the animals I saw during my stay. Among the fish, I only noted the small yellow sand sharks with a black spot on the dorsal fin (Carcharhinus melanopterus) cruising lazily in the shallow lagoon near Tavae islet or on the reef, and some flat fish (Bothus sp.) camouflaged on the shallow reef flat.

We were told by the plantation workers that green turtles were caught in some number, arriving in Sept.-Oct. into the lagoon and on beaches. They said they took about 200 a year, all females; one person who had lived on Scilly for a number of years reported that turtles were much more numerous there, and that many were taken, possibly too many. A skink was extremely abundant in the plantation and elsewhere, the larger ones having an azure stripe on the tail (Emoia cyanura). Two geckos were common also, one of them especially so in buildings. Lizard eggs were observed in assorted hiding places such as cracks in cupboards and drawers, old coconuts, under tree bark or even under small rocks on the ground. I collected Lepidodactylus lugubris, Emoia cyanura and Cryptoblepharus boutonii (determined by George Zug, who also kindly gave me the names in current use for all the lizards).

During his visits to Mopelia and Scilly atolls, E. H. Quayle observed and collected reptiles and his specimens were identified by Ortenburger (1923): a sea turtle, Chelonia mydas (as C. japonica), from Scilly; geckos, Gehyra mutilata (as Peropus mutilatus) from Mopelia, Gehyra oceanica from both atolls, Lepidodactylus lugubris from Scilly, and skinks, Lipinia noctua (as Leiolopisma noctua), Emoia cyanura and Cryptoblepharus boutonii (as C. poecilopleurus), all from both atolls.

According to Legand (1950:172), turtle eggs were collected and the young turtles raised in pens on Mopelia for later release. This experiment lasted only for a short time.

Birds were very abundant especially on the smaller motus. The reef heron occurred near the shore, or even far out on the reef flat at the edge of the surf, on the Main islet and off Aveu. I saw 5 together near Petero, on the reef, 2 dark gray-blue, 2 white and one with blue spots, all with yellow legs. Elsewhere I had noticed only one or 2, all white or all dark, but the spotted phase was also mentioned by the weather observer ("le météo") from Bora-Bora, who called the herons "otu'u." Other shore birds included curlews (Numenius tahitiensis) called kivi by the workers and golden plovers (Pluvialis dominica fulva) seen foraging on the lagoon shore or walking in the plantation. Also on shore, some yellow-legged grayish birds which may have been wandering tattlers (Heteroscelus incanus).

Of land birds I saw only a few mynah birds (Acridotheres tristis) in the village, and a long-tailed bird in a coconut palm which must have been the New Zealand cuckoo (Eudynamis taitensis). Quayle, in 1921, observed the vini (Vini peruviana) in small numbers on Mopelia, but it was nowhere to be seen in 1963. Chickens were kept in the village.

Seabirds: several species were present in large numbers.

Frigate birds (Fregata sp.) were observed flying and chasing boobies and tropic-birds to steal their fish. They were nesting in Pemphis trees and one very small naked chick and some downy young were observed, as well as one with white neck and breast and rusty head sitting in a tree. Many more birds could be seen but the nests could not be inspected.

Brown boobies (Sula leucogaster) were seen mostly around the bird islets on the NW side. Their nests, on sand or small gravel, were large, sometimes 10-15 cm thick, and made up of coconut husks, branches or plants of Portulaca, twigs and leaves of Pisonia and Tournefortia, and contained eggs or naked and downy chicks. Red-footed boobies (Sula sula rubripes) nest in the Pemphis shrubs or trees between Motu Aveu and the main islet and on the lagoon side of the main islet; on Petero islet, they sat in Pemphis but also in Tournefortia trees. The largest number were on Motu Tavae and the various bird islets, with large chicks and dark colored flying juveniles. I could not look into the nests for eggs or small chicks.

Red-tailed tropic-birds (Phaethon rubricauda) were fairly numerous on Mopelia. The plantation workers pulled out their red tail feathers and showed me large bunches of them. The birds were seen flying but mostly sitting in nests on Motu Manu and Motu Tavae. Large chicks, downy with white and black speckled wings and a strong black beak, sat under low Tournefortia tree branches, waiting for parents. On Motu Tavae, downy chicks, some very small, were hidden under large roots or horizontal tree limbs. To reach them, the parent birds had to crawl and drag themselves through tangled vegetation from their landing and taking off areas in the open.

Among the terns, the sooty terns (Sterna fuscata) were the most abundant, roosting and nesting in open areas among all the bird islets. A large colony with eggs sat on islets 1 and 2, another with eggs and tiny chicks on the next 2 islets and along the edges of Motu Manu and along the Pass.

The brown noddies (Anous stolidus) were not observed nesting. They flew over the lagoon and reefs or sat on reef remnants along the shore near Motu Aveu and S of Petero, all pointing into the wind.

The crested tern (Thalasseus bergii) fished singly or in small groups, patroling the lagoon shores of the main islet. A few were seen sitting on rocks S of Petero. Between bird islets 2 and 3, they sat on an open gravel bank, black crest erect, with one or two small chicks.

The most familiar and inquisitive of all the birds, the fairy terns (Gygis alba) occurred in small groups near Motu Manu and other bird islets. One at least had a downy chick in camouflage plumage, digging its sharp claws into the branch where it had hatched. The fairy terns flew over the reef and lagoon, and fluttered in the plantation and near buildings, visiting and examining everything.

Rats were present, as evidenced by holes chewed in fallen coconuts. I only saw 2, one on Motu Manu, and on Motu Tavae a small brownish one with a long tail which I took to be Rattus exulans, the Polynesian rat.

The plantation workers kept a number of pigs, wandering about the village and the plantation. Some had been given an armload of Portulaca sp. to eat. There were a dog and a cat or two.

Among land invertebrates, commonly seen insects were: mosquitoes (including Aedes polynesiensis), flies, including a bright metallic green one in grassy areas, wasps with small papery nests, ants, small moths, a black butterfly with blue spots (Hypolimnas sp.?) from Cordia, dragon flies with thick red bodies, beetles, a delicate green grasshopper and cockroaches. I observed many small spiders, an isopod, diplopods and a few earthworms. A few of these were collected but not yet named. Scolopendra morsitans is reported to be present, but I did not see it. Hermit-crabs were very common, I collected at least 2 species of Coenobita. The large red ones in their Turbo shells often piled up in the shade or among roots of shrubs, especially Tournefortia and could be found climbing up to 1 m or more in the trees. Coconut crabs (Birgus latro) were reported.

From an old coconut and dark soil and litter under *Guettarda* I collected tiny land molluscs (all det. H. A. Rehder): *Assiminea* sp., *Lamellidea pusilla* (Gould), *Gastrocopta pediculus* (Shuttleworth), *Opeas gracile* (Hutton), and *Opeas oparanum* (Pfeiffer). With these were 2 marine gastropods: *Bittium zebrum* (Kiener) and *Mitrella rosida* (Reese).

Marine Mollusca

by Harald A. Rehder, Smithsonian Institution

The following list of 64 species comprises all the species collected by my wife Lois and me on Mopelia, or recorded from there by Dautzenberg and Bouge (1933). These authors listed 27 species as occurring on this atoll. I have marked with an asterisk those species listed by them that we did not find during our brief stay on Mopelia of only one day in April 1973. I have cited in the synonymy of certain species the names given by Dautzenberg and Bouge that are not now in current use.

It goes without saying, of course, that this list is in no way complete, as more extensive collecting would considerably increase it.

Patella (Scutellastra) flexuosa Quoy & Gaimard
Patella stellaeformis var. tuamotuensis Gould (emend.)

Turbo (Senectus) setosus Gmelin

Astralium confragosum (Gould)

Littorina (Littoraria) coccinea (Gmelin)

**Littorina (Littorinopsis) scabra* (Linné)

Tectarius grandinatus (Gmelin)
Tectarium (Echinella) bullatum Martyn

Nerita plicata Linné

Rhinoclavis cedonulli (Sowerby)

Cerithium alveolus Hombron & Jacquinot

Cerithium columna Sowerby

Cerithium salebrosum Sowerby

Cerithium nesioticum Pilsbry & Vanatta

Sabia conica (Schumacher)

Strombus mutabilis Swainson

Cypraea caputserpentis Linné

Cypraea moneta Linné

Cypraea obvelata Lamarck

Cypraea maculifera Schilder

Cypraea depressa Gray

Cypraea ventriculus Lamarck

Bursa granularis Röding

*Cymatium mundum (Gould)

Thais (Thalessa) armigera (Link)

Drupa ricinus (Linné)
Ricinula ricinus var. arachnoides Lamarck

Drupa morum Röding
Ricinula horrida Lamarck

Drupa (Ricinella) clathrata Lamarck
Ricinula clathrata var. miticula Lamarck

Drupa (Drupina) grossularia Röding
Ricinula digitata Lamarck

Morula granulata Duclos
Sistrum tuberculata Blainville

Morula uva (Röding)

Muricodrupa fenestrata (Blainville)
Muricodrupa cariosa Wood

*Pascula species
Sistrum cavernosa Reeve

This is not Pascula ochrostoma (Blainville) but an undescribed species found in Micronesia and Polynesia.

Maculotriton serriale (Laborde)
Colubraria digitalis Reeve

Pollia undosa (Linné)

Peristernia nassatula (Lamarck)

*Mitra mitra (Linné)
Mitra mitra-episcopalis Linné

Mitra (Strigatella) litterata Lamarck

*Vexillum (Pusia) emiliae Garrett

*Vasum ceramicum (Linné)

Conus ebraeus Linné

Conus chaldaeus Röding

Conus miliaris Hwass

Conus nanus Sowerby

Conus sponsalis Hwass

Conus aristophanes Sowerby

Conus lividus Hwass

Conus miles Linné

Conus catus Hwass

*Conus pulicarius Hwass

Conus tulipa Linné

Conus canonicus Hwass

*Conus coronatus Gmelin

*Terebra crenulata Linné

Terebra maculata Linné

Arca zebra Bruguière

Hyotissa numisma (Lamarck)

Isognomon perna (Lamarck)

Isognomon concisum (Conrad)

Chama cf. spinosa Broderip

Chama species

Codakia (Epicodakia) bella (Conrad)

Tridacna maxima Röding

Gafrarium pectinatum (Linné)

Arcopagia (Scutarcopagia) scobinata (Linné)

Macoma (Scissulina) dispar (Conrad)

TERRESTRIAL FLORA

General observations

The native flora of Mopelia seems fairly typical for a coral atoll, though perhaps rather impoverished, as do those of the other two westernmost atolls of the Society Is., Scilly and Bellingshausen. The species present are all to be expected, with no surprises. 85 species are reported here from Mopelia, 35 of them probably native. The weed-flora of 30 species is large and indicates intense human influence. The planted species, 15 in number, are surprisingly few but reflect the transient nature of the human population.

More species could probably be found, both native and exotic, especially considering that I had very little time on one of the richer islets, Tavae. Some atoll species have a very limited or spotty distribution, and can easily be missed during a brief survey.

It is curious that so few of the phytogeographically interesting plants of the coral islands of eastern Polynesia are present on Mopelia. *Digitaria stenotaphrodes*, *Timonius polygamus*, *Heliotropium anomalum*, and *Solanum uporo* are all present, but as many others that might have been expected, were not found. Among those missing may be mentioned *Sesbania coccinea*, *Nesogenes euphrasioides*, *Terminalia samoensis*, *Nervillia aragoana* and *Hedyotis romanzoffiensis*. Mopelia, like the other four Society Islands atolls, apparently lacks any trace of elevated limestone, which might add a further set of species not usually found on low atolls.

A further visit to Mopelia would be desirable to examine more thoroughly areas not well covered in 1963, and to observe and assess any changes in the flora, additional weeds, or plants that have disappeared, and other effects of 20 more years of human activities.

Systematic List

In the following list, I have cited all the plants I collected or observed on Mopelia in 1963. All my specimens are deposited in the U.S. National Herbarium in Washington (US), with almost complete sets of duplicates at the B. P. Bishop Museum in Honolulu (BISH) and the Paris Herbarium (P). Another set, left in Tahiti, was destroyed by insects. An asterisk * before a name indicates that the plant was introduced by human activities.

I have in preparation a chapter on the plants of Scilly Atoll intended for a volume, edited by B. Salvat, on his research team's study of that island in January 1979. In addition to the plants then observed and cited in a preliminary report, that enumeration will include those listed by Papy (1956: 180-183) and the only specimens extant, collected by E. Quayle in Dec. 1921 - Jan. 1922. Considering how little has been published on the three atolls, I decided to include here with the Mopelia plants abbreviated records from the Scilly list, and sight records made on Bellingshausen Atoll by Pickering in Dec. 1839 and by Papy.

BRYOPHYTA

Calymperes quaylei Bartr.

Scilly (coll.).

Calymperes tuamotuense Bartr.

Main islet, south tip, Sachet 977.

Common on some tree trunks and on ground. Only seen sterile and dried.

Leucophanes cf. albescens C.M.

Main islet, south tip, Sachet 978.

On a coconut trunk. Silvery, seen only sterile and dried.

PTERIDOPHYTA

POLYPODIACEAE

Asplenium nidus L.

Motu Tavae, Sachet 975.

Common locally, mostly growing on piles of coconut husks in forest, coral ground.

Scilly (sight).

Nephrolepis hirsutula (Forst. f.) Presl

Main island, between village and middle of length of islet, Sachet 908.

Occasional in large clumps along road, in coconut plantation. This growing on pile of husks.

Polypodium scolopendria Burm. f.
Polypodium phymatodes L.

Main islet, in coconut plantation, coral ground, Sachet 959.

Very common everywhere.

Scilly (coll.), Bellingshausen (Pickering).

PHANEROGAMIA

PANDANACEAE

Pandanus tectorius Park.

Main islet, south tip, Sachet 979.

Keys found under tree. Found everywhere.

Scilly (sight), Bellingshausen (Pickering, Papy).

POACEAE (GRAMINEAE)

Cenchrus echinatus L.

Main islet, in coconut plantation, coral ground, Sachet 929.

One small patch along road.

Scilly (sight), Bellingshausen (Papy).

Digitaria stenotaphrodes (Nees) Stapf

Main island, between village and middle of length of islet, Sachet 910.

Common along road and cuts in coconut plantation. (Also just back of strand.)

**Eragrostis tenella* (L.) Beauv.

Main islet, in coconut plantation, coral ground, Sachet 928.

Common in ground cover.

Lepturus repens (Forst. f.) R. Br. var. *repens*

Main islet, Sachet 990.

Common on sand or gravel, planted in village. Tufted, spike-joints about 1 mm thick, glume acuminate but scarcely subulate, 7-8 mm long.

Scilly (sight), Bellingshausen (Pickering, Papy).

Lepturus repens var. *subulatus* Fosb.

Main islet, in coconut plantation, coral sand, Sachet 923.

Common in ground cover.

*Saccharum officinarum L.

Main islet, a few sickly plants cultivated in imported soil.

*Sporobolus fertilis (Steud.) Clayton

Main islet, in coconut plantation, coral ground, Sachet 925.

Occasional in ground cover and on roadside.

Stenotaphrum micranthum (Desr.) Hubb.

Main islet, in coconut plantation, coral ground, Sachet 926.

Common in ground cover.

Thuarea involuta (Forst.) R. & S.

Main island, between village and middle of length of islet, Sachet 907.

Occasional in patches along road through coconut plantation.

Scilly (coll.), Bellingshausen.

CYPERACEAE

Cyperus javanicus Houtt.

Motu Tavae, forming large patch in clearing around buildings, Sachet 914.

Fimbristylis cymosa R. Br. var. pycnocephala (Hbd.) Kük. ex F. Br.

Main islet, in coconut plantation, coral ground, Sachet 961.

Very common in paths (also at top of beaches). Has compact, button-like head, styles with either 2 or 3 branches, predominantly 3, achenes mostly trigonous, smooth.

Scilly (coll.).

ARECACEAE (PALMAE)

*Cocos nucifera L.

Planted over most of main islet and some smaller ones.

Scilly, Bellingshausen (Papy, but absent in 1839 according to Pickering).

LILIACEAE s. l.

*Crinum asiaticum L.

Main islet, Sachet 984.

Planted in village, forming hedge.

Scilly (sight).

TACCACEAE

Tacca leontopetaloides (L.) O. Ktze.

Main islet, in coconut plantation, coral ground, Sachet 963.

Common locally in undergrowth.

Scilly (sight).

MUSACEAE

*Musa sp.

Main islet, several plants seen, with one tiny bunch of bananas; in village.

Scilly (sight).

CASUARINACEAE

*Casuarina equisetifolia L.

Main islet, in coconut plantation, coral ground, Sachet 936.

Planted as hedge at Weather Station, on ocean side.

MORACEAE

*Artocarpus altilis (Park.) Fosb.

Main islet, Sachet 967.

A few trees planted near village.

URTICACEAE

Laportea ruderalis (Forst. f.) Chew

Main islet, in coconut plantation, Sachet 942.

Common locally in ground cover.

Scilly (coll.), Bellingshausen (Pickering).

OLACACEAE

Ximenia americana L. var. *americana* (det. R. deFillips 1968)

Motu Tavae, Sachet 913.

Two plants seen at edge of forest, perhaps planted.

NYCTAGINACEAE

Boerhavia tetrandra Forst. f.

Main islet, Sachet 968.

Occasional in ground cover in coconut plantation, coral ground.

South tip, Sachet 970.

Common in ground cover in coconut plantation and dense forests.

Scilly (coll.), Bellingshausen (Pickering, Papy).

Pisonia grandis R. Br.

Main islet, in coconut plantation, coral ground, Sachet 962.

Occasional, remaining among coconut palms.

Bellingshausen ? (Pickering).

AMARANTHACEAE

Achyranthes velutina H. & A.

Main islet, south tip, Sachet 971.

Common in undergrowth in coconut planation and dense forests; coral ground.

Bellingshausen (Pickering).

**Amaranthus viridis* L.

Main islet, Sachet 966.

Only a few plants seen in yard.

PORTULACACEAE

Portulaca johnii v. Poelln.

Main islet, south tip, Sachet 973.

Common in ground cover in recent plantation and dense forest; coral ground.

Portulaca spp.

Scilly (sight), Bellingshausen (Pickering, Papy).

LAURACEAE

Cassytha filiformis L.

Main islet, in coconut plantation, coral ground, Sachet 958.

Very common everywhere.

Scilly (coll.), Bellingshausen (Pickering, Papy).

HERNANDIACEAE

Hernandia sonora L.

Main islet, in coconut plantation, coral sand, Sachet 915.

Only one tree seen near ocean shore at edge of plantation.

BRASSICACEAE (CRUCIFERAE)

Lepidium bidentatum Montin
Lepidium piscidium Forst.

Main islet, in coconut plantation, Sachet 940.

Occasional in undergrowth, Main islet, south tip, Sachet 976.

Diseased plants forming occasional patches.

Scilly (coll.), Bellingshausen (Pickering, Papy).

FABACEAE (LEGUMINOSAE)

*Albizia lebbeck (L.) Benth. ?

Main islet, Sachet 980.

A few individuals planted in weedy area around village in coconut plantation; coral ground.

*_Crotalaria incana_ L.

Main islet, in coconut plantation, coral sand, _Sachet 919_.

In weedy area, near village, occasional.

*_Crotalaria verrucosa_ L.

Main islet, in coconut plantation, coral ground, _Sachet 935_.

Occasional in weedy area near village.

*_Desmodium incanum_ DC.

Main islet, in coconut plantation, coral ground, _Sachet 930_.

Occasional in weedy areas.

*_Desmodium triflorum_ (L.) DC.

Main islet, in coconut plantation, coral ground, _Sachet 934_.

One patch seen in weedy area near village.

*_Indigofera spicata_ Forsk.

Main islet, in coconut plantation, coral ground, _Sachet 937_, forming mat in open area in yard under coconuts; _938_, in weedy area near village.

*_Leucaena leucocephala_ (Lam.) deWit

Main islet, in coconut plantation, coral sand, _Sachet 920_.

Occasional in weedy area near village.

*_Mimosa pudica_ L.

Main islet, in coconut plantation, coral ground, _Sachet 952_.

Common in weedy area near village.

*_Phaseolus lathyroides_ L.

Main islet, in coconut plantation, coral ground, _Sachet 932_.

Occasional in weedy area near village.

*_Rhynchosia minima_ DC.

Main islet, in coconut plantation, coral ground, _Sachet 933_.

One large clump in weedy area near village.

Vigna marina (Burm.) Merr.

Main islet, in coconut plantation, coral ground, Sachet 964.

Common near shores.

RUTACEAE

**Citrus aurantifolia* (Christm.) Swingle

Main islet, one small spineless lime tree seen, said to have been brought from the Leeward Islands.

Scilly (sight).

SURIANACEAE

Suriana maritima L.

Motu Manu, on coral sand, along shore, Sachet 912.

Scilly (coll.), Bellingshausen (Pickering).

EUPHORBIACEAE

**Euphorbia hirta* L.

Main islet, in coconut plantation, coral sand, Sachet 924.

Common in ground cover.

Scilly (sight).

**Euphorbia thymifolia* L.

Main islet, in coconut plantation, coral ground, Sachet 956.

Local in weedy yard.

**Phyllanthus amarus* Schum. & Thonn.

Main islet, in coconut plantation, coral ground, Sachet 954.

Local in weedy area near village.

Scilly? (sight).

SAPINDACEAE

*<u>Cardiospermum halicacabum</u> L.

Main islet, in coconut plantation, <u>Sachet 943</u>.

Local in weedy area near village.

*<u>Pometia pinnata</u> Forst.

Main islet, <u>Sachet 987</u>.

One small tree planted in village.

RHAMNACEAE

<u>Colubrina asiatica</u> (L.) Brongn.

Main islet, in coconut plantation, coral sand, <u>Sachet 922</u>.

Only one shrub seen in weedy area near village.

TILIACEAE

<u>Triumfetta procumbens</u> Forst.

Main islet, in coconut plantation, coral ground, <u>Sachet 960</u>.

Very common everywhere.

Scilly (coll.).

*<u>Triumfetta rhomboidea</u> Jacq.

Main islet, in coconut plantation, coral sand, <u>Sachet 921</u>.

Only one plant seen in weedy area near village.

MALVACEAE

<u>Hibiscus tiliaceus</u> L.

Main islet, <u>Sachet 917</u>.

Planted along lagoon near village, probably native on smaller islets; in coconut plantation.

Scilly (sight).

*Malvastrum coromandelianum (L.) Garcke

Main islet, in coconut plantation, Sachet 945.

Local in weedy area near village.

*Sida rhombifolia L.

Main islet, in coconut plantation, coral ground, Sachet 951.

Common in weedy area near village.

BOMBACACEAE

*Ceiba pentandra (L.) Gaertn.

Main islet, 2 small very chlorotic plants seen in village.

STERCULIACEAE

*Waltheria indica L.

Main islet, in coconut plantation, coral ground, Sachet 950.

Occasional in undergrowth, very common near village.

CLUSIACEAE (GUTTIFERAE)

Calophyllum inophyllum L.

Main islet, single tree in coconut plantation, Sachet 939.

Others apparently planted in village.

Scilly (sight).

CARICACEAE

*Carica papaya L.

Main islet, a few planted in village, bearing fruit.

Scilly (sight).

LYTHRACEAE

Pemphis acidula Forst.

Main islet, Sachet 981.

Occasional (common elsewhere on coral rock).

Scilly (coll.), Bellingshausen (Pickering, Papy).

COMBRETACEAE

*<u>Terminalia</u> <u>catappa</u> L.

Main islet, one tree, planted in village, <u>Sachet 985</u>.

Scilly (sight).

APOCYNACEAE

*<u>Catharanthus</u> <u>roseus</u> (L.) G. Don

Main islet, in village, seen planted in garden, a white form "pervenche".

CONVOLVULACEAE

<u>Ipomoea</u> <u>macrantha</u> R. & S.

Main islet, in coconut plantation, coral sand, <u>Sachet 916</u>.

Occasional, climbing over shrubs.

Scilly (coll.), Bellingshausen (Papy).

BORAGINACEAE

<u>Cordia</u> <u>subcordata</u> Lam.

Main islet, <u>Sachet 986</u>.

Trees planted in village, others occasional in coconut plantation.

Scilly (sight), Bellingshausen (Papy).

<u>Heliotropium</u> <u>anomalum</u> H. & A. var. <u>anomalum</u>

Main islet, in coconut plantation, <u>Sachet 941</u>.

Occasional in undergrowth. Also found in bare sand at top of beaches.

Scilly (sight), Bellingshausen (Pickering, Papy).

<u>Tournefortia</u> <u>argentea</u> L.f.

Main islet, <u>Sachet 983</u>.

Common at top of beach (also inside forest), on beach ridge; coral cobbles.

Scilly (coll.), Bellingshausen (Pickering, Papy).

VERBENACEAE

*<u>Lantana</u> <u>camara</u> var. <u>aculesta</u> (L.) Moldenke

Main islet, in coconut plantation, <u>Sachet 944</u>.

Occasional in weedy area near village.

*<u>Stachytarpheta</u> <u>urticaefolia</u> Sims

Main islet, in coconut plantation, coral ground, <u>Sachet 949</u>.

Common in undergrowth, especially near village.

Scilly (sight).

LAMIACEAE (LABIATEAE)

*<u>Ocimum</u> <u>basilicum</u> L.

Main islet, a few planted in village, <u>Sachet 989</u>.

SOLANACEAE

*<u>Capsicum</u> <u>frutescens</u> L.

Main islet, one plant, planted in village, <u>Sachet 988</u>.

<u>Solanum</u> <u>uporo</u> Dunal

Main islet, in coconut plantation, coral ground, <u>Sachet 955</u>.

One shrub seen; many more at south end of islet and on Motu Tavae.

Scilly ? (sight), Bellingshausen ? (Papy).

RUBIACEAE

*<u>Gardenia</u> <u>taitensis</u> DC.

Main islet, in coconut plantation, coral sand, <u>Sachet 918</u>.

Planted around village.

Scilly (sight).

Guettarda speciosa L.

Main islet, south tip, <u>Sachet 972</u>.

Common everywhere on atoll in coconut plantation and dense forest; coral ground.

Morinda _citrifolia_ L.

Main islet, _Sachet 974_.

Common in coconut plantation, coral ground.

Scilly (sight).

Timonius _polygamus_ (Forst. f.) Rob.

Main islet, in coconut plantation, coral ground, _Sachet 957_ (male).

Occasional in undergrowth; also on boulder fields on ocean shore, _Sachet 969_ (female).

Occasional on boulder field above ocean level (with _Scaevola_ and other shrubs), also in coconut plantation.

Scilly (coll.), Bellingshausen (Pickering).

GOODENIACEAE

Scaevola _sericea_ var. _tuamotuensis_ (St. John) Fosberg
_S._ _taccada_ (Gaertn.) Roxb.

Main islet, _Sachet 982_.

Very common at top of beach on beach ridge, coral cobbles; also in coconut plantation.

Scilly (coll.), Bellingshausen (Pickering, Papy).

CAMPANULACEAE

*_Hippobroma_ _longiflora_ (L.) G. Don

Main islet, in coconut plantation, coral ground, _Sachet 948_.

Occasional in weedy area around village.

ASTERACEAE (COMPOSITAE)

*_Ageratum_ _conyzoides_ L.

Main islet, in coconut plantation, coral ground, _Sachet 946_.

Local in weedy area around village.

*Bidens pilosa L.

Main islet, in coconut plantation, coral ground, Sachet 927.

Occasional along road.

*Blumea sinuata (Lour.) Merr.

Main islet, in coconut plantation, coral ground, Sachet 945a.

See Fosberg and Sachet, Micronesica 2:159, 1966 [1967].

*Elephantopus mollis HBK.

Main islet, in coconut plantation, coral ground, Sachet 953.

Occasional in weedy area near village.

*Synedrella nodiflora (L.) Gaertn.

Main islet, in coconut plantation, coral ground, Sachet 947.

Local in weedy area around village.

*Vernonia cinerea (L.) Less. var. parviflora (Bl.) DC.

Main islet, in coconut plantation, coral ground, Sachet 931.

Occasional in weedy areas.

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Fig. 1. View of Aveu Islet from lagoon, with emerged reef-remnants along reef to right of islet.

Fig. 2. Emerged remnants of former higher reef surface on reef between Aveu Islet and main islet, <u>Pemphis acidula</u> scrub on remnants in middle distance.

Fig. 3. Outer edge of reef, with surge channels between remnants of a former algal ridge. Main islet.

Fig. 4. North end of main islet, with slightly elevated consolidated platform on left, showing intertidal "notch" or "nip", and present reef surface at center and right, slightly exposed at low tide.

Fig. 5. Reef surface between main islet and Aveu Islet, showing "micro-atolls" of Porites (?) and mushroom-like remnants of former higher reef surface.

Fig. 6. Reef flat with eroded higher reef surface, deep inter-tidal notches, exposed surfaces blackened by endolithic blue-green algae, west end of Tavae Islet.

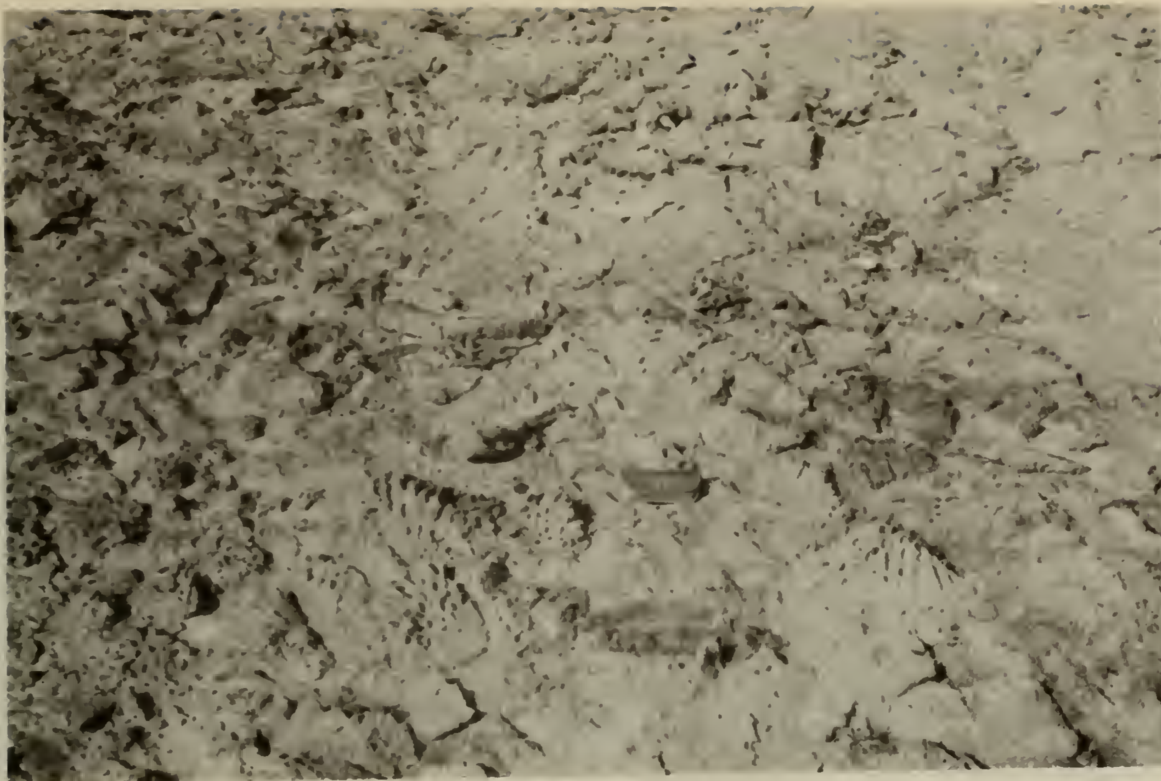

Fig. 7. Eroded surface of consolidated elevated reef-conglomerate, showing cemented corals, between main islet and Aveu Islet.

Fig. 8. Slightly submerged reef surface near Petero Islet, showing camouflaged flat-fish, Bothus sp., lying on rock surface.

Fig. 9. Bare shingle ridge or berm on northeast reef facing ocean.

Fig. 10. Outer reef-flat and shingle beach ridge on E side of main islet, coconut plantation back of ridge, fringed by *Suriana maritima* and *Scaevola sericea* with some scattered *Timonius polygamus* shrubs.

Fig. 11. Abraded beach-rock beds, N shore of Tavae Islet, forest of Tournefortia and Pisonia with scattered coconut palms in background.

Fig. 12. Eroded remnants of fossil beach-rock beds with an older reef-rock remnant farther out, same locality as Fig. 11.

Fig. 13. Tournefortia argentea on sand-flat back of beach, tufts of pioneering Lepturus repens at top of coral sand and gravel beach, on Motu Manu lagoon side.

Fig. 14. Pemphis acidula forest with nesting frigate birds on Motu Manu.

Fig. 15. *Pemphis acidula* forest on slightly elevated reef-rock platform on "bird islet" along pass.

Fig. 16. Depressed *Pemphis acidula* dwarf scrub on exposed rock flat between S end of main islet and Petero Islet, latter in background. This and Fig. 15 show extremes in growth habit of *Pemphis*.

Fig. 17. Passage between "Bird islets", eroded reef-rock surface in foreground.

Fig. 18. Bird islet no. 5 seen from Pass, with Pemphis forest on slightly elevated reef-rock surface, Monument Goëlette Zélée on rock platform in front.

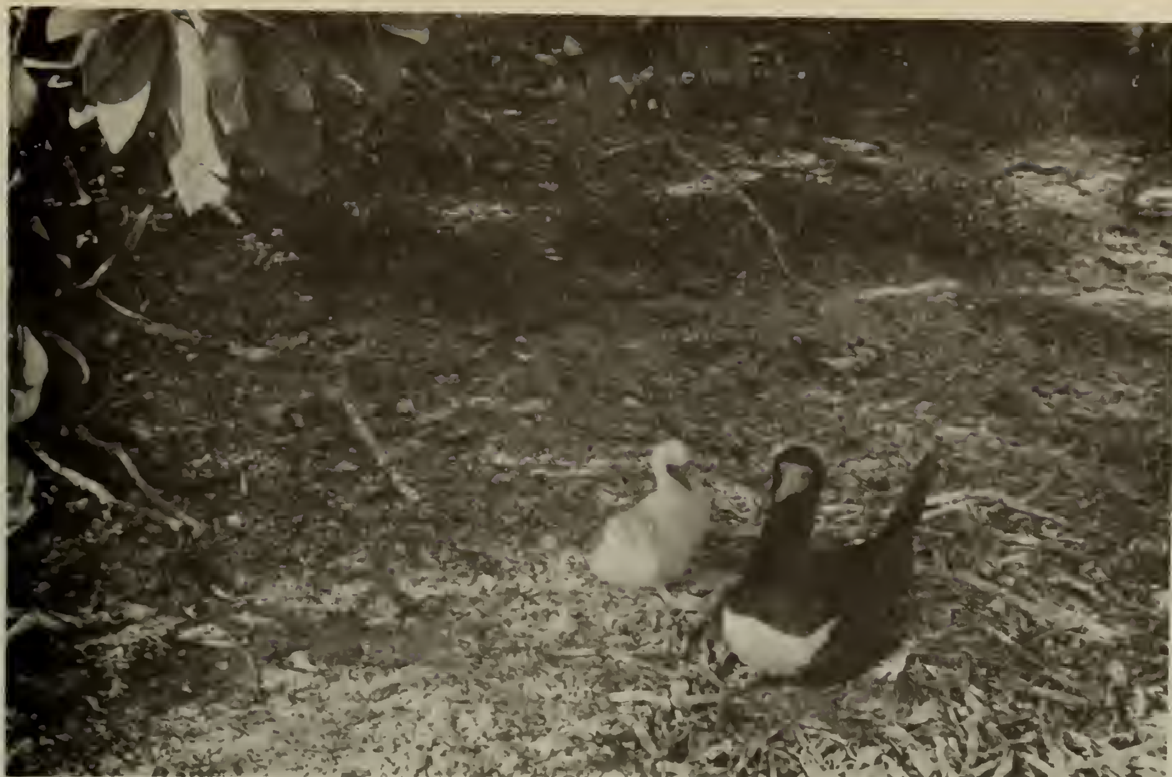

Fig. 19. Brown booby (Sula leucogaster) with downy young, nesting on ground in Tournefortia forest opening, on Bird islet no. 5.

Fig. 20. Red-tailed tropic-bird (Phaëthon rubricauda) nesting on ground in shelter of a fallen Tournefortia tree on Bird islet no. 5.

Fig. 21. Shingle beach on E (ocean) side of main islet, coconut plantation back of Suriana maritima fringe at top of beach, scattered Scaevola (prostrate), Timonius, and Suriana, on beach slope.

Fig. 22. Detail of Fig. 21: Suriana maritima and Tournefortia (back), and Timonius polygamus in foreground.

Fig. 23. Pandanus tectorius - Tournefortia argentea forest, with scattered coconut palms, top of sand beach, N shore of Tavae Islet.

Fig. 24. Old, slightly elevated rock platform, much eroded and broken up, protruding from under sand beach with Tournefortia - Pisonia - Pandanus forest on NW Tavae Islet.

Fig. 25. Interior of _Guettarta_ - coconut forest with ferns _Asplenium nidus_ and _Polypodium scolopendria_ on Tavae Islet.

Fig. 26. Mixed broad-leaf forest with _Polypodium scolopendria_ in opening in foreground, interior of Tavae Islet.

Fig. 27. Guettarda speciosa in foreground, Pandanus tectorius showing prop-roots and litter, interior of Tavae Islet.

Fig. 28. Sparse coconut plantation with Pandanus, interior of south end of main islet.

Fig. 29. S. end of main islet, _Pisonia_ trees growing from fallen trunk, thick lianas of _Ipomoea macrantha_.

Fig. 30. Coral cobbles ridge on E (ocean) shore of main islet, with _Scaevola sericea_ var. _tuamotuensis_ and _Suriana maritima_; coconut plantation and _Guettarda_ in background.

ATOLL RESEARCH BULLETIN

No. 275

AN ECOLOGICAL RECONNAISSANCE OF TETIAROA ATOLL, SOCIETY ISLANDS

BY

M.H. SACHET AND F. R. FOSBERG

ISSUED BY

THE SMITHSONIAN INSTITUTION

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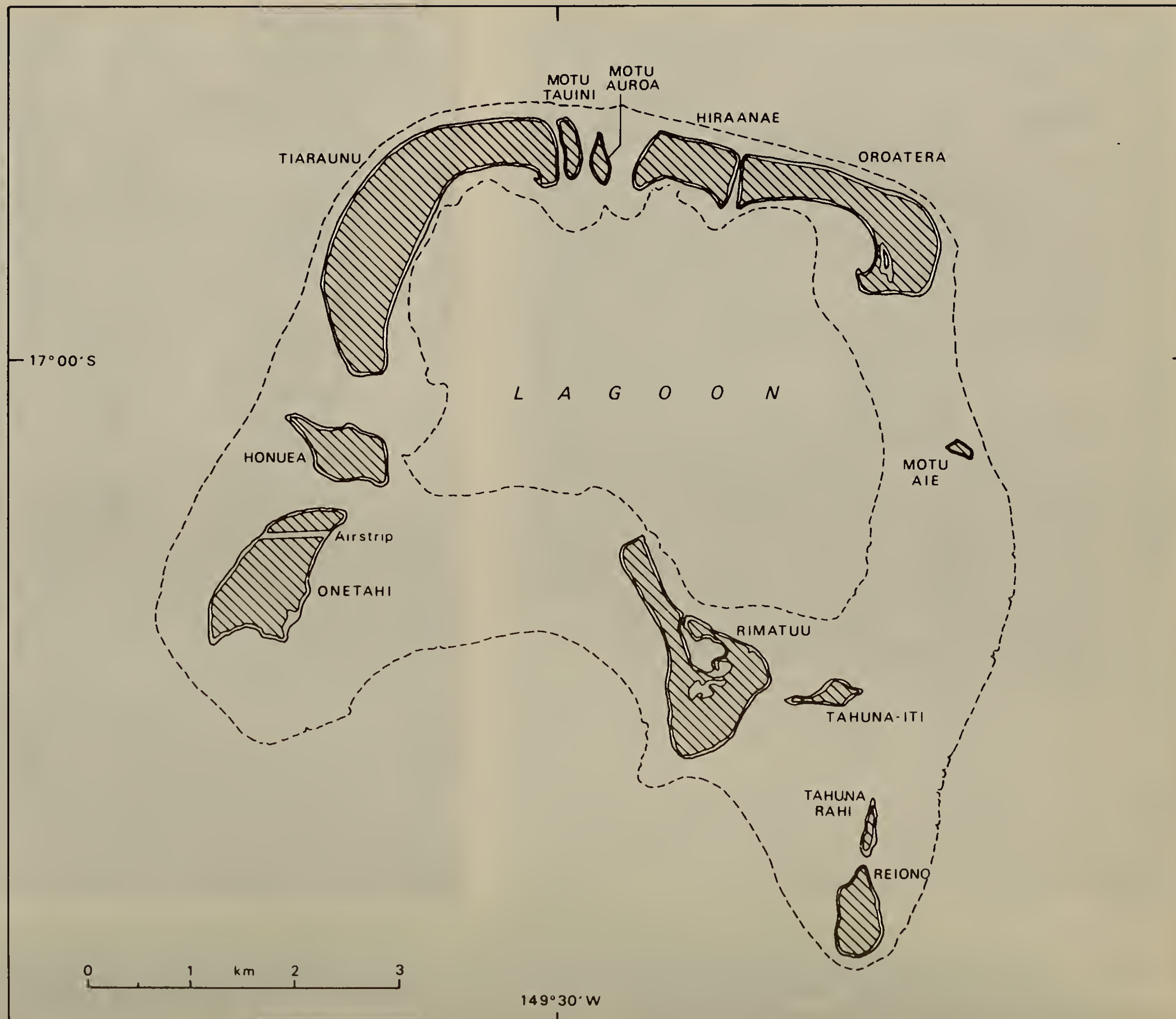

Fig. 1. Tetiaroa Atoll.

AN ECOLOGICAL RECONNAISSANCE OF TETIAROA ATOLL, SOCIETY ISLANDS

BY

M.H. SACHET AND F. R. FOSBERG[1]

PREFACE

This paper is a somewhat revised and updated version of a report, written in 1973 after our 9-day visit, at the request of Mr. Marlon Brando, proprietor of Tetiaroa Atoll, and published here with his accord. The original version was based on that visit to the atoll, as explained in the introduction. It was supplemented by a few observations culled from herbarium specimens and field notes of Dr. Gerrit Wilder, who visited the island briefly on March 12, 1925 and August 30, 1929, and of E. H. Quayle, of the Whitney Expedition, who stopped there on November 19-21, 1921.

In 1974-1975, at the turn of the year, one of us (Sachet) paid a second visit, during a very rainy period which limited work, especially collecting. In 1982 we paid a third visit of three days, July 27-29, and in 1983 one of us (Sachet) again visited it in March. All of our visits were made possible by Mr. Brando and his staff, to whom we are most grateful. We wish to remember especially Reiko Sato's help. Her knowledge and understanding of the atoll were remarkable and her long stays there provided a valuable continuity in observations.

The report has been revised to note some changes, additional plant records, and other observations, but still retains the character of information, comments, and recommendations that might be useful in the management of the atoll. We are glad to note that, notwithstanding the greatly increased number of tourist visits, only the areas in the vicinity of the Visitor Center, on the north third of Onetahi Islet and on Honuea Islet across a narrow channel, have been conspicuously changed from their condition in 1973, and some recommendations have been successfully implemented.

For this revision we have also had the benefit of information gathered by several visitors, not available to us in 1973.

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During his 14-months stay in French Polynesia (1949-1950), R. Papy visited Tetiaroa and gave a brief description of its vegetation (1956: 178-179). J.-N. Maclet spent Aug. 23-24, 1972, there and a list of trees, shrubs and herbs was prepared for the Service de l'Economie Rurale. Shortly after our March 1973 survey, Jean Raynal, of the Paris Herbarium collected plants - including some we had missed (June 27-29, 1973). Finally, just before our July 1982 visit, J. Florence with M. Guérin made a quick visit and collection. We have seen only part of these specimens.

The references listed at the end of the text do not all specifically deal with Tetiaroa, but some of them are principal general sources of information on atolls that might be of interest to readers wanting to know more about these fascinating bits of land.

I. INTRODUCTION

Late in 1972 Mr. Marlon Brando, owner of Tetiaroa Atoll, spent several hours at our office in the Smithsonian Institution with some of his advisors, discussing coral atoll ecology and his plans for the development of Tetiaroa Atoll in particular. As a result of this conference a short reconnaissance visit was arranged to give us some familiarity with the island as a basis for possible future ecological and botanical consultation. This visit lasted 9 days, from March 19 through March 27, 1973. All of the 13 vegetated islets were visited one or more times, and walked over to get a reasonable idea of their ecological features. The notes on vegetation features and collections of plants are the most complete, though a few land animals were noted or collected. Time did not permit a thorough examination and sampling of soils, as had been hoped, nor were the fresh and brackish water bodies, or the ground water, studied as intended.

The present report summarizes factual observations, impressions, and suggestions. It cannot be regarded as anything near a complete description of the atoll, except for the lists of vascular plants, which are probably nearly complete.

The comments and suggestions regarding human activities, management, and future development on the atoll were written for the use of Mr. Brando and his associates, but may still be of use as guides for management of the scores or hundreds of atolls and other coral islands that may be used for human occupation in the tropical seas. The descriptive and natural history portions have been revised and substantionally added to. Their publication will augment, somewhat, the general information available on terrestrial aspects of coral atolls. We deeply appreciate this opportunity to become familiar with one more atoll.

Certain shortcomings in the present report are the result of our failure to receive, in time for use in the field, the promised air photos that would have enabled us to make better use of our time, and to prepare a preliminary ecological map of the atoll. Under the circumstances we have not attempted to map any of the features of interest, but would recommend that an ecological map be prepared as the project is continued. It would serve as a guide in designing and implementing plans.

Historical background: The early history of Tetiaroa is obscure, perhaps expressed only in the legends of Tafai, who, it is said, drew all the islands in the region up above the surface of the sea.

In historic times Tetiaroa belonged to the Pomare family, rulers of Tahiti. They placed it in the care of faithful retainers, who managed it and lived there. The members of the royal family spent time there when they needed quiet and relaxation. The feminine members of the family are said to have gone there and "indulged in the art of ha'apori (fattening)... for the purpose of beautifying their person." The king placed his treasures there for safe-keeping during times of political trouble. "In times of peace, Pomare I sometimes held his heathen orgies while Tahiti was becoming Christianized." Tessier (1962) provides this information, in great part based on Henry (1928: 26).

Tetiaroa must have been known to early European navigators and Capt. Cook sailed by it on July 14, 1769. In 1904 the atoll was sold to Dr. Williams, of Papeete, who managed it as a copra plantation, with a small village on Rimatuu Islet where the labor force lived and where the copra was dried.

Mr. Marlon Brando acquired the island in the 1960's, and at first attempted to maintain the village on Rimatuu. The "nono" (*Culicoides* flies), which breed in brackish shores, as around the pond or "inner lagoon" on Rimatuu, proved very troublesome, and when his plan to build a tourist attraction was to be implemented, he moved his activities to Onetahi Islet. Here a landing strip was constructed and the present visitors enterprise is centered.

II. TETIAROA--ECOLOGICAL SETTING

Tetiaroa is a small atoll about 35 miles from Tahiti, in the Society Islands. It is thus within easy access from the larger island and metropolis of French Polynesia. This has been so since man first came to the Society Islands, which fact has had an enormous bearing on the ecological history and present ecological condition of the atoll.

The greatest diameter of the atoll is about 8.5 km and the periphery of the outer reef is about 28 km.

Thirteen vegetated islets are scattered on the reef ring, varying from a tiny remnant of reef platform less than half a hectare in extent to Tiarauna Islet, 205 hectares.

Surface features: The total land area is 645.5 hectares, reaching an elevation of not over 3 m. The deeper part of the lagoon is about 1288 hectares in extent, but a broad zone surrounding the islets is very shallow, apparently comprising wide coalesced sand aprons or fans. This entire area of apron, 2155 hectares, seldom exceeds 1 m in depth. It is of fine lime-sand and silt, with occasional coral fragments and many shells. Tiny clumps of coral (*Acropora cervicornis*) are scattered over it. It is very narrow only along the north side of the lagoon.

There are no boat passes into the lagoon except a very shallow one near the south end of Rimatuu Islet and a very small shallow one opposite the south end of Tiaraunu Islet. The east reef is largely free of islets and water enters the lagoon from waves breaking over the reef-edge.

The deeper parts of the lagoon are liberally beset with coral pinnacles and patch reefs, many of these reaching the surface at low tide.

On the outer reef platform are numerous remnants of one, or probably two, higher reef surfaces. They vary from small rocks and coral "mushrooms" to undercut platforms many meters long. Most are about 1 m high above the reef flat, but a few are about twice as high. Only one of these was examined and its surface was found to be very rough. Most of them are not vegetated except for darkening of surfaces by microscopic blue-green algae. A very few have scrubby *Pemphis acidula*.

Remnants of the 1 m platform, some eroded to much less than this, extend a short distance from the seaward sides of some of the islets, especially along the north shores of the islets on the north reef. Beachrock is found here and there along the shores of some islets. Its extent could not be mapped in the time available without air photos.

Peripheral ridges occur around most parts of most of the islets, especially on the seaward side, where they tend to be of pebble-, cobble-, or even, locally, boulder-gravel. Elsewhere, especially on lagoon shores, they tend to consist of sand or fine gravel. On some shores they are lacking altogether, while on some seaward shores they are very wide and gently sloping. Locally they are being cut away by waves, and in some such places, as on the northeast point of Onetahi Islet, trees are undermined and fall into the shallow water. The surface in the interior of the larger islets is generally of sand or small gravel; in places a sparse layer of pebbles lies on a surface of sand or mixed sand and gravel. No layers of phosphate rock were noticed, but, judging by the abundance of *Pisonia grandis* trees and of sea-birds, it doubtless occurs locally (see Fosberg 1954, 1957, Fosberg and Carroll 1965).

Rather extensive depressions occur on some of the islets, mostly with a soft organic soil and dense stands of saw-grass (Cladium jamaicense). They may have been ancient taro marshes, excavated by the Polynesians. This view is strengthened by the presence, adjacent to such a marsh on Honuea Islet, of irregular mounds of fine earth, possibly excavated from the marsh. In one such depression on Reiono Islet in rather dense coconut forest, this one lacking saw-grass, were a few plants of puraka or giant taro (Cyrtosperma chamissonis), possibly persisting from Polynesian plantings.

The soils of the islets varied from typical Shioya Series, scarcely altered coral sand and gravel, to soils with a black highly organic surface layer or A horizon, and to the deep organic muck of the putative taro pits mentioned above. No real study of these soils was attempted. One pit already dug to about 0.5 m, on Onetahi Islet, showed a typical Shioya profile about 40 cm deep, then a buried fine-textured darkened layer.

A rather extensive lake or pond of brackish to fresh water occurs on Rimatuu Islet. Maps show it to be open to the sea, but it seems closed now.

Climate: Tetiaroa is a moderately wet atoll, with an annual rainfall of about 2800 mm, but this tending to be somewhat irregular in distribution, with occasional dry spells.

Tetiaroa is in the belt of the Southeast Trade Winds, which generally make the temperature rather pleasant, except in the shelter of the coconut plantation and other dense vegetation. During occasional periods of calms, as in March, the temperature can be oppressively hot and the humidity high. Weather data are almost lacking and should be collected to substantiate present estimates.

A short series of rainfall measurements, covering the period February 23 to Dec. 31, 1974, was recorded by Reiko Sato. The total recorded was 1687.5 mm, with the lowest amount, 19.0 mm, for September, and the highest, 654.8 mm, for December. March, October, and November, each had between 100 and 300 mm. Some measurements may have been recorded in more recent years by resort personnel, but we do not have any of the figures.

Several storms have hit Tetiaroa since 1973. It does not take a full-fledged hurricane to create havoc on a low island. In Dec. 1974 heavy rainfall brought about flooding, especially in the area of the Visitor Center where the low buildings were awash. On New Year's Eve and New Year's Day, residents and visitors stood ankle deep in water and sand. The water receded fairly quickly and plants, except for some exotic ornamentals, didn't suffer too much from the effects of salt.

Some buildings were undermined and construction on the atoll set back.

By July 1982 it was obvious that the coastline along the channel between Onetahi and Honuea was especially vulnerable to erosion, it had receded conspicuously from its 1973 position. In the first 4 months of 1983, an unprecedented series of hurricanes hit French Polynesia, some reaching Tahiti. Residents and visitors on Tetiaroa were evacuated several times. Sachet's visit on March 20-21 followed hurricane Reva (Rewa), and by then many of the buildings on Onetahi had collapsed, lost their roofs, or been almost washed into the channel where erosion had scoured the coast line. On one of the "bird islands", Tahuna-iti, the low sandy part of the island had been flooded, many birds killed, trees defoliated or uprooted. The inside of the islet, however, had not been under water and the ground cover of grass and herbs was unchanged under the tall trees some of which had lost foliage or branches.

From Tahuna-iti, one could see in the distance some defoliated shore shrubs on Tahuna-rahi. The very low western tip of Tahuna-iti seemed cut off as a sand bank and all its vegetation dead.

The sea breached the sand bars which separate the sedge marshes from the lagoon on Rimatuu islet, mixing sea water into the brackish and locally fresh water. This phenomenon may be a recurrent occurrence, as the east coasts of Rimatuu have been variously described or mapped with or without openings onto the lagoon.

Honuea islet could not be visited, but appeared to have suffered from flooding, at least along the channel side opposite Onetahi.

Generally, prolonged flooding by sea water, with relatively little rain, and damage to buildings as a result of erosion and strong winds were the most striking effects of this hurricane. Most of the exotic ornamental plants had disappeared. Tall trees, including coconut palms, appeared relatively little touched, at least as far as one could see in a visit of a few hours.

After Sachet's departure from French Polynesia, hurricane Veena (April 8-13) caused much damage in Tahiti and may well have further devastated Tetiaroa, but no detailed information has been received.

Ground water: A lens of fresh ground water exists about 1-1.5 m below the surface of the ground on the larger islets. This is potable but rather hard water. In places it has a noticeable hydrogen sulfide odor, perhaps originating in the organic muck of ancient taro pits, or possibly, in some areas, from recent pollution. During rainy periods, fresh water seeps through the beaches from the periphery of this lens.

Vegetation: The vegetation of the islets has been profoundly altered by man, both Polynesian and European. The Polynesians certainly introduced the coconut palm, but did not plant it generally to form large plantations. More likely it was planted only around dwelling sites and to the extent that the nuts were needed for food and drink. The Polynesians probably, as noted above, excavated substantial areas for marsh cultivation of taro. Their extensive use of the native plants most likely did not result in serious change in areas of indigenous forest away from dwelling or other sites. They certainly brought some additions to the flora, beside the coconuts, plants such as _Morinda citrifolia_, _Hibiscus tiliaceus_, _Gardenia taitensis_, _Tacca leontopetaloides_, _Cyrtosperma chamissonis_, and probably others.

With the purchase of the atoll in 1904 by a European and possibly even earlier, coconuts were planted for copra production on all suitable, and some not so suitable, parts of the islets. The native vegetation was almost completely replaced, though most of the plant species may well have persisted.

Little can be said about the original vegetation, except that it was undoubtedly mostly forest, either dense or sparse, with some areas of scrub, possibly occasional openings with grasses, _Boerhavia_ and _Portulaca_. On areas of bare coral rock or very thin soil a dense scrub of _Pemphis acidula_ must have predominated, even as it does today. The forest was probably mostly very mixed in its composition, possibly with areas of pure stands of _Pisonia grandis_ and, perhaps, groves of _Hernandia sonora_. Most of the present indigenous herbaceous species may have occurred in the forest, in openings, and around the tops of beaches.

Now the predominant vegetation on all but the smallest islets is coconut plantation, with a liberal mixture of trees, especially _Guettarda speciosa_, which have grown up with the decline of activity in the plantations. Harvesting of nuts was abandoned several years ago and coconuts falling on the ground and germinating have produced a prominent shrub layer of seedlings about 1.5-2 m tall in large areas of the plantation. Openings and thin areas in the plantation are occupied by _Boerhavia_, _Lepturus_, and _Portulaca_. A strong component of the shrub layer is _Timonius polygamus_. _Suriana_ and _Scaevola_ fringe the beaches and extend inland to some extent. The edges of the coconut plantations are filled with _Tournefortia_ and _Guettarda_. Within the plantations _Polypodium scolopendria_, and more locally, _Asplenium nidus_, _Davallia solida_, _Nephrolepis_, _Tacca_, _Triumfetta procumbens_, and still more locally, _Thuarea involuta_, and _Lepidium bidentatum_ form the herb layer, in places covering the ground completely. A liana, _Ipomea macrantha_, climbs in the trees. _Nervilia_ is a rare and local ground orchid. _Laportea ruderalis_, and _Psilotum_ are also occasional, either on the ground or on bases of coconut trees.

Dense and extensive stands of Cladium cover most of the ancient taro depressions, both in the open and under coconut trees, and also on the south side of the brackish lake on Rimatuu Islet. On Tiaraunu Islet, near the lagoon side, a large area of such marsh was originally under coconuts, but these have mostly died, leaving old headless trunks, and parts of the resulting open area have become dominated by Timonius and Scaevola scrub, with some tall Suriana on drier spots. Much of the marsh is covered by saw-grass (Cladium).

Peripheral areas where the islets are narrow, or on small islets, may be dominated by Suriana, mostly covered by a blanket of Cassytha, which in places seems to have killed its host, as an unusual amount of Suriana is dead. Where such areas have very thin soil or are exposed coral rock, Pemphis may be dominant forming a somewhat loose scrub, several meters tall, or a lower, very dense, almost impenetrable scrub.

On tiny Motu-Aie, and locally on one or two other small islets, a mixed forest of Pisonia, Guettarda, Cordia and Tournefortia survives, possibly similar to the original mixed forest but of rather low stature. Only a few coconuts have been planted on Motu-Aie. In 1982 these were seen to have been cut down leaving this islet in a natural condition. In at least two places, on Onetahi and Rimatuu, groves of Hernandia reach a very large size. Locally, especially on lagoon shores, thickets of Hibiscus tiliaceus and of Cordia subcordata occur. One small patch of Sophora tomentosa was found in the plantation on Hiraanae Islet. On Tiaraunu, local clumps of Pipturus argenteus occur well inland.

In sparse places in the coconut plantation and the west point of Honuea Islet, shrubs of Hedyotis romanzoffiensis characteristic of the Tuamotu atolls to the north and east, were common. Digitaria stenotaphrodes, also found in the Tuamotus, occurs in sparse vegetation on the south end of Tiaraunu and along the top of its seaward beach, also in the forest on Tahuna-iti Islet.

Around the two active camp sites on Onetahi and Tiaraunu islets (1973), several species of presumably planted trees have reached small-tree size: Terminalia catappa, Terminalia samoensis, Hibiscus tiliaceus, Casuarina equisetifolia, and Calophyllum inophyllum. These were fairly large in 1982 but T. samoensis was in very poor condition.

A number of exotic herbaceous weeds are found here, also, such as Cenchrus echinatus, Eragrostis tenella, Hippobroma longiflora, and Euphorbia hirta.

Around the abandoned village on the west side of Rimatuu Islet are many very large trees of *Cordia subcordata*, *Artocarpus altilis*, *Calophyllum inophyllum*, *Terminalia catappa*, and *Hibiscus tiliaceus*, as well as *Cocos* and one large *Pometia pinnata*. Many shrubs, such as *Gardenia taitensis*, *Morinda citrifolia*, *Acalypha wilkesiana*, *Polyscias guilfoylei*, *Codiaeum variegatum*, *Citrus aurantifolia*, *Plumeria rubra*, *Pedilanthus tithymaloides*, *Hibiscus* (double red hybrid), *Carica papaya* and *Chrysophyllum cainito* persist from former plantings. Here also are many weeds, some not seen elsewhere on the atoll, such as *Bidens pilosa*, *Conyza bonariensis*, *Euphorbia hirta*, *Vernonia cinerea*, *Cyperus kyllingia*, *Cenchrus echinatus*, *Eleusine indica*, *Eragrostis tenella*, *Digitaria radicosa*, and *Sporobolus fertilis*. *Sida fallax*, of the green-leafed large flowered form planted by Polynesians, is common in the plantation outside the village. In 1982 several weeds only seen on Rimatuu in 1973 had spread to Onetahi. Also *Waltheria indica*, not seen in 1973, had appeared and was abundant in the village site on Rimatuu.

In a very brief account of Tetiaroa, Papy (1956) offers a short characterization of the vegetation of Rimatuu Islet, which appears to be the results of one walk across from the lagoon beach to the "inner lagoon", dividing the vegetation into four "zones". These only vaguely suggest the distribution of the vegetation, and need not be considered seriously as reflecting either the pattern or the diversity of Tetiaroa, or of Rimatuu Islet.

III. ECOLOGICAL OBJECTIVES

After talking with Mr. Brando and Mr. Judge, reading the master-plan, and trying to think in ecological terms of what was said, we have attempted to formulate the ideas expressed in the form of a list of long-term ecological objectives. These aim to provide a set of scientific policy criteria under which proposed actions can be judged. If followed, these may make it possible to carry on the human objectives of the Tetiaroa enterprise over a long period, leaving the atoll relatively unimpaired in its capacity to support human life and activity and to satisfy human needs.

The objectives are as follows and seem to require no explanation:

1. To maintain the natural diversity of the living component of the Tetiaroa Atoll ecosystem.

2. To maintain the natural beauty of the atoll setting.

3. To avoid the depletion or impairment of any resource of the island on which man or other organisms inhabiting the atoll depend.

4. To avoid the accumulation, over a short term or long, of substances or waste products deleterious to life--human or other forms.

5. To avoid having any species of organism increase seriously in numbers at the expense of other species--in other words, to maintain an ecological equilibrium or balance.

6. To eliminate or reduce to reasonable numbers such exotic species as have been introduced and established in the past and have assumed pest proportions or threaten to do so.

7. To avoid introduction of exotics that may make life more difficult, less pleasant, or may disturb seriously the ecological equilibrium of the atoll, or pose a threat of disease.

8. To determine, and not exceed, the long-term carrying capacity of the atoll for humans in terms of the above stated objectives.

The last (no. 8) is, of course, the basic one, as violation of it will result in a spiral of environmental degradation that, if allowed to continue, will make the atoll unfit for habitation or only fit to serve as a platform to which can be brought the resources needed to support a very artificial sort of human existence.

IV. PRESENT STATE OF KNOWLEDGE

Factual information that contributes to an ecological understanding of the Tetiaroa ecosystem is rather meagre.

We have a certain generalized body of knowledge of coral atolls that permits some basic understanding of any atoll or coral island. This experience has been gained over a long period of years through the efforts of many people. It is nowhere summarized adequately. A great deal of information was assembled by Wiens (1962), but it was not reliably synthesized nor were his conclusions completely satisfactory.

Section II of this report offers a description of the superficial features of the atoll, especially the land geomorphology and vegetation, based on our own incomplete observations. This can and will be augmented from the study of air-photos when they become available. However, a detailed description remains to be written.

A reasonably good knowledge of the vascular flora is now available, though little quantitative information on the occurrence of the species is on hand. Only a superficial knowledge of the vegetation is on record and no vegetation map, even of the most schematic sort, is available.

Except for the birds, almost nothing is known of the animal life. We collected a few land crustacea, two lizards, and a few insects and spiders and are awaiting identifications of these. Four manuscript reconnaissance reports on the birds have been prepared by J.-C. Thibault, giving a pretty good idea of the present bird fauna and its occurrence on the islets of the atoll. Notes on the visit and collections of the Whitney expedition in 1921 are preserved in the American Museum of Natural History (Quayle 1922).

Little is on record on the behavior of any of the animals. Several of them have assumed pest proportions, but their life histories, habits, and behavior on Tetiaroa are not at all adquately known.

The fresh and brackish water hydrology are known only in a theoretical way, with very few samples and far fewer analyses. Nothing is known of ground water fluctuations and movements. Even rainfall figures are only extrapolated from Tahiti, except for the short series of records by Reiko Sato mentioned above, and records that we have not seen, said to have been made during Mr. Brando's project in the early 1970's.

No soil map is available and only the roughest observations have been made as to the soil types found on the islets. No soil profiles have been recorded.

Two reconnaissances have been made of the archeological sites, one by P. Vérin, R. Tessier and H. Picard about 1961 (?) (Vérin 1962), the other in December 1972 by Dr. Y. Sinoto (1974), of the Bishop Museum, Honolulu. Many sites are known that should be excavated or at least protected. Some excavating was done by Dr. Sinoto and his students in the 1970's.

The marine biology of the atoll is almost unknown, but recent surveys by Dr. John Randall and Dr. Harold Rehder, as well as those proposed by Dr. Bernard Salvat and his associates from the Paris Museum will remedy this lack.

V. PRIORITY REQUIREMENTS FOR FURTHER INFORMATION

It is almost a truism that the more complete the available information on an ecosystem the better the possible understanding of it. The gaps in recorded information are outlined above. Certain kinds of information may be more urgently needed than others, especially in view of the fact that development and change have already started.

The basic elements of the terrestrial ecosystem are the climate, rock and soils, water, vegetation, and fauna. Weather information must be collected over a considerable period before an adequate account of the climate can be prepared. Therefore, a matter of first priority is the establishment of a simple weather station with recording instruments, and with a reliable arrangement for changing the belts on the drums and keeping the records.

Advice on the best equipment available should be obtainable from the meteorological service in Papeete, or from the U. S. Weather Bureau of NOAA. It would be worth-while, in addition to standard weather observations, to make some records of microclimatic data, such as soil temperatures, temperatures near the ground in dense and open vegetation, wet and dry bulb readings, and temperatures in full sun, as well as temperatures in the sea close by, on the reef flat, in the lagoon, and in the surrounding open sea.

A related investigation that should be carried out would be to determine the amounts of salt spray that enter the soil and ground water at different distances from the windward beaches.

We would suggest a study of the soil types, with descriptions of representative profiles, correlation with physiographic features and vegetation, and a map showing distribution of profile types and textures. This probably could not be done well by an ordinary soil scientist, as atoll soils are very different from well-known continental or high island soils. Experience with atoll soils is limited to a very few people, principally Tercinier, E. L. Stone, Piggott, Hatheway, Catala, and Fosberg.

Ground water lens characteristics are one of the most essential sets of information on any island, and especially on coral islands. While certain general principles apply, the subterranean structure in limestone islands varies from island to island and even from place to place on the same one. The ground-water body in such an island behaves as a Hertzberg lens of fresh water floating on the salt sea-water, held by the friction with the porous body of rock and loose sediment. The porosity of these limestone accumulations varies enormously, and on this depends the salinity of the water, though it is also influenced by rainfall regime, the tide range and exposure to wind waves. The texture of the sediments controls the stability of the lens itself, the time required for renewal, as well as the ease with which the water may be polluted. These are not easy things to determine directly, as it would involve drilling a considerable number of holes, to a considerable depth. It would be more economical to get salinity or chlorinity determinations of water samples from all the soil pits and/or auger holes dug during the soil study. On the basis of these a selection could be made of spots for sampling wells for a study over a longer period.

With a selected 3-4 protected wells (lined pits or driven points) on each of the larger islands where any development is planned, sampling could be carried out seasonally and related to storms, high winds, and periods of heavy swells, as well as intensity of human use. Chlorinity or conductivity determinations, which can be made locally with very little apparatus and by anyone with a little training, could be used to determine the seasonal and shorter term fluctuations in salinity. The same sampling could be used detect certain types of pollution. The odor of the samples should be noted immediately as they are taken. Any suspected pollutants, such as detergents, could be analyzed for.

A study of the vegetation might well be carried out simultaneously with the soil survey, as the boundaries of the vegetation types tend to correspond to certain of the soil types. Because the vegetation controls some other aspects of the ecosystem, or at least is correlated with them, a description and map of the vegetation are a guide to other features and an aid to understanding the system's functioning.

The remaining related group of investigations that seem rather immediately important concern the fauna. Life histories and breeding places of the animals that have multiplied to pest proportions--rats, flies, mosquitoes, and "nonos" (Culicoides) -- should be studied immediately. Surveys of the insects and other land arthropods, as well as the other soil fauna, should be undertaken to find out what species are present, what are their habitats, and what are their roles in the ecosystem. Since this report was originally written several entomologists from ORSTOM (Papeete) and l'Institut Malardé have carried on investigations of certain insects on the atoll, particularly Culicoides. We have not had the results of these studies. This zoological information, even more than the other categories outlined above, would also be of general scientific importance because of the poor state of knowledge of the terrestrial invertebrate faunas of coral islands.

Various other lines of investigation, especially those related to animal and plant parasitology, have much scientifc as well as practical value. Perhaps they can be regarded as somewhat less urgent than those described above. They could be done opportunistically, as people willing and able to do them happened to be available.

Following is an outline indicating the range of data required for a proper description and understanding of the atoll ecosystem, regardless of priority. Areas in which more nearly adequate data are available are not mentioned.

Data needed:

Detailed areas of islets (above any arbitrary datum)

Hydrography:

Currents around atoll and in and out of lagoon. Residence time of lagoon water. Temperature and salinity stratification in lagoon. Seasonal changes in temperature and salinity in lagoon and in surrounding water.

Meteorology--Climatology:

Daily and seasonal temperature, wind, rainfall, solar radiation regimes. Relative humidity and evapotranspiration. Incidence and strength of storms and hurricanes.

Geology, geomorphology, and soils:

Distribution of consolidated sediments--beachrock, phosphate, and elevated reef platform; elevation of same. Distribution, width, elevation, and texture of peripheral ridges; spits and bars. Maps of same. Distribution, elevation and texture of inland dunes and hillocks. Outlines and depths, as well as thickness, of organic layers in all inland depressions.

Ground water hydrology

Tidal fluctuation in level.
Source H_2S
Lateral movement of ground water.

Limnology:

Mapping of permanent, seasonal, and temporary fresh and brackish water; fluctuation in salinity; existence and depth of peat layers; core samples for palynological examination to determine role and history of human activity in the formation of these water and peat bodies. Invertebrate faunas of fresh and brackish waters and life histories of important organisms. Nitrogen fixation and organic productivity by blue-green algae.

Life histories and behavior patterns of land crustacea.
Their roles in reduction of organic debris and refuse.

Nature and roles of soil macrofauna and microfauna.

Soil microbiology.
Decomposition of organic material.
Nitrogen fixing by bacteria and blue-green algae.

Contribution from marine environment to land organic and mineral matter budgets.
Fish and other marine animals brought to land by birds and dropped there as excrement or refuse.
Marine algae and bodies of animals washed ashore and incorporated into soils.
Marine animals caught and used as food by humans (and their domestic animals).
Floating tree-trunks and other plant parts cast ashore.
Water falling as rain.
Salt spray blown ashore.
Skeletons and tests of marine calcareous animals cast ashore by wave action.
Pumice and other volcanic rocks cast ashore.

Detailed entomological and arachnological survey.
Faunistics
Life history and host relations.

Parasitology (terrestrial).
Plant
Bacteria
Fungi
Insects
Helminths

Animal
Protozoa
Bacteria
Fungi
Insects
Helminths

VI. PROBLEMS AND PROBLEM AREAS

Problems, by definition, are in relation to (or caused by) man. Some are the result of natural phenomena to which man has difficulty in adapting. Most of them result from perturbations in the environment caused by man. Man's inevitable effect on the environment is to change it. The changes may be in the direction of improvement, but usually the result is degradation, often first noticeable as a process of gradual simplification and attrition of qualities important to man.

Our few days on Tetiaroa were sufficient to enable us to foresee certain of the problems likely to arise as the Tetiaroa master plan is carried out. For the most part we have no firm solutions to suggest, though we may discuss possibilities and possible lines of investigation as ideas worth trying. Ecology can furnish principles to serve as guides to avoid problems, and ecological research may suggest possible solutions, but a mere reconnaissance is seldom enough to find solutions.

Following are things that seem likely to come up. The order is not especially significant:

1. Water supply: This is likely to be a limiting factor to human activity on an island, even where the climate is wet. The ground water, though fresh and technically potable, is hard and very susceptible to pollution. The water table is very near the surface of the ground and the ground is very porous. Therefore anything poured or thrown on the ground will be washed down into the ground water. Although the Tahitians are a very clean people, personally, their habits otherwise are very much predisposed to accumulation of refuse in the vicinity of their dwellings. We consider, under present and likely circumstances, that pollution of the ground-water lenses on islands where there is substantial human activity is inevitable. For this reason, we suggest that a rainwater catchment for all cooking and drinking water is a must.

2. Sewage disposal: This is an inherently difficult problem on a small coral island if there is any sizeable population. The Polynesians in aboriginal times are said to have met the problem by defecation on the outer reefs where the tides took care of disposal. A modern sewer outfall, even if over the outer reef and if a pumping system could be built to compensate for the lack of gravity flow, would concentrate the sewage to an offensive degree.

The location of the Visitor Center is such that any practical sewer outfall would be so near the passage between Onetahi and Honuea islets that the sewage would be carried into the lagoon, where it would be a serious cause of pollution. Even if, as is likely, a septic tank system were built with an outfall into the sea, this problem would not be eliminated. The nature of the pollutant would merely be changed.

We have at present no suggestion to offer of a solution to this problem.

3. Solid waste disposal: Even the relatively minor activity now going on on the atoll produces a serious amount of non-biodegradable solid waste--bottles, tins, plastic containers, discarded items, etc. With the Visitor Center development, this would be multiplied many times. Burial of such waste , as well as of sewage, would result in pollution of ground water. (In 1982 it was being buried on Onetahi at some distance from the visitors center.) Taking it out to sea would be very difficult because there is no boat access to the lagoon. Dumping at sea would result in much of it being washed back onto the island.

The only thing we can recommend is some form of compaction and binding into non-buoyant packages that could be dropped into deep water.

4. Garbage disposal: The disposal of biodegradable refuse would be a simple matter of composting if it were not for the flies. They are attracted to refuse and breed in it. The present method of burying garbage, as well as human wastes, will inevitably result in water pollution.

Our only suggestion on this problem is a compost pit with an impermeable bottom, or a series of such pits, with covering plastic sheets to keep out the flies and elevate the temperature to hasten decomposition, this would necessitate regular and faithful attention. (See Composting, below).

5.. Water pollution: Pollution of the fresh-water lens has been mentioned under each of the above problem areas, thus pointing out the principal sources of pollution. Another source, possibly as serious as those already mentioned, is detergent in dish-water and wash-water. These are now being poured on the ground. We noticed that excessive amounts were being used, several to many times as much as necessary. That the ground-water carries a considerable burden of detergent was suggested by a great amount of foam along the lagoon beach of Onetahi Islet, as well as an unidentified scum on the wet sand just above the water line.

That detergent is not the only pollutant is suggested by the presence, observed in 1973, along this beach, in very shallow water, of a narrow zone of a green alga, probably an *Enteromorpha*. Since we have no earlier observations it is not certain that this may not be a normal result of the seepage from the edge of the fresh-water lens with some nutrients from the decomposition of vegetation and the muck from ancient taro pits, but the growth seemed rather lush for that. The algal growth should be carefully monitored, as any significant increase in this alga is a good indication of rising nutrient level in the seepage from the fresh-water lens, and a likely sign of pollution. In 1982 no such algae growth was seen on the lagoon beach, but some was seen along the passage beach near the staff residences.

6. Flies: The fly problem is directly correlated with human activity and that of man's domestic animals. Flies are attracted by odorous filth and garbage. They breed in fecal matter, human and aninal. Flies can be controlled in direct proportion to the elimination of these factors. Therefore the solution to the problem is directly dependent on the satisfactory solution of the garbage and sewage disposal problems mentioned above. These must, of course, be supported by changes in the personal habits of the people living on the atoll. It is strongly recommended that pigs, dogs, and other domestic mammals be strictly prohibited on the atoll. By 1982 all the pigs had been eliminated.

7. Rats: We have little direct knowledge of the rats on Tetiaroa, but indirect evidence suggests that they inhabit the larger islets in enormous numbers. We saw them on Onetahi around the camp and Oroatera in the forest, but cannot say which rat species they belonged to. Indications are that there has been a recent population explosion of a tree-dwelling rat. It is said they live in the crowns of the coconut trees.

There is an even-aged stand of coconut seedlings several years old, probably dating from the year after copra-making ceased, there are a few younger seedlings and germinated nuts, but no ungerminated ripe nuts on the ground, and no fully grown green nuts in the trees. The great numbers of half-grown nuts with holes gnawed in their sides, suggest that the abundant food supply, suddenly available when copra harvest ceased, encouraged a sudden increase in rat population. Demand for water caused the gnawing of half-grown nuts, which has now practically eliminated the supply of mature coconuts except on a few of the very small islets. The next phase may be a reduction in the rat population by starvation, but this will not be an effective control as long as garbage and unattended food supplies are available.

The rats must be brought under control for several reasons, among them the fact that they carry several serious diseases, but even more, their contribution to the mosquito problem. The coconuts with holes chewed in them are ideal breeding-places for mosquitoes, and their elimination would certainly mean a notable reduction in mosquitoes.

Man has been fighting rats for centuries, but to the best of our knowledge, never with complete success. The nearest to such an accomplishment that we know of was on Wake Island, where systematic poisoning with warfarin was the method used. However, information from Michèle Darr suggests that warfarin will also kill crustacea, such as land crabs. This should be verified before the method used on Wake is adopted. If the land, hermit, and coconut crabs are susceptible, refinements of the method would be required, as these crustacea form a very essential link in several of the ecological processes at work on the atoll.

We would recommend the engagement of a specialist in rat-ecology, such as Dr. Barbehenn, Dr. Kasimir Wodzicki or Dr. Wm. Jackson, to make a careful study of the rat situation on the atoll. High rat populations simply are not compatible with either a tourist enterprise or the vegetable production project proposed for the atoll.

8. Mosquitoes: According to an earlier mosquito survey, there are three species of mosquito on Tetiaroa. One of them, *Aedes polynesiensis*, was locally very abundant at the time of our visit. It is a very annoying day-flying species. Another species was noticed at night, but not caught for identification.

We are not experts in mosquito control; however, we would not like to see the professionals in this field given free rein, because of their tendency to use the easy temporary solution of spraying with DDT. The plan to chop up the coconut trash for compost, in addition to reducing the rat population, will make a great contribution to mosquito control. Steps beyond this will depend on an adequate knowledge of the life histories and behaviors of the species present on the atoll.

One urgent caution has been indicated by Dr. Guy Loison, of the South Pacific Commission. This is the need for careful spraying of all planes landing on the atoll to prevent further introductions of mosquitoes, especially of *Aedes aegypti*, carrier of dengue fever, common on Tahiti but not yet introduced on Tetiaroa. This precaution cannot be too strongly emphasized.

9. "Nonos" (Culicoides): This tiny biting fly is found at least on Rimatuu Islet, but we did not encounter it. We do not know details of its life-history, but are told that it breeds in the edges of brackish water ponds. We would suggest that a careful study be made of its habits and breeding places. Every effort should be made to eliminate it, but without at the same time eliminating other animals. The Public Health Department of the South Pacific Commission may have much of the basic information needed in its files. We have been informed that Mr. G. Pichon, of ORSTOM, plans to work on this problem.

In any event, this is a matter that cannot be neglected or procrastinated about.

10. Noxious weeds: Not many species of weeds will thrive on atolls, but some are very aggressive even under saline conditions, and some are very annoying. Several weeds already introduced should be ruthlessly eliminated. Examples are *Cenchrus echinatus* (sand-bur), *Bidens pilosa* (Spanish needle), and *Hippobroma longiflora* (Star of Bethlehem). At present sand-bur is found only around Rimatuu Village and at the camp-site on Onetahi, and Spanish needle only at Rimatuu Village where it is very abundant (now also on Onetahi). The poisonous *Hippobroma* is only around the camp-site on Onetahi.

Great care should be taken in the introduction of new ornamental and food plants to the atoll: Some of the ornamentals might become naturalized and get out of hand, and, more likely, weeds, nematodes and injurious insects might be carried in the dirt on the plant roots. Promiscuous, uncontrolled plant introduction should be stopped. A certain amount of it was going on at the time of our visit. Plant diseases, also, may be brought in on plant materials.

11. Quarantine: A quarantine is sometimes difficult to enforce, but to avoid the introduction of further noxious insects, plant diseases, and weedy plant species, regulations seem necessary. It would be best to prohibit the bringing of any plants, animals, or soil except by the management, and then under strictly planned and supervised circumstances.

12. Composting: As inhabitants of atolls have known for many centuries, the best way to dispose of vegetable trash is by composting. The organic soil that forms the bottoms of the low areas on most of the islets of Tetiaroa undoubtedly persists from the time when these depressions were taro pits of the ancient Polynesians. In the Gilberts, where population pressure necessitates maximum productivity, to this day all leaves, weeds, drift material, anything that will rot, are thrown into the taro pits.

We would recommend, without hesitation, that a fairly extensive hole be dug down to the water table and that all vegetable material be placed in it. A black plastic sheet somewhat larger than the hole should be used to cover it and keep flies out. Several such holes will doubtless be required, even to dispose of trash from the camp, visitor center, Polynesian village, and vicinity.

Garbage of animal origin, such as fish offal, had best be accumulated in covered large containers and rafted to an islet where the ground water is not to be used, and a composting operation started there. After such nitrogenous compost is well rotted, it could be recovered and mixed with vegetable compost for gardening and taro culture. Any areas where vegetables or ornamentals are to be raised should be liberally supplied with compost, as atoll soils are mostly notoriously poor.

A question arises about coconut trash. Such trash as accumulates around dwellings and facilities should, of course, be thrown in the vegetable compost pits. Mr. Judge informed us that the general accumulation of coconuts, leaves and trash will be put through a mobile shredder or chipper. This will at the same time get rid of water receptacles that breed mosquitoes and provide abundant material for compost; this can merely be allowed to decompose where it falls, or be brought to central compost pits. The former solution will result in a certain amount of general improvement of soil, if fires can be avoided. The latter solution will provide quantities of compost that can be placed where it is needed.

Mechanically shredding the trash has the drawbacks that the machines make much noise and have high energy requirements. These matters will at least have to be given some consideration.

13. Coconut seedling underbrush: Since copra-making was suspended, a thick undergrowth of seedling coconuts has filled much of the space in the coconut plantations, forming a practically impenetrable tangle. This is unattractive and tends to choke out the normal indigenous vegetation. If the shredder is brought in and used, such seedlings can be grubbed out and run through it, effectively disposing of them. Some decision must, in any event, be made about them.

If the rats are reduced or eliminated, of course there will be a continuing new growth of seedlings, unless the coconuts are gathered and used, either green or ripe. Incidentally, recently germinated coconut embryos make a delicious food novelty that could be offered to tourist visitors.

14. Coconut lumber: We noticed that coconut logs are being sawed up for lumber in the construction of the Visitor Center. We wonder if the durability of coconut lumber, especially green, has been looked into. Our impression is that it may be fairly short-lived, as will the coconut-thatched roofs.

15. Reaction of birds to tourists: One of the attractions about visiting an atoll is to see large numbers of sea-birds. There are several places on Tetiaroa, on certain small islets, where boobies, terns and frigate birds may be seen in numbers, at least at certain seasons. A problem that must be kept in mind is that crowds of noisy tourists may very well drive off the birds and discourage future nesting. Advice should be sought from ornithologists familiar with sea-bird behavior as to how this problem may best be minimized. Our only suggestion would be to have not-too-frequent visits by small, carefully selected parties, well guided and supervised.

In addition to the above problems directly involving the terrestrial ecosystem, several marine problems are apparent. These will in all likelihood be considered by the marine biologists, but may be mentioned here for emphasis and in case they are overlooked.

1. Fishing: In 1973 we observed catching of fish and lobsters on a fairly intensive scale. Boats were at work practically every night. They were even towed around the lagoon by Project personnel and boats. This fishing seemed on a scale that could only be commercial. Sport fishing could be one of the attractions for visitors. However, commercial fishing would soon deplete the resource to the point where sport fishing would become unrewarding.

2. Attrition of reef life: As soon as tourists begin to come in numbers, they will want to do scuba-diving, with spear-fishing and shell-collecting as objectives. This will surely deplete certain of the reef organisms. Corals will be broken off and the more attractive mollusks, especially cowries, will be picked up. The larger bright-colored fish, too, will disappear, as will lobsters.

3. Possible appearance of Ciguatera: The configuration of the lagoon and lack of boat passes will surely create a strong temptation to blast passes, eliminate coral heads, and dredge boat channels and mooring areas. This should be resisted. It would alter lagoon ecology with unforeseeable consequences. More serious, however, would be the possible appearance of ciguatera, or fish-poisoning. It seems to be associated with exposure of fresh surfaces of reef-limestone and their colonization by poisonous blue-green algae, which are eaten by the fish. This possibility should be very seriously considered before any work in the lagoon is undertaken. Dr. John Randall is an authority on ciguatera, as is Dr. Bagnis, and his group at the Institut Malardé.

VII. LONG-TERM VS. SHORT-TERM SOLUTIONS

For some of the problem areas listed, solutions may seem rather obvious and easy. Often the easy answer is a short-term one that, while it may solve the difficulties at hand, may creat more serious ones. A permanent solution may be more difficult and costly. It is well to try to look at each problem ecologically, in all of its aspects and ramifications, and to try to anticipate possible consequences and side effects. The only way to be able to do this is to collect all possible information, to develop an understanding of the whole system, and to look on the things man does as perturbations with good or bad effects, depending on the nature and direction of the perturbation. Perhaps the best guide is wherever possible to get nature to work with the Project, rather than to force nature into a human-made mold.

VIII. ECOLOGICAL FEASIBILITY OF THE PROJECT

It is difficult, if not impossible, on the basis of a brief reconnaissance, to form any firm opinion on the ecological feasibility of a complex project such as the development of Tetiaroa. A few observations can be offered as guidelines.

Archeological evidence suggests that over a considerable period of time Tetiaroa supported a substantial population. It was obviously a satellite of Tahiti, but in all probability was largely self-sufficient, food-wise. Perhaps it even contributed to the support of Tahiti, judging by the extent of the ancient taro pits. There is no obvious change in the environment that would preclude support of a present-day population, but modern methods of exploitation of resources are so effective that, without discipline, over-exploitation is almost inevitable.

Even on modern terms, and assuming that much in the way of food and goods of all kinds, including the basic energy source, will be imported, discipline is one of the two keys to long-term feasibility. The other is developing an understanding of the ecological constraints in operation.

The assumption that the enterprise, after it is established and operating, will be self-sustaining imposes certain constraints. The most obvious one is that no serious physical discomforts or hazards be allowed to develop or persist. Such, if they occurred, would deter both tourists and employees from coming to or remaining on the atoll. The present abundance of flies, rats, mosquitoes and nonos may fit into this category. Loss or deterioration of the unique features that will attract tourists could prove fatal to the tourist portion of the project. Pollution or serious alteration of the properties of the lagoon water might do the same for the mariculture aspect. Therefore, the consequences of any major manipulation of the environment must be very carefully weighed.

The unusual geomorphology of the atoll, especially the lack of boat passages through the reef and the very broad shallow-water zone lining much of the lagoon shore, place serious constraints on possible tourist activities, though they may be very favorable to some aspects of mariculture. If these features had been taken into account, the choice of location for the Visitor Center might have been different. These is little possibility of good swimming near the present location. Some of the proposed use of rafts or barges may not prove feasible, and even boat activity will be limited.

Tourist activities must be planned with an awareness of these features and keeping in mind the dangers of ciguatera if substantial excavation or blasting should be undertaken to change the lagoon configuration or open up channels.

A modest, well-planned facility, designed for a selected and limited class of tourists is certainly ecologically feasible, if the above constraints are borne in mind. This assumes, of course, that the existing pest problems are solved and that no new ones are created by careless introduction of organisms. It also assumes that pollution can be kept to a minimum.

It is our opinion that any large scale tourist development will fail, unless it is of such a character as to involve total alteration of the environment and provides almost complete insulation of the tourists from the natural environment. And under these conditions we do not see any special reason for tourists to come to Tetiaroa.

IX. IMMEDIATE PRACTICAL SUGGESTIONS AND RECOMMENDATIONS

In general, it is inadvisable to make recommendations on the basis of a short reconnaissance. However, there are a number of suggestions that seem appropriate on an immediate, short-term basis. These are neither of equal importance or organized in a completely logical fashion, nor are they mutually interdependent. Some are intended to correct conditions and practices observed to be wrong or detrimental, others to provide for future needs of the project, others to help determine future activities.

1. Institute spraying of incoming planes immediately.
2. Stop, at once, the pouring of wash-water and dish-water containing detergents on the ground.
3. Get rid of pigs and dogs.
4. Construct and operate fly traps.
5. Tighten up garbage and sewage disposal procedures.
6. Start composting operation.
7. Break up rat-chewed coconuts to eliminate mosquito breeding places, either using a shredder or chopping them with machetes.
8. Get expert advice on rat ecology and control.
9. Carry out a thorough limnological investigation of the brackish-water lake on Rimatuu, preliminary to planning for control of "nono" (*Culicoides*).
10. Make a survey of intensity of salt spray at different places and under different weather and sea conditions.
11. Build a water-catchment and water storage tanks to supply soft, safe drinking and cooking water. This should provide ample capacity for the size of population expected in the forseeable future.
12. Pull up and burn all plants of sand-bur (*Cenchrus*) beggar's ticks (*Bidens pilosa*), and star-of-Bethlehem (*Hippobroma*), and continue to do this at intervals short enough so that these plants do not set seeds.

13. Prepare list of available ornamentals that might be used for planting around the Visitor Center and other installations, submit it to us to check if any reasons are apparent for not importing some of them.
14. Check all possible habitats--coconut shells, fallen coconut bracts, crab holes, tin cans, and other receptacles, as well as standing water in low spots--for mosquito larvae. Preserve in alcohol samples of larvae from each habitat checked for species identification.

X. HUMAN RELATIONS

This is an important but difficult field of scientific study. Someone in close contact with the project should have as one of his duties to keep a log of all human events--arrivals, departures, illnesses, accidents, quarrels, cooperation, lack of it, alcoholism, personal friendships and liaisons to the extent that they can be observed, prevalence of gossip and rumor, violations of regulations, reactions and comments of visitors, complaints from residents and visitors, records of menus and of imports of foods and other items, as well as any other information bearing on human and social relations.

The interrelations between these things and the environmental factors and changes must be studied carefully and fully understood if any stable workable system is to be established.

XI. SUGGESTED LONG-TERM PROGRAM OF RESEARCH AND MONITORING OF ENVIRONMENT

The proposed development of Tetiaroa, deliberately planned so as to avoid the usual ecological mistakes, is an almost unprecedented experiment. For islands, especially coral islands, it is totally unprecedented. Hence there are no guide-lines to indicate what to do and what not to do, nor even to tell when mistakes have been made before it is too late to correct them. This project is therefore very important, as it may serve to establish such guidelines and be used as a model for other such developments. It may serve to demonstrate the practicability of rational development of islands.

For this reason, as well as to assure the success of the enterprise, itself, a program of research and continued monitoring of the environment is essential. Only by this means can sufficient understanding be developed to anticipate and deal with the problems that surely will arise, indeed, have in some cases already arisen. Basically, it is necessary to know what resources are available, what factors affect them, and at what rates they may be safely utilized to maintain a sustained "yield." We are speaking, here, of more than material, consumable resources.

Beauty, for example, is one of the most important resources on Tetiaroa. It is not consumable, but it is certainly destructible.

We have outlined a tentative program as a basis for discussion. Because the terrestrial and marine aspects are so closely interrelated, we have included some suggestions on the marine side, subject, of course, to modification and improvement in consultation with marine science collaborators.

The program is ambitious, and parts of it may be expensive. Some aspects, such as matters related to public health and sanitation might be of interest to public authorities, who are well-equipped to handle such investigations and concerns, as a part of their official programs in French Polynesia. We understand that a college may be established on the atoll. Many of the items listed below could be undertaken on a part-time basis by the faculty of this school, and some even as student research projects. A geology or geography student from a university might undertake the basic geomorphological work needed, in return for the opportunity to do work on an atoll. Dr. David Stoddart of Cambridge University might be willing to direct such a student. Further archaeological work might be appropriate, though much has been done by Dr. Vérin and Dr. Sinoto. This might point the way to further excavations which could provide training for students as well as round out the knowledge of the Polynesian occupation of the island.

If serious scientific work is contemplated, a meeting of those interested in Tetiaroa might be arranged, preferably on the island, to discuss this tentative program and develop it into a workable scheme.

Of extreme importance is the establishment of a central file of copies of all information collected concerning the atoll. This should be in duplicate or triplicate, one set being with whomever is running the project, the others at stable permanent scientific institutions, such as the Smithsonian and Bishop Museum.

Research Program for Tetiaroa Atoll

Terrestrial aspects

-- Detailed description of atoll.

-- Procure air-photos if available.

-- Make cover type overlay.

-- Detailed study of relief, soils and cover types and correlation with air-photo overlays.

-- Detailed traverse of all shore-lines with mapping of shores showing rock vs sand vs gravel vs beachrock; erosion, deposition; slope of ramps and beaches; pot-holes and channels on ramps; any other shore features.

-- Complete inventory of plants and animals, with rough data on abundance. Repeated annually, noting changes in abundance, disappearance of species, appearance and establishment of new exotics.

-- Establish a network of permanent photo points, to be used at regular intervals to detect long-term trends.

-- At each photo point establish a permanent plot with plants mapped, to be remapped at regular intervals.

-- Establish, measure accurately, and map vegetation, psychrometer readings, and soils, of several carefully selected transects, to be restudied and remapped at regular intervals.

-- Establish a line of 4 or 5 wells across widest parts of 4 largest islands and several on other islands, these to be lined, above water-table, with concrete pipe or ceramic tile, and capped with removable lid. Water to be sampled at regular intervals and samples analyzed for salinity, hardness, bacteria, H S and other measures of water quality. Driven points could be substituted for wells if desired, at least in non-rocky areas.

-- Establish series of air-salinity points, to be checked at regular intervals.

-- Establish simple weather station to measure and record rainfall, temperature, relative humidity, wind strength and direction, solar energy amount and regime.

-- Careful description of the condition of coconut and other trees at photo-points, repeated at regular intervals.

-- Life history studies of animals of particular interest. e. g. mosquitoes, flies, nonos, hermit-crabs, land-crabs, coconut-crabs, etc.

-- Regular censuses of breeding birds.

-- As detailed a history of the atoll as possible from recorded and contemporary sources.

Fresh and Brackish Water Aspects

-- Detailed limnological survey of all permanent and temporary standing fresh and brackish water on the atoll, with life histories of abundant organisms, especially *Culicoides* and those suspected of being predators or parasites on it.

Marine Aspects

-- Detailed hydrographic description of lagoon and reef waters. Standard physical oceanographic study of off-reef waters around atoll, especially current data.

-- Plankton survey and analysis of waters around atoll and in lagoon, repeated at established intervals.

-- Complete inventory of benthic organisms on outer reefs and in lagoon, repeated at established intervals.

-- Establishment of several sets of transects across outer reef flats and fronts and similar ones across lagoon, with mapping of sessile organisms and depths, recording of free-swimming animals, transects to be remapped at regular intervals.

-- Water quality studies of lagoon water at regular intervals.

-- Food web studies of outer reef and lagoon reef faunas.

-- Annual pesticide and heavy-metal residue analyses of selected species of larger marine animals and sea-birds.

-- Periodic censuses of *Acanthaster* populations.

-- Establishment of a number of permanent underwater photo points, to be rephotographed at established intervals.

-- Regular counts of sea-turtle landings and egg-laying.

-- Periodic quantitative monitoring of green algae on lagoon beaches.

-- Monitoring of population increases and decreases of selected marine animal and plant species.

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APPENDIX I

List of indigenous, spontaneous and well established plant species.

This list includes all plants collected or observed by us and by other collectors, except for recently planted ornamentals or fruit trees whose survival seems somewhat doubtful. Most species were collected only once or twice, even though they occur on several islets (see Appendix II). Of our own collections, the first set is deposited in the U.S. National Herbarium (US) with duplicate sets at the B. P. Bishop Museum in Honolulu (BISH) and the Herbarium in Paris (P). Other specimens are cited from Royal Botanic Gardens, Kew (K), New York Botanical Garden (NY) and Brooklyn Botanical Garden (BKL). The herbarium symbols or abbreviations follow the Lanjouw scheme, Index Herbarium, adopted by the International Association of Plant Taxonomists.

An asterisk * placed before a name indicates that we believe the species to be introduced to the Society Islands by human agency (ornamentals, food plants or weeds).

FUNGI

Albugo platensis Speg. — White Rust

Motu-Aie Islet, *Fosberg & Sachet 54625*

Parasitic on *Boerhavia tetrandra*, producing erect, condensed, witches-broom-like branches.

Fomes sp. — Shelf Fungus

Oroatera I., *Sachet & Fosberg 1688*

Saprophytic on dead coconut trunks. Dark brown to black woody semicircular shelf-like fruiting bodies with fine pores beneath.

Schyzophyllum commune L. — Leather-gills

Motu-Aie I., *Fosberg & Sachet 54622*

Saprophytic on dead wood. Thin tough bracket-like fungus fruiting body.

LICHENES (all det. Mason E. Hale, Jr.)

Parmelia saccatiloba Tayl.

Onetahi I., *Sachet 1672*.

On coconut trunk.

Parmelia sp.

Onetahi I., Fosberg 54680.

Epiphytic on coconut trunks. Flat leaf-like greenish-white lichen.

Physcia sp.

Reiono I., Sachet 1661b.

A gray crustose lichen on tree-trunks.

Pyxine cf. chrysanthoides Vain.

Oroatera I., Sachet & Fosberg 1682.

A light gray knobby crustose lichen on coconut trunk on lagoon beach.

Pyxine cocoes (Sw.) Nyl.

Reiono I., Sachet 1661a.

A gray crustose lichen on tree trunks.

Pyxine retirugella Nyl.

Onetahi I., Sachet 1663.

A dark gray crustose lichen with black fruiting bodies on coconut trunk.

Pyxine sp.

Onetahi I., Sachet 1662.

A light creamy slightly greenish gray crustose lichen on coconut trunk.

ALGAE

Nostoc sp.

Onetahi I., Sachet 1657.

On bare moist sand along side of air strip. Dark greenish black amorphorus masses, gelatinous when wet.

Enteromorpha sp.

Onetahi I., Sachet 1677.

Forming a narrow zone on lagoon beach, just below mid-tide. Tufts of fine green filaments.

Trentepohlia sp.

Onetahi I., *Sachet 1665*.

On surfaces of tree trunks. Forming a fine bright orange fuzz on surface of bark.

MUSCI (all det. H. Robinson)

Brachymenium indicum (Doz. & Molk.) Basch & Lac. Moss

Rimatuu I., *Fosberg 54580*.

A small terrestrial moss forming thin cushion on coral sand in semi-open areas.

Calymperes tenerum C. Müll. Moss

Onetahi I., *Sachet 1667*.
Oroatera I., *Sachet & Fosberg 1686*, *1687*.

A brownish or golden green epiphytic moss forming loose cushions on tree trunks.

Calymperes tuamotuense Bartr. Moss

Onetahi I., *Sachet 1666*.
Honuea I., *Fosberg 54575*.

A golden green epiphytic moss forming dense cushions on coconut trunks and their enlarged bases.

Leucophanes nukahivense Besch. Moss

Oroatera I., *Sachet & Fosberg 1684*.

Forming thick pale green cushions at bases of coconut trees and stumps.

Taxithelium vernieri (Duby) Besch. Moss

Oroatera I., *Sachet & Fosberg 1685*.

An extensively spreading slender green moss forming thin mats, especially on rotting coconut trash, in shade.

Trichostelum hamatum (Doz. & Molk.) Jacq. Moss

Rimatuu I., *Fosberg & Sachet 54650*.

A light green moss forming a thin mat on fallen Pandanus branch.

PSILOTACEAE

Psilotum nudum (L.) Beauv.

Onetahi I., Sachet 1637
Oroatera I., Fosberg & Sachet 54617
Rimatuu I., Fosberg 63765
Reiono I., Sachet 1641
Tiaraunu I., Raynal 18002 (P)

Occasional on bases of coconut trees and on coral boulders in shaded interiors of islets. Broom-like tufts of prismatic, dichotomously branching stems bearing large yellow spore-cases on sides of terminal branchlets.

POLYPODIACEAE (Fern family)

Asplenium nidus L. — Birds-nest fern

Oroatera I., Sachet & Fosberg 1689
Tiaraunu I., Fosberg & Sachet 54647
Reiono I., Sachet 1643

On ground and bases of coconut trees in shaded interiors of islets. Also seen planted as ornamental on Onetahi and Rimatuu. Nest-like rosettes of ascending broadly lance-shaped undivided fronds, the fertile ones having a zone of pinnately arranged, parallel, crowded, linear fruiting sori on the under sides.

Davallia solida Sw. — Fern

Rimatuu I., planted or persisting, seen by Fosberg in 1982.
Oroatera I., Sachet & Fosberg 1685
Tiaraunu I., Raynal 18004 (P)

On rocks and fallen coconut trunks in interiors of islets. Creeping stems with scattered triangular finely several-times divided fronds; spores borne in pockets along edges of segments of fronds.

Nephrolepis hirsutula (Forst.) Presl — Sword fern

Tiaraunu I., Fosberg & Sachet 54615, 54648
Oroatera I., Fosberg & Sachet 54618

On ground in interiors of islets. Short erect stems above ground, bearing slender cord-like runners which bear the roots, and erect or ascending fronds with many pinnately arranged pinnae or leaflets that bear kidney-shaped spore-dots or sori on under surfaces, pinnae shed when old, leaving stiff persistent rachis.

Polypodium scolopendria Burm. f. Lawai fern (Hawaii)

Tiaraunu I., Sachet 1679
Rimatuu I., Quayle 194 (BISH, BKL)

Abundant in shade on ground and on bases of coconut trees. Creeping stem or rhizome bearing scattered erect, long triangular-ovate deeply and coarsely pinnately divided fronds with two rows of brown fruiting dots or sori beneath, fronds shed from rhizome when old.

PANDANACEAE

Pandanus tectorius Park. Fala; fara; screw-pine

Onetahi I., Fosberg & Sachet 54633; Raynal 18018 (P)
Tahuna-rahi I., Sachet 1650
Tiaraunu I., Sachet 1680
Honuea I., sight record by Sachet in 1974.
Rimatuu I., Raynal 18011 (P); Florence 3267 (P, US).

Generally distributed, especially on peripheral ridges of islets. Small trees, sparsely and grotesquely branched, pyramidal, branches thick, bearing 3 spirally twisted ranks of long, strap-shaped, prickly, tough leaves with slender whip-like points; male and female flowers on different trees, the male in long branched pendent catkins with white leaf-like bracts, odor rather unpleasant; female in globose tightly packed heads; fruits packed in a tight head-like cluster, 15-20 cm in diameter, individual fruits or keys lobed at apex, distal part hard and bony, lower half or third fleshy, orange, fragrant, acrid sweet.

GRAMINEAE (POACEAE) (Grass family)

*Cenchrus echinatus L. var. echinatus Sand-bur

Onetahi I., Fosberg & Sachet 54630

Locally established in shaded area of camp on Onetahi, not seen elsewhere. Small tufted grass, bearing spikes of prickly unpleasant burrs. This form is smooth.

*Cenchrus echinatus var. hillebrandii (Hitchc.) F. Br.

Rimatuu I., Fosberg 54609
Onetahi I., Fosberg & Sachet 54646

Very local around old village and around camp. A form that is notably hairy rather than smooth.

*Cynodon dactylon (L.) Pers.

Onetahi I., Sachet 1676; Fosberg 63787; Raynal 18019 (P).

Planted and growing well and abundantly on airstrip. A close-growing, creeping, mat-forming, fine-leafed grass, with digitate fine flower and fruit clusters on erect stems.

Digitaria setigera Roth

Rimatuu I., Fosberg 63773

Rare, around ruins of old village.

Digitaria stenotaphrodes (Nees) Stapf

Tiaraunu I., Fosberg & Sachet 54616, 54649; Raynal 17998 (P).
Tahuna-iti I., Fosberg 63756

Scattered tufts in open scrub forest and along top of seaward beach. A stiff, tufted, erect grass, with stiff spikes of flowers and fruits, crowded in 3's or 4's at tops of erect stems.

*Digitaria radicosa (Presl) Miq. Crab=grass

Rimatuu I., Fosberg 54602, 54606, 54611; Raynal 18024 (US, P).

Locally established at top of beach and edges of old village. Depressed, spreading weak-stemmed slender grass with several slender digitate spikes radiating from ends of slender stems.

*Eleusine indica (L.) Gaertn. Goose-grass

Onetahi I., Raynal 18014 (P); sight record, Fosberg in 1982.
Rimatuu I., Fosberg 54593

Local in old village. Tufted, tough-rooted grass, with several broadly linear divergent spikes of flowers radiating from ends of stems.

*Eragrostis tenella (L.) Beauv.

Onetahi I., Sachet 1693b
Rimatuu I., Fosberg 54594
Honuea I., small patch seen by Sachet in 1974.

Local in old village and around camp. A fine, delicate grass with a diffuse feathery flower cluster.

Lepturus repens R. Br. Bunch-grass

Onetahi I., Raynal 18015 (P, US)
Honuea I., Fosberg 63779, 63781

Motu-Aie I., Fosberg & Sachet 54623
Rimatuu I., Fosberg 63769, 63771
Tiaraunu I., Raynal 18007 (P)
Tahuna-rahi I., Sachet 1645

Generally common or abundant. Tufted to creeping stiffish grass with long, awl-shaped jointed flower spikes, in fruit disarticulating into small cylindric floating segments, each carrying a seed. Found on all islets.

*Sporobolus fertilis (Steud.) Clayton

Onetahi I., Fosberg 63790
Rimatuu I., Fosberg & Sachet 54596; Fosberg 63774; Raynal 18022 (P)'

Local in old village. Tufted grass with long slender linear flower spikes.

Thuarea involuta (Forst.) R. Br. ex R. & S.

Oroatera I., Sachet & Fosberg 1690
Reiono I., Sachet 1638

Very local in shaded interior of islets. Creeping, mat-forming, broad-leafed grass with very short, few-flowered flower clusters on erect stems, and very small, fist-shaped fruits.

CYPERACEAE (Sedge family)

Cladium jamaicense Crantz — Saw-grass

Onetahi I., Sachet 1656
Honuea I., Fosberg 63782
Hiraanae I., in small water-hole, sight record by Sachet in 1974.
Rimatuu I., Wilder 955 (BISH); Quayle 195 (BISH); Raynal 18009 (P).
Oroatera I., Fosberg & Sachet 54619
Tiaraunu I., Fosberg & Sachet 54654

Abundant in wet depressions (old taro pits?) where not too shaded, dominant in such places in full sun. Coarse, harsh, stiff grass-like sedge with tall, arching, loose sprays of scaly brown flowers and tiny nut-like fruits.

*Cyperus kyllingia Endl.

Rimatuu I., Fosberg 54607

Scattered tufts around abandoned village site; seen at this locality only. Small tufted grass-like sedge, with small, white, globose clusters of tiny flowers.

*Cyperus polystachyos Rottb.

Rimatuu I., Raynal 18030 (P)

Slender wiry slightly tufted sedge, with compact head of narrow green spikelets and three or four long narrow bracts.

*Eleocharis geniculata (L.) R. & S. Spike-rush

Onetahi I., Fosberg & Sachet 54645; Raynal 18016 (P).
Rimatuu I., Fosberg 63772
Honuea I., sight record by Fosberg & Sachet in 1982.

Seen around a small active taro pit near the end of the runway close to the lagoon beach on Onetahi. Perhaps a recent introduction, brought with taro plants by a laborer. Tufts of very slender leaf-like stems 10 cm or so tall, each bearing a tiny scaly pine-cone-like flower spike at the top. Found also to form a belt around the large Cladium marsh on Rimatuu.

Fimbristylis cymosa R. Br.

Onetahi I., Fosberg & Sachet 54635, Sachet 1693a
Tiaraunu I., Fosberg & Sachet 54660
Rimatuu I., Quayle 195 (BKL)

General in openings, forming small tufts, roots fragrant; leaves linear, blunt, slightly stiffish; small button-like tufts of small scaly flowers.

ARACEAE (Arum family)

*Colocasia esculenta (L.) Schott Taro

Onetahi I., Fosberg & Sachet 54644

Planted in mud in a small pit. Plant with edible underground tuberous corms, no above-ground stem, erect purple leaf-stalks bearing large glaucous, arrowhead-shaped, peltate leaves. Seldom flowering. One of the principal Polynesian food plants. Not seen in 1982.

*Cyrtosperma chamissonis (Schott) Merr. Puraka; Giant taro

Reiono I., Sachet & Fosberg 1640

Small patch persisting in ancient taro pit in deep shade. Large tuberous underground corm, with enormous erect leaves, triangular arrowhead-shape, on thick round leaf-stalks to 1.5 m tall, glossy, flower-stalk erect, topped by a folded bract surrounding a spike of crowded very much reduced flowers.

*Syngonium angustatum Schott

Rimatuu I., Fosberg 63777

Large plant, climbing in large tree around ruins of former village.

ARECACEAE (Palm family)

*Cocos nucifera L. Niu; Coconut

Generally planted on all the islands. Tall tree with columnar trunk and enormous pinnate leaves in a giant rosette at top of trunk; flowers, both male and female, borne in large complex branched clusters among the leaves, protected by a woody boat-shaped bract which falls off as the flower cluster expands, flowers cream color, with stiff sepals and petals; fruit a large fibrous drupe with a hard stone 10-20 cm in diameter with one seed completely filling the cavity, shell filled with excellent water when immature, with a layer of white oily flesh when ripe. Had been eliminated from Motu-Aie in 1982.

LILIACEAE

Cordyline fruiticosa (L.) Chev. (cv)

Planted on Onetahi.

TACCACEAE

Tacca leontopetaloides (L.) O. Ktze. Pia; Island Arrowroot

Onetahi I., Sachet 1678; Fosberg & Sachet 54634

Very common in coconut groves. Bearing potato-like underground tubers, no above-ground stem; erect terete leaf-stalks, large palmate, deeply and complexly divided leaves, tall erect hollow flower-stalks with umbellate clusters of small flowers, filiform conspicuous bracts; fruits globose, marble-like, packed with seeds. Tubers an important source of starch for the ancient Polynesians, but bitter and needing processing before use.

ORCHIDACEAE (Orchid family)

Nervilia aragoana Gaud.

Oroatera I., Sachet & Fosberg 1692
Honuea I., Fosberg 54579

Occasional but very local in sandy, usually shaded soil, uncommon. A small ground orchid, with a small fleshy underground corm, a single expanded leaf, and when this disappears a short raceme of whitish delicate flowers appears. Searched for in July 1982 on Honuea but not found.

CASUARINACEAE

Casuarina equisetifolia L. — Toa; Ironwood; She-oak; Beef-wood

Onetahi I., Fosberg & Sachet 54567

Local, probably planted, only seen around camps, but probably native in the Society Islands. A tree with no normal leaves, but with needle-like green jointed branchlets which drop as do leaves; flowers very reduced, in catkin-like clusters; fruits like diminutive pine-cones. Yields a very hard, extremely heavy but brittle timber.

MORACEAE (Mulberry family)

*Artocarpus altilis (Park.) Fosb. — Mai; Breadfruit

Rimatuu I., Fosberg 54601

Planted, only seen at Rimatuu Village. A large tree with milky sap; large alternate deeply cut leaves, flowers very reduced, the male in large club-shaped clusters, the female in light green balls; fruit large, globose or slightly elongate, with geometrically roughened surface. Fruit cooked in various ways and eaten; the staff of life for the ancient Polynesians, still extensively used.

*Ficus carica L. — Edible Fig

Onetahi I., seen planted around buildings by Sachet in 1982.

URTICACEAE (Nettle family)

Laportea ruderalis (Forst.) Chew

Rimatuu I., Quayle 186 (US, BISH, BKL); Wilder 303 (BISH)
Tahuna-rahi I., Sachet 1646
Onetahi I., Sachet 1653
Tiaraunu I., Raynal 18000 (P)
Reiono I., Sachet 1642

Uncommon but generally distributed, mostly in shaded places. A small succulent-stemmed herb with alternate broadly ovate toothed leaves, flowers very small and inconspicuous in branched clusters, fruit small, grain-like. Seen on Motu-Aie and Tahuna-iti in 1982.

Pipturus argenteus (Forst. f.) Wedd. — Roa

Tiaraunu I., Fosberg & Sachet 54657, 54658

Very local in low places in sparse coconut plantation, seen only on Tiaraunu. Large shrub or very small tree, leaves alternate, broad, toothed; flowers in tiny clusters on a string-like spike; fruit resembling a very small white strawberry. Inner bark tough, used by ancient Polynesians for cordage and bark cloth.

AMARANTHACEAE (Amaranth family)

Achyranthes velutina H. & A.

Motu-Aie I., Fosberg & Sachet 54627; Fosberg 63759

Very local, only seen on Motu-Aie, in interior openings. An elongate ascending herb with opposite gray-green softly pubescent leaves spikes of scaly flowers and small backward-pointing unpleasantly sharp dry fruits.

NYCTAGINACEAE (Four-o'clock family)

Boerhavia tetrandra Forst.

Tahuna-rahi I., Sachet 1648
Motu-Aie I., Fosberg & Sachet 54624; Fosberg 63757
Rimatuu I., Fosberg 63764
Tiaraunu I., Raynal 17999 (P)

Very common, especially in openings and sparse places in coconut groves, where abundant forming a mat on the ground. Prostrate elongate creeping stems from a thick root crown; opposite oblong-elliptic leaves pale beneath; small clusters of tiny pink flowers; sticky, ribbed club-shaped tiny fruits that stick to clothing. Often affected by a white rust fungus, Albugo platensis that causes branches to become erect, condensed, distorted, and witches-broom-like (Fosberg & Sachet 54625).

Pisonia grandis R. Br.

Tahuna-rahi I., Sachet 1647
Motu-Aie I., Fosberg 63760, 63761, 63732; Raynal 18031 (P)
Hiraanae I., sight record by Sachet in 1974.

Common, locally forming groves and forests, but these mostly cleared away when coconuts were planted. Large trees with pale creamy-gray trunks, soft brittle wood; large, usually smooth, opposite, broadly elliptic leaves, clusters of small, pale greenish flowers; dry, very sticky, minutely spiny club-shaped fruits, admirably adapted to be carried sticking to birds' feathers.

PORTULACACEAE (Purslane family)

Portulaca johnii v. Poelln. Purslane

Onetahi I., Fosberg & Sachet 54631; Fosberg 63789
Honuea I., Fosberg 63780

Hiraanae I., Fosberg & Sachet 54653
Rimatuu I., Wilder 949 (BISH)

Very common in openings and edges of woods. Very fleshy small herb with obovate leaves; flowers yellow, rather small, opening late in morning, closing in late afternoon; seeds tiny, black, shiny, borne in small capsules with lids.

LAURACEAE (Laurel family)

Cassytha filiformis L. Giant Dodder

Onetahi I., Sachet 1675, 2548
Rimatuu I., Wilder 305A (BISH); Quayle 188 (BISH)

Very common, especially in open or bushy areas, parasitic on other plants, especially *Suriana*, often killing it. Leafless, tangled string-like, rootless plant, orange to greenish, twining around other plants, penetrating them with tiny sucker-like haustoria to get nourishment; flowers very small, white, fruit globose, small, white, fleshy.

HERNANDIACEAE

Hernandia sonora L.

Onetahi I., Fosberg & Sachet 54639
Rimatuu I., Fosberg 54583
Hiraanae I., sight record by Sachet in 1974.

Very local, forming groves among coconut trees. Trees reaching very large size, leaves alternate large, round, glossy; branched clusters of grayish-white flowers; fruits black nut-like surrounded by a thin inflated fleshy envelope, white, turning pink, or even deep carmine.

BRASSICACEAE (CRUCIFERAE) (Mustard family)

Lepidium bidentatum Mont. Scurvy-grass

Tiaraunu I., Raynal 18003 (P)
Rimatuu I., Fosberg 54582; Quayle 187 (BISH)
Motu-Aie I., Fosberg & Sachet 54626; Fosberg 63758
Hiraanae I., sight record by Sachet in 1974.
Honuea I., sight record by Fosberg in 1982.

Locally common in semi-open places. An herb, sometimes rather woody at base, with alternate usually coarsely toothed leaves, elongating racemes of tiny whitish flowers and small dry elliptic capsules bearing 2 orange seeds each. Said to have been eaten by early sailors to prevent or cure scurvy.

FABACEAE (LEGUMINOSAE) (Bean family)

Derris malaccensis Prain ?

Reiono I., Sachet 1644

Sterile vine.

Sesbania coccinea (L.f.) Poir. s. l.

Rimatuu I., Quayle 190 (BISH, K)
Motu Tiaraunu, Raynal 18001 (P)

Small tree or shrub with alternate pari pinnately compound leaves and large deep orange and maroon flowers. Not found on this survey.

Sophora tomentosa L.

Hiraanae I., Fosberg & Sachet 54651; Sachet 2105

One small clump seen in coconut grove in interior of islet. Sprawling shrub 1.5-3 m tall; leaves alternate pinnately compound, grayish green; flowers pea-like, yellow, in racemes; fruit a long lumpy pod, each lump containing a seed.

Vigna marina (Burm.) Merr.

Onetahi I., Fosberg & Sachet 54642; Fosberg 63788
Hiraanae I., sight record by Sachet in 1974, 3 m from high-water mark.

Occasional in openings and edges of coconut groves. Creeping herb with alternate trifoliolate, broad obtuse leaves; yellow pea-like flowers on erect stalks; pods small, cylindric. Roots bear nodules containing nitrogen-fixing bacteria.

RUTACEAE (Citrus family)

Citrus aurantifolia (Christm.) Swingle Lime, "citron vert"

Rimatuu I., Fosberg 54592

A few small shrubs in Rimatuu Village around abandoned dwellings. Shrub with spines and alternate elliptic slightly toothed leaves, aromatic when broken; fragrant waxy white flowers and greenish sour fruits with glandular aromatic skin. Juice used for drinks, antiscorbutic.

SURIANACEAE

Suriana maritima L.

Tiaraunu I., _Raynal 18006_ (P)
Onetahi I., _Fosberg & Sachet 54636_
Honuea I., sight record by Sachet in 1974.
Rimatuu I., _Quayle 189_ (BISH), _Wilder 312_ (BISH), sight record by Fosberg in 1982.

The commonest shrub on the island, abundant around edges of woods and coconut groves at top of beaches, also in openings in interior. Shrub branching from base and abundantly so above; leaves alternate,narrow, numerous; flowers rather small, bright yellow; fruits small, dry, grain-like.

EUPHORBIACEAE (Spurge family)

Acalypha amentacea ssp. _wilkesiana_ (M.-A.) Fosberg

Rimatuu I., _Fosberg 54599_, _54600_

Planted in old village. Shrub with alternate variegated bronze-red, broad, toothed leaves, catkins of small reddish or bronze flowers. Widely planted as an ornamental and hedge plant throughout the tropics. The form here has curious circinately curved leaves (f. _circinata_).

Codiaeum variegatum (L.) Bl. Croton

Rimatuu I.

One large shrub seen by Sachet in 1973.

Euphorbia hirta L.

Onetahi I., _Sachet 1654_; _Florence 3251_ (P, US)
Rimatuu I., _Raynal 18027_ (P)

Very common around camp site. Small arching, milky, hairy herb with opposite, toothed, pointed leaves and dense clusters of tiny white flowers.

*_Pedilanthus tithymaloides_ (L.) Poit. Shoe-flower

Rimatuu I., _Fosberg 54591_

Sparingly planted in old village. Fleshy, green-stemmed weak shrub, leaves pointed, arranged in 2 ranks, flowers red, slipper-shaped, pointed. Widely planted in the tropics as an ornamental.

*<u>Phyllanthus amarus</u> Schum. & Thonn.

Onetahi I., <u>Sachet 1651</u>; <u>Fosberg 63784</u>
Rimatuu I., <u>Fosberg 54595</u>; <u>Raynal 18023</u> (P)

Very local around old village and camp site. Erect herb with very small pinnately arranged, two-ranked leaves, tiny yellowish green flowers, and round capsule-like fruits on slender spreading branches.

*<u>Phyllanthus tenellus</u> Roxb.

Onetahi I., <u>Fosberg 63785</u>

Weed in garden.

SAPINDACEAE (Soapberry family)

*<u>Pometia pinnata</u> Forst. Kava

Rimatuu I.

Large tree in old village, seen by Fosberg in 1973 and 1982.

RHAMNACEAE (Buckthorn family)

<u>Colubrina asiatica</u> (L.) Brongn.

Rimatuu I., <u>Fosberg 54608</u>

One small shrub seen near old village. Scrambling shrub with alternately arranged broad, heart-shaped finely toothed leaves, small open clusters of very small greenish-yellow star-shaped flowers; fruit a hard 3-seeded capsule.

TILIACEAE (Linden family)

<u>Triumfetta procumbens</u> Forst. f.

Onetahi I., <u>Sachet 1668</u>
Rimatuu I., <u>Fosberg 54610</u>

Very common, creeping, forming loose mats in coconut groves. Prostrate spreading creeper with hairy stems and variable often lobed leaves, bright yellow flowers, and burr-like globose fruits.

MALVACEAE (Mallow family)

<u>Hibiscus tiliaceus</u> L. Purau

Onetahi I., <u>Sachet 1673</u>, <u>1693</u>

Very local on lagoon-sides of islets in edges of woods and coconut groves, in places, at least, probably planted. Spreading, often tangled tree, leaves round, usually pale beneath; flowers large, in few-flowered clusters, yellow with maroon center when opening in morning, turning light maroon and falling toward evening; fruit a 5-parted capsule.

*Hibiscus (hort. var.) Red hibiscus

Rimatuu I., Fosberg 54597

Planted around old village. Shrub with toothed ovate-triangular leaves; large bright red flowers. A widely planted tropical ornamental hybrid, propagated only by cuttings.

*Sida fallax Walp. Ilima (Hawaii)

Onetahi I., Sachet 1674
Rimatuu I., Fosberg 54581, 63763; Raynal 18025 (P); Florence 3265 (P, US).

Local in semi-open coconut groves, uncommon except near old village. Small erect shrub, with round, heart-shaped bluntly toothed leaves, round bright orange flowers.

*Sida rhombifolia L.

Rimatuu I., Fosberg 54603

Rare in abandoned village. Ascending herb with longer rhombic-ovate short-petioled leaves with blunt points, long-stalked dull orange flowers.

Thespesia populnea (L.) Sol. ex Correa Miro

Honuea I., Fosberg 54578
Onetahi I., Fosberg & Sachet 54641; Sachet 1671

Found only as seedlings on beaches. Trees not seen on atoll.

STERCULIACEAE

*Waltheria indica L.

Rimatuu I., Fosberg 63776; Raynal 18010 (P)

Two large flourishing colonies around ruins of former village; not noticed in 1973. A suffrutescent herb, spreading, branched, to 1.5 or 2 m long, flowers small, yellow.

CLUSIACEAE (GUTTIFERAE)

*Calophyllum inophyllum L. — Tamanu

Rimatuu I., Fosberg 54584

Planted around old village and camp site. Very large spreading tree, leaves oblong, leathery; flowers white with yellow stamens, borne in clusters among leaves; fruit pendent, globose, 2.5-3.5 cm in diameter. Widely distributed in Pacific, probably both by human agency and naturally by its floating fruits. Timber hard, workable, highly prized; also a superb shade tree.

CARICACEAE (Papaya family)

*Carica papaya L. — Papaya, Pawpaw

Rimatuu I., Fosberg 54590

Sparingly growing in old village, persisting after cultivation. An erect, usually unbranched small tree with a soft trunk and milky sap; large palmate deeply divided round leaves on long stalks forming a huge rosette at top of stem; male flowers cream color, in large open clusters among leaves, female sessile on stem among and just below leaves, larger, often some bisexual flowers mixed in clusters; fruit orange when ripe, fleshy, melon-like, with many black seeds in large central cavity. Widely planted in tropics for its delicious fruits and the proteolytic enzyme produced in its sap. Readily becomes naturalized, but then the fruit is commonly small and of poor flavor.

CUCURBITACEAE

*Citrullus lanatus var. caffrorum (Alef.) Fosberg — Watermelon, pasteque

A large healthy plant, bearing melons, seen and photographed, near houses back of channel beach, by Sachet in 1974, Onetahi I.

*Cucumis melo L. var. melo — Melon, cantaloupe

A healthy plant with an immature melon, seen and photographed, in garden and climbing on house, near channel, by Sachet in 1974, Onetahi I.

LYTHRACEAE (Loosestrife family)

Pemphis acidula Forst.

Honuea I., Fosberg 54573
Rimatuu I., Fosberg 54604

Reef rock remnant between Honuea and Tiaraunu, Fosberg & Sachet 54613
Tiaraunu I., Fosberg & Sachet 54659
Oroatera I., Fosberg & Sachet 54620
Hiraanae I., sight record by Sachet in 1974.

Locally very common, mostly on rough limestone on seaward coasts and rocks on reef-flat, forming pure stands of low to tall scrub in such places. Much-branched shrub or small tree with very hard dark reddish wood; leaves small, oblong, thick, astringent when chewed; flowers white, rather small; fruit a round somewhat flattened, dark reddish capsule, seeds many, small.

COMBRETACEAE

*Terminalia catappa L. — Indian Almond; Tropical Almond

Onetahi I., Sachet 1669, 1681

A few small trees around camp site. A pagoda-form tree with flattish horizontal branches, large obovate leaves that turn red when old, slender spikes of small white flowers, somewhat flattened ovoid corky fruits with 2 keels, and edible almond-like seeds. Widely planted in the tropics, doubtfully native in eastern Polynesia.

Terminalia glabrata Forst. f. ?

Rimatuu I., Fosberg 63767

A single seedling that must be this, found in interior of coconut plantation.

Terminalia samoensis Rech.

Onetahi I., Fosberg & Sachet 54632

Single tree seen, around camp site. Small tree, with obovate leathery leaves, slender spikes of whitish flowers, small, dark red somewhat elongate cherry-like fruits, said to be edible, at least the almond.

LECYTHIDACEAE

Barringtonia asiatica (L.) Kurz

Hiraanae I.

A sprouted seedling 7 dm tall seen about 3 m back of high-water mark by Sachet in 1974.

ARALIACEAE (Ginseng family)

*Polyscias guilfoylei (Bull) Bailey — Hedge-panax

Rimatuu I., Fosberg 54588; Raynal 18029 (P)

Several plants in old village. Shrub, here reaching small tree-size, very erect, sparingly branched, leaves pinnately compound, leaflets elliptic, coarsely toothed, margins whitish, with an oily smell when broken, strong coumarin odor when dried; flowers in large, loose clusters, small, greenish, very seldom produced; fruits small, somewhat fleshy, rarely seen. Widely planted tropical ornamental.

SAPOTACEAE

*Chrysophyllum cainito L. — Star-apple

Rimatuu I., Fosberg 54589

One small plant seen in old village. Tree with elliptic leaves bright coppery pubescent beneath; fruit globose, edible.

APOCYNACEAE

*Catharanthus roseus (L.) G. Don — Madagascar Periwinkle
Pervenche

Onetahi I., sight record by Sachet in 1974-75.

Seen established around camp site. Erect leafy-stemmed herb, with white or pink flowers, sometimes with dark red eye.

*Plumeria rubra L. — Frangipani

Rimatuu I.
Onetahi I.

Seen planted around old village; also around camp site. Small tree with very thick branches; vari-colored, extremely fragrant five-parted large flowers, much used for garlands.

CONVOLVULACEAE (Morning-glory family)

Ipomoea littoralis Bl.

Onetahi I., Fosberg 63791
Rimatuu I., Fosberg 63766

A purple-flowered morning glory found near the air strip, and a somewhat doubtfully identified sterile vine seen rarely in the undergrowth in the coconut plantation on Rimatuu.

Ipomoea macrantha R. & S. — Pohue; Wild Moon-flower

Rimatuu I., Wilder 306 (BISH)
Honuea I., Fosberg 54576, Sachet 2647 (seedling)
Onetahi I., Fosberg & Sachet 54640, 54661
Tiaraunu I., Raynal 18005 (P)

Occasional to common in scrub and undergrowth near the seaward coasts and in interiors of islets. Extensive twining liana becoming woody in older parts, leaves heart-shaped, flowers large, trumpet-shaped, white, opening at night, collapsing in afternoon or when exposed to strong sun, fruit a globose capsule enclosed in fleshy enlarged sepals, then drying to a parchment-like texture.

BORAGINACEAE (Borage family)

Cordia subcordata Lam. — Tou

Rimatuu I., Quayle 185 (BISH, US); Florence 3263 (P, US)
Honuea I., Fosberg 54577
Onetahi I., Fosberg & Sachet 54643; Sachet 1670
Tahuna-rahi I., Sachet 1649
Hiraanae I., Raynal 18017 (P)

Occasional in margins of woods and coconut plantations, especially near beaches. Tangled tree with low branches, leaves alternate, with broad ovate or elliptic, slightly rough, blades and often yellow stalks; flowers in small clusters, large, brilliant deep orange, corolla thin, delicate, fruit nut-like, enclosed in enlarged calyx. Wood hard but workable, prized for carving, banded light and dark brown.

Heliotropium anomalum H. & A.

Rimatuu I., Wilder 951 (BISH)

Dwarf shrub with narrow silky leaves, dense clusters of fragrant white flowers with yellow centers. Not found on present survey.

Tournefortia argentea L. f. — Tree Heliotrope

Rimatuu I., Fosberg 54612; Quayle 191 (BISH, NY)
Onetahi I., Fosberg & Sachet 54668
Tiaraunu I., Raynal 18008 (P)

Locally common to rare, along seaward beach ridges, in places dominating marginal vegetation, old trees persisting in interior but not reproducing. Shrubs and small trees, leaves obovate, spirally arranged, fleshy, gray-green, silky, flowers small, white, fragrant, in clusters with "scorpioid" or fiddle-neck shaped branches fruit a pea-like pale green drupe with four small stones, this drying to a small corky globose floating dry fruit.

SOLANACEAE

*<u>Solanum</u> <u>lycopersicum</u> L.

Onetahi I.

Seen by Sachet in 1974-75, growing around houses, fruiting.

BIGNONIACEAE

*<u>Saritea</u> <u>magnifica</u> (Sprague ex v. Steenis) Dugand

Onetahi I., <u>Fosberg 63783</u>

Sterile vine planted in garden near buildings.

RUBIACEAE (Coffee family)

*<u>Gardenia</u> <u>taitensis</u> DC. Tiare Tahiti; Tahitian Gardenia

Rimatuu I., <u>Fosberg 54598</u>; <u>Quayle 184</u> (BISH); <u>Raynal 18028</u> (P)
Oroatera I., <u>Sachet & Fosberg 1683</u>

Planted around old village and camps, a few large old plants persisting in forest. Shrub or small tree, leaves opposite, broad, obovate; flowers solitary among leaves, large, white, very fragrant, corolla lobes 6-7, spreading. Generally planted in Polynesia for its highly prized deliciously fragrant flowers.

<u>Guettarda</u> <u>speciosa</u> L.

Rimatuu I., <u>Quayle 192</u> (K, BISH)
Honuea I., <u>Fosberg 54572</u>
Onetahi I., <u>Fosberg & Sachet 54638</u>, <u>54662</u>, <u>54663</u>, <u>54664</u>, <u>54665</u>, <u>54666</u>, <u>54667</u>; <u>Sachet 1655</u>
Hiraanae I., <u>Fosberg & Sachet 54652</u>

Very common generally. Shrub or small to medium-sized tree, with large, broad, obtuse leaves, conspicuous stipules; small clusters of large white flowers, opening and very fragrant at night, losing their fragrance and dropping their corollas during following day; fruit a globose white fleshy-fibrous floating drupe.

<u>Hedyotis</u> <u>romanzoffiensis</u> (C. & S.) Fosb.

Honuea I., <u>Fosberg 54574</u>, <u>63778</u>

Scattered in open scrub vegetation on coral sand and gravel, seen only on Honuea Islet. Small shrub with opposite, obovate, small leathery leaves; greenish-white flowers in very few-flowered clusters; fruit globose, fleshy, white to purple, opening at one end to let out the small seeds.

Morinda citrifolia L. Nono

Onetahi I., Fosberg & Sachet 54629

Common generally in coconut groves. Shrub or small tree, with opposite, large, elliptic, glossy leaves; small heads of small white flowers, fused together at base; fruit dull whitish, potato-shaped, fleshy, with many large seeds, developing a rancid very disagreeable odor when old.

Timonius polygamus (Forst.) Rob.

Rimatuu I., Quayle 193 (BISH, US, P)
Honuea I., Fosberg 54569, 54570, 54571
Tiaraunu I., Fosberg & Sachet 54614, 54655, 54656
Onetahi I., Raynal 18013 (P); seen by Sachet in 1982
Reiono I., Sachet 1639

Very common generally in undergrowth and in open scrub. Shrub with opposite obovate leaves, very variable in shape; small white flowers, male in few-flowered clusters, female solitary; fruit black, fleshy, globose, with a number of small stones.

CAMPANULACEAE (Bluebell family)

*Hippobroma longiflora (L.) Don Star-of-Bethlehem

Onetahi I., Sachet 1652; Raynal 18012 (P)

Established around camp site. Small herb with milky sap; alternate, long, pointed, coarsely toothed leaves; long-tubular, white, showy, star-shaped flowers, capsular fruits with many small seeds. Said to be very poisonous.

GOODENIACEAE

Scaevola sericea Vahl var. sericea Naupata

Onetahi I., Fosberg & Sachet 54637

Very common especially around peripheries of islets and in marginal fringe vegetation. Low rounded shrub with rosettes of leaves at ends of branchlets, obovate, bright green; flowers in small clusters among leaves, white, corolla 5-lobed, one-sided as though half had been torn away; fruit globose, fleshy, white, or purple on one side, with a large slightly ribbed stone.

Scaevola sericea var. tuamotuensis (St. John) Fosberg

Rimatuu I., Fosberg 63770

Rare, only one patch seen at the top of the beach near the ruins of the former village. It differs from var. sericea in the rather depressed habit, usually narrower, glabrous leaves and in the dull purplish yellow flowers.

COMPOSITAE (ASTERACEAE) Aster family

*Bidens pilosa L. var. pilosa

Onetahi I., Fosberg 63792

Common near air strip. Differs from var. minor in lacking ray flowers.

*Bidens pilosa var. minor (Bl.) Sherff

Rimatuu I., Fosberg 54585, 63768; Raynal 18026 (P)
Onetahi I., Florence 3256 (P, US)

Abundantly naturalized in old village. Weedy herb, leaves opposite, pinnately 3-5 foliolate, leaflets pointed and finely toothed; flowers small, yellow, in dense heads, marginal corollas somewhat expanded, petaloid, white; fruit black, needle-shaped, with 2 or 3 barbed, stiff, sharp, short bristles at one end.

*Conyza bonariensis (L.) Cronq. Large Horse-weed

Rimatuu I., Fosberg 54587, 63775; Raynal 18020 (P, US)

Occasional in old village. Tall herb with unbranched leafy stem with narrowly oblong, scattered, coarsely toothed leaves, much branched conical inflorescence at top, flower heads small, of many closely packed very tiny flowers; fruiting heads masses of brownish white fine bristles on tiny dry prismatic fruits, tufts of bristles acting as parachutes to carry fruits on wind.

*Emilia fosbergii Nicolson Flora's paint-brush

Onetahi I., Fosberg 63786

Soft-stemmed slightly glaucous weed with red flower-heads, in gardens around buildings, doubtless a recent introduction.

*Vernonia cinerea (L.) Less. Little Iron-weed

Rimatuu I., Fosberg 54586; Raynal 18021 (P); Florence 3260 (P, US)

Common in old village. Small herb with leafy stems and open terminal clusters of narrow purplish flower heads; these showing fine white bristles when past flowering and in fruit.

*Wedelia trilobata (L.) Hitchcock

Onetahi I., very abundant near buildings, seen by Sachet in 1982.

APPENDIX II

Table of occurrence of indigenous and long-established exotic plants in Tetiaroa by islets.

Symbols used in Table

a	abundant
la	locally abundant
c	common
lc	locally common
l	local
o	occasional
r	rare
s	seedlings only
l(cu)	locally cultivated

HERBS, VINES and CREEPERS	Onetahi	Honuea	Tiaraunu	Motu-tauini	Motu-auroa	Hiraanae	Oroatera	Motu-Aie	Tahuna-rahi	Reiono	Tahuna-iti	Rimatuu	rock
Achyranthes velutina								1					
Asplenium nidus	1(cu)		1c	a	la	la	a			1		1(cu)	
Boerhavia tetrandra	c	r	c	a	1	la	c	a	c		a	o	
Cassytha filiformis	a	a	c	r		c	a		la	la	1	1	
Cenchrus echinatus	1											1	
Cenchrus echinatus var. hillebrandii	1											1	
Cladium jamaicense	1	la	a			1	la					la	
Cynodon dactylon	1												
Cyrtosperma chamissonis										1			

HERBS, VINES and CREEPERS	Onetahi	Honuea	Tiaraunu	Motu-tauini	Motu-auroa	Hiraanae	Oroatera	Motu-Aie	Tahuna-rahi	Reiono	Tahuna-iti	Rimatuu	rock
Davallia solida	r		r	r		la	la					1 (cu)	
Derris malaccensis										o			
Digitaria radicosa												1	
Digitaria setigera												1	
Digitaria stenotaphrodes			1								1		
Elaeocharis geniculata	1	1										la	
Emilia fosbergii	1												
Eragrostis tenella	la	1										1	
Euphorbia hirta	la											la	

HERBS, VINES and CREEPERS	Onetahi	Honuea	Tiaraunu	Motu-tauini	Motu-auroa	Hiraanae	Oroatera	Motu-Aie	Tahuna-rahi	Reiono	Tahuna-iti	Rimatuu	rock
Fimbristylis cymosa	c	l	c			l	lc					c	
Hippobroma longiflora	l												
Ipomoea littoralis	l											l	
Ipomoea macrantha	c	s	c			c	c	lc		o		r	
Laportea ruderalis	l	l	l		r	r	o	o	o	r	l	o	
Lepidium bidentatum	r	l	c	r		l	l	la				l	
Lepturus repens	a	c	a	la	l	c	c	c	c	c	c	a	
Nephrolepis hirsutula	l		lc			la	lc						
Nervilia aragoana		r					o						

HERBS, VINES and CREEPERS	Onetahi	Honuea	Tiaraunu	Motu-tauini	Motu-auroa	Hiraanae	Oroatera	Motu-Aie	Tahuna-rahi	Reiono	Tahuna-iti	Rimatuu	rock
Polypodium scolopendria	a	la	a	a	a	a	c-a	c	l	c	c	c	
Portulaca johnii	a	o	o	a	o	l	o	c	c	c	c	o	
Psilotum nudum	r		o			o	o			r		r	
Sida rhombifolia L.												l	
Tacca leontopetaloides	a	l	c	la		a	a					a	
Thuarea involuta			o		l	r	l			a			
Triumfetta procumbens	la	l	a	c		c	c	r		l		a	
Vigna marina	l					l							
Waltheria indica												l	

SHRUBS	Onetahi	Honuea	Tiaraunu	Motu-tauini	Motu-auroa	Hiraanae	Oroatera	Motu-Aie	Tahuna-rahi	Reiono	Tahuna-iti	Rimatuu	rock
Hedyotis romanzoffiensis		lc											
Pemphis acidula		lc	r		c	la	la	la			lc	r	a
Scaevola sericea	la	c	c	o		r	a			la	lc	la	
Sesbania coccinea			r									r	
Sida fallax	l											l	
Sophora tomentosa						r							
Suriana maritima	a	a	c	a	l	l	a		la		c	l a	
Timonius polygama	a	c	lc	o	r		o			l			
Colubrina asiatica												r	

TREES and LARGE SHRUBS	Onetahi	Honuea	Tiaraunu	Motu-tauini	Motu-auroa	Hiraanae	Oroatera	Motu-Aie	Tahuna-rahi	Reiono	Tahuna-iti	Rimatuu	rock
Calophyllum inophyllum	1											1a	
Carica papaya												o	
Casuarina equisetifolia	1c		c										
Cocos nucifera	a	a	a	a	c	a	a	o	1	a	a	a	
Cordia subcordata	1	s	r			1		1	1c	1a	r	1a	
Gardenia taitensis	1						r					1	
Guettarda speciosa	a	c	a	c	c	c-a	o	o		1	c	c	
Hernandia sonora	1		o			1						1	
Hibiscus tiliaceus	1c		o			1	1					1a	

TREES and LARGE SHRUBS	Onetahi	Honuea	Tiaraunu	Motu-tauini	Motu-auroa	Hiraanae	Oroatera	Motu-Aie	Tahuna-rahi	Reiono	Tahuna-iti	Rimatuu	rock
Morinda citrifolia	c		c	1		c-la	c			o		c	
Pandanus tectorius	c	a	c	o	o	l	c	l	c	la	l	la	
Pipturus argenteus			l										
Pisonia grandis		r	c	c	a	c	o	a	a	a	c	r	
Terminalia catappa	l											l	
Terminalia samoensis	r												
Thespesia populnea	s	s											
Tournefortia argentea	l c	c	c	a	a	la	c	c	a	c	a	l c	

APPENDIX III

List of established planted species at Rimatuu village and around camp-sites on Onetahi and Tiaraunu islets (1973).

Acalypha amentacea ssp. wilkesiana
Artocarpus altilis
Calophyllum inophyllum
Carica papaya
Casuarina equisetifolia
Catharanthus roseus
Chrysophyllum cainito
Citrus aurantifolia
Cocos nucifera
Codiaeum variegatum
Cordia subcordata (probably indigenous)
Cordyline fruticosa cv.
Crinum sp.
Gardenia taitensis
Hibiscus (hort. var., red)
Hibiscus tiliaceus (possibly indigenous)
Pedilanthus tithymaloides
Plumeria rubra
Polyscias guilfoylei
Pometia pinnata
Syngonium angustatum
Terminalia catappa
Terminalia samoensis (possibly indigenous
Wedelia trilobata

APPENDIX IV

List of recently planted ornamentals and useful plants (1973, 1974, 1975)

Acalypha hispida
Allamanda hendersonii
Allamanda sp.
Annona reticulata
Apium graveolens
Asclepias curassavica
Alternanthera
Bougainvillea sp.
Catharanthus roseus
Citrullus lanatus
Citrus nobilis
Cucumis melo
Dracaena or Cordyline sp.
Eichhornia crassipes
Hippeastrum sp.
Leucaena leucocephala
Muntingia calabura
Ocimum sp.
Persea americana
Plectranthus scutellarioides
Polyscias fruticosa
Portulaca grandiflora
Saritaea magnifica
Solanum melongena
Spondias dulcis
Syngonium angustatum
Thevetia peruviana

In addition there is the following list, furnished in 1973 by Miss Michèle Darr, of plants said to have been recently brought to Tetiaroa. This is copied exactly except for correction of some obvious spelling errors. The numbers apparently indicate the numbers of cuttings or rooted plants introduced. Possible identifications are given in [ ].

110 Tiare Tahiti [Gardenia taitensis]
3 Tiare Moorea [Tabernaemontana divaricata]
20 Taina [Gardenia jasminoides]
80 Tipanier (Bouture) [cuttings of Plumeria]
3 Pedilanthus [P. tithymaloides]
10 Laurier Rose [Nerium]
1 Pittosporum
10 Thevetia [T. peruviana]
25 Pandanus Panache
25 Plumbago Route [Plumbago indica]
30 Pervenches [Catharanthus roseus]

50 Pourpier [Portulaca grandiflora]
50 Cosmos [Bidens sp.]
20 Gomphrena [G. globosa]
40 Rhoeo [R. spathacea]
5 Lantana Mauve [L. montevidensis]
10 Asparagus [A. sp.]
4 Sansevieria [S. trifasciata ?]
20 Gros Poireau Jaune [?]
Amaryllis [Hippeastrum sp. ?]
Crinum Jaune [?]
10 Strobilanthus à Feuille Rouge [Pseuderanthemum ? or Graptophyllum ?]
10 Crotons [Codiaeum variegatum]
10 Begonias [B. sp.]
10 Impatiens [I. sultanii? or I. balsamina ?]
20 Amaryllis [Hippeastrum sp. ?]
1 Sac [bag] Wedelia [W. trilobata]
100 Boutures [cuttings] Hibiscus [H. sp. ?]
1 Sac [bag] Pothos [Rhaphidophora aurea ?]

Additional planted species seen in 1982 on Onetahi:

Acalypha amentacea ssp. wilkesiana
Alternanthera brasiliana
Alocasia macrorrhiza
Asplenium nidus
Begonia sp.
Codiaeum variegatum
Carica papaya
Casuarina equisetifolia
Cordyline fruticosa
Crinum asiaticum
Cryptostegia grandiflora
Dieffenbachia seguine
Ficus carica
Impatiens sultanii
Ipomoea batatas
Pilea microphylla
Sanseviera trifasciata
Saritaea magnifica
Wedelia trilobata
Zebrina pendula

APPENDIX V: List of "weedy" species

These are introduced plants that behave in a somewhat aggressive manner, especially in disturbed or pioneer situations. Some are potential pests.

Bidens pilosa
Cenchrus echinatus
Conyza bonariensis
Cynodon dactylon
Cyperus kyllingia
Cyperus polystachyos
Digitaria radicosa
Digitaria setigera
Eleusine indica
Emilia fosbergii
Eragrostis tenella
Euphorbia hirta
Hippobroma longiflora
Ipomoea littoralis
Phyllanthus amarus
Sporobolus fertilis
Vernonia cinerea
Wedelia trilobata

APPENDIX VI

List of animals collected for which we have identifications

Coenobita perlatus Milne Edw. - Red hermit crab
Coenobita brevimanus Dana - Purple hermit crab
Cardiosoma carnifex (Herbst) - Land crab

All determined by Dr. Dennis Devaney

Birgus latro - Coconut crab

Aedes (Stegomyia) polynesiensis Marks - Day-flying mosquito

Determined by W. A. Steffan

Spodoptera mauritia (Boisduval) - Cut-worm

Determined by D. M. Weisman

Emoia cyanura (Less.) - Blue-tailed Skink
Gehyra oceanica (Less.) - Gecko

Both determined by George Zug

Scolopendra morsitans - Centipede, cent pied

Fig. 1 Landing strip on Onetahi Islet, coconut plantation in background. FRF, 1973

Fig. 2 Narrow pass (hoa) between Hiraanae and Oroatera Islets, N side of atoll; boobies flying overhead. MHS, 1974-75

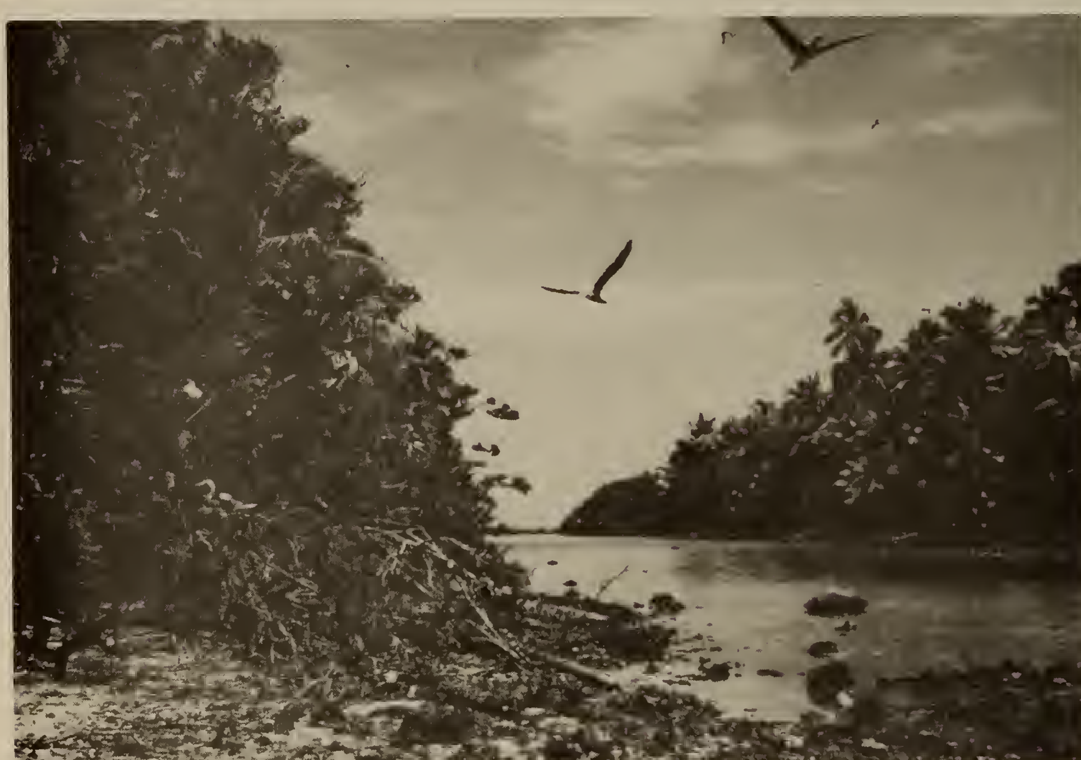

Fig. 3 Seaward end of hoa between Hiraanae and Oroatera with Pemphis and Tournefortia. MHS,1974-75

Fig. 4 Wind-sheared Tournefortia-Scaevola scrub on Motu-Aie. MHS,1974-75

Fig. 5 Lagoon shore on N side, coconut plantation. FRF,1973

Fig 6 Seaward shore, coconut plantation with protective native scrub fringe. FRF, 1973

Fig. 7 Coconut palms with Pemphis acidula scrub red-footed boobies, adult and young on nest. MHS, 1974-75

Fig. 8 Reiko Sato looking at red-footed booby on nest in Pemphis forest, Motu-Aie. MHS, 1974-75

Fig. 9 Red-footed booby in Tournefortia tree. FRF, 1973

Fig. 10 Red-footed booby fledgling on nest, in Pemphis tree. MHS, 1974-75

Fig. 11 Red-footed booby downy young on nest in Pemphis bush. MHS, 1974-75

Fig. 12 MHS looking at young red-footed booby on nest in Pemphis forest. FRF, 1973

Fig. 13 Tahuna-iti Islet, beach fringe of Tournefortia argentea in front of coconut grove, blue-faced boobies on ground at top of beach. FRF, 1982

Fig. 14 Tahuna-iti, Tournefortia with Suriana maritima in background. FRF, 1982

Fig. 15 Onetahi Islet, ocean beach. Tournefortia in flower, Suriana maritima covered with strings of Cassytha filiformis. MHS, 1973

Fig. 16 North side of atoll, erosion remnants of higher reef rock, with Pemphis acidula and nesting birds. MHS, 1973

Figs. 17 and 18 N side of inner part of passage between Tiaraunu and Honuea islets, showing conglomerate platform with intertidal notch or undercut and *Pemphis acidula* on bare rock. MHS, 1973

Fig. 19 Rimatuu Islet, Pandanus tree at back of seaward beach. FRF, 1982

Fig. 20 Rimatuu Islet, head of Pandanus tectorius fruits. FRF, 1982

Fig. 21 Rimatuu Islet, coconut plantation choked with seedlings from fallen nuts. FRF, 1982

Fig. 22 Honuea Islet, fruiting *Timonius polygamus*. FRF, 1982

Fig. 23 Honuea Islet, staminate flowering Timonius polygamus. FRF, 1982

Fig. 24 Honuea Islet, fruiting Hedyotis romanzoffiensis. FRF, 1982

Fig. 25 Honuea Islet, flowering Guettarda speciosa. FRF, 1982

Fig. 26 Honuea Islet, fruiting Guettarda speciosa. FRF, 1982

Fig. 27 Motu Aie, staminate infloresence of Pisonia grandis. FRF, 1982

Fig. 28 Motu Aie, staminate and pistillate flowers and fruit on same tree of Pisonia grandis. FRF, 1982

Fig. 29 Tiaraunu Islet, Casuarina trees in sedge marsh. MHS, 1973

Fig. 30 Onetahi Islet. Hernandia grove at W end of airstrip, with remnants of limestone marae slabls. MHS, 1973

Figs. 31 and 32 Onetahi Islet, along airstrip. Ruins of ancient marae excavated by Y. Sinoto. MHS, 1973

Fig. 33 Onetahi Islet, partially restored marae in coconut plantation, near airstrip. MHS, 1983

Fig. 34 Onetahi Islet, basalt round cobbles brought from Tahiti by aboriginal inhabitants for use in cooking oven. MHS, 1973

Fig. 35 Rimatuu Islet, Eleocharis geniculata zone in front of Cladium jamaicense, coconut plantation in background. FRF, 1982

Fig. 36 Tahuna-iti Islet, results of 1983 hurricane, note turned up coconut root-masses. Tahuna-rahi and Reiono Islets in distance. MHS, 1983

Fig. 37 Onetahi Islet, badly eroded beach front along passage; buildings were in use. MHS, 1982

Fig. 38 Same place, beach completely eroded away by 1983 hurricane exposing tree roots; buildings destroyed. MHS, 1983

Fig. 39 Onetahi Islet, beach along pass washed away by 1983 hurricane. MHS, 1983

Fig. 40 Tahuna-iti Islet, trees defoliated in interior of islet by 1983 hurricane. MHS, 1983

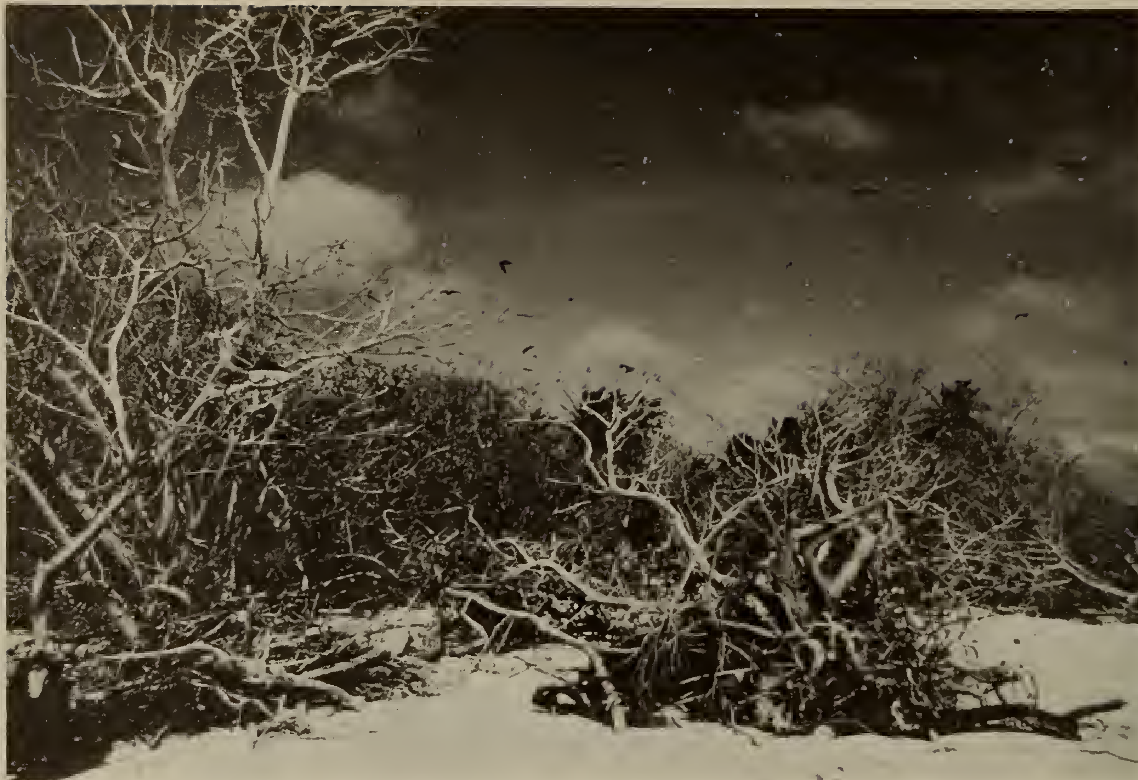

Fig. 41 Tahuna-iti, destruction of vegetation by 1983 hurricane. Compare with Figs. 13 and 14. MHS, 1983

Fig. 42 Tahuna-iti, defoliation of trees where frigate birds and boobies roost. Many dead birds were found under the trees. MHS, 1983

ATOLL RESEARCH BULLETIN

No. 276

BOTANIQUE DE L'ILE DE TUPAI, ILES DE LA SOCIETE

PAR

M.-H. SACHET

ISSUED BY

THE SMITHSONIAN INSTITUTION

WASHINGTON, D. C., U.S.A.

DECEMBER 1983

Fig. 1. La Polynésie Française. Dispersion géographique des îles comparée à l'Europe. D'après une carte de G. Richard, 1982.

BOTANIQUE DE L'ILE DE TUPAI, ILES DE LA SOCIETE*

PAR

M.-H. SACHET

INTRODUCTION

L'île de Tupai ou Motu-Iti (16°15'S, 151°50'W), l'un des cinq atolls des Iles de la Société, est, après Bellingshausen (souvent écrit Bellinghausen) (15°45'S, 154°33'W), le plus au nord de cet archipel, à 280 km NNW de Papeete. C'est grâce à l'amabilité de son propriétaire, Maître Marcel Lejeune, et à l'intérêt qu'il porte aux travaux scientifiques que j'ai pu y séjourner en Déc. 1974 et Mars 1983 (et F. R. Fosberg en Juin 1981). Qu'il veuille bien trouver ici, ainsi que son fils, l'expression de ma reconnaissance pour son hospitalité. J'ai bénéficié aussi de la gentillesse et des connaissances sur les plantes des résidents de l'île et, en 1983, de l'assistance de mon collègue Bruno Delesalle, et je les en remercie. Bernard Salvat, qui visita Tupai en Juin 1983 m'a communiqué ses photographies dont certaines sont reproduites ici, ce done je lui suis bien reconnaissante.

HISTORIQUE

Tupai est une des premières îles découvertes par le Capitaine Cook, pendant son premier voyage. Le navigateur originaire de Raiatea, Tupaia (ou Tupia, Tobia), après lui avoir indiqué l'existence et la position des Iles sous le Vent, avait mentionné une petite île sableuse au nord de Bora-Bora, que l'Endeavour apercut le 27 juillet 1769:

"Between 5 and 6 o'Clock p.m., as we were standing to the Northwest, we discover'd a small low Island lying N. by W. or N.N.W. distant 4 or 5 Leagues from Bola Bola. This island is called Tubai. Tupia says it produceth nothing but a few Cocoa-Nuts; that there are only 3 families live upon it, but that the people from these Islands [Bora Bora, Raiatea-Tahaa] resort thither to Catch fish" (Cook 1955: 146). Joseph Banks, naturaliste de l'Expédition, décrit la découverte à peu près dans les même termes (1962, 1: 321). Banks s'était entouré d'un groupe de botanistes, zoologistes, artistes et autres assistants et l'un d'eux, le jeune dessinateur-peintre Sydney Parkinson, qui ne devait jamais revoir son île natale, cita aussi cette découverte dans son journal (Banks 1773: 71): "In the evening, at sun-set, we discovered the island of Toopbai, making in low land."

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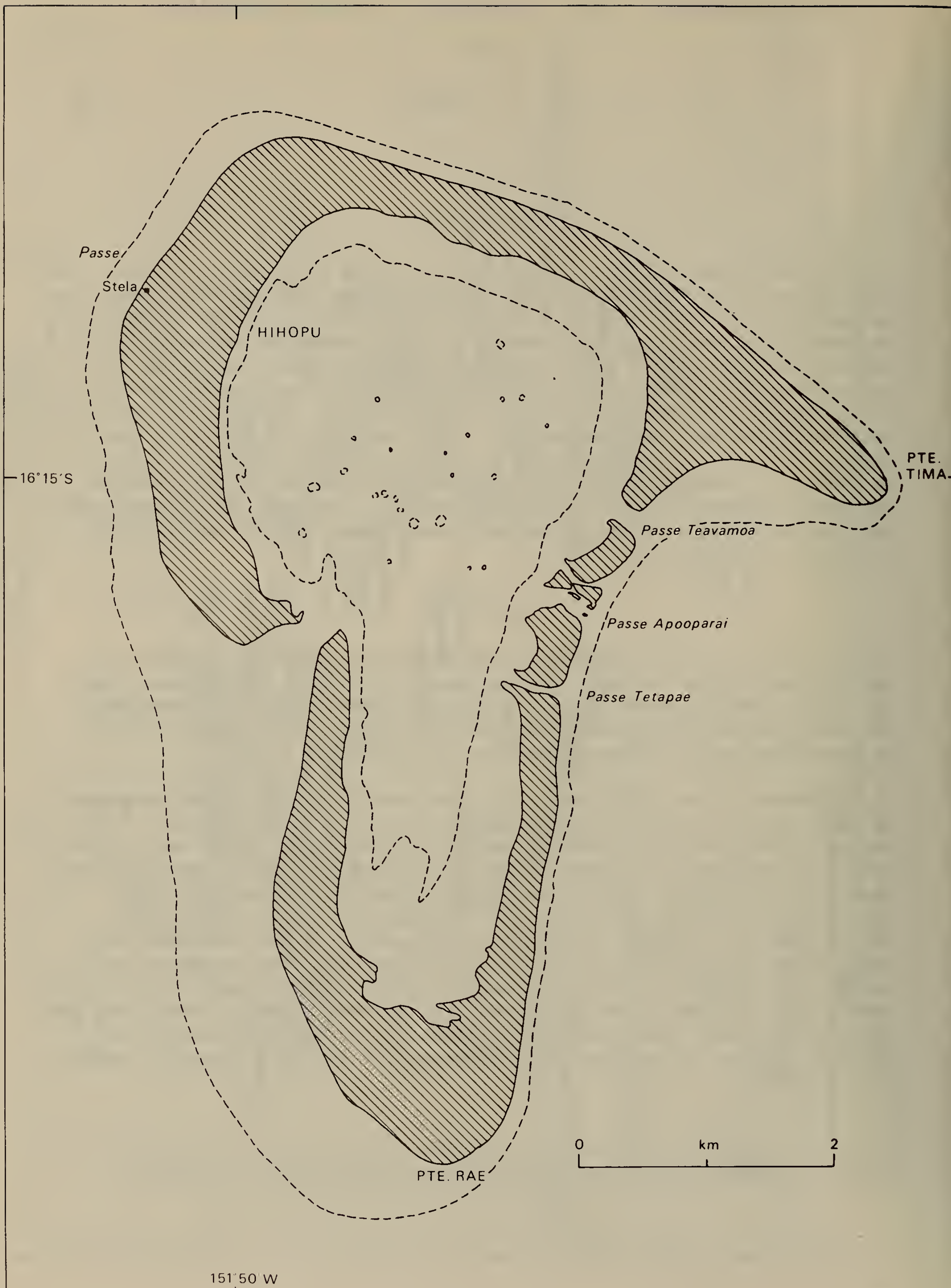

Fig. 2. L'atoll de Tupai

Il est à peu près certain que ni l'Endeavour, ni aucune de ses embarcations, n'approchérent davantage de l'atoll. Pourtant Parkinson, dans sa liste des plantes utiles de Tahiti mentionne (p. 39) "Towhannoo Guettarda-speciosa. "The timber of this tree which grows pretty large at Toopbai, and other low islands near Otaheite ..." et (p. 43) "E owhaee. Aeschynomene-speciosa. "This shrub grows wild, in great abundance, on the island of Toopbai; and is planted on the other islands to shade their houses; and the flower of it, which is very beautiful, they often stick in their ears."

Cette liste de Parkinson est célèbre, car elle représente la première énumeration vraiment botanique à être publiée pour la Polynésie du Sud-Est, et certains noms latins, choisis mais jamais publiés par le botaniste de l'Expédition, D. C. Solander, datent de cette époque; c'est le cas pour "E owhaee," maintenant Sesbania coccinea sensu lato. Cette belle plante existe toujours sur l'atoll.

Il faut croire que Parkinson avait reçu les indications sur ces deux plantes de quelqu'un d'autre. Sa splendide peinture de "E owhaee" (ofai) a été exécutée à Yoolee-Etea (Ulietea = Raiatea), soit que la plante y soit cultivée, soit qu'elle ait existé sur un des motus du récif de Raiatea où l'Expédition passa quelque temps.

George Bennett (1840, 1: 365) décrit Tupai ou Motuiti en ces termes: "A small, rocky, and uninhabited island remarkable ... as having been formerly a kind of preserve, whence the royal chiefs of Tahiti obtained their supplies of the tail feathers of the tropic-bird."

Tupai n'a été étudié en détail et sa flore enfin explorée que bien plus tard: Dr. Martin L. Grant y séjourna quelques jours en Décembre 1930 et récolta la plupart des plantes observées (70 en tout). Il avait fait le projet d'écrire une description de la végétation (1937) mais elle n'a jamais été complétée. Ses collections sont citées ci-dessous avec les miennes et celle de F. R. Fosberg. M. R. Papy (1954-56) pendant son séjour en Polynésie Française a décrit les îles de la Société, dont les 5 atolls, et dit de Tupai qu'il s'y trouvait une vingtaine de travailleurs s'occupant de la cocoteraie et de la pêche (1956: 56).

Outre les recherches botaniques, Maître Lejeune a encouragé le travail de B. et J.-C. Thibault (1973) sur la faune, plus spécialement l'avifaune, et les observations sur les insectes piqueurs de J. Duval (1978). B. Delesalle étudie le phytoplancton du lagon à intervalles réguliers.

Autrefois, Tupai était une dépendance de Bora-Bora, et après le développement des plantations de cocotiers, les gens de Faanui venaient faire le rahui du copra sur la partie E de l'atoll, abordant par les petites passes. Les terres de la partie W appartenaient aux gens de Vaitape (Ropiteau 1962). Ropiteau signale l'existence de plusieurs marae, et décrit en particulier le marae de Tupaiofai, sur la terre Farepaea (juste au nord de la passe Peavamoa). Ce marae était encore en très bon état pendant les années 20, mais, d'après M.L. Grant, en

Déc. 1930 il avait déjà été endommagé et partiellement détruit au moment de la visit du Yacht Genese.

Il existait aussi autrefois un village à Farepaea.

GEOGRAPHIE

Tupai est une île très petite, d'environ 8 km de long sur 6 à l'endroit le plus large (partie N), construite sur un récif sans passe. La bande de terre émergée est presque continue, interrompue seulement par des chenaux (hoa) très peu profonds, l'un à l'ouest, et une série d'autres à l'est. Il se forme ainsi deux grands îlots (motu) au nord et au sud, avec à l'est, une série de petits motus très rapprochés et de taille et forme variables, suivant le déplacement des hoas.

La couronne émergée est relativement large, et la surface en est d'environ 1300 hectares, soit presqu'autant que les 3 atolls de l'ouest réunis. La piste d'aviation se trouve au NNW, traversant de l'océan au lagon une des parties les plus larges de la couronne. C'est le site marqué Hihopu sur les cartes. Pour permettre aux embarcations d'approcher de l'île on avait fait sauter à la dynamite une passe en travers du récif. L'unique village actuel, d'une vingtaine de maisons de travailleurs, avec une école et des séchoirs à copra, s'élève à l'W de la piste, au bord du lagon, et des hangars, ateliers et maisons d'habitation se trouvent à l'E, avec un jardin. En 1974, 2 mares entourées de Typha et de Cypéracées diverses contenaient des nénuphars bleu-mauve.

Le platier du récif est particulièrement large à l'ouest, en face du hoa, et par temps calme, on peut y observer, d'un bateau plat, le biome corallien dans toute sa variété et sa beauté. De ce hoa de l'ouest on voit la silhouette de Bora-Bora au sud, et Maupiti au SW. Le récif est le plus étroit sur les côtes N-E et E.

Au-dessus du platier, s'élèvent des grèves de sables ou graviers avec des blocs de tailles diverses, dont la pente varie d'un endroit à l'autre de la couronne émergée. A la limite, on rencontre en certains points une bande de conglomérat corallien peut-être continu avec le soubassement de l'îlot. Ailleurs, en particulier sur la côte nord-est, des couches bien litées de grès de plage (beach-rock) sont des témoins de l'évolution du rivage. Les formes littorales ont été altérées par le cyclone Reva en mars 1983, des lits de graviers frais et blanc déposés ou empilés en bermes sur les sédiments grisâtres sous-jacents, les bords des couches de conglomérat brisés ou affouillés, et parfois de très gros blocs arrachés au récif extérieur et lancés sur le platier ou même sur les plages (cf. photos prises par B. Salvat, Figs. 11-18).

Le lagon de Tupai est peu profond, avec une large bande sableuse tout autour, et encombré de "patates", piliers de corail qui remontent presque jusqu'à la surface et qui sont tapissés de coraux vivants et d'algues calcaires, avec un biome libre associé.

Le climat de Tupai, comme celui de tout l'archipel de la Société, est un climat océanique tropical humide. La température varie peu au cours de l'année avec un écart de 2°C seulement entre les moyennes des mois les plus chauds (Février-Mars, 27°2) et les plus frais (Juillet-Août, 25°2), différence légèrement inférieure aux écarts journaliers.

La saison chaude est aussi celle où les précipitations sont les plus abondantes. A cause de sa petite surface et malgré son piton volcanique, Bora-Bora (station météorologique la plus proche de Tupai) ne profite pas de pluies d'origine orographique et certaines saisons sèches peuvent être très sèches et entraîner une sérieuse carence d'eau. Ceci s'applique sans doute également à Tupai, d'autant que l'eau de pluie s'y infiltre immédiatement dans le sol et soubassement très poreux. La moyenne des précipitations annuelles pour la période 1951-1969 est d'environ 2000 mm à Bora-Bora.

Le régime des vents est celui des alizés, et les vents dominants sont du secteur NE pour plus de la moitié des observations. Mais des vents des secteurs W, bien que peu fréquents, peuvent être particulièrement violents.

Les tempêtes cycloniques et les vrais cyclones (vents de plus de 65 noeuds ou 120,5 km/h) sont rares mais peuvent avoir des effets désastreux. Arbousset (1867) rapporte qu'à Tupai, 1 ou 2 villages furent anéantis par un cyclone le 2 Février 1865. Un certain nombre des cyclones énumérés par Teissier (1969) avaient frappé les Iles sous le Vent et donc peut-être Tupai, en particulier celui du 1er Janvier 1926 qui ravagea Bora-Bora. Le cyclone Rewa (Reva) de Mars 1983 est le seul dont la trajectoire et les effets à Tupai soient bien documentés. Le cyclone se dirigeait vers l'ouest mais tourna en épingle à chevaux vers l'E puis SE au nord de Bora-Bora et Tupai le 11 mars. Le lagon de Tupai avait déjà gonflé 1 veille et c'est par ses vagues que le village fut inondé et dévasté. Une douzaine de maisons et autres installations au bord du lagon étaient complètement démolies, la rangée de maisons un peu plus à l'intérieur fort endommagées, les jardins et plantations ensevelis sous les sables et graviers coralliens blancs. Les effets du vent dans la cocoteraie furent relativement minimes, et la piste d'aviation qui la traverse de l'océan au lagon ne fut pas mise hors de service, ce qui permit l'arrivée rapide de secours et vivres, en particulier d'eau potable, pour les 48 habitants de l'île.

L'impact du cyclone sur les rivages de l'océan est mentionné ci-dessus.

VEGETATION

Comme presque tous les atolls et motus de Polynésie, Tupai a été transformée en plantation de cocotiers, de sorte qu'il ne reste que peu de traces de la végétation naturelle, surtout dans l'intérieur. Contrairement à ce que j'ai observé à Mopelia, dans les Tuamotus et à Tarawa (Iles Gilbert) on ne pratique pas à Tupai le "nettoyage par le vide" coupant et brûlant tout ce qui n'est pas cocotier. Le sol n'est mis à nu que lorsqu'on replante certains secteurs. Parmi les cocotiers on trouve donc des arbres et arbustes témoins de la végétation disparue, avec leur cortège d'herbacées de sous-bois. Ce système a l'avantage de ne pas appauvrir le sol en matière organique et de lui garder un maximum d'humidité.

On peut distinguer 6 principaux types de végétation dans ce petit atoll:

1. Zone des rivages de l'océan (en général fourrés de composition et d'aspect différents suivant le substratum)
2. Végétation des rivages du lagon
3. Forêt mésophile de l'intérieur (largement remplacée par la cocoteraie)
4. Forêt ouverte à <u>Cordia</u>-<u>Pisonia</u> des régions caillouteuses
5. Dépressions à cypéracées
6. Végétation des abords du village et de la piste

1. Zone de végétation côtiere

Une sorte de haie, plus ou moins dense, s'étend en haut des crêtes de plages, composée d'espèces résistant à la sécheresse, au vent et au sel, telles que <u>Scaevola sericea</u> aux grandes feuilles luisantes, <u>Suriana maritima</u>, aux petites feuilles veloutées et fleurs jaunes, et <u>Tournefortia argentea</u> à grandes feuilles argentées et petites fleurs très parfumées, arrangées en thyrses. Toutes ces espèces pionnières se rencontrent en descendant vers la plage comme petits plants venus de fruits et graines roulant de la crête ou amenés par les vagues. Sur les plages même on peut trouver des germinations d'autres espèces, dont la plupart ne survivent pas. Les régions sableuses assez larges sont occupées par des individus isolés de <u>Suriana</u>, des <u>Tournefortia</u> en arbres avec en dessous leur litière caractéristique de feuilles mortes, puis des touffes isolées de graminées (surtout <u>Lepturus repens</u>, dont les épis se désarticulent en petits segments cylindriques qui flottent), parfois des plants de pourpier (<u>Portulaca</u> sp.), des tiges rampantes de <u>Boerhavia tetrandra</u> avec leurs petites fleurs roses, et enfin des plants isolés d'<u>Heliotropium</u>.

Là où la crête est rocheuse, <u>Suriana</u> est remplacé par <u>Pemphis acidula</u>, aux petites feuilles gris-vert et fleurs blanches. Ceci se rencontre en particulier dans la région des hoas de l'est, où des dalles gris-foncé de récif ancien apparaissent sous le sable des plages ou forment des îlots barrant le plus au nord des hoas. <u>Pemphis</u> est presque toujours une plante indicatrice d'un substratum rocheux, qu'il soit à découvert ou pas.

2. Végétation des rivages du lagon

Le long des hoas et de certains points du lagon, les même plantes, Suriana, Tournefortia et Scaevola, avec Guettarda speciosa, bordent les plages étroites, mais comme individus isolés, elles ne forment pas un rempart épais et continu comme du côté océan. En bien des endroits, la cocoteraie vient jusqu'au bord du lagon.

Le long du large hoa de l'ouest, la pointe en crochet de l'îlot du nord est caillouteuse et la cocoteraie est nettement séparée d'un site où la végétation est très ouverte; parsemée de buissons bas de Timonius polygamus aux rameaux souples et retombants, d'arbustes dressés d'Hedyotis romanzoffiensis, de petits plants de Scaevola, et d'une strate de plantes basses telles que Portulaca, Heliotropium et Lepturus.

Juste au nord des hoas de l'Est, dans une courbe du rivage du lagon et au-dessus d'une étroite plage de sable fin se trouve un bosquet de Sesbania coccinea s.l. En 1974, à ma première visite, il se composait d'un petit nombre de ces arbustes hauts de 4-5 m, sans fleurs mais avec quelques boutons déformés et de longues gousses sèches. Ils ont un tronc mince et élancé, formant assez bas des branches latérales redressées en candélabre, un feuillage d'un vert clair légèrement glauque, feuilles paripennées. Les fleurs de cette espèce sont orange avec des stries ou points rouge carminé plus ou moins denses, et de la taille d'un pois de senteur. Ces plants paraissaient étouffés par la végétation environnante de cocotiers, Pandanus et fougères qui leur donnaient aussi sans doute trop d'ombre. En Juin 1981, F. R. Fosberg accompagné de Michel Guérin, trouva le site complètement débroussé et dégagé pour la plantation de nouveau cocotiers, et sur le sol mis à nu on ne trouvait que quelques germinations de 10 à 20 cm de haut. En Mars 1983 (1-3), le bosquet, sous une ombre légère, s'était reformé et étendu, et comptait une centaine d'arbustes jusqu'à 2 m et plus de hauteur, couverts de gousses sèches et avec en-dessous beaucoup de germinations. Le site est maintenant protégé contre le travail de la cocoteraie. Mais le 10 mars 1983, le cyclone Rewa (ou Reva) inonda cette partie de l'atoll et tous les Sesbania furent défeuillés par le vent (B. Delesalle, communication personnelle).

Ce type de végétation est rare dans les îles de la Société et aux Tuamotus, et se trouve le plus souvent le long des lagons, mais parfois aussi dans l'intérieur; l'aire de distribution de l'espèce est nettement en régression comme l'avait prédit Cuzent (1860: 211-212).

3. Forêt mésophile de l'intérieur

Derrière la végétation littorale protectrice s'étendait autrefois une forêt mésophile composée d'un petit nombre d'espèces d'arbres mais pouvant atteindre une grande taille: Pisonia grandis et Guettarda speciosa surtout, avec Cordia subcordata, Barringtonia asiatica, Hernandia sonora et Calophyllum inophyllum; ces 3 dernières essences ne se rencontrent qu'en petit nombre et localement, et ont probablement été apportées d'îles voisines par les Polynésiens et plantées, comme sans doute dans les 4 autres atolls des îles de la Société. A Tupai, on les trouve en particulier au nord des hoas de l'est dont le premier était utilisable par les pirogues et les baleinières, et où un ancien village aurait été situé. Pandanus tectorius est abondant un peu partout dans cette forêt. De nos jours, tous ces arbres subsistent en petit nombre, parsemés dans la cocoteraie. Ils donnent une ombre plus épaisse et enrichissent localement le sol.

Suivant la densité de cette strate arborée, le sous-bois varie en composition et hauteur. Dans la forêt la plus touffue, ce sont des fougères (Davallia solida, Nephrolepis sp., Polypodium scolopendria en touffes très serrées de jeunes cocotiers et Pandanus, des rejets ou germinations de Morinda citrifolia. Dans les trouées formant de petites clairières, des fourrés hauts de 1,5 à 2 m d'Achyranthes velutina au feuillage grisâtre s'entourent de jeunes plants de Pandanus, des lianes d'Ipomoea macrantha couvrent buissons et sol, la pelouse de Lepturus repens et Fimbristylis cymosa est plus épaisse. Là où les cocotiers sont clairsemés, on remarque Tacca, dont les tubercules sont à l'occasion utilisés comme plante médicinale à Raiatea, Euphorbia atoto jusqu'à plus d'un m de haut, et Laportea ruderalis. Sur les chemins ensoleillés et là où les arbres manquent, Portulaca spp., Boerhavia tetrandra, Lepidium bidentatum sont particulièrement abondants.

Au sud de l'atoll et dans les petits motus de l'est, la forêt est très dense, avec de grands Pisonia et Guettarda, quelques Cordia, des cocotiers et Pandanus. Achyranthes se rencontre dans les petites clairières. Cette végétation est difficile à pénétrer, très ombragée et humide.

4. Forêt ouverte à Cordia-Pisonia des régions caillouteuses

La branche W du motu Sud, dont le sol est très caillouteux, porte une végétation arborée relativement ouverte, où les cocotiers ne se trouvent qu'en petit nombre. La forêt offre un caractère intermédiaire entre la forêt mésophile dense telle qu'elle devait être avant sa transformation en cocoteraie et les formations arbustives élevées des rivages abrités. Elle comprend des arbres de Cordia subcordata et Pisonia grandis dont certains atteignent une très grande taille, avec Guettarda speciosa et Pandanus. En approchant des plages, on rencontre des petits arbres de Tournefortia argentea et de grands buissons de Suriana maritima, dont beaucoup sont tellement chargés des ficelles orangées de Cassytha filiformis que cette liane parasite finit par les tuer, laissant des squelettes noirs.

La où la forêt est assez clairsemée, on trouve parmi les arbres des arbustes tels que Timonius polygama, avec Euphorbia atoto, Boerhavia tetrandra, Portulaca johnii, Polypodium scolopendria, Lepidium bidentatum, et localement Laportea ruderalis.

C'est dans ce type de forêt ouverte que l'on voit le plus d'oiseaux de mer, en particulier les fous à pieds rouges (Sula sula rubripes) qui y nichent et dont j'ai observé des poussins en duvet et des juvéniles en plumage brun.

5. Depressions à Cypéracées

En survolant Tupai, on peut reconnaître plusieurs régions marécageuses avec ou sans eau libre. Outre les petites mares observées en 1974 près de la piste et des habitations, j'ai pu en étudier une vers la pointe Est de l'atoll, non loin du bosquet de Sesbania. Comme à Tetiaroa et dans certains atolls des Tuamotus, la végétation est formée de zones concentriques très nettes de différentes espèces de cypéracées: au centre, Cladium jamaicense haut de 1 m environ, autour une zone moins élevée de Cyperus javanicus au feuillage gris-vert, et à l'extérieur dans la boue fine les touffes vert vif d'Eleocharis geniculata dont les minces tiges surmontées d'inflorescences en forme de pommes de pin minuscules ne dépassent pas 15 ou 20 cm. Fimbristylis cymosa var. pycnocephala est commun sur le terrain plus sec longeant le marécage.

Duval (1978) indique la position de mares ou vasières sur les rivages du lagon, en particulier une grande étendue dans le V du grand motu sud. Si la salinité de ces mares est favorable (2-15 ‰) elles deviennent des gites pour la reproduction du "nono", Culicoides belkini (Ceratopogonidae), un insecte piqueur extrêmement désagréable qui a peu à peu envahi les îles de la Société et les Tuamotus depuis son apparition à Bora-Bora vers 1959.

6. Végétation des abords du village et de la piste

Les maisons des travailleurs, alignées en 2 rangées le long du lagon, ont chacune un petit jardin de plantes vivrières, telles que tomates, citrons verts, pastèques, et quelques plantes ornamentales telles que Crinum et Catharanthus. Au delà du "village" dans la cocoteraie, on avait dégagé en 1974 l'emplacement d'un verger et planté plusieurs centaines d'agrumes (citrons verts, oranges, pomelos), de "kava" (Pometia pinnata) et autres arbres fruitiers dont un certain nombre paraissaient souffrir de chlorose. Je n'ai pas pu savoir ce qu'ils étaient devenus en 1983. Non loin se trouvait un champ de pastèques.

Du côté E de la piste, il subsistait près d'une maison d'habitation quelques grands arbres de Cordia subcordata et Hernandia sonora, un Tournefortia à tête arrondie, accompagnés de papayers. On avait planté un Coccoloba (raisin de mer), un Thespesia, un Gardenia taitensis (tiare), un grand Nerium couvert de fleurs (laurier rose), ainsi que des fougères (Asplenium nidus) et des plantes à fleurs ou à feuillage coloré. En 1983, ces plantations s'étaient agrandies, mais ont sans doute été endommagées sinon détruites par le cyclone Rewa.

De chaque côté de la piste, et entre les groupes de bâtiments, s'étend une pelouse rase de graminées et cypéracées dont quelques espèces indigènes et beaucoup d'adventices. On y trouve aussi Euphorbia hirta, E. prostrata, Phyllanthus niruri, Sida rhombifolia, plusieurs composées et les tiges rampantes de Triumfetta procumbens et Boerhavia tetrandra, plantes très communes dans la végétation naturelle sur le sable et dont les fruits crochus ou collants facilitent la dispersion. Près des bâtiments et dans les coins humides on rencontre d'autres adventices plus élevées.

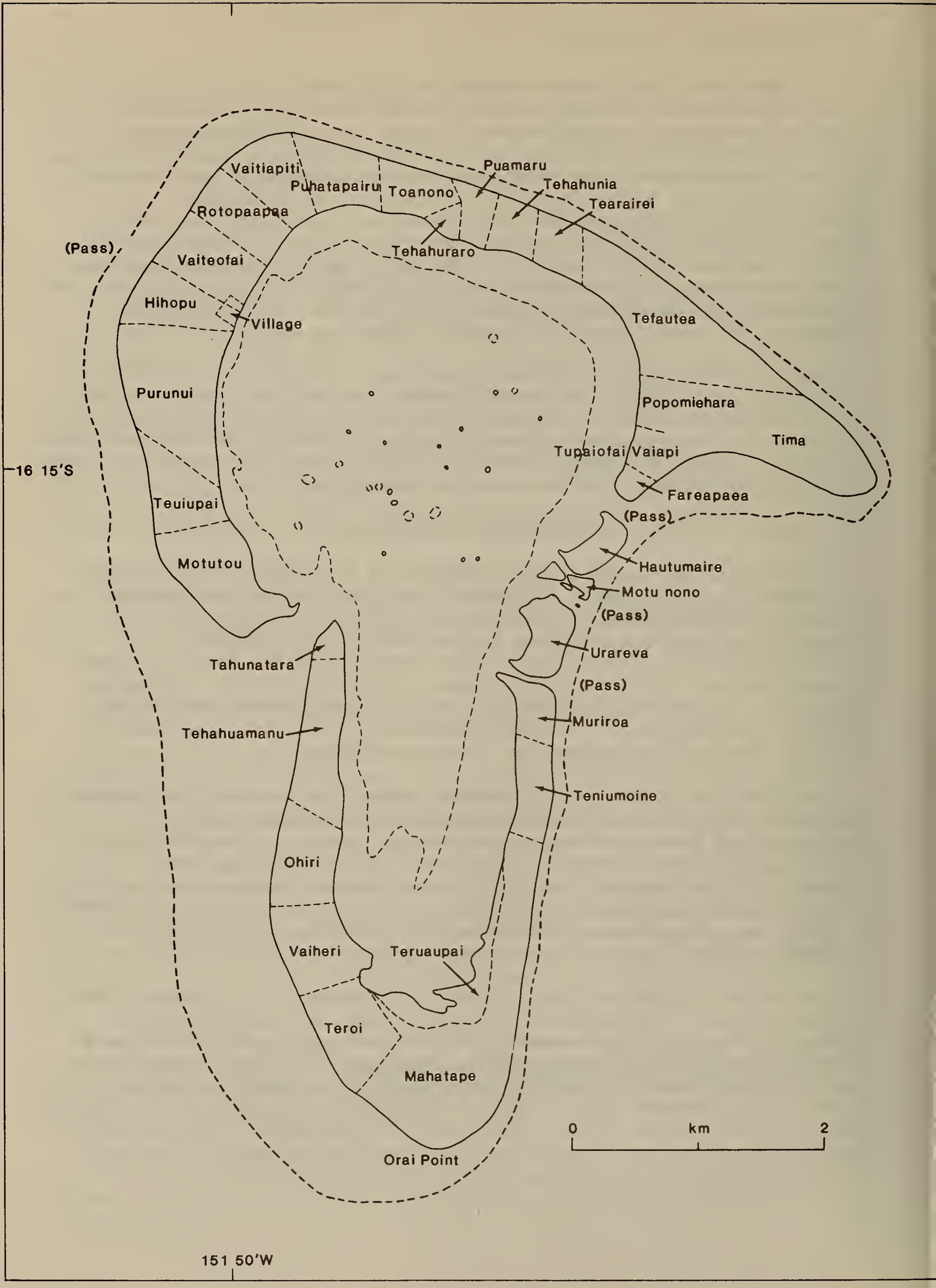

Fig. 3. Noms des terres à Tupai, d'après une carte manuscrite de M. L. Grant (1930).

PLANTES RECOLTEES OU OBSERVEES A TUPAI

Dans la liste qui suit, j'ai inclus tous les spécimens que j'ai pu voir dans divers herbiers. De mes collections, la première série est déposée au U.S. National Herbarium (US), mais des séries presqu'aussi complètes sont destinées au B.P. Bishop Museum de Honolulu (BISH) et au Muséum National d'Histoire Naturelle, Paris (P).

Il se trouve que les étiquettes sont toutes rédigées en anglais et elles sont donc citées dans cette langue. Je n'ai pas récolté de noms polynésiens à Tupai, puisque la population n'est pas autochtone, les travailleurs venant d'îles voisines. Les noms qui sont cités avaient été recueillis par Martin Grant. Les noms des terres sont indiqués sur la Fig. 3, basée sur une carte manuscrite de Grant.

La flore terrestre de Tupai contient certainement un certain nombre d'espèces non encore signalées, car mes deux séjours de 48 h chacun environ ne m'ont pas permis d'explorer complètement l'atoll. Quelques espèces autochtones peuvent ne pas avoir été observées, et il s'y trouve certainement davantage d'adventices (mauvaises herbes, "weeds"). Quant aux plantes introduites (indiquées dans la liste par un astérisque *), ornamentales ou vivrières, leur nombre ne cesse de varier suivant le goût des jardiniers et les aléas du climat. La plupart sont plus vulnérables aux tempêtes que les plantes autochtones qui y sont adaptées et sont bien établies.

Je n'ai pas eu le temps de rechercher les cryptogames, champignons, lichens et mousses, dont le nombre est toujours restreint sur les atolls, mais varie suivant le climat et divers autres facteurs du milieu. J'ai toutefois noté la présence d'un polypore de couleur vermillon, probablement *Polyporus cinnabarinus*.

PSILOTACEAE

Psilotum nudum (L.) Beauv.

Mototou, Grant 4854 (BISH) "aito", on Cocos roots.

POLYPODIACEAE (s. l.)

Asplenium nidus L.

Area of Pass, east end of island, Sachet 1958 (US). Also seen planted near houses.

Davallia solida (Forst. f.) Sw.

Hihopu (S. island only), Grant 4823 (BISH) "titi", on *Cocos*.

Area of Pass, east end of island, Sachet 1957 (US).

On ground, coconut wood and husks in dense shade of coconut plantation. North Islet, Fosberg 61350 (US).

Nephrolepis biserrata (Sw.) Schott

Tefautea, Grant 4824 (BISH), on *Cocos*.

East corner of atoll, Sachet 1994 (US). Very abundant in shade in coconut plantation.

Polypodium scolopendria Burm. f.

Purunui, Grant 4822 (BISH). "atuapuaa", on trees.

Popomiehara, Grant 4825 (BISH). "iriopeho", on trees.

Teniupae, Grant 4826 (BISH). "oro", on trees.

North Islet, Fosberg 61348A (US).

TYPHACEAE

**Typha* sp.

Seen in water hole near runway in 1974.

PANDANACEAE

Pandanus tectorius Park.

Farepaea, Grant 4810 "fara", Grant 4811 "uea" (all BISH).

POACEAE

*<u>Cenchrus echinatus</u> L.

Common around buildings and near runway.

*<u>Cymbopogon citratus</u> (DC.) Stapf

Hihopu, <u>Grant 4843</u> (BISH). "ti"

*<u>Cynodon dactylon</u> (L.) Pers.

Camp on lagoon side of runway, N. end of atoll, <u>Sachet 1974</u> (US).

<u>Digitaria stenotaphrodes</u> Stapf

Purunui, <u>Grant 4842</u> (BISH)

*<u>Digitaria</u> sp.

Weedy grass at edge of coconut plantation near buildings.

*<u>Eleusine indica</u> (L.) Gaertn.

Camp on lagoon side of runway N. end of atoll, <u>Sachet 1980</u> (US), common in weedy area near buildings.

Hihopu, strand, <u>Grant 4839</u> (BISH). "tamaomao".

*<u>Eragrostis tenella</u> (L.) Beauv.

Hihopu, <u>Grant 4838</u> (BISH).

<u>Lepturus repens</u> (Forst.) R. Br. var. <u>repens</u>

East end of atoll, area of Pass, <u>Sachet 2000</u> (US). Common at top of beach in open vegetation.

East corner of atoll, <u>Sachet 1997</u> (US). In shady path in coconut plantation.

Hihopu, <u>Grant 4840</u> (BISH).

Tearairei, <u>Grant 4841</u> (BISH), creeping.

Urareva, <u>Grant 4844</u> (BISH), sterile.

North Islet, <u>Fosberg 61346</u> (US).

*<u>Paspalum distichum</u> L.

Vaiteofai, marsh, <u>Grant 4845</u> (BISH), sterile.

*Stenotaphrum secundatum (Walt.) O. Ktze.

Lagoon side of runway, north end of atoll, Sachet 1991 (US).

CYPERACEAE

*Cyperus brevifolius (Roltb.) Hassk.

Seen in seep around water tank.

Cyperus javanicus Houtt.

Around water holes near runway and in several low areas.

*Cyperus kyllingia Endl.

Occasional in workers' village.

*Cyperus polystachyos Rottb.

Camp on lagoon side of runway, north end of atoll, Sachet 1982 (US).

*Cyperus rotundus L.

Camp on lagoon side of runway, north end of atoll, Sachet 1981 (US).

Cladium jamaicense L. (sensu lato)

East point of atoll, filling marshy spot with other sedges, Sachet 2574 (US).

Purunui, Grant 4829 (BISH) "mouraurii".

Eleocharis geniculata (L.) R. & S.

Purunui, Grant 4834 (BISH).

Camp on lagoon side of runway, north end of atoll, Sachet 1985 (US).

Fimbristylis cymosa R. Br.

Purunui, Grant 4831, 4832, 4833 (all BISH).

Hihopu, Grant 4857 (BISH).

Fimbristylis cymosa var. umbellato-capitata Hbd.

Area of Pass, east end of island, Sachet 1999 (US).

Common in coconut plantation (and everywhere on atoll); near marsh filled with _Cladium jamaicense_, _Sachet 2576_ (US).

East point of atoll, outer area of marsh filled with _Cladium_, _Sachet 2575_ (US).

ARECACEAE (PALMAE)

Cocos nucifera L.

Planted all over atoll.

ARACEAE

*_Epipremnum pinnatum_ (L.) Engler

Scindapsus aureus (Linden & Andre) Engler

North east side of island, area near Pass, _Sachet 1965_, _1963_ (both US). Climbing on palms in coconut plantation, smaller vines creeping on ground, variegated green and golden yellow.

North Islet, _Fosberg 61355_ (US).

*_Philodendron lacerum_ (Jacq.) Schott

Area near Pass, north east side of island, _Sachet 1964_ (US). Climbing on palms in coconut plantation.

COMMELINACEAE

*_Rhoeo spathacea_ (Sw.) Stearn

Growing in pot.

LILIACEAE (sensu lato)

*_Crinum_ sp.

Cultivated in settlement.

TACCACEAE

Tacca leontopetaloides (L.) O. Ktze.

North Islet, _Fosberg 61343_ (US).

CASUARINACEAE

*_Casuarina equisetifolia_ L.

North end of island, planted and trimmed as hedge near camp, sight record by Sachet, March 1983.

MORACEAE

Ficus tinctoria Forst. f.

Motutou, Grant 4812 (BISH). "mati".

URTICACEAE

Laportea ruderalis (Forst. f.) Chew

Hihopu, Grant 4837 (BISH). "upotiu".

North Islet, Fosberg 61342 (US).

POLYGONACEAE

*Coccoloba uvifera (L.) L.

One seen planted in 1974.

AMARANTHACEAE

Achyranthes velutina H. & A.

East corner of atoll, Sachet 1996 (US). Locally abundant in open spot in coconut plantation, plants up to 1.5 m tall.

*Alternanthera brasiliana (L.) O. Ktze var.

Planted, sight record, F. R. Fosberg, July 1981, red leaves and stems.

*Amaranthus dubius Mart. ex Thell.

Area west of runway, north end of atoll, Sachet 2002 (US).

NYCTAGINACEAE

Boerhavia tetrandra Forst. f.

East end of island, near Pass, Sachet 1959 (US). Vines on sand at edge of coconut plantation, corolla pink.

Camp at north end of atoll, on lagoon side of runway, Sachet 1973 (US). Local on sand pile in weedy area near buildings, common elsewhere.

North Islet, Fosberg 61341, 61353 (both US).

Vaiteofai, Grant 4846 (BISH). "toroura".

Pisonia grandis R. Br.

Area west of runway, north end of atoll, Sachet 2001 (US).

North west area of atoll, trees remaining in coconut plantation when it is cleared, Sachet 2578 (US).

PORTULACACEAE

Portulaca fosbergii von Poelln.

Camp on lagoon side of runway, north end of atoll, Sachet 1971, 1970 (both US). These represent a yellow and a white flowered form, otherwise looking similar.

Portulaca johnii von Poelln.

North Islet, Fosberg 61345 (US). This in seed surface and thickened stem at base approaches P. lutea Sol. ex. Forst. f. Area near Pass, north east side of island, Sachet 1968 (US).

NYMPHAEACEAE

*Nymphaea sp.

Main Island, sight record by Sachet in 1974. A blue-flowered species.

LAURACEAE

Cassytha filiformis L.

Purunui, Grant 4827a (BISH).

North Islet, Fosberg 61349 (US).

HERNANDIACEAE

Hernandia sonora L.

East end of island, area of Pass, Sachet 1961 (US). Two trees at edge of coconut plantation.

BRASSICACEAE

Cardamine sarmentosa Forst. f. ex DC.

Village area, north end of atoll, Sachet 2571 (US). Along edge of cement slab of house, in shade.

Lepidium bidentatum Montin

Area near Pass, east end of island, Sachet 1969 (US). Common locally, plants up to 75 cm tall (some seen taller), young branches from older dry plants. Flowers white.

Purunui, Grant 4856 (BISH). "maaroaro".

FABACEAE

*Leucaena leucocephala (Lam.) de Wit

North end of atoll, camp on lagoon side of runway, Sachet 1988 (US). A few plants up to 2-3 m tall, in weedy area near buildings.

Sesbania coccinea (L.f.) Poir. s. l.

East end of island, area of Pass, Sachet 1956 (US). A dozen or so slender trees, in poor shape, in shade of coconut palms.

Popomiehara, Grant 4818 (BISH). "faifai".

Area of Pass, east end of island, Sachet 2582 (US). Small grove of at least 100 plants grown back after clearing and cutting, dry pods only (fertile seeds).

Sophora tomentosa L.

Farepaea, Grant 4820 (BISH). "runa".

Northwest area of atoll, along track in coconut plantation, Sachet 2577 (US).

Vigna marina(Burm.) Merr.

Camp on lagoon side of runway, N. end of atoll, Sachet 1992 (US).

SURIANACEAE

Suriana maritima L.

Purunui, Grant 4813 (BISH). "miki miki" (confusion with Pemphis acidula).

North Islet, Fosberg 61347 (US).

RUTACEAE

*Citrus aurantifolia (Christm.) Swingle lime, citron vert

Seen in orchard in 1974.

*Citrus maxima (Burm.) Merr. pomelo, pamplemousse

Seen in orchard in 1974.

*Citrus sinensis (L.) Osbeck orange

Seen in orchard in 1974.

EUPHORBIACEAE

Euphorbia "atoto" Forst. f.

North end of atoll near runway, Sachet 1993 (US). Common everywhere under coconut palms in plantation, often forming pure stands up to 1.5 m tall.

Purunui, Grant 4855, 4814 (both BISH).

North Islet, Fosberg 61340 (US).

*Euphorbia hirta L.

North end of atoll, camp on lagoon side of runway, Sachet 1978 (US). Common in weedy area near buildings.

*Euphorbia prostrata Ait.

Hipopu, Grant 4836 (BISH). "papati".

Camp on lagoon side of runway, north end of atoll, Sachet 1972 (US).

*Phyllanthus amarus Sch. & Th.

Camp on lagoon side of runway, north end of atoll, Sachet 1989 (US).

Purunui, Grant 4828 (BISH).

SAPINDACEAE

*Pometia pinnata Forst. kava

Seen in orchard in 1974.

RHAMNACEAE

Colubrina asiatica (L.) Brongn.

Motutou, Grant 4821 (BISH). "tutu".

TILIACEAE

Triumfetta procumbens Forst. f.

Vaiteofai, Grant 4827 (BISH). "piripirimotu".

North Islet, Fosberg 61348 (US).

MALVACEAE

Hibiscus tiliaceus L.

Planted in settlement, and scattered locally in coconut plantation.

*Sida acuta Burm. f.

Hihopu, Grant 4848 (BISH).

*Sida rhombifolia L.

North end of atoll, camp on lagoon side of runway, Sachet 1987 (US). Local in weedy area near buildings.

Hihopu, Grant 4849 (BISH).

Thespesia populnea (L.) Sol. ex Correa

Planted near settlement.

STERCULIACEAE

*Waltheria indica L.

Hihopu, Grant 4850 (BISH).

CLUSIACEAE

*Calophyllum inophyllum L.

Area of Pass, east end of island, Sachet 1960 (US). One tree at edge of coconut plantation, probably planted.

CARICACEAE

*Carica papaya L.

Planted in settlement.

CUCURBITACEAE

*<u>Citrullus</u> <u>vulgaris</u> var. <u>caffrorum</u> (Alef.) Fosberg   water melon, pastèque

Cultivated in opening in coconut plantation near orchard.

LYTHRACEAE

<u>Pemphis</u> <u>acidula</u> Forst.

Purunui, <u>Grant</u> <u>4819</u> (BISH).   "aie".

LECYTHIDACEAE

<u>Barringtonia</u> <u>asiatica</u> L.

North east side of island, near Pass, <u>Sachet</u> <u>1962</u> (US). A few very tall trees, probably planted near former settlement, in coconut plantation.

North Islet, <u>Fosberg</u> <u>61354</u> (US).

ONAGRACEAE

*<u>Ludwigia</u> <u>octovalvis</u> (Jacq.) Raven

North side of atoll, camp on lagoon side of runway, <u>Sachet</u> <u>1986</u> (US). Local in wet spot in weedy area near buildings.

APOCYNACEAE

*<u>Catharanthus</u> <u>roseus</u> (L.) G. Don

Planted, sight record, F. R. Fosberg July 1981.

*<u>Nerium</u> <u>oleander</u> L. var. <u>indicum</u> (Mill.) Deg. & Deg.

North end of atoll, camp on lagoon side of runway, <u>Sachet</u> <u>1976</u> (US). One plant cultivated near building.

CONVOLVULACEAE

<u>Ipomoea</u> <u>macrantha</u> R. & S.

North east end of island, near Pass, <u>Sachet</u> <u>1966</u> (US). Locally common in coconut plantation climbing palms or covering vegetation.

Hihopu, <u>Grant</u> <u>4851</u> (BISH).   "pohue motu".

BORAGINACEAE

Cordia subcordata Lam.

In forest on S side of atoll; also planted in village.

Heliotropium anomalum H. & A.

Hihopu, Grant 4835 (BISH). "papati".

Tournefortia argentea L. f.

Purunui, Grant 4809 (BISH) "tahinu".

CHLOANTHACEAE

Nesogenes euphrasioides DC.

Purunui, Grant 4852 (BISH). "nau".

VERBENACEAE

*Stachytarpheta urticaefolia Sims

Camp on lagoon side of runway, north end of atoll, Sachet 1984 (US). Local in weedy area near buildings and runway.

SOLANACEAE

*Datura metel L.

Hihopu, Grant 4853 (BISH). "puaoe".

*Physalis angulata L.

Camp at north end of atoll, on lagoon side of runway, Sachet 1975 (US). Local in taller weeds near buildings.

*Solanum lycopersicum L. tomato, tomate

Cultivated in settlement gardens, fruiting.

SCROPHULARIACEAE

*Angelonia sp.

Planted, sight record, F. R. Fosberg, July 1981.

RUBIACEAE

*Gardenia taitensis DC.

East corner of atoll, Sachet 1995 (US). Four trees, 5 m tall, in shade in coconut plantation. Small plants in camp seen in March 1983.

Hedyotis romanzoffiensis (C. & S.) Fosberg

Tupaiofai Vaiapi, Grant 4817 (BISH). "poroporo".

West side of atoll, bare coral sand and gravel along wide, shallow "hoa", Sachet 2579 (US).

Guettarda speciosa L.

North Islet, Fosberg 61343 (US). Scattered in coconut plantation and along shores.

Morinda citrifolia L.

Seen in coconut plantation, growing back as shrubs after clearing.

Timonius polygamus (Forst.) Rob.

Vaiteofai, Grant 4816 (BISH). "turaumoa".

West side of atoll, bare coral sand and gravel along wide, shallow "hoa", Sachet 2580 (US) female plant, Sachet 2581 (US) male plant.

North Islet, Fosberg 61352 (US).

GOODENIACEAE

Scaevola sericea Vahl
Scaevola taccada (Gaertn.) Roxb.

Vaiteofai, Grant 4815 (BISH). "naupata".

Looks somewhat like var. tuamotuensis of (St. John) Fosberg.

North Islet, Fosberg 61351 (US).

East corner of atoll, Sachet 1998 (US). Common locally at edge of plantation. Seems intermediate between var. sericea and var. tuamotuensis (St. John) Fosberg.

ASTERACEAE

*Bidens pilosa L.

Camp on lagoon side of runway, north end of atoll, Sachet 1979 (US).

*Conyza bonariensis (L.) Cronq.

Camp on lagoon side of runway, north end of atoll, Sachet 1990 (US). Heads unusually small.

*Eclipta prostrata (L.) L. var.

Camp on lagoon side of runway, north end of atoll, Sachet 1977 (US).

*Emilia fosbergii Nicolson

North end of atoll, camp on lagoon side of island, Sachet 1983, 2573 (both US). Common in weedy area near buildings and runway.

*Emilia sonchifolia (L.) DC. in Wight

Landing strip and village area, north end of atoll, weed in gravel, Sachet 2572 (US).

*Synedrella nodiflora (L.) Gaertn.

Weed in coconut plantation and around settlement.

*Vernonia cinerea (L.) Less. var. parviflora (Bl.) DC.

Weed in coconut plantation and around settlement.

*Wedelia trilobata (L.) Hitchc.

Area near Pass, north east side of island, Sachet 1967 (US). Large patch on roadside in coconut plantation (another patch near runway). More abundant in March 1983.

FAUNE

Les seules observations faites sur la faune de Tupai sont celles de Duval (1978) sur l'écologie des "nonos" et celles sur les oiseaux de B. et J.-C. Thibault (1973, 1974). Ces derniers mentionnent aussi les autres éléments les plus communs de la faune. J'ai pu noter la plupart des mêmes espèces. Les crustacés terrestres sont représentés par des bernards l'hermite dont le gros Coenobita à pinces rouges qui se rencontre en nombres énormes dans certains sites et à certaines heures de la journée; le crabe des cocotier (Birgus latro) dont j'ai vu trois beaux exemplaires capturés dans la partie sud de l'atoll; les crabes terrestres ou "tupa" (Cardisoma carnifex) sont très abondants au bord du lagon près du village et dans les endroits bas et humides. Leurs terriers retiennent de l'eau quand les mares s'assèchent et constituent un gîte pour la reproduction des "nonos". Ces insectes (Culicoides belkini), avec les moustiques très abondants et plusieurs espèces de fourmis et de mouches, sont les plus en évidence sur l'atoll. Le "cent-pied" (Scolopendra sp.) est signalé comme présent, mais je ne l'ai pas observé. Un catalogue des espèces de petits invertébrés (insectes, arachnides, mollusques, vers, etc.) serait intéressant, surtout s'il faisait partie d'une étude écologique détaillée de leurs rôles dans les écosystèmes de l'atoll.

Quant aux vertébrés, outre les tortues de mer qui viennent de temps en temps sur les plages, des geckos et autres lézards, les oiseaux sont évidemment les plus nombreux en espèces: j'ai observé dans le SW de l'atoll les fous à pieds rouges qui y nichent, quelques frégates (Fregata sp.), sternes (Sterna fuscata), sternes huppées (Sterna bergii), et sternes blanches (Gygis alba). Les noddis (Anous stolidus) se trouvaient surtout aux abords de la cocoteraie et sur un petit embarcadère s'avançant dans le lagon (en 1974). Parmi les échassiers, outre de petites espèces non identifiées, le héron (Egretta sacra) était présent avec ses 2 phases, blanche et bleu-ardoise. Comme espèces introduites, je n'avais noté que les poules, et les mammifères: rats, chats et chiens.

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Fig. 1 Tournefortia argentea sur la plage, côte E; platier du récif semé de blocs de corail noirci.

Fig. 2 Suriana maritima dans un fourré d'espèces diverses longeant la cocoteraie côté océan. (Figs. 1-8, Sachet, Dec. 1974).

Fig. 3 Intérieur de la cocoteraie avec Pandanus. Ipomoea macrantha et fougères (Nephrolepis sp.) en sous-bois.

Fig. 4 Hibiscus tiliaceus autour d'une mare avec Cyperus javanicus et quelques Typha sp.

Fig. 5 Marécage vers la pointe E, avec Cladium jamaicense et Pandanus. (Mars 1983).

Fig. 6 Mare à Nymphea entourée de Cyperus javanicus et Hibiscus tiliaceus.

Fig. 7 Euphorbia aff. atoto dans une pelouse de Lepturus repens.

Fig. 8 Plant de Portulaca fosbergii a feuilles charnues et fleurs jaunes.

Figs. 9, 10. Sous-bois de _Sesbania coccinea_, s.l. Photos de B. Delesalle et Sachet, 3 Mars 1983.

Fig. 11 Plateforme de conglomérat récifal avec rocher perché amené par une ancienne tempête et dont une partie a été arrachée par le cyclone Reva (10 Mars 1983). Au sud de l'entrée de la passe Apooparai, côte Est.

Fig. 12 Plateforme de conglomérat découvert, rive sud de la passe Tetapae, côte Est.

Fig. 13 Détail de la Fig. 12, montrant des taches blanches là où Reva a arraché des plaques au rocher (les surfaces anciennes sont noircies par la présence de cyanophycées). Les arbustes défeuillés sont probablement Pemphis acidula.

Fig. 14 Galets et débris coralliens grossiers (blancs) rejetés par Reva contre une levée (grise) plus ancienne. Pointe Rae, sud de l'atoll.

Fig. 15 Crête de débris grossiers accumulée par Reva, juste au Sud de la Fig. 14. Végétation côtière défeuillée ou tuée.

Fig. 16 Dépôt d'une couche de débris coralliens et destruction de la végétation au sud de la passe Apooparai, côté océan. Vue vers le N.

Fig. 17 Même site que Fig. 16, vue prise vers le NE.

Fig. 18 Même site que Figs. 16 et 17, mais vue prise vers le Sud.
(Photos 11-18 prises par B. Salvat, 22 Juin 1983).

ATOLL RESEARCH BULLETIN

No. 277

TAKAPOTO ATOLL, TUAMOTU ARCHIPELAGO: TERRESTRIAL VEGETATION AND FLORA

BY

M.-H. SACHET

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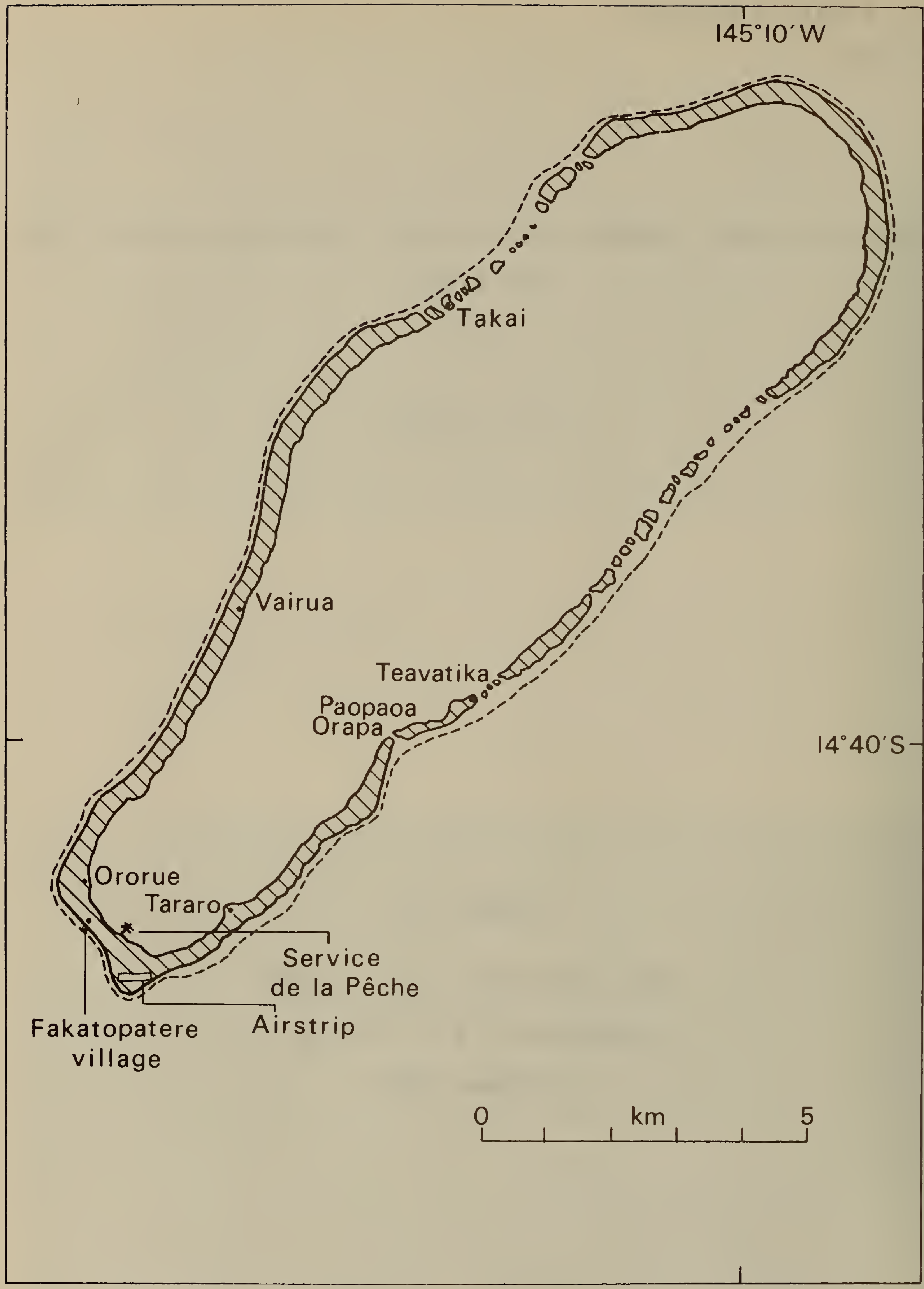

Fig. 1. Takapoto Atoll

TAKAPOTO ATOLL, TUAMOTU ARCHIPELAGO: TERRESTRIAL VEGETATION AND FLORA

BY

M.-H. SACHET

INTRODUCTION

The Man and the Biosphere (MAB) programme of UNESCO, first thought of in 1968, launched in 1970 and endorsed by the Stockholm Conference of 1972, includes a number of scientific projects, of which No. 7 is devoted to the Ecology and Rational Utilization of Island Ecosystems. All the programmes are to be interdisciplinary and intergovernmental. Among member countries which developed their own national plans within the framework of the separate MAB projects, France drafted a vigorous one in MAB 7 in French Polynesia, under the leadership of Dr. B. Salvat (1977). The French programme includes a detailed study of an atoll, Takapoto in the Tuamotus, and comparison of its ecosystems and their functioning with those of a high island already under scrutiny, Moorea in the Society Islands.

Teams of over 40 scientists representing many disciplines visited Takapoto over a period of several years (1974-1976). Several research organisations participated, in some cases bending their own study goals to fit the MAB-7 framework, so that an extensive body of information has become available and lends itself to integration and synthesis. Preliminary reports, as well as some final papers have been published.

I was already in SE Polynesia in 1974-75 and it was arranged that I would visit Takapoto in Dec. 1974 to study its flora and vegetation. The host institution was the Service de la Pêche, and I stayed in one of the bungalows of their Pearl Experiment Station. These were built on pilings over the quiet shallow lagoon, and linked by wooden walkways, forming a small attractive over-the-water village. I am very grateful to Philippe Siu, then of the Service de la Pêche, and to B. Salvat for this opportunity. Unfortunately I could not take the fullest advantage of it because the person in charge, Danny Carlson, was on leave. I could have learned much from her about the flora and its native names and uses. No boat was available at that time, so I could not visit the

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NE half of the atoll. My principal guide was Huri Maire then schoolteacher in the village, and I remember with gratitude his friendly company and eagerness to inform, as well as that of other inhabitants I met. All Polynesians are passionately interested in plants and enjoy sharing their knowledge of them, and it is a pleasure to work with them.

GEOGRAPHY

The Tuamotu Archipelago, between 14° and 24° S and 134° and 149° W, is the largest group of atolls anywhere (about 75), and includes low islands of every size and shape. Some are tiny single motus with no lagoon, others are very large atolls with enormous lagoons, which may be very deep or shallow and cluttered with scattered reefs or coral pinnacles, widely opened to the ocean or closed or almost so. A few are somewhat elevated. Distances between the islands vary, but altogether the group creates a formidable obstacle to navigation, and sailing through the maze was considered very hazardous, hence the name Dangerous archipelago coined by Bougainville. Sailing vessels tried to avoid it as much as possible and quite a few, as well as modern ships with sophisticated navigational aids, finished their career on the reefs. The chain stretches in a general NW-SE direction and many of the atolls in the main alignment are so oriented. Others, along the NE edge of the group especially, are arranged at right angle, with their larger dimension SW-NE. Takapoto (14° 40' S, 145° 10" W) and its sister island Takaroa (King George's Islands) are so oriented as are the nearby pair of Manihi - Ahe.

Takapoto is an atoll, about 17 by 5.5 km, with a continuous reef and no real pass, the only communication with the ocean consisting of slight depressions of the reef surface devoid of land deposits but forming shallow channels called "hoa." The emerged land strip on the reef, about 40 km long, varies in width from 350 to 800 m at the SW point where the only village is located and where an airstrip has been established between it and the ocean-side reef. The reef flat is relatively narrow all around the atoll. The lagoon bottom slopes fairly regularly down to 40 m, with a few deeper basins (45 m). Many coral pinnacles rise from the bottom to varying heights, some almost breaking the surface of the water. The SW end of the lagoon is a conservation and research area for the Pearl Oyster Experiment Station.

The reef and especially the lagoon were studied in great detail by French biologists and oceanographers and their observations assembled by Salvat (1977) and in a special issue of the Journal de la Société des Océanistes, 1979. The geomorphology is described in some detail by Chevalier et al., 1979.

CLIMATE

The humid tropical oceanic climate of the Tuamotus, including Takapoto, varies little over the year. Atmospheric humidity is always high (80%) and temperatures are only slightly higher during the "summer"

(Nov.-April) and change little during the day (average 21° C). Atmospheric pressure, sunshine and cloud cover remain also relatively even except in stormy weather.

The NE trade winds predominate during most of the year, passing to the SE during the "winter" when stormier conditions may occur. The principal disturbances come with winds from the W and NW quadrant, with rain storms and high winds. Because the atolls rise so little above sea level, windstorms can bring very high and powerful waves and some land areas may be inundated and reef and beach sediments redistributed. Large blocks of coral torn from the undersea slopes of the reefs and thrown up on the reef flats are evidence of the power of such waves, and are especially noticeable on Takapoto along the NW reef near the several shallow "hoa."

Rainfall is the most seasonally variable factor in the climate. The "winter" season corresponds roughly to a dry season, and if the rains are slow in returning in November, a water shortage may occur. Water supplies have two main sources, ground water percolating through the porous substratum to the ground water lens and reached by shallow wells, and rain water collected from roofs into cisterns. Rain water collectors are not always maintained in good conditions, and wells, which are not habitually used nowadays for drinking or cooking, are often polluted or neglected, and do not suffice to replenish the supply.

Tsunamis generally do not affect atolls severely, except under very special conditions, because the wave, oscillating vertically, can pass an atoll with almost vertical submarine walls without breaking and releasing the enormous amount of water and energy it carries. Cyclonic storms and other violent storms, however, can be devastating in their effects on low islands which are not only vulnerable to high winds, but suffer great damage from flooding. The Tuamotus are generally said to be in a zone relatively free of cyclonic storms (cyclones, typhoons or hurricanes), but such are in fact frequent enough to need taking into account in planning construction and settlement.

Giovanelli (1940) and Teissier (1969) have published lists of tropical storms and hurricanes known to have affected French Polynesia and especially the Tuamotus (a tropical storm becomes a hurricane when the winds reach 65 knots = 120.5 km/h). The records go back to 1822 when the atoll of Anaa is known to have been devastated (Morenhout 1837, 1:365), as well as several neighboring atolls. Anaa was hit again in 1825. In Jan. and Sept. 1877, several storms caused important damage to various atolls including Manihi. The hurricane of 6-7 Feb. 1878 was extremely violent and 117 persons were killed in Kaukura.

The first well documented hurricane known to have hit Takapoto is that of Jan. 14-15, 1903. This terrific storm devastated a large number of atolls and 515 persons died, 377 of them at Hikueru where pearl divers and their families had assembled from other atolls for the diving season.

Another storm (March 23-25, 1905) caused extensive damages on Manihi and Takaroa. The hurricane of 6-8 Feb. 1906 was also a tremendous storm, causing immense damage in the Society Is. and Tuamotus, including Manihi and Takaroa, where the N. coast was so pounded and flooded that there would have been many victims, except for the lucky fact that the population was on the other side of the atoll. Still, almost all the casualties (at least 121) occurred in the atolls. In those three great hurricanes (1878, 1903 and 1906) most of the damage was caused by the storm tides rather than directly by winds.

Teissier mentions only one more storm to hit the Tuamotus, in Jan. 1958. But there must have been others in pre-European times, and perhaps also since 1958, to reach Takapoto.

According to DeAngelis (1983:108) only 6 tropical storms formed east of 160° W between 1969 and Nov. 1982. But from Dec. 1982 (Lisa) through April 1983 (Veena), 6 formed in this region and affected French Polynesia, 4 of them some of the Tuamotus. Of these, Nisha/Orama (Feb. 20-28), Rewa/Reva (March 6-15) and Veena (Apr. 8-14) passed close to the Takapoto-Manihi area, the first demolishing buildings and other installations such as airstrips, defoliating and breaking coconut palms and other trees. Piling up sheets of coral shingle on shores and occasionally far into the land strip is probably the worst and most durable effect of these storms. Waves tear up large blocks of coral from reef fronts and throw them on reef flats, across "hoas" or, in some lagoons, on top of coral pinnacles. Small sandy islets can be built up or swept away, channels opened or closed. In the case of large lagoons, storm waves of sufficient height and energy may carry sheets of coral shingle onto lagoon shores. At Rangiroa, Orama and Rewa piled coral from the lagoon into both of the large and handsome villages.

Most trees and shrubs commonly native on atolls are relatively resistant to the effects of storms. Even Pisonia trees, with their shallow root systems, brittle wood and thin leaves, survive rather well. They leaf out quickly and branches of fallen trunks grow vertically and become new trunks of trees. Nothing can be done to save coconut palms that have been snapped or completely uprooted, and coconuts and copra crops are lost for some years even after the palms recover. Introduced trees and plants tend to be much more vulnerable than native species and are often killed. Breadfruit trees never thrive if underground water is too salty or if they are exposed to sea spray, and they are easily killed when villages or plantations are flooded with sea water, or hit with strong salt-laden winds.

In the 1983 series of hurricanes, aside from anxiety and fright, lack of food and more crucially water, one of the worst hardships the people had to endure especially on those atolls, including Takapoto, which were hit more than once, was lack of protection against the sun: buildings had been flattened, roofs swept away, trees defoliated and when clear weather returned, there was no shelter from heat and glare.

DISCOVERY AND EXPLORATION

Takapoto was probably discovered by Dutch navigators early in the 17th century, and in 1622 Roggeven lost a galley on its reef; the wreck was seen by Byron, Cook and other navigators; eventually (Moerenhout), only the guns could be observed; these guns were located anew by Danny Carlson and are described by Chazine (1977: 197-198). The two atolls, Takaroa and Takapoto, were named King George's Islands by Byron in 1765. During his second voyage Captain Cook (1961: 376-379) located them (April 17, 1774) and landed on the easternmost, called Teookea [Takaroa]. This is an important botanical landmark, as some of the Forsters' atoll plants are labelled Teoukea and represent some of the earliest collections from the Tuamotus. They found (1777, 2:41) "a scurvy-grass, which was common, and seemed to be very wholesome. The natives showed us that they bruised this plant, mixed it with shell-fish, and threw it into the sea..." to intoxicate fish. "The name which they give to this useful plant is e-Now [Lepidium piscidium Forst. = L. bidentatum Montin]. We likewise met with plenty of purslane, resembling the common sort, which the natives call e-Tooree." The Forsters described the natives, their huts and canoes, their dogs, the clumps of bushes and trees, and the abundance of coconut palms. Incidentally, while sailing past many Tuamotu atolls, but especially at Takaroa, J. R. Forster described the process of soil formation and vegetation development (1983, 3:494-495), a view which he expanded in a more general account of atoll formation (1778, 2:148-159).

After this landing, Cook passed Takapoto (Oura, Taapouta), and then sailed on through the archipelago. Voyages became fairly frequent in the 19th century. Navigators who have published descriptions of Takapoto include Turnbull on the Margaret, Capt. Byers, in 1803, cited by Robineau (1977: 4), Kotzebue in 1816 and 1824, Moerenhout in 1830, Dumont d'Urville with l'Astrolabe and la Zélée in Sept. 1838, and Wilkes with the U. S. Exploring Expedition in 1839.

Moerenhout describes the atoll as follows:

"L'île de Taapouta n'a aucune ouverture par où la moindre embarcation puisse entrer dans son lac intérieur; mais comme la mer était belle, nous débarquâmes facilement sur le rescif, où je fus reçu par une vingtaine d'Indiens, qui m'accueillirent avec des démonstrations d'amitié, et me conduisirent à leurs maisons, toutes construites, comme dans l'île de la Chaine, à l'intérieur, sur le bord du lac. Là, ils me montrèrent une quantité de nacre qu'ils avaient entassée dans une de leurs habitations; ......

"Je ne voulus pas quitter cette île sans l'examiner un peu. Le sol en est assez étendu pour qu'on y puisse cultiver le taro, dont je trouvai des plants en divers endroits. Quoique le lac soit très-petit et déjà presque comblé, il ne s'y trouve que fort peu de cocotiers. Je présume qu'ils ont été détruits, dans cette île comme dans toutes les îles voisines, pendant les guerres de ses habitans avec les habitans d'Anaa. Elle possède, comme les autres, le fara (pandanus odoratissimus), et autres arbres propres à divers usages. Pendant notre promenade, les Indiens me parlèrent de canon."

Dumont d'Urville (1842, 4:53) passed "Tiokea" and "Oura" and wrote of the first (Takaroa) that it was low, well-wooded, with a lagoon and enormous clumps of coconut palms. He noted a large hut and many smaller ones and perhaps 50 inhabitants. Of Takapoto, also low, well wooded and with a lagoon, he remarked that it was well furnished with coconut palms, which must have become more numerous since Moerenhout's visit 8 years before.

The Wilkes Expedition (1845, 1:336), on the Vincennes, did not land at Takapoto but did at Manihi and Ahii on Sept. 6 and 7, 1839, and the Flying-Fish surveyed Takaroa and Takapoto a few days later. Charles Pickering, botanist and biogeographer, sailed with the Vincennes. In his Distribution of Plants ... (1876) he gives accounts of vegetation and plants for areas he visited (this volume was never officially published, but some copies were assembled from printed stock). Pickering's method in describing floras consisted in listing the plants observed on the first island encountered in a particular group, and thereafter in referring to this list, according to his "geographical order of numbering," with a mention of additional or missing species for each island visited. Thus of Manihi he says (p. 232): "The vegetable growth, as far as examined by myself, proved entirely the same as on Taiara coral-island; but with less variety, nearly one-half of the species being absent. An additional species [a sedge] was however discovered by Mr. Brackenridge..." The plants these botanists collected are almost always labelled by island group only. They are preserved principally at the Gray Herbarium, Harvard, and in the U.S. National Herbarium. Many shells were collected on Manihi also.

Among the other great natural history expeditions, the Whitney South Sea Expedition did stop at Takapoto, Manihi, and nearby atolls to collect birds and a few plants, in Aug. 1922 and Feb.-March 1923. E. H. Quayle also examined and perhaps preserved corals and other reef animals, and algae.

VEGETATION

As with all (or most) atolls in regions of moderate to heavy rainfall, much of the landstrip of Takapoto was probably covered by forest before the arrival of human settlers. Areas with very thin or no soil may have had a scrub vegetation or even bunch-grass. With the coming of European man, much of the forest was destroyed and replaced by coconut groves or plantations.

During my stay of only 5-1/2 working days (Dec. 12-18), I was able to visit only the S half of Takapoto, from Takai to Orapa and Teavatika. Most of the time was spent exploring on foot and collecting around the village and airstrip, and between Vairua and Tararo and a little beyond. Two trips by car, walking back on a track which follows the lagoon shore, led me to the hoas at both ends of the V-shaped South islet.

Woody vegetation

Along the West arm of the V, the geometrically planted coconut palms extend only part way from lagoon toward ocean in most places, probably because the ground is very rocky nearer the ocean shore; but along the lagoon, they frequently come almost to the shore, which is lined by a narrow very gently sloping beach.

On the ocean side, extends a strip of rather poor scrubby open forest, perhaps resembling what was there in pre-human times and including Guettarda speciosa, Pandanus tectorius, Tournefortia argentea, and Pipturus argenteus, with a shrub layer of Timonius polygamus, Scaevola sericea var. tuamotuensis and Suriana maritima, and a ground cover of grasses, Heliotropium anomalum and Euphorbia near E. atoto. The shrubs scattered under the forest become dominant as an irregular hedge as the ocean shore is approached. Where the soil is sandier or of fine gravel, Suriana maritima is common, frequently parasitized, often covered, by tangles of orange to greenish strings of Cassytha filiformis, a leafless parasite. On bare limestone, reef or island conglomerate, or where this is only thinly covered with sand, the vegetation is a dense, tough scrub or scrub-forest of Pemphis acidula, which is seldom seen except in such habitats. It can reach a height of 3 or more meters. Suriana and Pemphis have a very similar habit, and seem to replace each other as the substratum varies from limestone sand to rock. These two plants are much in demand, especially Pemphis (mikimiki), as bunches of their tangled branches and twigs are cut or uprooted and used in the lagoon as collectors for pearl-oyster larvae ready to become attached (spat) (Reed, 1973, Robineau, 1978). Occasionally, the lagoon shore is formed by island conglomerate (called papa in the Tuamotus) with or without a sand cover, and Pemphis forms small clumps of wiry shrubs; elsewhere Suriana (u'u) is found scattered on the sand.

Approaching the hoas at Takai, the coconut plantation thins out and the trees look sickly, yellowish, giving way to scrub of low Timonius polygamus with scattered rather chlorotic Tournefortia bushes. The ground is very rocky with a layer of papa emerging from under the islet at the edges of the hoas. On such bare conglomerate, which also forms flat islands above the level of the rocky hoas, Pemphis is usually the only plant to be found.

Near Vairua, about 8 km NW of the village, inside the coconut plantation, groves of tall Pisonia grandis rise above the nearby palms. Contrary to what has been assumed in descriptions of Takapoto and other atolls, Pisonia does not occur where there is deep rock soil. It is the other way round: This tree, which can reach enormous size, is exceptional in the tropics in producing an acid, peat-like or mor-like raw humus, forming a layer on the coral sand and gravel floor of the forest. Locally these trees are a favored roosting and nesting place for white-capped noddies (Anous tenuirostris), red-footed boobies (Sula rubripes) and fairy terns (Gygis alba). Where abundant white excrement from these fish-eating birds accumulates on the litter of leaves and the humus layer and is washed down through it by rain, a hard-pan of phosphatized coral limestone is likely to form beneath the humus. Such formation of Jemo soil, first described from the Marshall Islands (Fosberg 1954), was observed at Vairua.

I was told that the Pisonia groves at Vairua had been left as a sort of bird reserve, since noddies were eaten, but whether this information was correct, and whether the groves survive I do not know.

Under the tall dense Pisonia trees, the dark somewhat spongy soil is bare of vegetation but around them, where the shade is less, occur larger Guettarda and Tournefortia, smaller trees of Pipturus argenteus, sprouts of Morinda citrifolia, and other scattered trees. Tall clumps of gray Achyranthes velutina fill a sunny clearing. The ground cover here includes Polypodium, Boerhavia tetrandra, Laportea ruderalis and where the shade is less dense, Lepidium, Digitaria and locally Hedyotis romanzoffiensis.

The coconut plantation itself is very neat or "clean", which means that brush and ground cover are regularly cut or burned. This practice is intended to make it easier to collect nuts at harvest time, and to discourage rats. However, it also results in impoverishing the ground of part of its meager organic matter supply, and in impeding soil formation. The shrub or small tree layer which keeps sprouting from cut plants includes Guettarda speciosa, Calophyllum inophyllum, Morinda citrifolia, Timonius polygamus and, when the canopy is not too dense, some Suriana. On the ground are Triumfetta procumbens, Polypodium scolopendria (also on palm boles), Lepidium bidentatum, Lepturus repens and other grasses, Portulaca johnii and, especially on bases of coconut trees, Psilotum nudum. Nervilia aragoana, a very small ground orchid with a single plicate deciduous leaf, replaced at the flowering season by raceme of small flowers is quite rare. Tufts of a rather coarse grass, Digitaria stenotaphrodes, are distributed here and there.

Where the sandy ground slopes toward the lagoon occur taller trees of Guettarda, Calophyllum and other species.

Along the East arm of the V, on the other side of the village, the coconut plantation seemed rather poorer, except for an experimental plot of a dwarf coconut variety of a beautiful orange color not far past the airstrip. At Tararo, the sandy lagoon shore was lined with Suriana shrubs, and locally with Sesbania coccinea, a shrub or small tree with feathery paripinnate leaves, sweet-pea size orange and red flowers and long thin hanging pods (kofai). Whether they survived increased construction and effects of storms is problematical.

Beyond Tararo, the coconut plantation was locally interrupted by fields of coral blccks and boulders which appeared to be ancient hoas completely filled in by masses of coral shingle possibly carried in and deposited by storm waves. Such boulder fields are entirely covered by a pure scrub of tangled Timonius polygamus about 2 m high and practically impenetrable, the long arching woody branches of the shrubs being intertwined into a very dense, scratchy thicket. It is the most unpleasant type of vegetation because even only a short distance into it, the total lack of air circulation makes the heat and humidity appear much worse than anywhere else in the atoll.

Herbaceous vegetation

In former times, taro (*Colocasia esculenta*) was cultivated in Takapoto and all other inhabited atolls of the Tuamotus. This involved a tremendous amount of very hard work, because pits or winding trenches had to be dug down to the water table (1 to 1.8 m down), often through a layer of conglomerate (papa). From all accounts, the taro tubers produced in such pits were small and of poor quality. Other food plants were most probably grown with the taro. At present all such cultivation has been abandoned in Takapoto, as in most if not all of the Tuamotus. The trenches or "maite" can still be recognized in the form of ditches more or less filled in (Chazine, 1977). Near the village, near the Service de la Peche buildings, a low muddy area locally with open water, was filled with sedges and gelatinous mats of blue-green algae drying to a crust. Dense thickets of *Hibiscus tiliaceus* line this marsh. Other small depressions occur locally in the coconut plantation and the village.

Village vegetation

The population of Takapoto is now concentrated in a village (Fakatopatere), very open and attractive as are those I saw on other atolls, Mataiva, Tikehau and Rangiroa. Roadways of white compacted sand or gravel separate large holdings with scattered buildings. Everything gives an impression of care and neatness, the white or pastel colors of fences and structures, the flowering shrubs very bright and cheerful. At the time of my visit there were not many actively cultivated gardens, much of the village vegetation consisting of an herbaceous cover with scattered shrubs and trees, both useful and ornamental, such as oleanders of many colors planted along fences or walk, crotons and *Acalypha* varieties, bright red *Ixora* sp., *Russelia equisetiformis* forming cascading bushes with scarlet flowers, *Plumeria rubra* (frangipani, tipanie) of many shades, *Delonix regia* (flamboyant) and *Adenanthera pavonina* as isolated specimens. Fruit trees included *Muntingia calabura* planted along the road to the airstrip, papayas, citrus fruit, a few large *Eugenia cuminii*, some breadfruit trees including an enormous one shading the main store and the street along it, many large *Terminalia catappa* and especially *Pometia pinnata* or kava, the fruit of which are so much prized by both adults and children that they seldom have a chance to ripen and fruit-bearing branches are broken off repeatedly giving the trees a strange shape.

The herbaceous cover includes grasses, sedges, weedy *Euphorbia* spp. and many other species.

Of the more actively cultivated gardens, one included a small patch of taro plants carefully kept wet and weed-free, cuttings of *Plumeria* obtusa recently brought from Tahiti, and other relatively uncommon plants. Another garden had a hedge of Acalypha with colorful foliage, and of Cryptostegia grandiflora vines covered with rose-mauve flowers, as well as a cactus-like Euphorbia which served as support for drying small children's clothes. This garden also included a fine Zoysia lawn, and all sorts of potted plants arranged on the ground, on the house steps, or hanging in trees.

On the ocean side, the village ends with a wharf where whaleboats load and unload passengers and supplies across the reef while ships wait outside the line of breakers. There were copra sheds, an old lighthouse and a grove of large old trees including the only large Thespesia populnea seen. Nearby a garden enclosed with chicken wire included some vegetables such as "chou chinois", Brassica pekinensis and vines of watermelon bearing fruit (pastèque). These may have been growing in soil brought from Tahiti or the Marquesas.

As described above (p. 6), the repeated blows of hurricanes in the first months of 1983 brought considerable devastation to Takapoto. The buildings of the Service de la Pêche over the lagoon were wiped out, the airstrip piled up with coral gravel and boulders, many houses and other structures lost their roofs or were flattened, debris of all sorts scattered in the yards and gardens, including roofs, overturned cisterns, boats and worst of all sheets of coral shingle. The attractive and colorful village was a pitiful sight immediately afterwards. This type of damage is very quickly and industriously cleared up, as well as broken or uprooted shrubs and trees. Generally, the remaining vegetation leafs out rapidly, but it takes a long time for the surviving palms or fruit trees to bear again, and some years before newly planted replacements can develop and fruit and coconut crops become available again.

MARINE FLORA AND VEGETATION

The role of algae in the fabric and ecology of Takapoto atoll is discussed and illustrated in several papers (Chevalier et al., Chevalier & Denizot (1979), but no enumeration of algae or list of collections is included anywhere except for the phytoplancton (Ricard et al., 1979).

FAUNA

Rivière (1979) paints a picture of the five main Takapoto biotopes placing the elements of the fauna within each and indicating their relationships to the landscape and substrata and among themselves (food chains, public health). A check-list of species collected in the Tuamotus is appended

Some elements of the marine fauna, especially corals, are mentioned and their role briefly described in other papers of the special issue edited by Salvat (1979). Lagoon invertebrates and especially molluscs, are discussed by Richard et al., and the fish fauna by Bagnis et al.

SYSTEMATIC LIST OF LAND PLANTS

Because I stopped several times at the Manihi airport in 1974-75, and had seen herbarium specimens from that atoll, I have included records of Manihi plants in the list below.

In size and orientation Manihi (14°26'S, 146°04'W) is very like Takapoto, 71 km away. However, Manihi has many more reef openings, including a pass deep enough for ships, at the SW tip of the atoll. Near it a deep concrete basin holds fish alive until ready to ship or use. The village, on the E side of the pass is very different from the Takapoto village, and most others in the Tuamotus, in that the buildings are much closer together, with small enclosed gardens. It looks more like a small city. But as elsewhere, everything is white-washed, bright and very neat. The 1983 hurricanes, unfortunately, demolished the village, and caused much damage to installations and vegetation.

The airstrip is on a separate motu, reached by boat through coral shoals and fish traps. This motu consists almost entirely of a large ridge of coral fragments, and pioneer shore vegetation extends all the way from ocean to lagoon at least in the vicinity of the airstrip. Some ornamentals had been planted near the "airport."

I have included English and other common names of plants when known. Those marked (P = Paumotu) or (T = Tahitian) were given to me by Huri Maire originally from Takaroa. The names for the Manihi plants are from the specimen labels of W. T. and C. C. Brooks who made an extensive collection of plants there in 1967, not all of which I was able to examine.

All my collections are deposited in the U. S. National Herbarium (US), with duplicates for the Bishop Museum (BISH) and the Paris Museum.

BRYOPHYTA

Brachymenium melanothecium (C. Mill.) Jacq.

Bright green moss, fairly common on ground in coconut plantation.
Vairua, Sachet 2060 (US).

Calymperes tuamotuense Bartram

Manihi, Bartram 1933 p. 6, citing Whitney Exped. 1929.

PSILOTACEAE

Psilotum nudum (L.) Beauv.

Broom-like green or orange tufts of prismatic, dichotomously branching stems bearing large yellow or orange spore-cases on side of terminal branchlets.
Area around first cistern, Sachet 2021 (US). Quayle 1953 (BISH).
Occasional on bases of coconut trees and on coral sand in shaded interior.
Manihi, Quayle 1914; 1922 (BISH).

POLYPODIACEAE

Asplenium nidus L. — Birds-nest fern

Nest-like light-green rosettes of ascending broadly lance-shaped undivided fronds, the fertile ones having a zone of pinnately arranged parallel,crowded, linear fruiting sori on the under sides.
Vairua, Sachet 2063 (US). Whitney Exped. 1956 (BISH).
On ground and bases of coconut trees in shaded interior of plantation.
Manihi, Whitney Exped. 1919 (BISH).

Nephrolepis hirsutula (Forst. f.) Presl

Short erect stems above ground, slender cord-like runners which bear the roots, and with erect or ascending fronds with many pinnately arranged pinnae or leaflets that bear kidney-shaped spore-dots or sori on under surfaces; pinnae shed when old, leaving stiff persistent rachis.
Village, Sachet 2077 (US).
Planted in yards and gardens, very common, probably spreading.

Polypodium scolopendria Burm. f. kikipa (P)

Creeping stem or rhizome bearing scattered erect, long triangular-ovate deeply and coarsely pinnately divided fronds with two rows of brown fruiting dots or sori beneath, fronds shed from rhizome when old.

Vairua, Sachet 2069 (US). Jones 1011 (BISH), Quayle 1948, 1953 (BISH). Very common everywhere in shade on ground and on bases of coconut trees.

Manihi, Jones 1908 (BISH, BKL, US), Whitney Exped. 1871 (BISH).

PANDANACEAE

Pandanus tectorius Park. tima; fala; fara; hinano (flower)
Screw pine

Small trees, sparsely and grotesquely branched, pyramidal, branches thick, bearing 3 spirally twisted ranks of long, strap-shaped, prickly, tough leaves with slender whip-like points; male and female flowers on different trees, the male in long branched pendent catkins with white leaf-like bracts, odor rather unpleasant; female in globose tightly packed heads; fruits packed in a tight head-like cluster, 15-20 cm in diameter, individual fruits or keys lobed at apex, distal part hard and bony, lower half or third fleshy, orange, fragrant, acrid sweet.

Seen by Sachet, December, 1974.

Very common everywhere, probably one of the most important trees in original vegetation now replaced by planted coconut palms. Generally distributed, especially on peripheral ridges of islets.

Manihi, seen by Sachet and earlier collectors.

GRAMINEAE (POACEAE)

*Cenchrus echinatus L. Sand-bur

A small tufted grass, bearing spikes of prickly burs that stick to clothing, shoes, etc.

Area just behind Service de la Pêche, Sachet 2033 (US).

Common in weedy yard and roadway, very common in village and plantation.

Manihi, seen by Sachet in 1974 near airstrip.

*Cynodon dactylon (L.) Pers. Bermuda-grass

A thick, creeping, mat-forming fine-leafed grass with long runners, digitate inflorescences and fruit clusters on erect stems.

Along runway and near airport, Sachet 2011 (US).

Abundant locally in weedy areas.

Digitaria stenotaphrodes (Nees) Stapf

A stiff, tufted, erect grass, with stiff spikes of flowers and fruits, crowded in 3's or 4's at tops of erect stems. A native species in the Society and Tuamotu atolls.

Along runway and near airport, Sachet 2012 (US).
Scattered tufts in open scrub forest and along top of seaward beach. Also in coconut plantations.
Manihi, U.S. Expl. Exped. in 1839 , cited by Fosberg 1939, p. 45.
Seen near airstrip by Sachet in 1974.

*Eleusine indica (L.) Gaertn. Goose-grass

Tufted, tough-rooted grass, with several broadly linear divergent spikes of flowers radiating from end of stems.
Along runway and near airport, Sachet 2010 (US).
Local in weedy places.

*Eragrostis tenella (L.) Beauv. ex R. & S.

A fine, delicate grass with a diffuse feathery flower cluster.
Village, Sachet 2071 (US).
Common in village and along paths.

Lepturus repens (Forst.) R. Br. var. repens

Tufted to creeping stiffish grass with long, awl-shaped jointed flower spikes, in fruit disarticulating into small cylindric floating segments, each carrying seed.
Along runway and near airport, Sachet 2013 (US).
Generally common or abundant.

*Sporobolus fertilis (Steud.) Clayton

Grass with stems and leaves in small tufts, leaves very slender, narrow, tightly rolled when old, much shorter than flowering stems, inflorescence a very narrow rather dense spike-like panicle, flowers and fruits green, not much over 1 mm long.
Village, Sachet 2074 (US).
Occasional in weedy yard in village.

*Zoysia matrella var. pacifica Goudsewaard

A fine wiry matted grass with slender awl-shaped leaves.
Village, Sachet 2040 (US).
Cultivated in garden, forming dense carpet under shrubs.

CYPERACEAE

Cyperus javanicus Houtt.

Coarse gray-green sedge with several stems from the base, elongate minutely roughened leaves and bracts, loosely branched cluster of brownish fruits.
Area around first cistern, Sachet 2022 (US).

*Cyperus kyllingia Endl.

Small tufted grass-like sedge, with small, white, globose clusters of tiny flowers.

Village, Sachet 2056 (US).

Local in damp spots, not common generally.

*Cyperus polystachyos Rottb.

Slender smooth sedge forming small tufts, leaves shorter than culms, spikelets many flowered, thin, flattened, lance-linear, greenish brown, crowded in dense heads, surrounded by several leaf-like bracts.

Area between Service de la Pêche and runway, Sachet 2015 (US).

Common in low wet places here and elsewhere on atoll.

*Cyperus rotundus L.

Plant with scattered, often solitary culms, small hard tubers on the roots, few dark green glossy leaves, loose clusters of few linear dark-brown many-flowered spikelets.

Village, Sachet 2047 (US).

Very common generally in weedy areas.

Fimbristylis cymosa R. Br. var. pycnocephala (Hbd.) Kük. ex F. Brown

Forming small tufts, roots fragrant; leaves linear, blunt, slightly stiffish; small button-like tufts of small scaly spikelets.

Area just behind Service de la Pêche, Sachet 2038 (US).

Forming tufts in low, damp place, frequent in openings.

Manihi, seen by Sachet in 1974.

PALMAE

*Cocos nucifera L. hakari, niu; coconut

Tall tree with columnar trunk and enormous pinnate leaves in a giant rosette at top of trunk; flowers both male and female, borne in large complex branched clusters among the leaves, protected by a woody boat-shaped bract which falls off as the flower cluster expands; flowers cream color, with stiff sepals and petals; fruit a large fibrous drupe with a hard stone 10-20 cm in diameter with one seed completely filling the cavity, shell filled with excellent water when immature, with a layer of white oily flesh when ripe .

Seen by Sachet, December, 1974.

Generally planted on all the islands. A dwarf, early bearing, variety is planted near Tararo Point, East of Village. The small palms and their nuts have a generally orange hue.

Manihi, seen by Sachet and earlier collectors.

ARACEAE

*<u>Caladium bicolor</u> (Ait.) Vent.

Stemless plant with long-stalked leaves arising from a tuberous root-crown,blades large, thin, variously marked with pink and white spots, heart-shaped, the stalks attached well inside the margin at base; flowers rarely if ever produced.
Seen by Sachet, December, 1974.
Cultivated in village garden.

*<u>Colocasia esculenta</u> (L.) Schott — taro

Stemless plant with stalked leaves arising from an edible tuberous root-crown, leaf blades large, dull grayish or bluish green, heart-shaped, stalk attached well in from the margin at base, flowers very rarely produced, in a spike enclosed in a rolled tubular bract.
Seen by Sachet, December, 1974.
A few plants cultivated with great care in damp area of garden.

BROMELIACEAE

*<u>Ananas comosus</u> L. — Ananas

Cited as sparingly cultivated in village by Robineau (1977:22)

COMMELINACEAE

*<u>Rhoeo spathacea</u> (Sw.) Stearn

Erect, often clustered short-stemmed dark purple plants with large crowded spirally arranged broadly lanceolate pointed leaves, flowers white, in small clusters in boat-shaped pairs of bracts on short stalks in the axils of the leaves.
Seen by Sachet, December, 1974.
Commonly cultivated in village.

LILIACEAE s.l.

*<u>Asparagus setaceus</u> (Kunth) Jessop

Vine-like, with flat sprays of extremely fine green hair-like branchlets in place of leaves, round black berries.
Seen by Sachet, December 1974.
Cultivated in village.

*<u>Cordyline fruticosa</u> (L.) Chev. — ti

Singled-stemmed, or slightly branched shrub with ascending tufts of large lanceolate leaves, among which are large branched open clusters of purplish-white flowers. Leaves glossy green or variously striped with red, or white.

Seen by Sachet, December, 1974.
Planted in village.

*Crinum sp. aff. asiaticum L.

Rosettes of spirally arranged large sword-shaped leaves, with tall erect somewhat flattened fleshy flower-stalks arising from between the leaves, bearing large tight clusters of tubular white or pinkish flowers with 6 long strap-shaped lobes, protruding stamens and style; seeds large, irregularly marble-like, fleshy.
Seen by Sachet, December, 1974.
Cultivated in village.

*Zephyranthes rosea Lindl.

Small plant with dark green linear leaves growing from a bulb, with single pink flowers, several cm across, six-parted, on stems about as high as the leaves are long.
Village, Sachet 2081 (US).
Cultivated in gardens and persisting in weedy area.

TACCACEAE

Tacca leontopetaloides (L.) O. Ktze. pia; island arrowroot

Bearing potato-like underground tubers, no above-ground stem; erect terete leafstalks, large palmate, deeply and complexly divided leaves, tall erect hollow flower-stalks with umbellate clusters of small greenish flowers, filiform conspicuous bracts; fruits globose, marble-like, packed with seeds. Tubers an important source of starch for the ancient Polynesians, but bitter and needing processing before use.
Area just behind Service de la Pêche, Sachet 2032 (US).
Common locally in coconut groves.

MUSACEAE

*Musa sp. Banana

Giant herb with pinnately-veined leaves, bracted racemes of male and female flowers, later producing large clusters of fleshy, edible fruit, usually seedless.
Seen by Sachet, December, 1974.
Growing in village.
Mahihi, seen by Sachet in 1974.

ORCHIDACEAE

Nervilia aragoana Gaud.

A small ground orchid, with a small fleshy underground corm, a single expanded plicate leaf, and when this disappears, a short raceme of whitish delicate flowers appear. From Eastern Asia at least to the Tuamotus.

Area around first cistern, Sachet 2020 (US); also seen in damp area between Service de la Pêche and runway.

Occasional but very local in sandy, usually shaded, soil, uncommon.

CASUARINACEAE

*Casuarina equisetifolia L. — Aito, Toa; Ironwood; She-oak; Beef-wood

A tree with no normal leaves, but with needle-like green jointed branchlets which drop as do leaves; flowers very reduced, in catkin-like clusters; fruits like diminutive pine-cones. Yields a very hard, extremely heavy but brittle timber.

Seen by Sachet, December, 1974, probably native in the Society Islands.

Planted as hedges or windbreaks.

Manihi, seen along airstrip in 1974.

MORACEAE

*Artocarpus altilis (Park.) Fosb. — Breadfruit

A large tree with milky sap; large alternate deeply cut leaves, flowers very reduced, the male in large club-shaped clusters, the female in light green balls; fruit large, globose or slightly elongate, with geometrically roughened surface. Fruit cooked in various ways and eaten; the staff of life for the ancient Polynesians, still extensively used.

Seen by Sachet, December 1974.

Planted in village and elsewhere, one very large tree, healthy and bearing well in center of village near store.

Manihi, seen in 1974.

*Ficus carica L. — fig

The cultivated fig, a shrub or small tree with rough hand-shaped lobed leaves, milky sap, and purple or green pear-shaped fruits or figs, filled with tiny hard seeds in a sweet juicy pulp.

Seen by Sachet, December, 1974.

URTICACEAE

Laportea ruderalis (Forst.)Chew

A small succulent-stemmed herb glossy, with alternate broadly ovate toothed leaves, flowers very small and inconspicuous in reddish, branched clusters; fruit small, grain-like.

Area around first cistern, Sachet 2023 (US).

Very common locally, but generally distributed, mostly in shaded places.

Manihi, U.S. Exp. Exped. in 1839 (GH), seen by Sachet in 1974.

Pilea microphylla L. Artillery-plant

Much branched fleshy-stemmed spreading herb, with small unequal roundish or obovate leaves and inconspicuous greenish flowers, with stamens that dehisce explosively, producing a small puff of pollen, resembling smoke, hence the vernacular name, "Artillery-plant."

Village, Sachet 2041 (US).

Cultivated in pot.

Pipturus argenteus (Forst. f.)Wedd. Roa (T); Ronga (P)

Large shrub or very small tree, leaves alternate, broad, toothed; flowers green with white stigmas, in tiny clusters on a string-like spike; fruits resembling a very small white strawberry. Inner bark tough, used by ancient Polynesians for cordage and bark cloth.

Both Takapoto and Manihi plants are of an unusual form with leaves green on both sides, the under leaf surface strongly papillose beneath the pubescence.

Vairua, Sachet 2064 (female plant) (US), 2065 (male plant) (US).

Common in coconut plantation and Pisonia grove, and everywhere on atoll.

Manihi, seen by Sachet near airstrip in 1974.

OLACACEAE

Ximenia americana L.

Shrub or small tree, at times tending to be subscandent, with or without stipular spines, branches and leaves glabrous; leaves alternate, elliptic to obovate, 3-5 cm long, obtusish to rounded at apex; flowers small, yellowish, in small axillary racemes, corolla lobes conspicuously coarse pilose within; fruit a plum-like orange drupe with thin sour flesh, endocarp thin, seed one, large. Pan-tropical strand or coastal plant.

Manihi, Quayle 1920 (BISH).

POLYGONACEAE

*Coccoloba uvifera (L.) L. Sea-grape

Shrub or small tree with thick twigs, large round leathery leaves, cordate at base, with short petioles sheathing the stem at base; elongate pendent spike-like racemes of small white 3-parted flowers developing into globose grape-like fleshy fruits, purple, rather acrid.

Seen by Sachet, December 1974.

Planted in village. Increasingly introduced in Tuamotus and to Marquesas, where it prospers and may spread.

Manihi, seawall of village, Brooks & Brooks 106 (BISH).

NYCTAGINACEAE

Boerhavia tetrandra Forst.

Prostrate elongate creeping stems from a thick root crown; opposite oblong-elliptic leaves pale beneath; small clusters of tiny pink flowers; sticky, ribbed club-shaped tiny fruits that stick to clothing. Often affected by a white rust fungus, Albugo platensis, that causes branches to become erect, condensed, distorted, and witches-broom-like.

Vairua, Sachet 2068 (US).

Very common, especially in openings and sparse places in coconut groves, where abundant forming a mat on the ground.

Pisonia grandis R. Br. puatea (T); puka (P)

Large trees with pale creamy-gray trunks, soft brittle wood; large, usually smooth, opposite, broadly elliptic leaves, clusters of small, pale greenish flowers, dry, very sticky, minutely spiny club-shaped fruits, admirably adapted to be carried sticking to birds' feathers.

Area along runway, Sachet 2034 (US);Area near first cistern from village, Vairua, Sachet 2019 (US); Jones 1005 (BISH).

Grove of very large trees remaining in section of coconut plantation, sprouting abundantly from fallen trunks and branches, heavily used by noddies. Very black humus forming under trees. Common locally forming groves and forests, but these mostly cleared away when coconuts were planted.

AMARANTHACEAE

Achyranthes velutina H. & A.

Gray-green woolly suffrutescent herb with stiffish ascending or spreading stems, to 1 m tall, leaves ovate to broadly elliptic, acute; flowers in spikes elongating to 1-several dm, rachis woolly, perianth 5-parted, the parts chaff-like, pointed, purplish within, stamens 5, staminodia 5, both on margin of a membranous cuplike structure of united filaments surrounding the ovary; fruit sharply reflexed, prickly from hardened pointed perianth closely investing matured ovary.

Area near first cistern from village, Vairua, Sachet 2018 (US).

Large patch in open spot among Pisonia trees.

*Amaranthus sp.

Weedy herb with ovate leaves, terminal clusters of small inconspicuous garden flowers, black seeds in tiny membranous sac-like fruits.

Seen as weed in village near store, Sachet, December 1974.

PORTULACACEAE

Portulaca johnii v. Poelln. pokea (P); Purslane

Spreading prostrate herb, rarely erect, with bright red fleshy stems with obovate leaves; flowers bright golden yellow, rather large, opening late in morning, closing in late afternoon; many stamens; seeds tiny, black, borne in small capsules with lids.

Vairua, Sachet 2066 (US).

Very common in openings and edges of woods.

Manihi, airstrip, seen by Sachet in 1974.

Portulaca oleracea var. granulato-stellulata v. Poelln.

Fleshy herb with alternate to opposite small obovate dull green leaves, apex rounded to subtruncate, base V-shaped, petiole very short; flowers yellow, in heads subtended by involucral leaves, opening after sunrise, closing usually before noon, petals thin, emarginate, deliquescent; stamens about a dozen, pistil with 4-5 palmately spreading stigmatic branches, fruit a pyxis, dehiscing by lid or operculum, seeds small asymmetrically kidney shaped, black, tuberculate.

Vairua, Sachet 2070 (US).

Uncommon in coconut plantation near Pisonia grove.

ANNONACEAE

*Cananga odorata (Lam.) Hook. f. & Thoms. Ylang-ylang, muto'i

Manihi, village, Brooks & Brooks 80 (BISH).

LAURACEAE

Cassytha filiformis L. Giant dodder

Leafless, tangled, string-like, rootless plant, yellow to greenish, twining around other plants, penetrating them with tiny sucker-like haustoria to get nourishment; flowers very small, white, fruit globose, small, white, fleshy.

Lagoon side near first cistern, Vairua, Sachet 2026 (US). Whitney Exped. 1960 (BISH).

Abundant locally, here on ground and on Triumfetta procumbens. Very common locally, especially in open or bushy areas, parasitic on other plants, especially Suriana, often killing it.

Manihi, seen by Sachet in 1974.

CRUCIFERAE

*Brassica pekinensis (Lour.) Rupr. chou chinois = celery cabbage.

Low herb with broad thin crowded green leaves with wide white midribs, erect clusters of bright yellow flowers. Raised as a vegetable.
Seen cultivated in small patch in village, Sachet, December 1974.
Manihi, seen in village by Sachet in 1974.

Lepidium bidentatum Mont. Scurvy-grass.

An herb, sometimes rather woody at base, with alternate usually coarsely toothed leaves, elongating racemes of tiny whitish flowers and small dry elliptic capsules bearing 2 orange seeds each. Said to have been eaten by early sailors to prevent or cure scurvy.
Area southeast of airport, Sachet 2004 (US).
Locally common in semi-open places.

CRASSULACEAE

*Kalanchoe pinnata (Lam.) Pers.

Erect slightly woody herb with fleshy, opposite, simple or pinnately compound leaves, blades with very shallowly scalloped or crenate margins, the notches giving rise to plantlets when they fall on the ground or are pinned up on a wall; flowers in large open clusters with opposite branches and long pendulous flowers, calyx inflated, cylindric, corolla tubular, deeply lobed, exceeding calyx.
Seen cultivated in village, Sachet, December 1974.

*Kalanchoe tubiflora (Haw.) Hamlet

Erect herb with opposite almost cylindric brownish-gray variegated leaves with a few teeth at tips, producing new plants when they fall on ground ; flowers in large open clusters, pendent, calyx short, deeply lobed, corolla red, tubular greatly exceeding calyx.
Seen cultivated in village, Sachet, December 1974.

LEGUMINOSAE

*Adenanthera pavonina L.

Tall tree with well-developed trunk, leaves alternate, bipinnately compound, leaflets oblong-elliptic; flowers in narrow elongate racemes, regular, small, yellow, fragrant; pods in clusters, thin, dehiscing and becoming twisted, shedding the bright scarlet lens-shaped seeds.
Village, Sachet 2079 (US).
One very large umbrella-shaped tree, flowering and fruiting.

*Cassia occidentalis L.

Coarse erect herb to 1 m tall, leaves alternate, pinnate, leaflets ovate, slightly acuminate, 4-5 pairs, flowers in terminal leafy racemes, yellow.

Village, Sachet 2055 (US).

Local in weedy yard.

*Crotalaria pallida Ait.

Erect herb to 1 m tall, sparsely branched, appressed pubescent, leaves alternate, trifoliolate, leaflets elliptic to obovate, flowers in terminal racemes, yellow, standard with brown striations; fruit a cylindric inflated pod several times as long as thick.

Area around first cistern, Sachet 2024 (US).

Local near buildings.

* Delonix regia (Bojer) Raf. Flamboyant, flame-tree

Flat-topped tree with lacy twice pinnately compound leaves with small oblong leaflets, compound stipules; loose flat-topped clusters of large showy scarlet flowers with petals narrowed toward base, one of them erect, pink and white spotted; pods large, woody, long narrow, pointed, with the seeds placed transversally.

Seen by Sachet, December, 1974.

Cultivated in village.

Manihi, village, Brooks & Brooks 87 (BISH). faefae

*Inocarpus fagifer (Park.) Fosb.

Tree reaching a large size in favorable habitats, trunk buttressed, leaves oblong, petiole short, thick, curved, flowers small, white, in spikes a few cm long, fruit a fleshy-leathery indehiscent oblong-asymmetric slightly compressed drupe-like one-seeded pod; seed large, nut-like, edible when cooked.

Seen cultivated in village, Sachet, December 1974.

Sesbania coccinea (L. f.) Poir. s.l. Kofai

Sesbania atollensis St. John

Sesbania speciosa var. tuamotensis F. Br.

Small trees or shrubs, up to 2.5-3 m tall, with alternate pinnately compound leaves, light green. Flowers deep-orange, streaked with red. Long thin pods.

East of airport, Tararo, Sachet 2007 (US); Southeast side of atoll, between village and first pass (Paopaoa) Rapa, Sachet 2036 (US).

Small group of plants scattered at edge of lagoon.

*Tamarindus indica L. tamarini, tamara, pakai

Manihi, village, Brooks & Brooks 35 (BISH).

Vigna marina (Burm.) Merr.

Creeping herb with alternate trifoliolate, broad obtuse leaves; yellow pea-like flowers on erect stalks; pods small, cylindric. Roots bear nodules containing nitrogen-fixing bacteria.

Area just behind Service de la Pêche, Sachet 2031 (US).

Extensive vines, forming thick blanket on old fence and ground near old drums and base of rainwater tank. Deep green foliage, probably from nutrients available at this site.

Manihi. Tearamahipa, W.T. & C.C. Brooks 28 (BISH).

Introduced on one piece of land as fertilizer for coconut plantation.

OXALIDACEAE

*Oxalis corniculata L.

Herb with creeping stems with erect branches, leaves alternate, stipulate, palmately trifoliate, leaflets obcordate, folding at night, sour to taste, cymes 1-5-flowered, flowers 5-parted, sepals elliptic, green, petals obovate, yellow; stamens 10, pistil with ovary and 5 styles; capsule thin-walled, cylindric or prismatic, seeds many.

Village, Sachet 2045 (US).

Local weed in garden.

RUTACEAE

*Citrus aurantifolia (Christm.)Swingle Lime

Shrub with spines and alternate elliptic slightly toothed leaves, aromatic when broken; fragrant waxy white flowers and greenish sour fruits with glandular aromatic skin. Juice used for drinks, antiscorbutic.

Seen by Sachet, December 1974.

Cultivated in village.

*Citrus maxima (Burm.) Merr. Pamplemousse, Shaddock, pomelo

Small dark green evergreen tree with broadly winged petioles jointed to ovate or elliptic pointed blades; flowers white, fragrant; fruit very large, globose or slightly broader toward apex, yellow or greenish yellow, rind several cm thick, spongy, white within, pulp sections and juice sacs tough, pulp pale yellow to pink, juice pleasantly acid, with strong flavor.

Seen by Sachet, December 1974.

Cultivated in village. (Pomelo rather than grapefruit).

*Citrus reticulata Blanco mandarine

Small dark green evergreen tree with broadly elliptic leaves and slightly winged petioles jointed to the blades; fruit round, broader than high, orange, with a loose very fragrant skin, pulp juicy pleasantly acid, with a very good flavor.

Seen by Sachet, December 1974.

Cultivated in village.

*Citrus spp.

Manihi, several seen by Sachet in 1974.

SURIANACEAE

Suriana maritima L. uu (P)

Shrubs with many small flexible branches, simple alternate small spatulate leaves, flowers axillary with bright yellow petals, fruit of 5 separate 1-seeded carpels. Easily confused with Pemphis acidula "mikimiki" when defoliated.

Area just behind Service de la Pêche, Sahet 2028 (US).

Abundant around edges of woods and coconut groves at top of beaches, also in openings in interior. Whitney Exped. 1964 (BISH), Jones 1016 (BISH).

Manihi, airstrip, seen by Sachet 1974

EUPHORBIACEAE

*Acalypha amentacea ssp. wilkesiana (M.-A) Fosb.

Shrub with alternate variegated green and white or bronze-red, broad, toothed leaves, catkins of small reddish or bronze flowers. Widely planted as an ornamental and hedge plant throughout the tropics.

Seen by Sachet, December 1974.

Several ornamental varieties cultivated in village.

*Acalypha amentacea ssp. wilkesiana f. circinata (M.-A.) Fosb.

Shrub with alternate variegated, toothed, strongly curved leaves, flowers dioecious or monoecious, in catkin-like axillary spikes.

Village, Sachet 2043 (US).

Cultivated as hedge in garden. This form a shrub 3 m tall, foliage dark reddish bronze.

*Codiaeum variegatum (L.) Bl. Croton

Shrubs with simple, alternate, toothed, variegated leaves on short stalks; flowers small, light greenish, in short spikes or narrow racemes. There are many widely variable leaf forms, mostly variously variegated, and of many different colors. A yellow and a green variegated one seen in Takapoto.

Seen by Sachet, December 1974.

Cultivated in village.

Manihi, cultivated in village in Tahiti soil, Brooks & Brooks 78 (BISH).

*<u>Euphorbia</u> <u>antiquorum</u> L.

Tall shrub or small tree with milky sap and erect candelabra-like branching, branches cerioid (cactus-like), deeply 3-ribbed, margins shallowly scalloped or crenate, spines in pairs; flowers small, greenish.
Seen by Sachet, December 1974.
In garden in village, 3 m tall, used to hang small garments to dry!

<u>Euphorbia</u> <u>atoto</u> Forst. f. s.l. tahetahe (P)

Plants 50-70 cm tall, but others seen much taller, nodding. White latex in stems, flowers white.
Vairua, <u>Sachet 2067</u> (US).
Common in coconut plantation and everywhere on atoll.

*<u>Euphorbia</u> <u>hirta</u> L.

Small somewhat lactiferous pubescent herb with ascending stems arching at tips, opposite serrate ovate acute subsessile leaves, flowers in dense axillary cymes, fruit a tiny 3-locular, 3-seeded, septicidal capsule.
Village, <u>Sachet 2051</u> (US).
Very common in weedy yards in village and elsewhere on atoll.
Manihi, near airstrip and in village, seen by Sachet in 1974. Taea, <u>Brooks</u> & <u>Brooks</u> <u>47</u> (BISH).

*<u>Euphorbia</u> <u>prostrata</u> Ait.

Prostrate small lactiferous much branched annual herb, stems and leaves purplish, leaves opposite, suborbicular or broadly oblong, flowers axillary, ovaries strongly exserted, especially in fruit, capsules trigonous with hairs only on angles.
Village, <u>Sachet 2072</u> (US) (green form, attacked by fungus); <u>Sachet 2073</u>(US)(reddish form).
Growing together in weedy yard.
Manihi Atoll, airport, <u>Sachet 1850</u> (US) (reddish form, attacked by fungus).

*<u>Jatropha</u> <u>heterophylla</u> Jacq.

Shrub with simple oblong to somewhat heart-shaped alternate leaves and terminal stalked clusters of handsome crimson rather bell-shaped or funnel-shaped flowers.
Seen by Sachet, in village, December 1974.

*<u>Pedilanthus</u> <u>tithymaloides</u> (L.) Poit. Shoe-flower

Fleshy, green-stemmed weak shrub, leaves pointed, arranged in 2 ranks, flowers red, slipper-shaped, pointed. Widely planted in the tropics as an ornamental.
Seen by Sachet, December 1974.
Planted in village.

*Phyllanthus amarus Schum. & Thonn.

Erect herb with very small pinnately arranged, two-ranked leaves, tiny yellowish green flowers, and round capsule-like fruits hanging under slender spreading branches.

Village, Sachet 2044 (US).

Weed in garden and elsewhere.

Manihi, village, Brooks & Brooks 20 (BISH).

ANACARDIACEAE

*Mangifera indica L. Mango, mako

Manihi, village, planted in Tahiti soil, Brooks & Brooks 58 (BISH).

SAPINDACEAE

*Melicocca bijugatus L. Quenettes (Fr.)

Tree with compound leaves with 2 pairs of leaflets, clusters of marble-like fruits with a thin outer shell and an edible gelatinous acid pulp around a large seed.

Seen by Sachet, December 1974.

Planted.

Manihi, village, Brooks & Brooks 64 (BISH).

*Pometia pinnata Forst. Kava

Tree with alternate pinnately compound leaves. Fruit like a green apricot, very much appreciated.

Seen by Sachet, December 1974.

Cultivated and fruiting abundantly in village.

Manihi, seen in village by Sachet 1974; planted in Tahiti soil, Brooks & Brooks 55 (BISH).

TILIACEAE

*Muntingia calabura L.

Small tree; leaves pubescent, alternate, ovate, with 3 strong nerves, margins serrate, apex acuminate; flowers in upper axils, sepals lanceolate, 5 white obovate petals, many stamens, single ovary with sessile stigma; fruit a globose pink sweetish berry with a persistent stigma and many small seeds.

Seen by Sachet, December 1974.

Small planted trees seen on road to airstrip from village.

Manihi, seen near airstrip by Sachet in 1974

Triumfetta procumbens Forst. f. Vavai oviri (P)

Prostrate spreading creeper with hairy stems and variable often lobed leaves, bright yellow flowers, and burr-like globose fruits.

Southeast side of atoll, between village and first pass (Paopaoa) Rapa, Sachet 2037 (US).
Very common, creeping, forming loose mats in coconut groves.

MALVACEAE

*Hibiscus schizopetalus L. aute tautau = aute ua'a piti

Manihi, Brooks & Brooks 39 (BISH).

*Hibiscus tiliaceus L. purau (P), hau, fau (T)

Spreading, often tangled tree, leaves round, usually pale beneath; flowers large, in few-flowered clusters, yellow with maroon center when opening in morning, turning light maroon and falling toward evening; fruits a 5-parted capsule.
Seen by Sachet, December 1974.
Not common, probably planted.

*Hibiscus (ornamental hybrids)

Shrubs with rather ovate-triangular, bluntly toothed leaves and axillary very large showy flowers with 5 spreading petals, the stamens united into a tubular column with many anthers at the top, through which runs the long style with 5 branches at top with globose velvety stigmas. Many varieties with flowers of different sizes and colors.
Seen by Sachet, December, 1974.
Several varieties planted in village.
Manihi, Brooks & Brooks 15, 16, 17 (BISH), 3 different varieties.

* Malvastrum coromandelianum (L.) Garcke

Wiry, erect or ascending herbs with alternate, simple, ovate, serrate leaves with appressed hairs especially on the nerves beneath, flowers orange, axillary, small, fruit breaking into toothed segments.
Village, Sachet 2076 (US).
Local in weedy yard.

*Malvaviscus arboreus Cav.

Shrub with alternate ovate serrate leaves, axillary flowers pendent with an involucre of narrow bracts, calyx united, 5-lobed; corolla usually scarlet, of 5 petals united at base with staminal column, strongly auriculate, remaining closed around column, which closely surrounds style, stigmas exserted, fruit a berry, usually not developing in cultivated plants.
Seen by Sachet, December 1974.
Cultivated in village, blooming abundantly.
Manihi, village, cultivated in soil from Tahiti, Brooks & Brooks 81 (BISH).

aute'umoa

*Sida rhombifolia L.

Small wiry shrub or suffrutescent herb, leaves alternate, small, narrowly oblong, rhombic, or ovate, toothed distally, tomentose at least beneath, dull green above; flowers axillary on long pedicels jointed near middle, petals weak orange, fruits of 5 segments that separate at maturity, each 1-seeded.

Village, Sachet 2054 (US).

Local weed.

*Thespesia populnea (L.) Sol. ex Correa miro (T), amae (P)

Small trees with alternate simple strongly cordate thinly leathery leaves, flowers on short ascending axillary pedicels, calyx almost truncate, petals large, showy, opening wide, butter-yellow, with maroon center, limb turning maroon and corolla falling in afternoon or evening, fruit dry, indehiscent, 5-loculed, many-seeded.

Along runway, Fakatopatere, Sachet 2009 (US).

One tree planted in village.

BOMBACACEAE

*Ceiba pentandra (L.) Gaertn. cotton-tree

Tree reaching enormous size, trunk thick, gray-green when young, smooth or with conical large prickles, often becoming buttressed when older, leaves alternate, palmately compound, flowers small one or two cm across, grayish, with 5 stamens, fruit a large thick-walled capsule splitting into 5 valves, releasing cottony masses, small seeds bearing long fine hairs that cause them to be carried by wind. Cotton-like seed-fiber used to stuff cushions.

Seen by Sachet, December 1974.

STERCULIACEAE

*Waltheria indica L.

Suffrutescent prostrate to ascending herbs with alternate, ovate obtuse strongly nerved crenate or crenate-serrate petiolate notably pubescent leaves, axillary cymes of small yellow flowers densely crowded and embedded in pubescence.

Village, Sachet 2057 (US).

Locally common weed.

GUTTIFERAE

Calophyllum inophyllum L. Tamanu (T), ati (P)

Very large spreading tree, leaves oblong, leathery; flowers white with many yellow stamens, borne in clusters among leaves; fruit pendent, globose, 2.5-3.5 cm in diameter. Widely distributed in Pacific, probably both by human agency and naturally by its floating fruits. Timber hard, workable, highly prized; also a superb shade tree.

Seen in village by Sachet, December 1974.

Manihi, seen in village by Sachet in 1974.

CARICACEAE

*Carica papaya L. Papaya, pawpaw

An erect, usually unbranched small tree with a soft trunk and milky sap; large palmate deeply divided round leaves on long stalks forming a huge rosette at top of stem; male flowers cream color, in large open clusters among leaves, female sessile on stem among and just below leaves, large, often some bisexual flowers mixed in clusters; fruit orange when ripe, fleshy, melon-like, with many black seeds in large central cavity. Widely planted in tropics for its delicious fruits and the proteolytic enzyme produced in its sap. Readily becomes naturalized, but then the fruit is commonly small and of poor flavor.

Seen by Sachet, December 1974.

Cultivated in village.

PASSIFLORACEAE

*Passiflora foetida L. var. gossypifolia (Desv.) Mart.

Slender tangled foetid tendriliferous herbaceous vine, leaves alternate glandular-pubescent palmately 3-lobed, involucre of 3 pinnatifid bracts, flowers showy, white and purple with 5 green sepals, 5 petals, and a corona of many filament-like staminodes, 5 stamens united into a tube sheathing the stalk of the one-celled subglobose ovary, styles and stigmas 3, placentae parietal, fruit thin-walled, soft, filled with small seeds embedded in a gelatinous aril.

Along runway, Sachet 2008 (US); Village, Sachet 2058 (US).

CUCURBITACEAE

*Citrullus lanatus var. caffrorum (Alef.) Fosb. Water-melon, pastèque

Prostrate herbaceous vines with alternate deeply pinnatifid leaves, the lobes with rounded apices, flowers axillary, yellow, unisexual, monoecious, the corollas gamopetalous, pistillate with inferior ovary, fruit an enormous berry with firm rind, usually red sweet fleshy interior bearing many flat elliptic black seeds, each in a cavity in the flesh.

Seen by Sachet, December 1974.

In garden surrounded by wire mesh, bearing fruit.

*Cucurbita sp. citrouille

Cited as sparingly cultivated in village by Robineau (1977:22)

CACTACEAE

*Opuntia sp. ? Figue de barbarie, Indian fig, prickly pear

Erect, spiny, leafless plant with broadly obovate or elliptic stems

thick, fleshy but flattened and jointed; flowers large, fruits fleshy, juicy, with many seeds.
Seen in village, Sachet, December 1974.

LYTHRACEAE

Pemphis acidula Forst. mikimiki (P), aie (T)

Much-branched shrub or tree with very hard dark reddish wood; leaves small, oblong, thick, astringent when chewed; flowers white, rather small; fruit a round somewhat flattened, dark reddish capsule, seeds many, small.
East of airport, Tararo, Sachet 2006 (US).
Locally common, mostly on rough limestone on seaward coasts and rocks on reef-flat, forming pure stands of low to tall scrub in such places.
Branches used as supports for young pearl-oysters.
Manihi, seen near airstrip by Sachet in 1974.

COMBRETACEAE

*Terminalia catappa L. Indian Almond, Tropical Almond, autara'a (P)

A pagoda-form tree with flattish horizontal branches, large obovate leaves that turn red when old, slender spikes of small white flowers, somewhat flattened ovoid corky fruits with 2 keels, almond-like and edible seeds. Widely planted in the tropics, doubtfully native in eastern Polynesia.
Seen in village, Sachet, December 1974.
Very large trees common in village, flowering and fruiting abundantly.
Manihi, seen in village by Sachet in 1974.

MYRTACEAE

*Eugenia cuminii (L.) Druce pistache, Java plum Jambulan

Aromatic trees with opposite simple leathery elliptic or oblong gland-dotted leaves, flowers in paniculate cymes, sepals and petals small, stamens many, white, strongly exserted; ovary inferior, fruit a dark purple one-seeded berry about 1 cm long, rather astringent.
Takapoto, seen in village, Sachet, December 1974.
Quite a few large trees planted, flowering abundantly. Fruit said to be made into jam.

*Eugenia uniflora L. Surinam cherry

Shrub with ovate sessile simple opposite thin leaves, flowers on axillary pedicels, sepals large, suborbicular, petals white, not large, stamens many white, ovary inferior; fruit a juicy deeply lobed sweet 1-seeded berry, rather aromatic, becoming red and darkening to maroon or almost black when ripe.
Village, Sachet 2078 (US).
One sterile tree observed, planted.

*Psidium guajava L. Guava, tuava

Shrub with smooth bark, opposite simple leaves, axillary white flowers with many stamens, inferior ovary; fruit a berry with many round hard seeds, capped by persistent sepals.

Doubtfully seen in village, Sachet, December 1974.

Manihi, village, planted in yard, Brooks & Brooks 34 (BISH).

ARALIACEAE

*Polyscias spp.

Ornamental shrubs with compound variegated toothed leaves, oily aromatic when broken, with a strong coumarin odor when dried, very rarely flowering, flowers in loose clusters, inconspicuous, dull purplish. A number of distinctive forms--species or cultivars--are widely planted in the Pacific Islands.

Seen by Sachet, December 1974.

Several species cultivated in gardens of village.

SAPOTACEAE

*Manilkara zapota (L.) v. Royen

Manihi, village, growing in Tahiti soil, Brooks & Brooks 60 (BISH).

OLEACEAE

*Jasminum fluminense Vell.

Vine-like, somewhat woody, with small compound leaves with 3 ovate leaflets; flowers rather star-shaped, white, in small clusters, very fragrant. Fruit a black berry.

Village, Sachet 2082 (US).

One large clump seen in abandoned garden, flowering and fruiting.

APOCYNACEAE

*Catharanthus roseus (L.) G. Don Madagascar periwinkle

Erect leafy-stemmed herb, with white or pink flowers, sometimes with dark red eye. Planted and often naturalized in tropical and subtropical areas.

Area just behind Service de la Pêche, Sachet 2029 (US).

Seen established around camp site.

Manihi, Brooks & Brooks 19 (BISH).

*Nerium oleander L. var. oleander

Shrub with opposite lance-elliptic leathery leaves and terminal cymes of showy white to pink or rose-colored flowers, corolla campanulate with a broadly spreading limb, with lacerate scales in the throat; fruit a linear follicle. All parts of this plant extremely poisonous.

Area just behind Service de la Pêche, Sachet 2030 (US).
Several varieties of different colors seen in village.

*Nerium oleander var. indicum (Mill.) Deg. & Deg. Tarona

Differs in having double very fragrant flowers, usually rose colored.
Seen by Sachet, December 1974.
Manihi, Brooks & Brooks 13, 38 (BISH).

*Nerium sp.

Manihi, seen by Sachet in 1974 in village.

*Plumeria obtusa L. Singaporu(=Singapore plumeria

Small tree with milky sap, with few thick branches, leaves crowded near ends of branches, large, spatulate-ovate, very obtuse or rounded at apices, dark green. thick; flowers in clusters, white with yellow center, 5-parted, tubular below, fragrant.
One small tree seen in village, Sachet, December 1974.

*Plumeria rubra L. frangipani

Small tree with very thick branches; vari-colored, extremely fragrant five-parted large flowers, much used for garlands.
Seen by Sachet, December 1974.
Planted around village, many varieties of different colors.
Manihi, seen near airstrip and in village by Sachet in 1974.

ASCLEPIADACEAE

*Asclepias curassavica L.

Erect wand-like lactiferous herb, leaves linear-lanceolate, opposite; flowers in umbels, on slender pedicels, with dark red petals and orange corona, fruit a lance-fusiform pointed follicle, seed with a tuft of silky hairs.
Seen by Sachet, December 1974.
Uncommon weed.

*Cryptostegia grandiflora (Roxb.) R. Br.

Woody vine with abundant milky sap, opposite glossy ovate somewhat acuminate leaves without stipules, flowers with short tube, campanulate throat, purple spreading limb, anthers sessile at summit of tube, fruit of two spreading smooth follicles.
Village, Sachet 2042 (US).
One large vine seen, very floriferous.

CONVOLVULACEAE

*<u>Ipomoea batatas</u> (L.) Lam. Sweet potato

Slender herbaceous vine with thick fusiform edible roots, alternate cordate entire to deeply lobed leaves, few-flowered cymes of pale lavender flaring trumpet-shaped flowers, dark purple in center; flowers rather rarely produced, propagation mostly vegetative.

Seen by Sachet, December 1974.

A few small vines seen cultivated.

Manihi, village, at least two varieties seen by Sachet in 1974.

BORAGINACEAE

<u>Cordia subcordata</u> Lam. Tou

Tangled tree with low branches, leaves alternate, with broad ovate or elliptic, slightly rough blades and often yellow stalks; flowers in small clusters, large, brillant deep orange, corolla thin, delicate, fruit nut-like, enclosed in enlarged calyx. Wood hard but workable, prized for carving, banded light and dark brown.

Village, <u>Sachet 2083</u> (US).

Uncommon, one large tree seen near light, obviously planted.

Manihi, large trees seen by Sachet in 1974.

<u>Heliotropium anomalum</u> H. & A. parahiahi (P)

Dwarf shrub with narrow silky leaves, dense clusters of fragrant white flowers with yellow centers.

Along runway and near airport, <u>Sachet 2014</u> (US).

Common in open places on coral sand or gravel.

<u>Tournefortia argentea</u> L. f. Tree Heliotrope; ngeongeo (P) tohonu (T)

Shrubs and small trees, leaves obovate, spirally arranged, fleshy, gray-green, silky, flowers small, white, fragrant, in clusters with "scorpioid" or fiddle-neck shaped branches; fruit a pea-like pale green drupe with four small stones, this drying to a small corky globose floating dry fruit.

Vairua , <u>Sachet 2061</u> (US).

Locally common in coconut plantation, along seaward beach ridges, and in places dominating marginal vegetation, old trees persisting in interior.

Manihi, seen by Sachet in 1974 near airstrip, <u>Whitney Exped. 1915</u> (BISH).

CHLOANTHACEAE

Nesogenes euphrasioides DC.

Creeping herb, many stems from slender root-crown; leaves small, oblong, stipules lacking; flowers axillary, pedicellate, calyx gamosepalous, corolla gamopetalous, limb bilabiate.

Area southeast of airport, Sachet 2005 (US).

Local in coconut plantation.

VERBENACEAE

*Stachytarpheta urticifolia Sims

Erect shrub or suffrutescent herb, leaves opposite ovate or obovate, sharply toothed, bright green, spikes slender elongate, flowers sessile sunken in grooves in rachis, corolla with tube curved outward, limb spreading, dark blue, falling very readily; fruit oblong, sunken in grooves in rachis, style persistent on young fruit.

Village, Sachet 2053 (US).

Common weed.

LABIATAE

*Plectranthus scutellarioides (L.) R.Br.
Coleus scutellarioides (L.) Benth.

Erect sparsely branched soft herb, leaves opposite, heart-shaped, with scalloped margins, variously colored and variegated, flowers in whorls on a loose terminal raceme, corollas very irregular, blue.

Seen by Sachet, December 1974.

*Ocimum sp. Basil, miri (P, T)

Herb, strongly and pleasantly aromatic, branched; leaves opposite ovate; flowers in terminal racemes of whorls, calyx united, somewhat 2-lipped, corolla white, 2-lipped.

Seen by Sachet, December 1974.

SOLANACEAE

*Brugmansia sp.

Large shrub; leaves alternate, very shallowly lobed, petiolate, elliptic; flowers solitary, pedicellate, pedicels curved and flower pendent, calyx tubular-prismatic, corolla white, very large, trumpet-shaped, shallowly 5-lobed, the lobes with acuminate tips, these separated by wide shallow sinuses, stamens inserted low in tube, included, style subequal or longer than stamens; flowers very fragrant at night; fruit a large irregularly beaked capsule but seldom produced by cultivated plants.

Seen in village, Sachet, December 1974.

*Cestrum diurnum L. — Arii vahine

Manihi, village, Brooks & Brooks 41 (BISH).

*Physalis angulata L.

Erect or ascending bushy herb, stems somewhat angled, leaves thin, broadly ovate, petiolate, base truncate or rounded, apex acute or somewhat acuminate, margins entire to undulate or bluntly toothed, calyx campanulate very much enlarged in fruit, forming a loose envelope enclosing fruit; corolla rotate-campanulate, pale yellow with dark center, stamens not connivent, style filiform fruit a globose yellowish berry with many seeds.

Village, Sachet 2052 (US).

A few plants seen in weedy areas.

*Solanum lycopersicum L. — Tomato

Branched glandular pubescent herb, up to 1 m or more tall when supported; leaves alternate, pinnately dissected; flowers in axillary racemes, calyx deeply 5-lobed, practically to base, lobes lanceolate; corolla yellow, deeply 5-lobed, lobes ovate-lanceolate; stamens 5 closely connivent, opening by apical slits; fruit a globose to depressed globose, soft berry with 2-several cells, axile fleshy placentae, seeds pubescent, disk-like, borne in a mass of jelly, walls and partitions of fruit fleshy, red when ripe.

Seen by Sachet, December 1974.

*Solanum melongena L. — huapua'aniho

Manihi, village, Brooks & Brooks 66 (BISH).

SCROPHULARIACEAE

*Russelia equisetiformis Schlecht. & Cham.

Essentially leafless much branched green-stemmed herb, branches opposite or whorled; flowers pedicellate in short racemes on ends of stems, corolla tubular, bright red.

Village, Sachet 2080 (US).

One large clump seen in garden.

ACANTHACEAE

*Graptophyllum pictum (L.) Nees ex Griff.

Erect shrub with blotchy dark purple leaves, deeply 2-lipped purple flowers.

Seen by Sachet, December 1974.

*Pseuderanthemum carruthersii var. atropurpureum (Bull) Fosb.

Shrub with opposite dark-purple variegated often misshapen oblong leaves, flowers in terminal branched racemes, sepals free, corolla salverform, 5-lobed, somewhat bilabiate, limb so abundantly crimson-spotted as to appear almost crimson.

Seen in village, Sachet, December 1974.

*Pseuderanthemum carruthersii (Seem.) Guill. var. carruthersii

Shrub with opposite bright green oblong to ovate sessile entire leaves, no stipules, flowers in terminal branched racemes, sepals free, corolla salverform, 5-lobed, somewhat bilabiate, limb white with crimson spots especially around the throat.

Seen in village, Sachet, December 1974.

RUBIACEAE

*Gardenia taitensis DC. Tiare Tahiti; Tahitian Gardenia

Shrub or small tree, leaves opposite, broad, obovate, shiny; flowers solitary among leaves, large, white, very fragrant, corolla lobes 6-7, spreading. Generally planted in Polynesia for its highly prized deliciously fragrant flowers.

Seen by Sachet, December 1974.

Planted around village.

Guettarda speciosa L. kahaia (P)

Shrub or small to medium-sized tree, with large, broad, obtuse leaves, conspicuous stipules; small clusters of large white flowers, opening and very fragrant at night, losing their fragrance and dropping their corollas during following day; fruit a globose white fleshy-fibrous floating drupe.

Vairua, Sachet 2062(US). Whitney Exped. 1946 (BISH). Jones 1002(BISH).

Very common generally, most common tree on atoll.

Manihi, Whitney Exped. 1923 (BISH); seen near airstrip.

Hedyotis romanzoffiensis (C. & S.) Fosb. koporoporo (P)

Small shrub with opposite, obovate, small leathery leaves; greenish-white flowers in few-flowered clusters; fruit globose, fleshy, white to purple, opening at one end to let out the small seeds.

Rapa, Sachet 2035 (US).

Southeast side of atoll, between village and first pass. Whitney Exped. 1961 (BISH), Jones 1009 (BISH).

Manihi, seen near airstrip by Sachet in 1974.

*Ixora casei Hance ?

Robust notably leafy shrub; leaves oblong or elliptic, opposite, shortly petiolate, entire, stipules ovate somewhat acuminate; flowers in large corymbiform many-flowered heads, with inferior ovary, short cup-like 4-toothed calyx, showy scarlet salverform corollas with 4 oblong-ovate spreading lobes, anthers exserted from sinuses, style with stigma bilobed, strongly but tardily exserted.

Seen by Sachet, December 1974.

Cultivated in village.

Morinda citrifolia L. Hora (P), nono (T)

Shrub or small tree, with opposite, large, elliptic, glossy leaves; small heads of small white flowers, fused together at base; fruit dull whitish, potato-shaped, fleshy, with many large seeds, developing a rancid very disagreeable odor when old.

Area just behind Service de la Pêche, Sachet 2039 (US).

Common generally in coconut groves. Whitney Exped. 1968 (BISH). Manihi, seen by Sachet near airstrip in 1974, Whitney Exped. 1906 (BISH).

Timonius polygamus Forst. Ketoketo (P)

Shrub with opposite obovate leaves, very variable in shape; small white flowers, male in few-flowered clusters, female solitary; fruit black, fleshy, globose, with a number of small stones.

Area between Service de la Pêche and runway, Sachet 2016 (pistillate plant) (US), Sachet 2017 (staminate plant) (US). Jones 1019 (BISH), Whitney Exped. 1959 (BISH).

Very common generally in undergrowth and in scrub.

Manihi, seen near airstrip by Sachet in 1974, Whitney Exped. 1930, 1924 (both BISH).

GOODENIACEAE

Scaevola sericea var. tuamotuensis (St. John)Fosb. Ngapata (P) apata,
Scaevola taccada (Gaertn.) Roxb. naupata (T)

Depressed spreading shrub, glabrous except for axillary tufts of white hair, leaves alternate, spatulate, narrowed to base, rounded at apex, flowers in axillary few-flowered dichotomous cymes, ovary inferior, sepals small narrowly oblong or lanceolate, blunt, corolla salverform, tube split down one side, 5-lobes patent, arranged fan-wise, with heavy dark central zones and wide membranous yellowish margins, stamens free, filaments very slender, style with hook-like curve at the apex, stigma of 2 superimposed flaps; fruit a white juicy drupe with a single ribbed stone.

Vairua, Sachet 2059 (US). Jones 1018 (BISH), Whitney Exped. 1958 (BISH).

Very common everywhere especially in marginal fringe vegetation.

Manihi, Brooks & Brooks 61 (BISH), Whitney Exped. 1928 (BISH). Seen near airstrip by Sachet in 1974.

COMPOSITAE

*Bidens pilosa L.

Erect oily-aromatic herb, leaves opposite, pinnately compound, leaflets 3 or 5, oblong to elliptic, serrulate, acute or acuminate; heads of flowers few, pedunculate, rays none or short, broad, whitish (var. minor); disk yellowish; achenes blackish, prismatic, with 3 sharp retrorsely barbed pappus awns at one end.

Village, Sachet 2075 (US).
Occasional in weedy areas.

*Emilia fosbergii Nicolson

Slender succulent-stemmed sparsely branched herb, thinly pilose, leaves thin, slightly glaucous, basal larger, somewhat lobed, terminal lobe larger, cauline alternate, narrowly oblong, toothed, sagittate at base; heads of flowers few, involucre cylindric or narrowed toward summit, of a single series of linear bracts coherent by their overlapping margins; flowers brick-red, exceeding the involucre, achenes prismatic, 5-sides, angles microscopically grooved, with hairs in grooves, pappus of many white capillary hairs. This plant has commonly been called E. javanica.
Village, Sachet 2048 (US).
Common in weedy yard.

*Emilia sonchifolia (L.) DC. ex Wight var. javanica (N. Burm.) Mattf.

Slender, succulent-stemmed sparsely branched herb, thinly pilose, leaves thin, glaucous, basal leaves larger, lyrately lobed, terminal lobe larger, cauline leaves shallowly lyrate, involucres narrowly cylindric, of one series of linear bracts, flowers very slender, purple or lilac, subequal with involucre; achenes prismatic, 5-sided, angles grooved, pappus of many white fine capillary hairs.
Village, Sachet 2049 (US).
Rare in weedy yard.

*Emilia sp.

Diseased plants.
Village, Sachet 2050 (US).
Local in weedy yard with E. fosbergii.

*Synedrella nodiflora (L.) Gaertn.

Erect herb with opposite branching and opposite ovate serrate leaves, heads cylindric, sessile, axillary, involucre of few narrow oblong bracts, flowers few, several yellow rays, a few yellowish disk flowers, achenes of two sorts, ray achenes elliptic, strongly margined, margins toothed, two pappus spines rather erect.
Village, Sachet 2046 (US).
Common weed.

*Vernonia cinerea (L.) Less. var. parviflora (Bl.) DC.
Little Iron-weed.

Slender erect herb, sparsely branched, leaves alternate, elliptic to obovate, basal ones larger; heads discoid, small, about 5 mm long, in corymbiform clusters, involucres of several series of closely imbricate bracts, flower purple, pappus white, capillary.
Area just behind Sevice de la Pêche, Sachet 2027 (US). Whitney Exped. 1923 (BISH).
Common weed.

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Fig. 1. Channel (hoa) across reef, coconut grove in background, germinating coconuts in foreground.

Fig. 2. Coconut plantation with split nuts piled up to dry enough to loosen meat for copra. Vairua area, lagoon side.

Fig. 3. Shallow channel (hoa) through land-strip, Takai area. *Tournefortia argentea* tree on right.

Fig. 4. Almost dry, "non-functional" hoa, *Tournefortia* scrub forest at top of shore opposite.

Fig. 5. Timonius polygamus scrub, very tangled, with emergent Tournefortia tree, Takapoto Atoll.

Fig. 6. Prostrate Scaevola sericea var. tuamotuensis, Manihi Atoll, near airstrip. Nov. 1974.

Fig. 7. Tournefortia argentea, budding inflorescence, Manihi Atoll, near airstrip

Fig. 8. Tournefortia, flowering inflorescence, Manihi, both photos Feb. 1975.

Figs. 9-10. Fairy tern, Gygis alba, in Pisonia grandis tree, Takapoto Atoll, Vairua.

ATOLL RESEARCH BULLETIN

No. 278

MARINE TURTLES OF THE LEEWARD ISLANDS, LESSER ANTILLES

BY

Anne Barkau Maylan

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Figure 1. Leeward Islands

MARINE TURTLES OF THE LEEWARD ISLANDS, LESSER ANTILLES

BY

ANNE BARKAU MAYLAN [1/]

INTRODUCTION

Although marine turtles are conspicuous members of the Caribbean fauna, significant gaps remain in our knowledge of their distribution and status within the region. Nowhere is knowledge more fragmentary than for the Lesser Antilles which, following the definition of Bond (1978), include those islands from Saba and Anguilla south and east to Barbados and Grenada. Comprising 17 major islands and 16 banks, the Lesser Antilles lie in an arc some 630 km long, and provide nesting and foraging habitats for four species of marine turtles: the green turtle (Chelonia mydas), hawksbill (Eretmochelys imbricata), leatherback (Dermochelys coriacea) and loggerhead (Caretta caretta). Although the olive ridley (Lepidochelys olivacea) occurs peripherally in the wider Caribbean region, it is considered a waif in the Lesser Antilles. Kemp's ridley (Lepidochelys kempi) has not been recorded from this region.

The present paper is concerned with the marine turtle fauna of the northern group of islands of the Lesser Antilles, the Leewards (Fig. 1). Although the terms Leeward Islands and Windward Islands have historically been associated with the British islands, rather than with the French or Dutch, the official boundary at latitude 15°40'N serves as a convenient dividing line for the island chain, and this is the criterion that has been adopted for this paper. Results of a survey of the turtle fauna of the Windward Islands have been reported previously (Caribbean Conservation Corporation, 1980; Carr et al., 1982).

Bacon (1981) reviewed the literature pertaining to the status and distribution of marine turtles in the Western Atlantic. For five of the eleven Leeward Islands, he reported a complete lack of information. For the remaining six, the literature he cited is largely limited to isolated nesting records, many of which lack specific locality data. Guadeloupe is the only island for which detailed information on the turtle fauna is available (Caribbean Conservation Corporation 1980; Carr et al., 1982). General comments about species distribution and abundance in the Leewards were given by Carr et al. (1982). ECNAMP (1980) mapped turtle nesting localities in the Leewards in a series of resource atlases; data from the present study were incorporated in that for all the islands except Montserrat and St. Barthélemy. An overview of marine turtle populations in the Caribbean region was presented by Rainey and Pritchard (1972). Their evaluation of conservation problems remains pertinent to the Lesser Antilles. Publications concerning recent exploitation of marine turtles in the region include Kermarrec

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(1976), Cato *et al.* (1978), Carr and Meylan (1980) and Meylan and Mack (1983). The forthcoming proceedings of the Western Atlantic Turtle Symposium, a Caribbean-wide meeting held in July 1983, in Costa Rica, will add much to knowledge of Caribbean turtles.

The present paper is a preliminary description of the marine turtle fauna of the Leeward Islands. It covers a large area that has received almost no previous attention, and it deals with an animal group that presents unique sampling difficulties. Because of limited time and resources, the aim of the study has been modest--merely to begin filling the enormous gap in knowledge of the turtles of this region, and to provide background for improved conservation and management practices. All marine turtles that occur within the Lesser Antilles, with the exception of the loggerhead, are considered endangered by the International Union for the Conservation of Nature and Natural Resources (Groombridge, 1982).

METHODS

As are all mobile marine species, sea turtles are difficult to survey. Seasonal and ontogenetic shifts in habitat occupation compound the difficulty. In a short-term study, the surveyor is also hindered by unfamiliarity with the location of appropriate habitats, or by the lack of means to reach these habitats. When one spends only a short time in an area, it is unusual to see any live marine turtles at all, as those who have undertaken surveys of this type know. One survey technique that has been demonstrated to yield useful information is interviewing (Carr *et al.*, 1982). Interviews, carefully structured and executed, allow one to take advantage of the lifelong experiences of others. It is of no small advantage that sea turtles are of commercial value. Interviews are particularly effective when conducted with fishermen whose livelihoods have depended on their ability to catch turtles. Such people are keenly aware of the habitat preferences, seasonality and movements of these animals, and because of this, they can be valuable sources of information.

In the present study interviews were the primary method of gathering data. The interviews were conducted informally, but followed a procedural outline and standardized questionnaire developed by Carr *et al.* (1982). Informants included primarily fishermen, but also, fisheries personnel, divers, boat captains, other residents and some tourists. An effort was made to evaluate the experience and reliability of each informant, and several interviews were usually conducted at each locality to try to obtain corroboration.

Direct observations were used to corroborate and supplement the interview data. Beaches were surveyed for evidence of nesting (some several times), and whenever possible boat surveys were carried out in foraging habitats. An exhaustive search for specimens and information was made in public markets, fisheries offices, airports, hotels, and shops of many descriptions.

Field work was carried out during six short surveys, between April 1980 and May 1983, except in the case of Guadeloupe, which was surveyed in December 1978. Coverage of individual islands was roughly comparable; slightly more time was spent gathering information at Anguilla and Montserrat.

Nesting and foraging localities for turtles indicated on the maps include only data gathered during the present study. Information from other sources cited in the text is not included, nor are sites of desultory nesting. Data presented on the maps are by no means complete. For some areas, no information was available. I would appreciate any additions or corrections that readers can offer.

RESULTS

Anguilla (18°18'N, 63°17'W)

Anguilla is the northernmost island in the Leewards chain (Fig. 1). Situated 8 km north of St. Martin, the 90 km^2 island extends NE to SW for 26 km. It includes several small, uninhabited cays: Dog Island, Prickly Pear Cays, Seal Island, Sandy Island and Sombrero Island (Fig. 2). There are extensive reefs off the north coast of the island, along a line running westward from Island Harbour to Prickly Pear Cays; fringing reefs are present along most of the south coast (ECNAMP, 1980). The numerous short, white sand beaches around the island are potentially good nesting sites for turtles.

The green turtle and the hawksbill are the most common marine turtle species in Anguillan waters. Both are year-round residents, and both are represented by juvenile, subadult and adult size classes. Green turtles are reported to reach great size (227 kg), which is typical of the species in the Eastern Caribbean. Leatherbacks and loggerheads also occur around Anguilla, but in much smaller numbers. The ridley is not known from this locality. Vernacular names for each species are given in Table 1.

The hawksbill is the principal species nesting on Anguilla. The beaches on Dog Island (Savannah Bay, Stoney Bay, Pigfish Bay and Great Bay) are said to be the most frequently used nesting sites, although some nesting occurs on Prickly Pear Cays and on the main island, as well. A nest found by a resident of North Hill Village at Katouche Bay, in August 1979, contained 200 eggs, and thus was presumably the nest of a hawksbill. Despite the existence of much suitable habitat the total number of hawksbills nesting annually on Anguilla and its associated cays appears to be relatively low.

Green turtles rarely nest on Anguilla. One reliable informant recalled seeing a 227 kg green turtle nest at Pigfish Bay, Dog Island, some ten years ago. Local lore is that Anguillan green turtles do not nest at all on Anguilla, but instead migrate to Aves Island, 257 km west of Guadeloupe, to nest. This may well be the case. Although some solitary nesting does occur, the green turtle is primarily a group nester, and Aves is the only colonial nesting site known for the species in the Eastern Caribbean (Rainey and Pritchard, 1972).

The leatherback, although rare around Anguilla, is well known by residents because of its distinctive appearance. It occurs only as a nesting visitant. On the mainland, one or two leatherbacks nest each year on the northwest coast (Road Bay, Mead's Bay, Long Bay and Barnes Bay), and there are reports of even more sporadic nesting on the southeast coast at Sandy Hill, Mimi Bay and Captains Bay. It is likely that these turtles are strays from other nesting colonies--perhaps those in the British and U. S. Virgin Islands. Several tagged leatherbacks have been captured on Anguilla, according to residents, but I could not discover the origin of the tags.

Although nesting by leatherbacks on the main island is uncommon, a number of informants reported nesting on nearby Scrub Island. Scrub Island is uninhabited and seldom visited, and it is possible that a small colony of Dermochelys nests there. The reports deserve further investigation.

There are no reliable records of nesting by loggerheads on Anguilla. It is not even known whether mature individuals occur in the area.

Anguilla is one of the few localities in the Eastern Caribbean where hawksbills can be seen, more or less predictably, in foraging habitats around the main island. Throughout much of the region, they have been extirpated from shallow coastal waters by divers and net fishermen, and persist only in more inaccessible offshore habitats. Both hawksbills and green turtles are frequently sighted by residents from the cliffs at North Hill Village and Lower South Hill, and at Isaac's Cliff.

Green turtles, particularly juveniles, can be seen feeding in bays around the main island. Many informants reported seeing them in groups. On the main island, Mead's Bay is considered by local divers to be one of the best places to observe both green turtles and hawksbills.

There is good foraging habitat for hawksbills on the extensive reef that lies north of the island, and for both hawksbills and green turtles around the offshore cays. Both species are frequently sighted at Dog Island, Prickly Pear Cays and Sandy Island. One diver reported a group of 15 green turtles, ranging in weight from approximately 18 to 27 kg, on the eastern side of Sandy Island. A young green turtle captured by a diver at Sandy Island in August 1980, bore a tag that had been put on by the Florida Department of Natural Resources in 1975, when the turtle was released at Cape Canaveral, Florida (R. Witham, in litt.).

Hawksbills are also seen around Sombrero Island, some 48 km northwest of Anguilla. The island is uninhabited, but a boat travels there from Anguilla every 15 days to service the lighthouse. Curiously, all informants who mentioned Sombrero commented on the large size of the hawksbills there.

Information about foraging by loggerheads in Anguillan waters is fragmentary. Some reports were received that loggerheads feed around Dog Island, Scrub Island and Sandy Island, but identification of this species by most Anguillans seems to be unreliable--probably because of the turtle's scarcity there. The species definitely does occur around the island, however. The author saw a subadult on 12 April 1980 that had just been caught in a net at Scilly Cay, near Island Harbour (Pl.

1). On the rather crude public scale at Island Harbour, the turtle weighed 54.5 kg. In general, fishermen consider this species to be rare.

Marine turtles appear to be more abundant around Anguilla than at most of the other Leeward Islands. This abundance can at least partly be attributed to the fact that the island has extensive nesting and foraging habitats, many of which are located on and around offshore cays. Evidence of the value of these less accessible habitats is the abundance of turtles at Dog Island, situated some 13 km from the main island. The slow rate of development of the tourism industry has also been a positive factor in the continued survival of Anguilla's turtle fauna. The usual pressures exerted by the souvenir trade, and the market for turtle meat to supply hotel restaurants, have been minimal.

The survival outlook of marine turtles on Anguilla is by no means secure, however. Populations are already depleted, and exploitation pressures are rapidly escalating as tourism in the region increases. A factor that is already taking a toll is the export of turtles and turtle products to neighboring islands, particularly St. Martin.

A change in the method of fishing turtles is also having a negative effect on populations. The traditional method of setting tangle nets is dying out as costs for net materials and gasoline increase, and as fishermen turn to the more lucrative lobster business. Only about ten people were engaged in setting nets for turtles in 1980. The new generation catches turtles with spearguns. For the most part, they are young divers, who comb the reefs looking for lobster, fish and conch. They take turtles only opportunistically. With spearguns for weapons, however, they are able to catch nearly every turtle they encounter, and as a result, far more are being killed than ever before. Also, smaller size classes are for the first time included in the harvest. The hawksbill is by far the most vulnerable species, because it shares the habitat of the lobster. A few divers who have become aware of the profit to be had in the tortoiseshell trade now concentrate their efforts on hawksbills.

The meat of green turtles and hawksbills is sold locally to private individuals and to hotels on the island. In 1980, the price was approximately US$2/kg. Fishermen also carry meat to St. Martin to sell, where there is a steady demand to supply the many hotel restaurants. Live turtles are occasionally transported on the ferry that runs to Marigot, St. Martin. The meat of the leatherback is eaten on Anguilla, but is probably not exported. Eggs of all species are taken whenever they are found, but there appears to be no commerce in them--presumably because of their scarcity.

Tortoiseshell is sold to buyers on St. Martin, or to entrepreneurs from St. Thomas and Puerto Rico, who periodically visit Anguilla for this purpose. The price for raw shell in 1980 was US$20/kg. There is currently no local handicraft in tortoiseshell.

Carapaces of hawksbills and green turtles are dried and prepared for local sale, or are sold to shops on St. Martin. Currently, this trade is small in magnitude. Shells of 15 juvenile hawksbills and one subadult green turtle were seen by the author for sale at various places on Anguilla. All of the hawksbills were well below the 9 kg minimum size limit (Table 2), and thus had been captured illegally.

Several nesting beaches on Anguilla have been, or are currently being, mined for sand for construction purposes: Shoal Bay, Mead's Bay and Barnes Bay (ECNAMP, 1980). The impact of these operations on sea turtle nesting has not been assessed.

Anguilla has no sanctuaries or parks that provide protection for sea turtles (Table 3). However, a proposal under consideration recommends the establishment of three protected marine areas: Seal Island Coral Reef Reserve, which would include Seal Island, the eastern Prickly Pear Cay and an extensive tract of the north barrier reef; Sandy Island National Marine Park; and Shoal Bay National Marine Park (A. Putney, in litt.). All three could potentially benefit sea turtles, provided that specific regulations for their protection were included. Another area that deserves consideration as a possible sanctuary is Dog Island and its surrounding cays and reefs.

Saint Martin (18°05'N, 63°03'W)

Saint Martin is approximately 120 km^2 in size and is situated on Anguilla Bank, along with the islands of Anguilla, St. Barthélemy and Ile Fourche. The northern half of the island is a dependency administered through Guadeloupe, an overseas department of France; the southern half is one of six Netherlands Antilles, administered by a central government based in Curaçao. Major cays associated with St. Martin are Flat Island (Ile Tintamarre), Pinel Island and Green Cay, all of which lie off the windward (eastern) coast (Fig. 3). None is inhabited.

The waters around St. Martin are relatively shallow in depth (18-27 m). There are extensive seagrass beds off the northwestern and southwestern coasts. The northwestern seagrass bed is 11,600 ha in size (ECNAMP, 1982). Coral reefs extend along much of the coastline. Detailed descriptions of the shoreline are given by Vroman (1968). Most of the island's sandy beaches are on the southern and northwestern coasts; those on the windward shore are, in general, deeply eroded. Sand mining for construction purposes is carried out at nearly a dozen beaches around the island (ECNAMP, 1980). The beaches on the southern coast are among the most commercially developed in the Eastern Caribbean. Hotels and condominiums are under construction on much of the French coast as well, and there will soon be few beaches on the entire island that remain undeveloped.

The green turtle and hawksbill are the principal marine turtle species around St. Martin. Neither appears to be very abundant. The loggerhead and leatherback are also present but rarely encountered.

The frequency of nesting by all marine turtle species is apparently quite low. A few hawksbills and even fewer green turtles nest at Guana Bay and Oyster Pond on the windward coast, at Long Bay on the southwestern tip of the island, and on Flat Island. Divers have seen copulating pairs of both species in the Oyster Pond area.

Nesting by the leatherback is extremely uncommon, with only one or two individuals observed on the beaches annually. In the recent past leatherbacks have nested at Long Bay and Simpson Bay. Hermans (1961) reported the nesting of a leatherback on St. Martin on 17 April 1960. There are no reports of nesting by Caretta.

Hawksbills occupy reef habitats along the eastern coast of the island, especially off Oyster Pond, Flat Island and Pinel Cay. Two juveniles caught by a diver at Guana Bay had been feeding on a variety of sponges. Hawksbills are also found around Pelican Cay (Guana Cay), and at Man O'War Shoals, 3.2 km directly south of Philipsburg.

Green turtles forage in the extensive Thalassia beds off the northwestern coast. A turtle fisherman from Grand Case sets nets for green turtles at Point du Bluff, west of Marigot. In former times, green turtles could be seen foraging in the harbor at Philipsburg, but with the construction of a deep-water pier at Point Blanche, and the accompanying increase in ship traffic, they are now rarely sighted.

Turtles (species not identified) are also reported to forage around the rocky islet Molly Beday, a sea bird rookery. A resident of nearby St. Barthélemy witnessed the capture of seven turtles there in only a few hours in the late 1960's.

Turtles are not known to live in Simpson Bay Lagoon, although it has at times been freely connected to the ocean. There are currently two inlets, one on the south side of the island at Simpson Bay, and the other on the north.

Population levels of marine turtles on St. Martin appear to be low, despite the presence of much suitable foraging habitat. Although it is not clear what factors may have operated there in the past, commercial exploitation and loss of nesting habitat are the major problems today. Spearfishing is commonly practiced, as is the taking of female turtles and their eggs from nesting beaches. A few French fishermen still employ tangle nets. Fishermen from other islands--notably St. Barthélemy--also set nets around St. Martin. Turtle meat is occasionally sold at the public market in Marigot, the main town on the French side of the island.

Although some turtles are captured for local sale or subsistence use, the greatest pressure on St. Martin's turtle populations is exerted by the tourist industry. Souvenirs made from turtles, and turtle steaks for restaurants, are in great demand in the tourist-oriented economy. For the most part, the supply of turtles is provided by divers who use spearguns. The depleted status of local stocks necessitates travel by the divers to neighboring islands, such as Anguilla and St. Eustatius. There is also an active trade in tortoiseshell. In 1980, one tortoiseshell dealer in St. Martin was buying shell from several islands in the northern Leewards, and exporting it to Holland. Despite the high price he offered, US$100/kg, he was able to purchase less than half as much shell as formerly, presumably because hawksbill populations have been so badly depleted.

There are no laws protecting marine turtles on Dutch St. Martin. Controversy about the respective jurisdictions of the central government and the local island government has resulted in this situation, which prevails not only on St. Martin but also on Saba and St. Eustatius. The French portion of the island, as a dependency, is subject to the laws of Guadeloupe. Legislation bearing on turtles is summarized in Table 2.

St. Martin currently has no marine parks or sanctuaries, although several areas are under consideration (ECNAMP, 1980) (Table 3). Of these, Man O'War Shoal, Pelican Cay and Molly Beday are of importance as foraging habitat for turtles. Whether protection will be given to marine turtles in these sanctuaries is not known.

Saint Barthélemy (17°53'N, 62°50'W)

Saint Barthélemy lies 18 km southeast of St. Martin, and is also a dependency administered through Guadeloupe. The small rocky island is roughly 25 km in area. It includes several uninhabited islands and cays, the largest of which are Ile Fourche, Ile Bonhomme, Ile Frégate, Ile Toc Vers, and La Tortue (Fig. 4). There is almost no reef habitat around the island and its associated cays, but there are extensive seagrass beds off much of the coast (ECNAMP, 1980). There are several relatively short, white sand beaches that appear to be suitable nesting habitat for sea turtles.

Four species of marine turtles occur at St. Barthélemy: the green turtle, hawksbill, loggerhead and leatherback. Of these, the green turtle and hawksbill are by far the most common. They are seen primarily in coastal habitats, whereas the loggerhead and leatherback, on the rare occasions that they are seen, are encountered in the open sea. So few loggerheads occur that one turtle fisherman interviewed at Flamand had seen only five in his lifetime of some 50 years. The last he had captured 8-10 km offshore; its straight carapace length was 52 cm (Pl. 5).

The beach at Anse Columbier and one on Ile Fourche were indicated as nesting sites by ECNAMP (1980). The species involved was not identified. Very little evidence of nesting was found during the present survey. Reports of incidental nesting at Flamand presumably involved hawksbills, although one leatherback had nested there in the recent past. Flamand residents reported that turtles formerly nested there in somewhat greater numbers, but never in any concentration. No other reports of nesting by leatherbacks were received. It appears that the loggerhead does not nest at all on the island.

A resident of the village of Corossol reported that turtles used to nest on the small beach at this village up until 15 years ago, but had ceased to do so after bright lights were installed behind the beach. The species of turtle was not identified.

The only nesting attributed by informants to the green turtle was that of a single turtle that emerged at Anse de Grande Saline in 1978. Grande Saline and nearby Anse du Gouverneur are two of the largest beaches on the island. They are on the southern coast, which is sparsely inhabited and difficult to reach by car. Because of their relative isolation, they hold the most promise as nesting sites for sea turtles. The beaches were not visited during the present survey. Sand mining is carried out at Grande Saline (ECNAMP, 1980).

ECNAMP (1980) identified feeding areas at Anse du Gouverneur and Anse de Grande Saline on the southern coast, off the northwestern peninsula near Columbier, and to the southwest of Ile Fourche. These feeding grounds closely correspond to seagrass beds described in the same publication, and are presumably pastures where green turtles forage.

At one time, turtles occupied feeding habitats around the many small cays. They have been depleted in these nearshore habitats, according to local fishermen, who complain that they now must travel farther to set their nets--to Ile Fourche, or to neighboring St. Eustatius or St. Martin. A tortoiseshell buyer from St. Martin reported having tried to purchase a "huge mound" of shell that St. Bart fishermen had accumulated from hawksbills caught around St. Eustatius.

Residents of St. Barthélemy recognize a decline in local turtle population levels, and offer as evidence reduced nesting levels and smaller catches. One net fisherman caught 40 turtles in 1975; in 1980, he caught only one, although he claimed to have tried equally hard. During the same year, another fisherman in the same village caught only three.

The number of men setting nets for turtles is small--probably fewer than seven on the island. Nobody is dependent on turtle fishing for a livelihood. They catch turtles to obtain meat for their own consumption, and to sell in their villages. To what extent the meat is sold to restaurants is not known. To an increasing extent, the fishermen also seek income from raw tortoiseshell--which was selling for US$18/kg in 1980--and from polished carapaces. The shells are sold directly to tourists. No turtle souvenirs were seen for sale in the shops in Gustavia.

Legislation pertaining to sea turtles is summarized in Table 2. There are no parks or protected marine areas.

Saba (17°38'N, 63°14'W)

Saba, another island of the Netherland Antilles, is situated 45 km south of St. Martin. It is approximately 13 km^2 in area. The island rises steeply from an ocean depth of about 650 m, and is formed by the cone of an extinct volcano. There are few sheltered bays around the rocky coastline and no permanent beaches, although seasonal accumulations of sand are occasionally used for nesting by sea turtles. There are only small, scattered patches of seagrass along the coast, the most extensive of which lie off Flat Point and Old Booby Hill; there is almost no reef habitat (ECNAMP, 1980) (Fig. 5). Saba Bank, an extensive shalllow, sandy shelf, lies southwest of the island.

The green turtle and the hawksbill are the only marine turtle species commonly seen at Saba. Of these, the green turtle is said to be the more common. Both are seen year-round in foraging habitats around the island. On rare occasions, leatherbacks are sighted on Saba Bank, presumably when passing in migration to other destinations. Only one report of a loggerhead was heard; the turtle had been captured on Saba Bank.

Saba has virtually no permanent beaches and it is difficult to imagine any but the most desultory nesting by sea turtles on the seasonally deposited beaches. Residents insist, however, that hawksbills and green turtles do nest on rare occasions at Cave of Rum Bay, Well Bay and Fort Bay. The numbers are undoubtedly very small. One octogenarian recalled the nesting of a leatherback at Fort Bay many years ago.

Both green turtles and hawksbills have been seen mating in Saban waters. Curiously, there have been several sightings of green turtles mating around the buoy in the harbour at Fort Bay. The turtles appear to be attracted to the floating buoy, as they are to decoys which fishermen sometimes use to catch them. The curved carapace length of a female green turtle that had been captured with a speargun while mating at the buoy was 115 cm. This is considerably larger than the average size of green turtles in the western Caribbean and comparable to that of turtles nesting at Aves Island.

Because of the island's small size and steeply sloping coastal shelf, there is limited foraging habitat for turtles. That which exists, however, appears to be well populated by green turtles, and to a lesser extent, by hawksbills. During the days when turtle nets were used, favorite netting locations--and thus, presumably, good feeding areas for turtles--were Ft. Bay, Cove Bay and Green Island (Pl. 9). Although turtle netting is not practiced today, information on turtle foraging areas is available from members of local scuba clubs. They report seeing adult green turtles and hawksbills around Green Island; green turtles in the area north of Corner Point, and along the south coast between Giles Quarter and Tent Bay; and hawksbills on the reef at Core Gut Bay. Green turtles are also seen by fishermen out on Saba Bank, but no one interviewed had knowledge of their abundance or seasonality there.

Turtles at Saba are said to be "not so plentiful, now." The hawksbill is thought to be particularly scarce, largely as a result of spearfishing. A former turtle fisherman considered turtles too scarce today to make setting nets worthwhile.

Indeed, not a single net fisherman could be identified on Saba in 1980. Turtles used to figure more prominently in the island's culture. During the early part of the century, Sabans used to sail by schooner to Aves Island to harvest green turtles. The men were dropped off on Aves for two week periods to turn turtles as they came up to nest. The ship then returned to transport them and their catch of as many as 50 turtles back to Saba. A small number of men on the island have customarily been involved in setting turtle nets in Saban waters. In the 1940's there were four turtlers operating out of The Bottom.

Although the practice of fishing for turtles with nets has essentially died out, spearfishing has replaced it. Spearfishing is very popular, especially among members of the active scuba clubs on the island. Club members estimate that only 10-20 turtles are killed annually with spearguns, but it is likely that the catch exceeds this. It was surprising to learn that even adult turtles are taken in this manner, as evidenced by the capture of the 115-cm green turtle at Fort

Bay. In order to capture such large turtles, a long line and a float are attached to the spear to allow pursuit of the turtle by boat, once the spear is well-lodged. The turtle can be quickly tired in this way, and then landed with little difficulty. Although spearfishing constitutes the greatest threat to turtles at Saba today, they are also captured and killed on the rare occasions that they are encountered on the beach.

Turtle meat is popular among Sabans, as are turtle curios. Polished carapaces are on display in many homes. One craft shop in Windwardside offered for sale the shells of five hawksbills and two green turtles, all of which had been taken from turtles captured with spearguns. The magnitude of the souvenir trade is small at present, owing to the small number of shops and tourists. There is no evidence of trade in tortoiseshell, presumably because the number of hawksbills that are caught is relatively small.

There are no laws pertaining to sea turtles, and no protected marine areas.

Saint Eustatius (17°30'N, 63°00'W)

Saint Eustatius, or Statia, as it is called, lies 22 km southeast of Saba, and is one of the Netherlands Antilles. It is of volcanic origin, and is approximately 30 km^2 in area (Fig. 6). Much of the shoreline is rocky and steep, with few beaches suitable for nesting by sea turtles. Coral reefs encircle almost the entire island, with the greatest development off the southwest quadrant; a large seagrass bed lies north of Oranjestad Bay (ECNAMP, 1980).

The hawksbill and green turtle are the only marine turtles that commonly occur. The hawksbill, which is said to be the more common of the two, appears to be relatively abundant, compared to population levels at neighboring islands. This is presumably due to the availability of extensive reef habitat and to an unusually low level of exploitation. The leatherback is known only from a few nesting records. The loggerhead has not been recorded.

Few turtles of any species nest at Statia. Those that do, favor beaches on the Atlantic side. The locality most frequently named by informants as a sea turtle nesting site is Zeelandia, in Concordia Bay. This is a wide, high-energy beach, backed by high dunes. It is the longest on the island--approximately 2 km in length. Both green turtles and hawksbills are reported to nest there on rare occasions. The leatherback has also been observed. Because of the orientation of Zeelandia with respect to Atlantic currents, it is subject to seaborne pollution; it also serves as the solid waste disposal site for the island (ECNAMP, 1980).

No nesting is reported on the second-largest beach on the island, that at Oranjestad, the capital. This is a relatively low-energy shore, and because of its proximity to the capital, it is heavily used by people. Single reports were received of nesting by hawksbills on small beaches at Nap, Corre Corre Bay, Kay Bay and Crook Bay, but were not corroborated by other interviews.

Divers from the local scuba club see hawksbills of all sizes on the reefs around Statia, and off the south coast near White Wall. Green turtles have been observed blowing in the harbour at Oranjestad. One fisherman related his view that small green turtles sleep in an area near the pier in the harbour, and move offshore each day to feed. Twenty years ago, when nets were still used to catch turtles, Oranjestad Bay, Jenkins Bay and White Wall were preferred netting locations.

Little information is available on population trends of Statia's marine turtles. Several of the residents interviewed believed that fewer turtles nested at present than formerly. This, in itself, is a weak criterion, however, because there is no evidence that the level of nesting was ever significant.

Statia's turtle populations seem to be subject to less pressure from exploitation than elsewhere in the region, at least at the present time. Netting is not practiced, and apparently has not been for several years. Turtles are captured by spearfishermen, but because there is relatively little tourism on the island, the usual markets for curios and turtle meat do not exist, and the catch appears to be small. No trade in tortoiseshell was reported, although it may occur. Turtles are killed on the nesting beaches whenever they are encountered, and unknown numbers are taken by net fishermen and divers from other islands. There is no legislation regarding their capture.

There is a protected marine area near Jenkins Bay (ECNAMP, 1980). The bay was once considered a good foraging area for turtles, but its status today is unknown.

St. Kitts ($17^{\circ}20'$N, $62^{\circ}45'$W)

St. Kitts, or St. Christopher, as it is officially named, lies 112 km southwest of St. Eustatius. It and the nearby island of Nevis have in the past been politically united as an Associated State linked to Great Britain. They gained independence in September 1983. The 168 km^2 island is of volcanic origin, and lies on a bank with St. Eustatius and Nevis. Most of the population of 36,000 is concentrated along the coastline; the long southeastern peninsula is nearly uninhabited (Fig. 7). The best nesting habitat for turtles is on the Atlantic coast, where an extensive beach stretches more or less continuously from the Cayon River to North Frigate Bay. There are also several small beaches around the tip of the southeastern peninsula. The beaches on the western coast of the island are relatively flat and narrow. Coral reefs extend along much of the coast and are particularly numerous on the windward side between Canada Estate and North Frigate Bay, and at Dieppe. There are extensive seagrass beds covering 1,200 ha around the southeastern peninsula (ECNAMP, 1980, 1982).

Three species of marine turtles commonly occur at St. Kitts. The green turtle and hawksbill are seen year-round and are represented by a wide range of size groups. The leatherback is present almost exclusively during the nesting season. The loggerhead is seen only rarely.

The nesting season for leatherbacks is March through May. They nest on the Atlantic coast, principally between the Cayon River and Key

Ghut, but also, to a lesser extent, on beaches as far south as Sand Bank Bay. Residents of the village of Key reported that 8-12 leatherbacks nest annually between the Cayon River and Key Ghut. On 19 May 1983 there were seven tracks of varying ages on the beach. The black sand beach is wide and has a high platform. Its approach from the sea is unobstructed, whereas beaches to the south are to varying degrees blocked by coral reefs.

Leatherbacks also nest in small numbers on the western coast at Belle Tete, the sandy promontory just north of Sandy Point Town. Caldwell and Rathjen (1969) reported the capture of a leatherback on this beach in June, 1968. This is also a black sand beach. It has a steeper profile than is characteristic of beaches on the leeward coast and is an area of sand accretion. Sand mining has been carried out there for many years (Pl. 4). Five leatherback tracks of varying ages were found on this beach during a survey on 18 May 1983. Another leatherback was reported to have nested during the period 19-26 May.

Hawksbills and, to a lesser extent, green turtles, nest sporadically on the island. The most frequently mentioned nesting sites for both species are on the tip of the southeastern peninsula--at Major Bay, Banana Bay, Cockleshell Bay, Mosquito Bay and Sand Bank Bay. These beaches are accessible only by boat, a factor that has probably contributed to their continued status as nesting sites. Both species also nest incidentally at Conaree and Belle Tete.

Green turtles forage, occasionally in groups, on the north coast at Willett's Bay and around the southeastern peninsula. Hawksbills are seen on shallow reefs around Dieppe, Belle Tete and Canada Estate. One loggerhead was reported to have been caught inside the reef at Dieppe, and another off Key Ghut.

Sea turtle populations at St. Kitts are considered by most residents to be declining. Net fishermen complain about declines in annual catches. Catch rates for fishermen today are of the order of 10-20 per year. A turtle fisherman at Dieppe used to catch 50 turtles per year in the early 1960's; in 1979, he caught a total of four green turtles and hawksbills, and one leatherback. He implied that he had exerted equal effort during both periods--although this is a difficult point to establish. Approximately ten people on the island still set nets for turtles. None are exclusively dependent on this for their livelihood, but the meat and income are undoubtedly an important contribution to their subsistence. Most of the turtles that are caught are immature green turtles. Legislation regarding the capture of turtles is summarized in Table 2.

Meat of all species of sea turtles is eaten; that of the leatherback is the least preferred. Meat is sold in many villages, and occasionally in the public market in Basseterre. It is also sold to local hotels. The price in 1980 was US$0.80/kg; it had increased to US$1.60/kg by 1983. Turtle eggs are also eaten, but are rarely sold. The oil of the leatherback is widely used for medicinal purposes.

In May 1983 tortoiseshell sold for US$24/kg. Some of the shell is worked locally, but most is exported raw. There is currently little use of turtles for souvenirs, presumably because of the low level of tourism.

There are currently no sanctuaries or parks on St. Kitts that provide protection for marine turtles. However, a planned protected area around the southeastern peninsula would include important foraging areas.

Nevis (17°09'N, 62°35'W)

Nevis is separated from St. Kitts by a strait 3.2 km wide. The roughly circular island, 93 km^2 in area, is a volcanic cone that rises to a peak of 985 m. Coral reefs are present around much of the coast, and extensive seagrass beds lie off the northwest and southern shores (ECNAMP, 1980) (Fig. 8).

The green turtle and hawksbill are the most common turtles around Nevis, the former being the more abundant. Both species are represented by a wide range of size classes. The leatherback is also known to occur, but only as an infrequent nesting visitant. The loggerhead is the least common species; the few individuals that have been seen were immature.

There is little nesting habitat for sea turtles on the island. The most extensive beach is Pinney's Beach. It is a flat, low-energy shore, backed by coconut groves, and located close to Charlestown, the capital. Because it is one of the few beaches on the island, it is heavily frequented by residents and tourists. There are reports that green turtles and hawksbills have nested there in the past, but it seems doubtful that much nesting occurs today. Caldwell and Rathjen (1969) reported nesting by a leatherback on the western coast of Nevis in 1966. According to the original source of this information, the leatherback had nested on Pinney's Beach (A. Anslyn, pers. comm.). This was considered by local people to be an unusual event.

Several small beaches on the southeast coast--at Indian Castle Estate and north of Red Cliff--are probably the only localities on the island that are still regularly used for nesting. Hawksbills nest there in very small numbers, as do leatherbacks. The second leatherback mentioned in Caldwell and Rathjen's paper (1969) had nested on the beach north of Red Cliff (A. Anslyn, pers. comm.). In terms of physical characteristics, these beaches seem to be marginal nesting habitat. Indian Castle Beach is partly cobble. It is heavily littered with debris, and the sandiest section is fronted by emergent rocks. The dunes behind it are being extensively mined for sand. The beach directly north of Red Cliff, called Black Bay by local residents and White Bay on the map, is also partially blocked by reefs. It is nearly flat, and its upper reaches are waterlogged in places. In May 1983, it was fouled by seaborne tar. That turtles nest at these southeast localities at all is probably due to the scarcity of beaches in the area, and to their relative isolation.

Green turtles forage widely around the island. They are caught in nets off the southeast and southwest coasts, and in the vicinity of Newcastle. Several have borne tags originally put on at the nesting beach on Aves Island, suggesting that Nevis may be one of the resident feeding grounds for that population. Hawksbills are captured in nets in the Black Bay area, although less frequently than green turtles.

There is limited information available on changes in population levels of marine turtles on Nevis. A tortoiseshell buyer in Charlestown reported a decrease in the amount of tortoiseshell that he was able to purchase from fishermen on the island--from 136 kg/yr in 1975 to 91 kg/yr in 1980. Inasmuch as hunting pressure increased during this period, a decline in the hawksbill population may have occurred. The status of green turtles around Nevis is unknown.

At least a dozen people on Nevis, most of whom live in Hanley's Road, Bath Village, and Newcastle, fish for turtles with tangle nets (Pl. 7). They fish turtles to supplement their incomes and diets; none are solely dependent on turtlefishing for their livelihood. Five to 15 turtles per year were reported to be the average catch per fisherman, although there is considerable fluctuation from year to year. Most of the turtles caught are green turtles.

In May 1983 turtle meat was selling for US$1.60/kg. The meat of the green turtle is preferred, but all species are eaten. Leatherback meat is sometimes mixed with meat of other species, and sold to hotel restaurants. When abundant, green turtles are shipped alive on the ferry or the "lighters" to the public market at Basseterre, St. Kitts. The price in 1983 was US$0.80/kg live weight, US$2.00/kg dressed. Turtle oil, principally derived from the leatherback, is widely used as a home remedy for colds.

There is an active market for tortoiseshell on Nevis. In 1980, a buyer in Charlestown was purchasing shell from fishermen around the island for US$16/kg and reselling it to a dealer from St. Lucia. The price in 1983 ranged from $16 to $24. Other buyers from Puerto Rico, Dominica and Guadeloupe periodically canvas the fishermen at their homes. There is limited marketing of tortoiseshell and polished turtle carapaces in local tourist shops. The ban on importation of turtle products into the United States is said to have sharply curtailed this trade in recent years.

There are no protected marine areas around the island.

Barbuda ($17^{o}40'$N, $61^{o}50'$W)

Barbuda, a coral limestone island, is located 41 km north of Antigua, and lies on the same shallow submarine shelf. The two islands are politically united as a two-state nation within the Commonwealth, having gained independence from Great Britain in 1981. Barbuda has a land area of approximately 160 km^2. The only settlement is the village of Codrington, situated on the east coast of a large lagoon (Fig. 9). An exceptionally high percentage of the coast line is composed of sandy beaches. Coral reefs encircle most of the perimeter of the island. An enormous seagrass bed (19,800 ha) lies off the western coast (ECNAMP, 1980, 1982).

Four species of sea turtles occur at Barbuda: the green turtle, hawksbill, loggerhead and leatherback. Local names for the various species are given in Table 1. The green turtle and hawksbill are the most common, occurring as juveniles, subadults and adults. Green turtles are the more abundant of the two, and, as elsewhere in the region, they attain great size (227 kg). Both species are present year-round in foraging habitats. Loggerheads are much less common than green turtles or hawksbills, but are well known to fishermen. Most are of intermediate size, weighing approximately 18-45 kg. The leatherback is the least common species at Barbuda.

Green turtles and hawksbills are the principal species that nest on the island. Nesting density is probably higher on Barbuda than on any other island in the Leewards, but absolute numbers are still very modest. Nesting localities are shown in Figure 9. The shore from Billy Point to The River is almost continuous beach, and green turtles and hawksbills are reported to nest along all of it. Hawksbills are the predominant nesters on the beach that extends from Spanish Well Point to Coco Point (Plate 8). Nesting probably occurs on several additional beaches on the east coast, but was not reported because of a lower level of surveillance by fishermen.

Only a few leatherbacks nest on the island each year. One that emerged at The River in 1979 became entrapped by debris and died of exposure. Loggerheads are not known to nest.

Green turtles and hawksbills are common in foraging habitats all around the island. A fisherman who sets nets inside the reef at Welch Point catches only green turtles there. Hawksbills are more common on the reefs near Goat Point and Cedar Tree Point. Immature green turtles have been caught in mangrove areas inside the entrance to Codrington Lagoon. The Creek, as the entrance area is called, is a favorite netting location. A juvenile green turtle estimated to weigh less than a kilogram was reportedly seen resting on top of a net at this location. Opinions as to whether hawksbills also enter the lagoon to feed were contradictory. Loggerheads are said to be most common around the northwestern end of the island.

The greatest number of turtles is caught in nets during January and February. Fishermen attribute this to the "groundswell" that occurs during this season. They believe that heavy seas and turbid water force turtles to move into shallow coastal areas to feed.

Cato et al. (1978) discussed exploitation of turtles at Barbuda. Heavy exploitation has continued, and possibly increased, since their report. Turtles are captured to provide meat for hotel restaurants in Antigua and Guadeloupe, and to a lesser extent, in St. Thomas and Puerto Rico. During the winter season live green turtles are flown out several times a week on cargo planes that come to Barbuda to pick up lobsters. Most of these are subadult and adult green turtles; juvenile turtles are kept for local consumption (Pl. 6). A resident who coordinates the export business reported that "several hundred" are exported annually. Turtle carapaces and tortoiseshell are also exported. There is no tourism on Barbuda to support a local souvenir trade.

Turtles are caught by both net fishermen and lobster divers (Pl. 3). A single fisherman may set as many as eleven nets. Loggerheads are sometimes released alive, when the meat of other preferred species is available. Turtles are also chased with outboard-powered boats and captured by hand. Small ones are taken incidentally in trammel nets. One fisherman reported that on several occasions he had found loggerheads floating at sea entangled in pieces of netting. He associated these events with the presence of Japanese fishing boats in the area, and was of the opinion that the entangled turtles had been cut loose from trawls and left to drift.

Turtles and eggs are routinely taken from nesting beaches. Surveillance for tracks is carried out by boat, incidental to other fishing activities.

Changes in population levels of marine turtles at Barbuda are difficult to assess because of changes in fishing methods and effort. The growth of the lobster fishery into a major industry has had significant repercussions, by increasing the number of people out on the reefs, and by providing a mechanism to transport live turtles to market that would not otherwise exist.

No information on the occurrence of turtles at Palaster Reef Marine Park, off the southern tip of the island, was gathered during the survey.

Antigua ($17^\circ05'$N, $61^\circ50'$W)

Antigua lies 64 km east of Nevis, and 64 km north of Guadeloupe. Along with its dependencies, Barbuda and Redonda, it was an Associated State linked to the United Kingdom until independence was gained in November 1981. The 280 km^2 island has a deeply indented shoreline with numerous white sand beaches and protected bays (Fig. 10). Coral reefs are well developed off the northern and eastern coasts; bays along the northern coast are fringed by mangroves and shelter seagrass beds (ECNAMP, 1980).

Green turtles and hawksbills are the most common marine turtles in Antiguan waters, the green turtle being the more abundant of the two. Both occur there year-round and are represented by a wide range of size classes. Leatherbacks are observed only rarely. Two informants were familiar with the loggerhead, but its occurrence at Antigua needs confirmation.

The hawksbill is the principal species nesting on the island. Nesting is reported on several beaches in the Five Islands Village area: Galley Bay, Landing Bay, Hawksbill Bay, Pinching Bay and Long Bay. Of these, Pinching Bay is reported to be the best, although even there nesting density is apparently of the order of only a few individuals per year. Deep Bay and all of the above bays except Long Bay were surveyed on 7 September 1980. No tracks were found, and local residents reported that no turtles had nested on those beaches so far that year. ECNAMP (1980) listed Deep Bay and all other west coast beaches south to Johnson's Point as turtle nesting areas; the species involved was not identified.

Elsewhere around Antigua, hawksbills and, more rarely, green turtles nest at Pasture Bay on Long Island, Grape Bay on Guiana Island, and at Long Bay, near Willikies. Hawksbills used to nest in Dutchman's Bay, but do so only rarely today. Hawksbills have been seen mating on the outer edge of the reef near Urlings in May.

Leatherbacks nest only rarely on Antigua, as reported by Bacon (1971). One caught in a net off Jolly Beach several years ago was believed to have been approaching to nest. Another emerged to lay 112 eggs on one of the beaches on the north coast on 7 April 1981. On 20 May 1981 residents identified a nesting turtle as the same individual.

The bays on the northern coast of Antigua provide particularly good foraging habitat for green turtles, and for this reason most netting is carried out in this area. Nets are also set at feeding sites on the western and southern coast at Hawksbill Bay, Pinching Bay, Dark Wood, Urlings, and Mt. Carmel. Green turtles and a smaller number of hawskbills are captured at all localities.

Turtles also forage around the uninhabited island of Redonda, which is politically associated with Antigua and Barbuda. The 2.6 km^2 island lies 42 km southwest of Antigua, and is surrounded by deep water. During calm weather spearfishermen from Montserrat travel there to catch turtles. Three green turtles (32, 32, and 42 cm in straight carapace length) and two hawksbills (27 and 47 cm straight carapace length) were caught there in a single day in November 1980 by one diver. There is no nesting habitat for turtles on the rocky island.

A decline has been noted in both the number of turtles caught at Antigua (Rebel, 1974) and in the number of turtles nesting (Cato et al., 1978). Hawksbill nesting, in particular, is said to have once been more frequent.

There are approximately a dozen fishermen on the island who still set nets for turtles. The practice was apparently more common in the past. Rebel (1974) gave landing statistics for Antigua for the period 1943-1948. The average annual catch during these years was 67 turtles (range 40-116). These were almost certainly turtles that had been taken in nets. Statistics on turtle landings are no longer kept, so comparison with today's fishery is not possible. In 1980 a turtle fisherman at Urlings reported that he was catching an average of 24 turtles per year, most of which were green turtles. At Willikies, a fisherman reported catching 50 turtles in 1978, and a total of 20 (16 green turtles, 4 hawksbills) between October 1979 and late April 1980. As elsewhere in the region, turtles are caught to an increasing extent by spearfishermen who are diving for lobsters, reef fish and conch.

A large percentage of the turtle meat available on the island is sold under contract by the fishermen to hotal restaurants. Some meat is sold in the villages at US$0.80/kg.

Tortoiseshell is worked locally and is marketed in tourist shops in St. John's. It is also exported raw (Pl. 2). In 1980 the price paid to fishermen for raw shell was US$12/kg. Shell buyers go directly to the fishermen's homes to purchase it. Whole polished carapaces are sold to local souvenir shops.

Because of the high value of turtle products, turtles are usually captured on the nesting beach whenever they are encountered. The meat and shell of an adult hawksbill that had been caught at Galley Bay in June 1979 brought the captor US$111. Residents of Five Islands Village used to hunt for turtles regularly on the beach, but they do so rarely today, presumably because so few turtles emerge.

Table 3 lists existing and proposed parks at Antigua that include marine areas. No information on the occurrence of marine turtles in Diamond Reef Marine Park was gathered during the present survey. The park lies approximately 4 km northwest of the island. The proposed park at Guiana Island would include a turtle nesting beach, Grape Bay, as well as foraging habitat. The second proposed park is on the southern coast, and it would also include a known turtle foraging area.

Montserrat (16°45'N, 60°15'W)

The British colony of Montserrat lies in the southern Leewards, 43 km southwest of Antigua. It is a rugged volcanic island, approximately 100 km^2 in area. Much of the 49 km shoreline is formed by steep cliffs or boulders. The only permanent beach on the windward (eastern) side is a 0.6 km stretch at Farm Bay, directly south of Blackburne Airport (Fig. 11). There are nine beaches on the leeward coast, ranging in length from 0.1 to 1.4 km. All are dark volcanic sand except the northernmost, Rendezvous Bay, which is composed of white coral sand. Depending on the season, there are temporary sand deposits in patches along the rocky coast, and the more substantial of these provide nesting habitat for turtles.

Seagrass beds are located off the northern and southern extremes of the island, around Bransby Point, and off Blackburne Airport (ECNAMP, 1980). The coastal shelf is extremely narrow off the southern end of the island, the 90 m bathymeter line being only 0.6 km offshore. Small scattered patches of reef are present along all but the windward coast (ECNAMP, 1980). An artificial reef was under construction between Isles Bay and Fox's Bay in mid-1983.

Green turtles and hawksbills are the only marine turtles commonly found around Montserrat. Both are year-round residents and are represented by a wide range of size classes. Adult green turtles reach very large size; one offered for sale in a local gift shop measured 104 cm in straight carapace length. Green turtles weighing as much as 180 kg are reported to occur. Hawksbill carapaces that I examined on the island ranged in size from 19.5 to 84 cm in straight-line length. The leatherback and the loggerhead are rarely encountered, either on the beach or in the water.

There is little nesting by marine turtles on Monserrat, presumably because of constant human activity on the island's few beaches. Beaches are used for recreational purposes, and because there are no natural harbors, fishermen store their boats there. The incidental nesting that does occur can be mostly attributed to hawksbills. ECNAMP (1980) indicated nesting sites (species not identified) at the following leeward beaches: Rendezvous Bay, Carr's Bay, Little Bay, Soldier Ghaut Bay, Old Road Bay and Isles Bay. Judging from information gathered during the present survey, these are most likely sites of incidental hawksbill nesting. Most nesting takes place at Rendezvous Bay, one of the less accessible beaches on the island. A nest discovered by local residents at this beach on 18 February 1980 contained 250 eggs, and thus was probably made by a hawksbill. Hawksbills apparently still nest at Old Road Bay, in spite of heavy human usage. Three disoriented hawksbill hatchlings were reported found on the golf course adjacent to this beach on 17 January 1980.

Some local residents believe that green turtles also nest on the island, but no evidence of recent nesting was found during the present survey. Bacon (1971) reported nesting by green turtles, as well as hawksbills, at Little Bay and Isles Bay.

Nesting by the leatherback is extremely rare, but does occur. A surprising record is that of a leatherback that emerged to nest in May 1980 at Whoppin Bay, a narrow, rocky beach adjacent to Plymouth. Another was reported to have nested years ago on the beach in front of Plymouth cemetery. Turtles are also reported to nest at Farm Bay, but it is not known which species are involved.

Green turtles and hawksbills are relatively common in foraging habitats around the island. One of the best feeding areas for both species is off the lower southwestern coast. One spearfisherman caught seven green turtles (26.5 to 41 cm straight carapace length) and three juvenile hawksbills there during September and October 1980. Larger turtles also occur in the same area, but they tend to stay in deeper water and are not usually pursued by the divers. Another informant reported seeing a group of 12 green turtles, ranging in size from 10 to 30 kg, feeding near the southern tip of the island. Other foraging areas around Montserrat are indicated in Fig. 11. A fisherman who sets nets around the northern end of the island reported catching more hawksbills than green turtles.

Rebel (1974) described the turtle fishery that existed on Montserrat in the 1940's. The fishing season was April to November. Sixteen nets were in use in 1948. During that year seventy turtles were landed at Plymouth, and an unknown number in the northern sector of the island. To a limited extent netting is still practiced today in the northern part of the island. The government apparently has discouraged the taking of turtles by buying the nets from the fishermen. Only a few individuals on the island still know how to make them, and the shortage has become a limiting factor. To an increasing extent, turtles are caught by young divers who use spearguns. Legislation regulating the capture of turtles is given in Table 2.

Turtle meat is usually sold privately, although during the open season it may be found at the public market or in restaurants in Plymouth. Green turtle meat is preferred to that of other species. One fisherman reported exporting small quantities of turtle oil to St. Kitts.

There has apparently been trade in tortoiseshell for many years. Rebel (1974) reported that 45.5 kg, valued at US$96, was exported from Montserrat in 1948. The price for raw shell in 1980 was US$13/kg. Some is worked locally, but most is exported raw. The prisoners at the jail are employed making tortoiseshell jewelry that is marketed at local shops.

In 1980, there was an active curio trade in turtles. Almost every tourist shop in Plymouth, and even some bars, had polished carapaces of green turtles and hawksbills for sale. The carapace of an 84 cm hawksbill was priced at US$74. Most of the shells for sale were of juvenile or subadult turtles. In 1983, this trade seemed to have abated somewhat. One shopkeeper attributed the decline to the U.S. ban on importation of turtle products. Tourists were apparently better informed about the law, or had heard about confiscation procedures at U.S. entry ports. The decline in sales was affecting local divers, who are the suppliers of the shops. One diver showed me an automobile trunk full of carapaces that he had been unable to sell.

Loss and degradation of nesting habitat are also factors affecting turtle populations on Montserrat. Little Bay, one of the less disturbed beaches remaining on the island, is to be developed into a large resort hotel site. Sand mining for construction purposes is being practiced at several beaches, including Fox's Bay and Farm Bay. Mining operations at Farm Bay have radically altered the beach profile. Whether sea turtles have been affected is not known, but they are reported to nest there. There are no protected marine areas.

Guadeloupe (16°20'N, 61°30'W)

Guadeloupe, an overseas department of France, includes two large islands, Grande Terre and Basse Terre (1513 km^2), and a number of smaller islands that are considered dependencies. Two of these, St. Martin and St. Barthélemy, have already been considered. The others--La Desirade, Marie Galante and Les Saintes--are adjacent to Grande Terre and Basse Terre, and are treated herein (Fig. 12). Beaches and important marine habitats around the various islands are mapped by ECNAMP (1980).

Four species of marine turtles occur at Guadeloupe: the green turtle, hawksbill, loggerhead, and leatherback. Olive ridleys may be occasional waifs in the area. A head and three carapaces of a fifth species, the olive ridley (Lepidochelys olivacea), were seen for sale at Basseterre, but a local origin could not be confirmed. I have seen only one live ridley (37 cm curved carapace length) in the Lesser Antilles. It was caught at Case-Pilote, Martinique, in December 1978. Vernacular names for sea turtles are given in Table 1.

Green turtles and hawksbills are the most common species at Guadeloupe. Both are year-round residents, and are represented by juvenile, subadult and adult size classes. Green turtles weighing as much as 250 kg have been captured. The carapace of a green turtle measuring 112 cm in straight-line length was seen for sale in Basseterre. Loggerheads are considerably less abundant than green turtles or hawksbills, but are well known to fishermen. They are seen more frequently around Grande Terre than elsewhere at Guadeloupe. Juveniles of this species are rarely observed. Almost all of the 38 loggerheads examined on the island were of subadult size. The leatherback is the least common species; only hatchlings and adults have been observed.

Nesting localities are indicated in Figure 12. Hawksbills and green turtles are the principal nesters, but neither nests in any abundance. The small islets in Grand Cul-de-Sac Marin (Ilet à Fajou and Ilet à Caret) are preferred nesting locations. Both species are also reported to nest in small numbers on beaches around the north coast of Basse Terre and on Ilet à Kahouanne. On rare occasions, leatherbacks have also been recorded on these beaches. One was reported to have nested at Kahouanne in early December 1978. Kahouanne is a French name for the loggerhead. One informant reported that loggerheads also nest on the islet, but this seems doubtful, inasmuch as mature individuals apparently occur only rarely in Guadeloupe waters.

Turtles used to nest at several localities on the west coast of Basse Terre, but no longer do so. Many parts of this coast have been developed for tourism. There is a nesting beach on the south coast of Basse Terre at Trois Rivieres. In addition to green turtles and hawksbills, the leatherback is said to nest there "regularly."

Few nesting beaches were identified on Grande Terre. Those at Anse Bertrand and Port Louis were not visited during the survey. Nesting is reported on Les Saintes, La Desirade, Iles de la Petite Terre and Marie Galante, but the species involved were not identified. No specific beaches were named for the first three localities; on Marie Galante, nesting is reported to occur at Ballet Beach. None of these islands was visited during the survey.

Grand Cul-de-Sac Marin, a sheltered area with seagrass beds and reefs, was identified as one of the most important feeding areas for turtles. A portion of it, including Ilet à Fajou, has been under consideration as a marine park for several years. Small green turtles and hawksbills forage on reefs off the central east coast of Basse Terre near Petit-Bourg. Foraging areas for turtles around Les Saintes and Marie Galante are also reported although specific localities were not identified. Turtle fishermen at Vieux-Fort travel to these islands daily to set nets. No information was gathered about foraging areas around eastern and southern Grande Terre.

There appears to have been a very definite decline in population levels of marine turtles at Guadeloupe. Fourteen out of 15 informants questioned on this point considered sea turtles to be less abundant than formerly. Only a fisheries officer considered there to have been no change in their abundance. Nesting has reportedly declined at beaches near Deshaies, Capesterre and St. Francois, and to have ceased altogether on most of the west coast of Basse Terre. Several informants could recall nesting at Vieux-Habitants some fifteen years ago. Fishermen at Ste. Rose, Deshaies and Vieux-Fort report that the number of turtles caught in nets has decreased.

Marine turtles are exploited to a greater extent at Guadeloupe than anywhere in the Lesser Antilles, with the possible exception of Martinique. Much of the exploitation is directly tied to the tourist industry. There is a tremendous trade in souvenirs of all kinds--polished carapaces, stuffed turtles, tortoiseshell jewelry and artifacts, etc. The largest producer of souvenirs is the jail at Basseterre, where prisoners are trained to manufacture them. The prison operates a gift shop that sells souvenirs at both the retail and wholesale level. In December 1978, I was permitted to take a quick inventory of their stock. A minimum of 103 turtles (37 green turtles, 28 hawksbills, 35 loggerheads, 3 olive ridleys) was represented by the carapaces, whole stuffed specimens and dried heads that were on display or stored in supply rooms. The guard apologized for how few turtles were on hand, explaining that a large order had just been filled.

Turtles at the jail were said to be caught locally, although this point needs further verification.

Turtle souvenirs are also available in many towns and villages (Pl. 10). In 1978, polished carapaces were priced at US$69-184. Tortoiseshell is worked by local artisans, and it is also exported to France. Not all of it is obtained locally. Buyers from Guadeloupe canvas islands throughout the Lesser Antilles for raw tortoiseshell scutes, buying them for a fraction of their resale value.

Meat of all species of turtles is consumed. That of the leatherback is even preferred by some residents. Meat is sold locally in villages, at Pointe-a-Pitre.

The legislation bearing on marine turtles is summarized in Table 2.

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	Green turtle (*Chelonia mydas*)	Hawksbill turtle (*Eretmochelys imbricata*)	Leatherback turtle (*Dermochelys coriacea*)	Loggerhead turtle (*Caretta caretta*)
Anguilla	greenback		river turtle river horse trunkback lanternback	
St. Martin	greenback		river horse rubberback leathercoat	
St. Barthélemy	tortue	caret	batacle	kahouanne
Saba			trunkback	
St. Eustatius			river turtle	
St. Kitts	greenback		river turtle trunkback	mulatto
Nevis	greenback		river turtle	bullhead
Barbuda			bandora	mulatto
Antigua			river turtle walava	mulatto
Montserrat			river turtle horse turtle	
Guadeloupe	tortue verte tortue tortue blanche	caret	batacle luth	kahouanne tortue jaune

Table 1. Vernacular names of sea turtles in the Leeward Islands. Standard English names are also widely used.

	Date of Legislation	Protected Species	Closed Season	Minimum Capture Size	Punishment for Violation
Anguilla	1948 (revised 1977)	all species	1 June-30 Sept (turtles, eggs)	> 9 kg	Fine ≤ US$37 Forfeiture of goods, equipment
St. Martin	Neth.-none Fr. see Guadeloupe				
St. Barthélemy	see Guadeloupe				
Saba	none				
St. Eustatius	none				
St. Kitts	1948	all species	1 June-30 Sept. (turtles, eggs)	> 9 kg	Fine ≤ $US9 Forfeiture of goods, equipment
Nevis	"	"	"	"	"
Barbuda	1927 (revised 1962)	all but _Caretta_	1 June-30 Sept. (turtles, eggs)	> 9 kg	Forfeiture of goods, equipment
Antigua	"	"	"	"	"
Montserrat	1951	all species	1 June-30 Sept. (turtles, eggs)	> 9 kg	Fine ≤ $US18 Forfeiture of goods, equipment
Guadeloupe	1979	_Chelonia_ _Eretmochelys_ _Dermochelys_	15 May-15 Sept. (_Chelonia_, _Eretmochelys_) year-round (_Dermochelys_) year-round (eggs, all spp.)	>60 cm carapace length (_Chelonia_ & _Eretmochelys_)	

Table 2. Legislation pertaining to marine turtles in the Leeward Islands, Lesser Antilles.

	Existing	Proposed
Anguilla	None	Seal Island Reserve, Sandy Island, Shoal Bay
St. Martin	None	Guana Cay, Molly Beday, Hen and Chicken, Cay Bay, Man O'War Shoal
St. Barthélemy	None	None
Saba	None	None
St. Eustatius	Jenkins Bay	None
St. Kitts	None	southeastern peninsula
Nevis	None	None
Barbuda	Palaster Reef Marine Park	Codrington Lagoon
Antigua	Diamond Reef Marine Park	Guiana Island to Great Bird Island; Fisher's Hill to Proctor's Point
Montserrat	None	None
Guadeloupe	Ilets à Goyaves	Grand Cul-de-Sac Marin

Table 3. Marine parks and protected areas in the Leeward Islands, Lesser Antilles. Source: ECNAMP 1980, 1982; A. Putney, *in litt*.

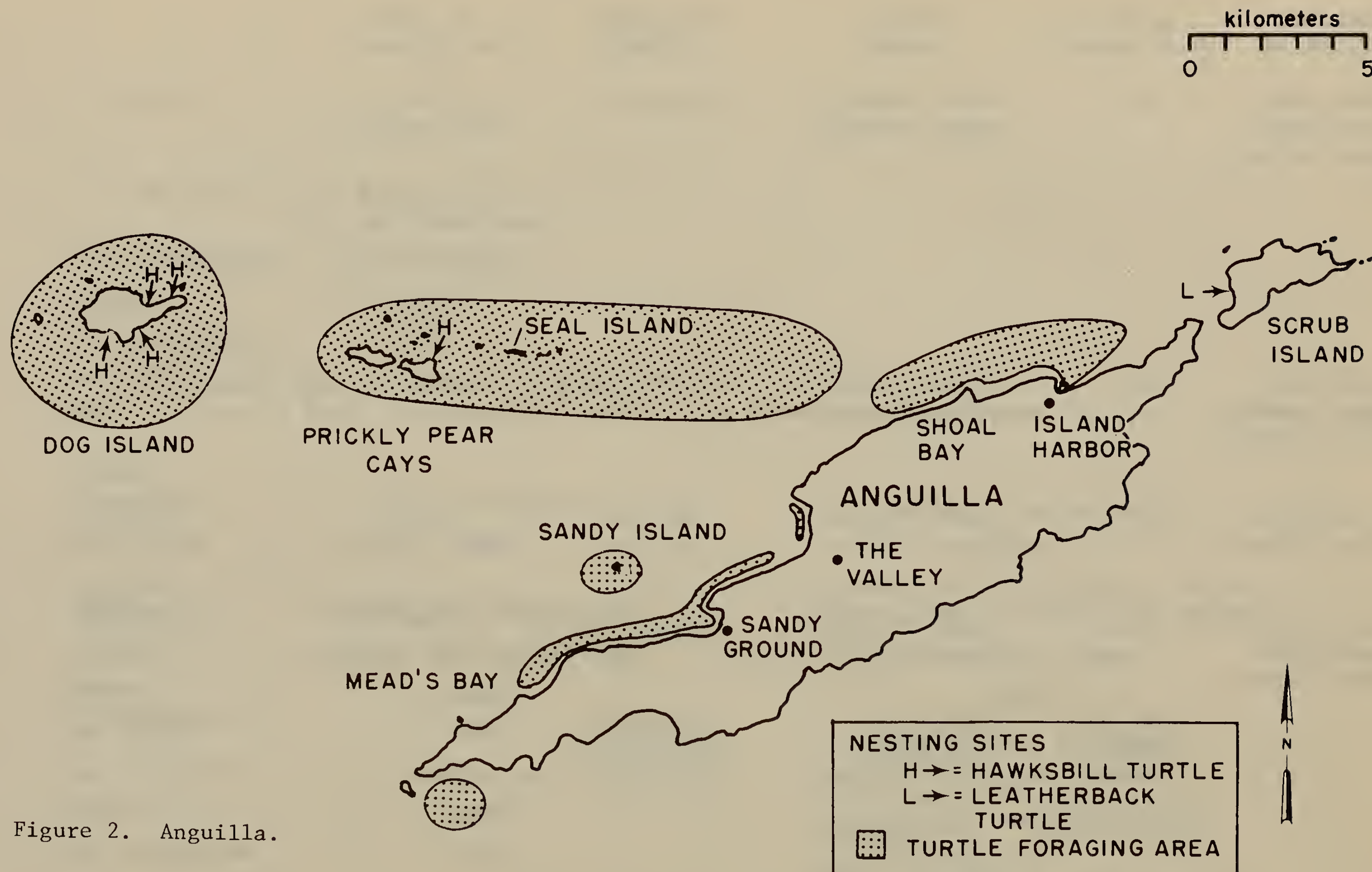


Figure 2. Anguilla.

Figure 3. Saint Martin.

Figure 4. Saint Barthélemy

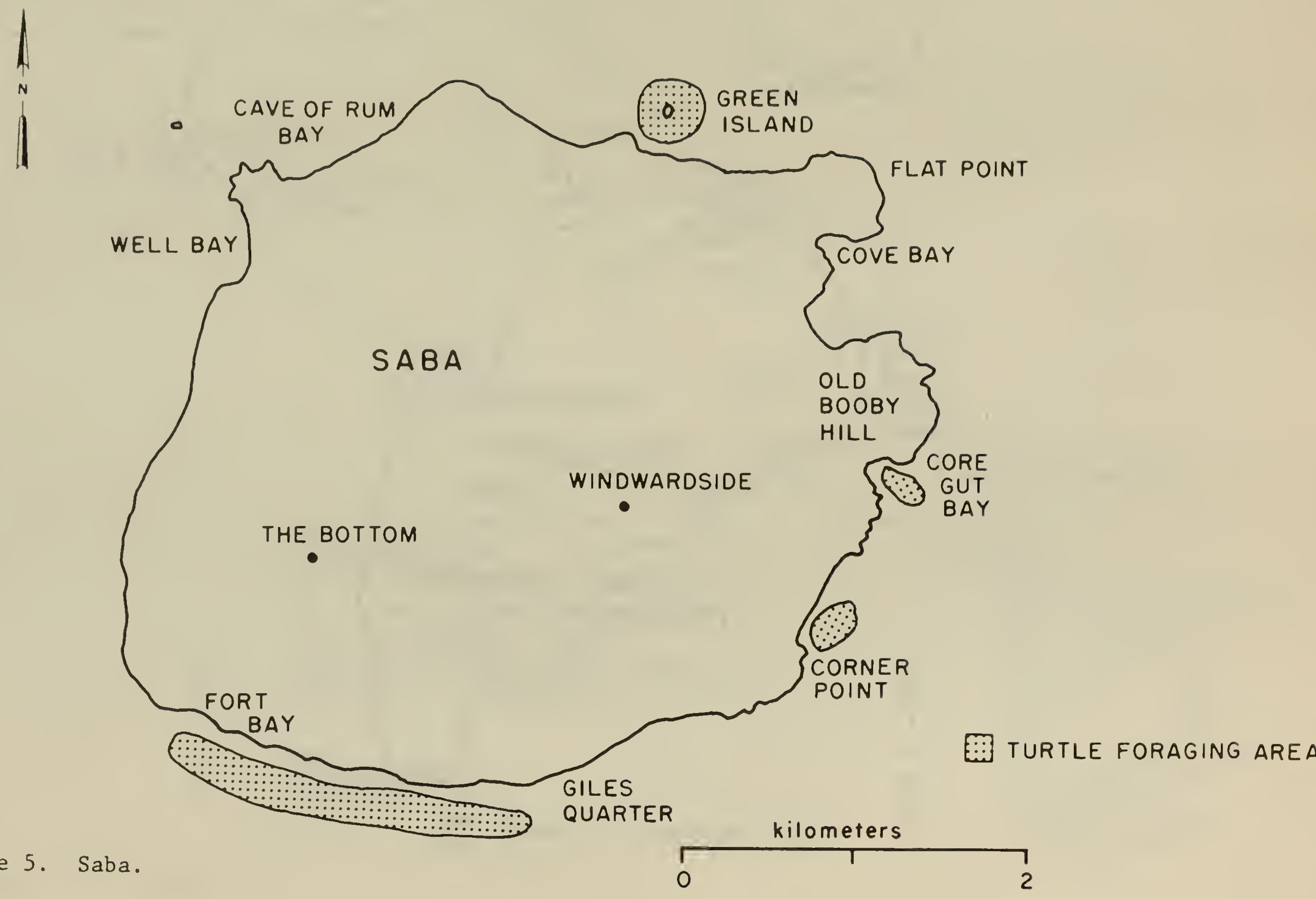


Figure 5. Saba.

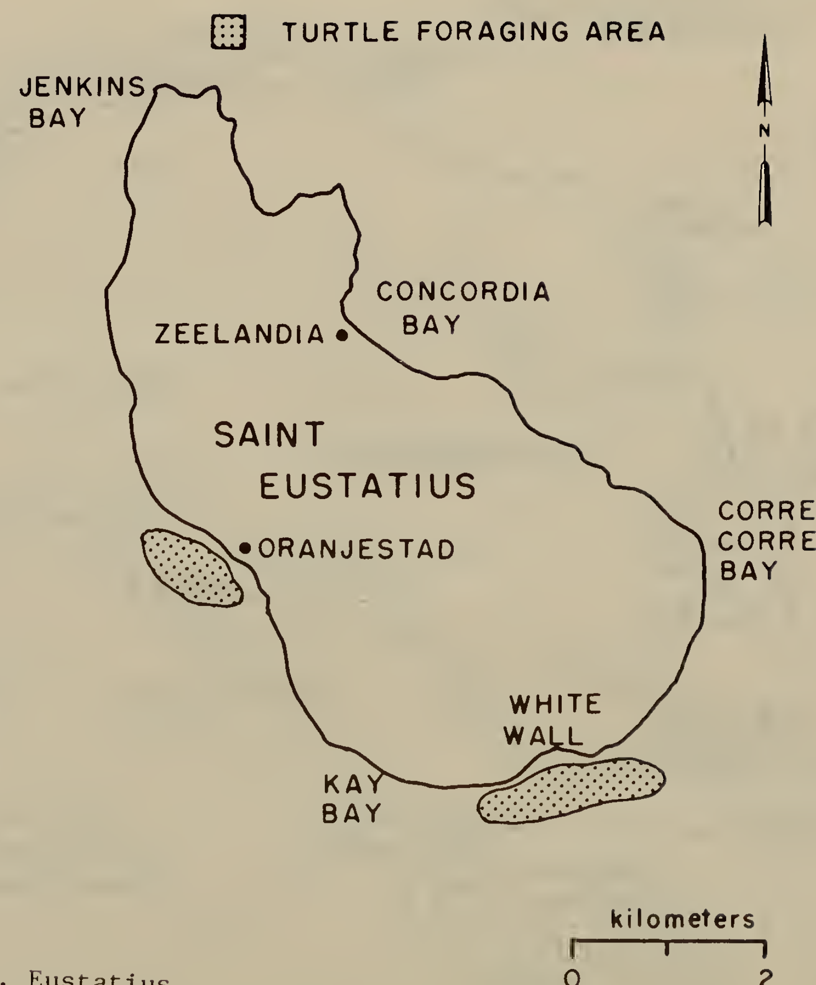


Figure 6. St. Eustatius.

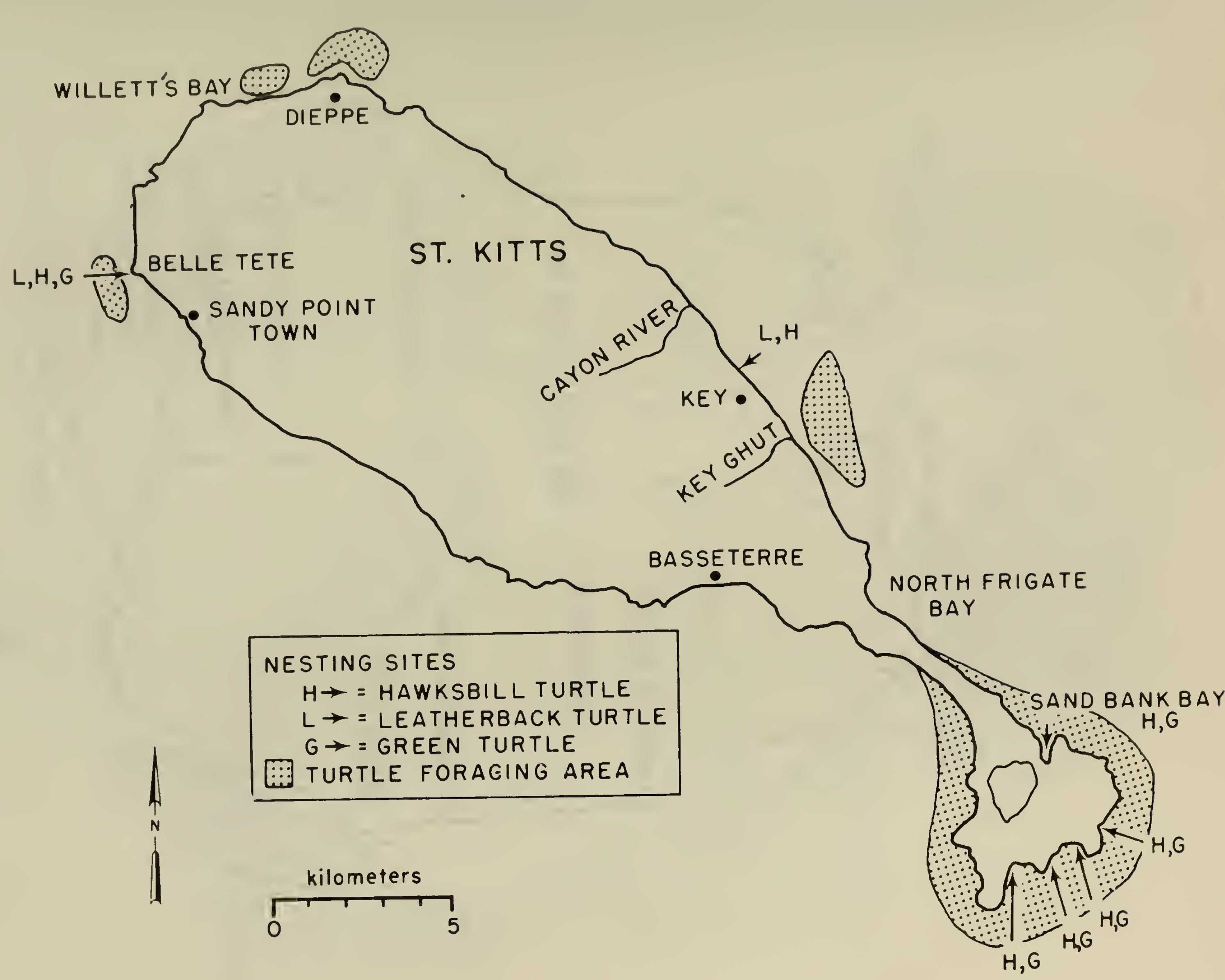


Figure 7. St. Kitts.

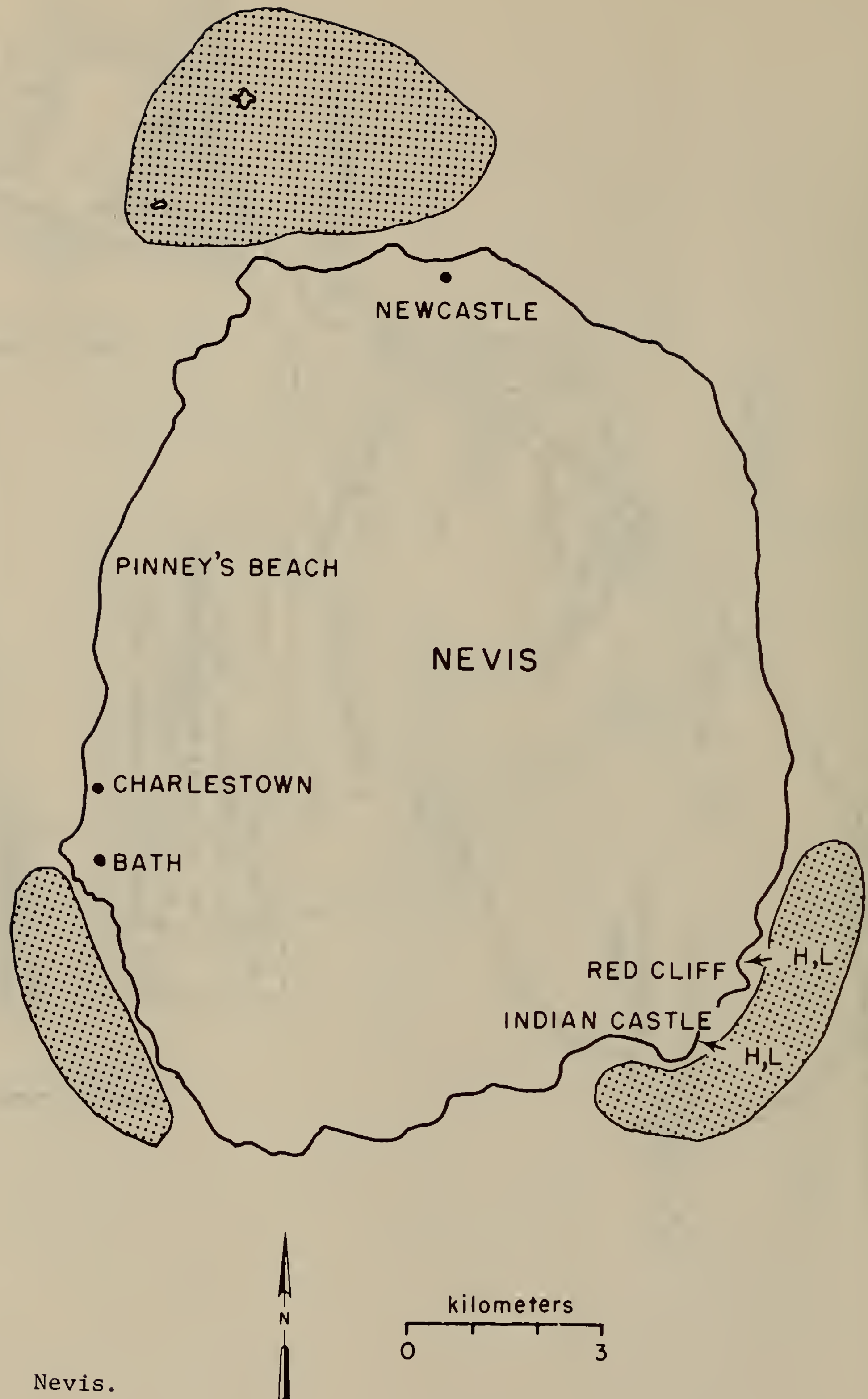


Figure 8. Nevis.

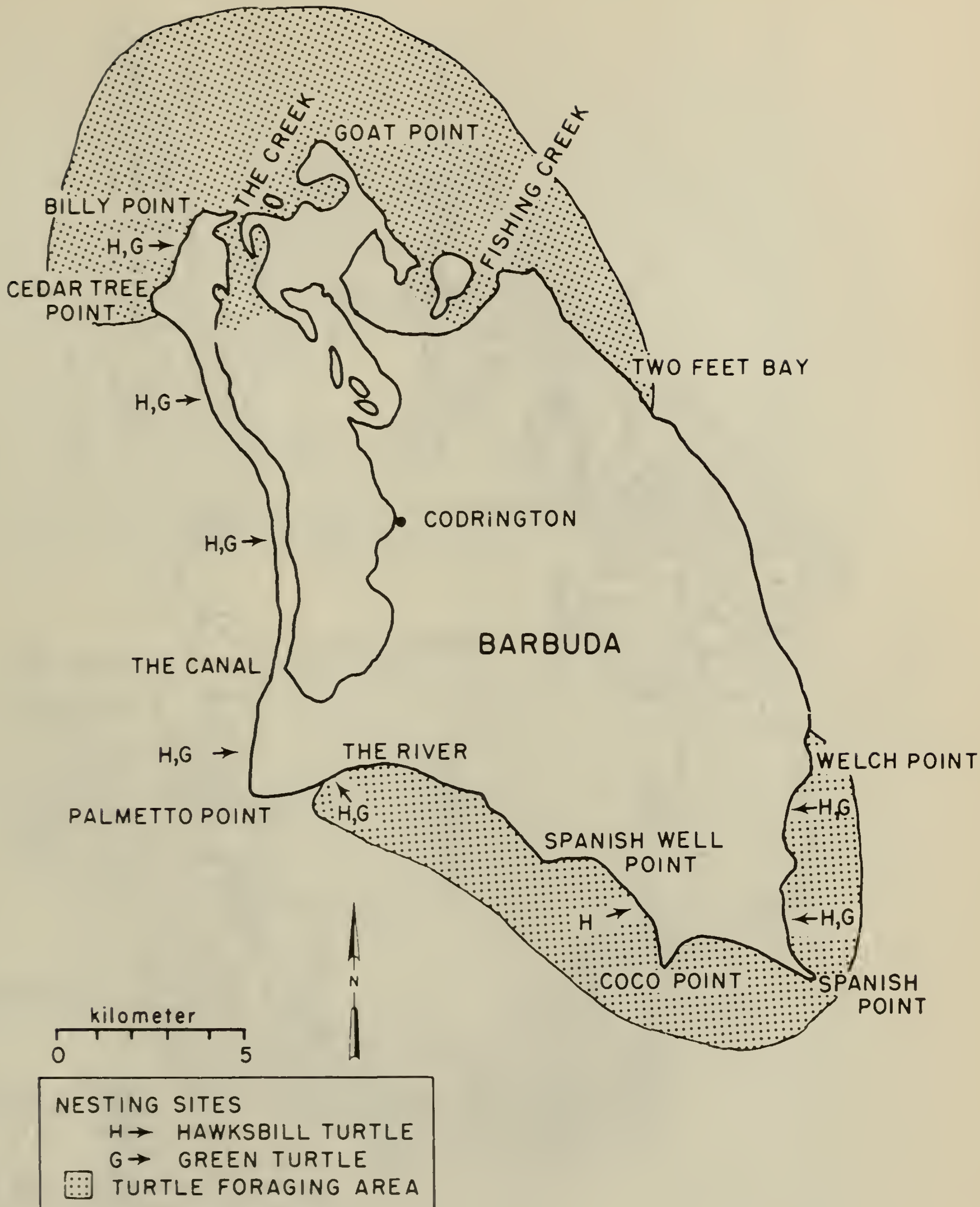


Figure 9. Barbuda.

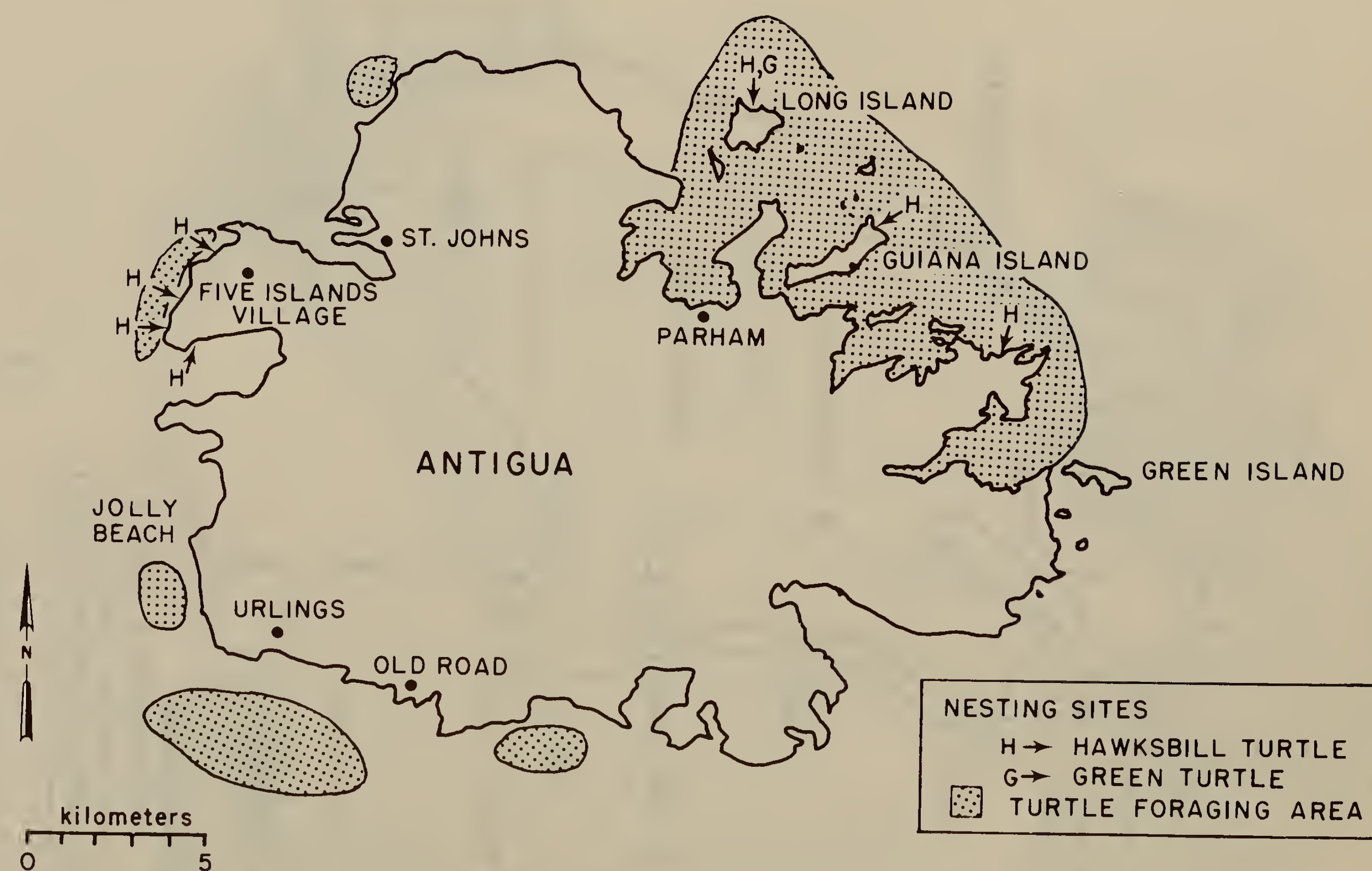
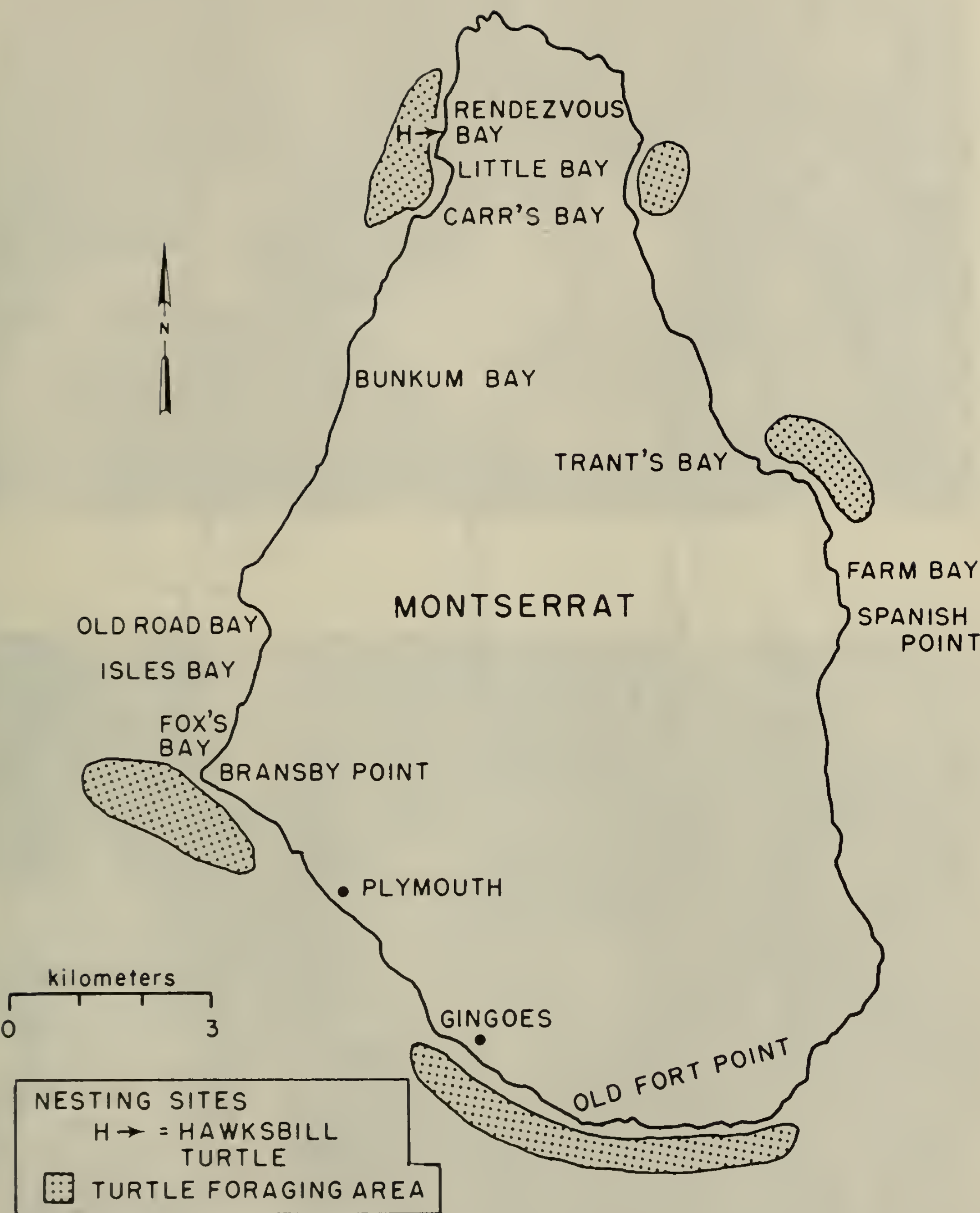


Figure 10. Antigua.



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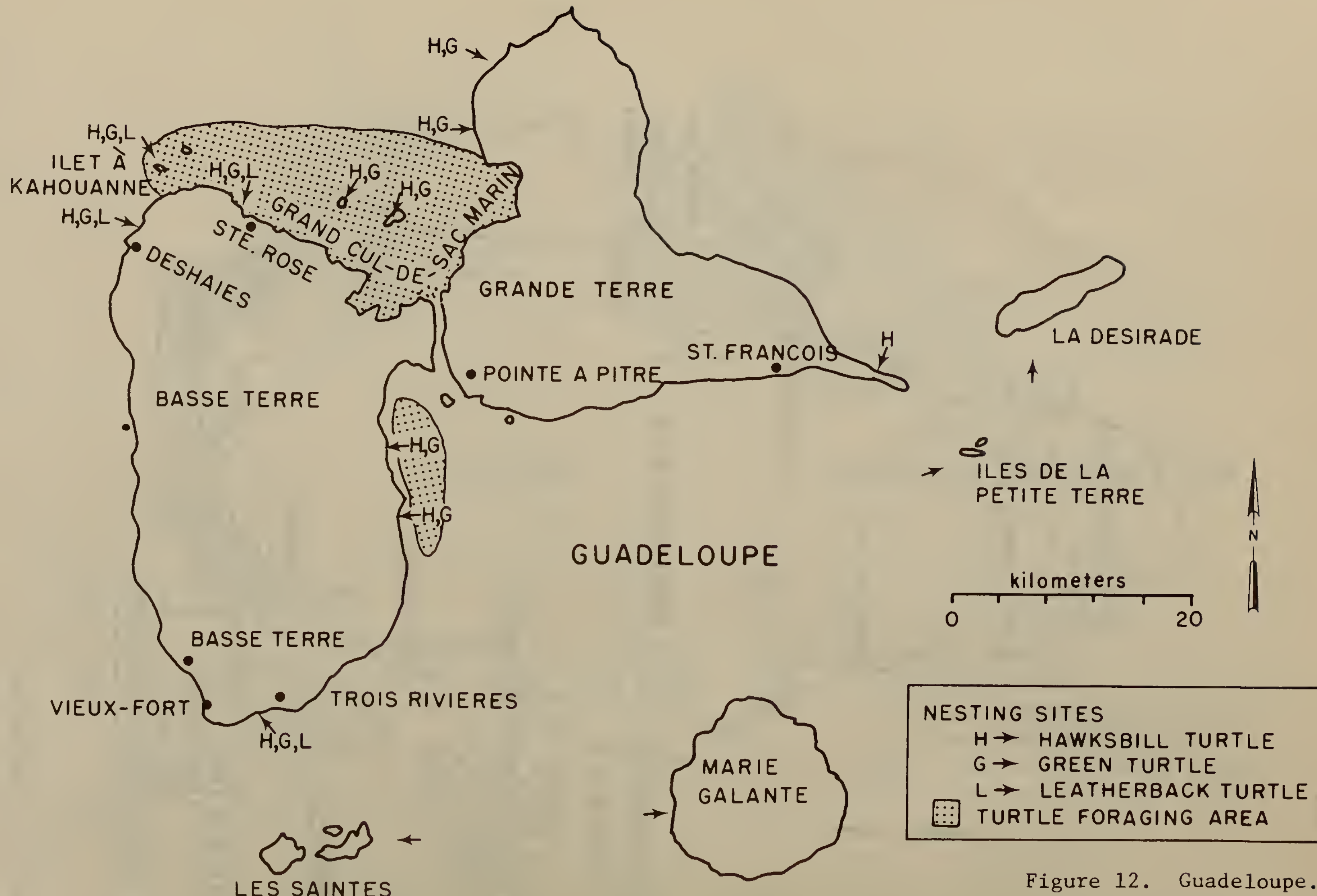

Figure 12. Guadeloupe.

Pl. 1. Loggerhead turtle (*Caretta caretta*) (54.5 kg) caught at Scilly Cay, Anguilla.

Pl. 2. Tortoiseshell scutes from hawksbill turtle (*Eretmochelys imbricata*).

Pl. 3. Young hawksbill turtle (*Eretmochelys imbricata*) (5.2 kg) caught by lobster diver, Barbuda.

Pl. 4. Effects of sand mining on nesting beach, Belle Tete, St. Kitts.

Pl. 5. Immature loggerhead turtle (*Caretta caretta*), St. Barthélemy.

Pl. 6. Green turtles (*Chelonia mydas*) awaiting export, Barbuda.

Pl. 7. Drying carapaces of hawksbills (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) captured in nets at Nevis.

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Pl. 9. Rocky cliffs along the coast of Saba provide foraging habitat for green turtles (*Chelonia mydas*) and hawksbills (*Eretmochelys imbricata*).

Pl. 10. Turtles being prepared for stuffing as souvenirs, Capesterre, Guadeloupe.

ATOLL RESEARCH BULLETIN

No. 279

SEA TURTLES AND THEIR TRADITIONAL USAGE IN TOKELAU

BY

George H. Balazs

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SEA TURTLES AND THEIR TRADITIONAL USAGE IN TOKELAU

BY

GEORGE H. BALAZS*

ABSTRACT

The conservation status, ecology, and cultural importance of sea turtles at the three Polynesian atolls of Tokelau are presented. The green turtle, Chelonia mydas, is the most common species, occurring as a migrant breeder mostly during September through November. The hawksbill, Eretmochelys imbricata, is present in small numbers at all three atolls, but nesting is only known at Nukunonu Atoll. A third species, the loggerhead, Caretta caretta, has also been recorded on rare occasions. In Tokelau, sea turtles are considered "sacred fish" (ika hā) that must be shared among the entire village by an equitable system known as inati. The number of sea turtles has declined within historical times apparently as a result of modern and more efficient hunting methods.

A main objective of this research is to help the Tokelauans effectively manage sea turtles so that these animals can continue to be part of the native diet and culture. Based on this study's findings, 11 recommendations for conservation are offered that either build upon, or reinforce, existing traditional practices. These conservation measures may also be applicable to sea turtle populations used by other insular people of the Pacific.

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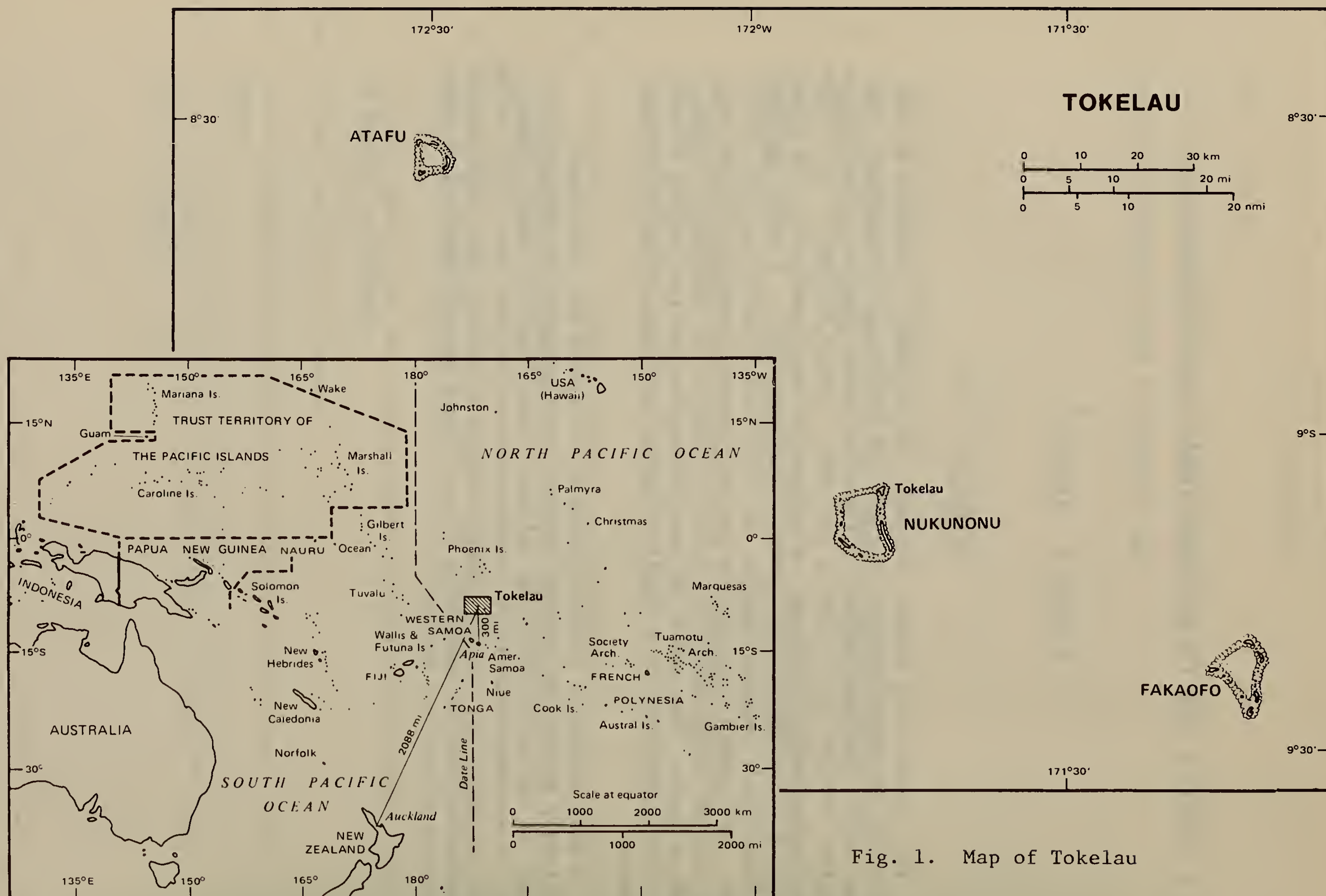

Fig. 1. Map of Tokelau

INTRODUCTION

This paper presents results of a field study undertaken in October of 1981 to assess the status, ecology, and human usage of sea turtles at the three Polynesian atolls of Tokelau in the central South Pacific Ocean. The ultimate aim of this study is to work in harmony with the native people to help conserve the area's sea turtles so they will continue to be part of the Tokelauan diet and culture.

The method being pursued to achieve this objective is to build upon existing traditional conservation practices, while taking into account the current biological knowledge of sea turtles and the legitimate needs of island people striving for an improved life. The need for such efforts in the Pacific is considerable. To a great extent, the numerous small islands of Polynesia, Micronesia, and Melanesia share the common problems of being extremely limited in natural resources and isolated from the outside world. These factors are even more pronounced on low coral atolls with small human populations. The Tokelau group is in many ways representative of such circumstances, where subsistence living is carried out in a remote island environment. Numerous changes have been brought about by outside influences over the past 125 years, but the basic cultural bonds and sense of unity among the people remain intact. There is a desire to retain many of the traditional ways of life, while selectively incorporating new ideas and more material goods and services into the culture. To maintain the necessary balance, it is essential that the environmental components upon which the culture depends remain viable. Sea turtles are one of these elements that constitute a high-protein seasonal food source offering welcome variety to the native diet. The capture, preparation, and sharing of turtles also serve as a social function that helps to strengthen and enrich the village community.

Sea turtles were formerly of considerable importance to many Pacific islanders. In addition to being a prized and nutritious food, they played key roles in certain religious ceremonies held at stone structures built on their behalf (Buck 1932a, 1932b; Emory 1947). The scutes and bones of turtles were used to fashion decorative ornaments, fishhooks, tattoo needles, and a variety of other implements. Sea turtle motifs were incorporated into petroglyphs and other works of art, as well as songs, dances, and folklore (Burrows 1933; Emory 1933; Pukui and Elbert 1971).

The decline in the importance of sea turtles within Pacific island cultures can be attributed to a number of factors, one of which is the decline of the resource itself. At many islands, traditional conservation methods that buffered turtles and other marine resources from overexploitation have deteriorated considerably, and in some cases disappeared completely. Three interrelated factors identified by Johannes (1978) that have contributed to this breakdown include the introduction of money economies, the decline of traditional authority, and the imposition of new laws and practices by foreign powers. The available evidence shows that the numbers of turtles throughout the Pacific islands have decreased markedly during historical times. However, for some areas no documentation exists on former levels of abundance and nesting distribution. Such information urgently needs to be gathered from the elders of each island before it is lost. A greater overall effort needs to be undertaken to conserve Pacific sea turtles, in collaboration with the people that are culturally linked to them. There is already a growing awareness of the problem, as demonstrated by recent reports and actions recommended (South Pacific Commission/National Marine Fisheries Service 1980; World Conference on Sea Turtle Conservation 1980). Also, information presented in McCoy (1974) and Pritchard (1977) for Micronesia, Balazs (1980) for Hawaii, Vaughan (1981) for the Solomon Islands, and Hirth (1971), Balazs (1977), and Dahl (1980) for Pacific islands in general, provides a basis for expanding and refining sea turtle conservation studies in the Pacific.

The study reported herein focuses attention on three atolls that are believed to be representative of many small islands scattered across the Pacific. Because of funding and other limitations, it will probably never be possible to carefully investigate the interrelations of turtles and people at all of these locations. I therefore plan to continue using Tokelau as a model study area, with the monitoring and cooperative assistance being carried out through fishermen, village elders, and other authorities that I met during my visit.

TOKELAU

Physiography

Tokelau consists of three coral atolls named Fakaofo, Nukunonu, and Atafu located between lat. 8° to 10°S and long. 171° to 173°W (Figure 1). The islands lie in a straight path extending from southeast to northwest. Fakaofo, the southernmost island, is 65 km from Nukunonu and 150 km from Atafu, the northernmost island. The group is about 500 km north of Upolu and Savai'i, the two large volcanic islands that comprise the independent nation of Western Samoa. The nearest neighbors to the west of Tokelau are the atolls of Tuvalu, which are about 650 km away. The atolls of the northern Cook Islands are situated to the east of Tokelau. Pukapuka, the closest of the group, is 500 km away. Gardner, Hull, and Sydney, three atolls in the Phoenix group (part of Kiribati), are about 450 km to the north of Tokelau, but all are currently uninhabited. Swain's, a 2-km long coral island known to the people of Tokelau as Olosega, lies 175 km south of Fakaofo. This island has historic cultural ties with Tokelau; however, since 1925 it has been a territory of the United States under the administration of American Samoa. Only about 15 people now live on Swain's Island.

The atolls of Tokelau consist of reefs that encircle large lagoons that lack a deepwater passage. Waves break on these protective reefs and flow over into the lagoon where relatively calm waters prevail. Many of the reefs are entirely bare during periods of low tide. On the ocean side of the reef the bottom drops off rapidly to great depths just a short distance from shore. Numerous islets (motu) ranging up to 6 km long, 400 m wide, and 5 m above sea level are located along the reefs. The motu soil is composed of coral sand and rubble generally low in organic matter. The principal vegetation cover consists of coconut palms, Cocos, along with Pandanus, Scaevola, and Tournefortia. Other noteworthy native plants include Cordia subcordata (kanava), Pisona grandis (pukakakai), Pemphis acidula (ngagie), Hernandia nymphaeaefolia (pukavaka), and Morinda citrifola (nonu). The estimated total land area of each atoll is 250 ha for Fakaofo, 260 ha for Nukunonu, and 205 ha for Atafu.

The southeast trade winds prevail in Tokelau from April to September, and northerly or variable winds prevail during the remaining hotter months of the year. The average temperature is 28°C and the average annual rainfall about 290 cm. Precipitation is greater during the months of October through March. Wells have been dug at each atoll, but most drinking water is obtained from coconuts and the collection of rainwater. Hurricanes are not common, but can cause great damage when they pass through the area. Severe storms are known to have hit Tokelau in 1846, 1914, and 1966.

Some good overall accounts of the physiography of Tokelau can be found in Macgregor (1937), Bryan (1942), Great Britain Naval Intelligence (1943), and Hooper and Huntsman (1973). Published information on the biota of Tokelau is available for the topics of seabirds (Wodzicki and Laird 1970), rats (Kirkpatrick 1966; Mosby and Wodzicki 1973), lizards (Whitaker 1970), arthropods (Hinckley 1969; Yaldwyn and Wodzicki 1979), and vegetation (Parham 1971; Whistler 1981). Wiens (1962) provides a comprehensive treatise on the environment and ecology of atolls in general, including some specific aspects of Tokelau.

Historical Overview

The discovery of Tokelau by European and American seamen started in 1765 with the sighting of Atafu. Nukunonu was discovered in 1791, but Fakaofo was not found until 1835. During the mid-1800's Christian missionaries became established on all three islands. In the 1860's the population was substantially reduced by the introduction of epidemic diseases and kidnapping by Peruvian slavers. Several foreign traders, mainly of Portuguese descent, settled in the islands during the latter 1800's and, through intermarriage, established family lines that continue to the present-day Tokelauans. A number of other ethnic groups were also absorbed into the genetic makeup of the population.

In 1877 the islands were placed under British protection and in 1916 Britain annexed the group. At that time Tokelau was known as the Union Islands. In 1925, responsibility for Tokelau was transferred to the New Zealand Government with administration being carried out from

Western Samoa. In 1948 the islands were formally incorporated as a territory of New Zealand. This status continues to the present with Tokelauans being full citizens of New Zealand. The group's external matters are handled by the Office for Tokelau Affairs based in Apia, Western Samoa.

An interesting event in the history of Tokelau that seems to be missing from the available literature is that a small U.S. Coast Guard loran station existed on Atafu in 1944 as part of the Pacific war effort.

The People

The Tokelauans are a stock of Polynesians that share a common language, culture, homeland, and way of life. The origin and early settlement of the islands are not clearly known; however, certain similarities exist with each of the surrounding Polynesian cultures. The traditional histories of Tokelau suggest separate founding populations at each atoll, and record the subsequent hegemony of Fakaofo by driving off the "true" Atafuans and conquering the people of Nukunonu. Atafu was not resettled until about 1800. Fakaofo's dominance was symbolized by the location of the temple and stone effigy of Tui Tokelau on that island (J. W. Huntsman, personal communication in April 1982).

Since the turn of the century the affinity with Samoan culture has increased in Tokelau due to such factors as greater travel opportunities on supply ships from Apia, use of the Samoan Bible, and broadcasts by Samoan radio stations. The Tokelauan language of the Polynesian family has only been written for about the past 15 years.

The population of Tokelau within historic times was reduced to a low of 200 in the 1860's, and reached a high of nearly 2000 during the 1960's. Emigration has occurred over the years, some of which was stimulated by a desire for wage employment and the limitations of natural resources, especially following the hurricane of 1966. There are now about 2500 Tokelauans living permanently in New Zealand, a few hundred in Western Samoa, and at least 150 in Hawaii (see Cooke 1975). This latter group originated from contract laborers on Swain's Island who were able to travel to American Samoa, and later north to Hawaii. The current population of Tokelau is approximately 1600, including about 675 people on Fakaofo, 350 on Nukunonu, and 575 on Atafu.

The people at Nukunonu and Atafu all live in a single village whereas at Fakaofo a second motu has been populated due to crowding at the historic village site. Each atoll operates as a relatively separate social unit since there is no transportation between islands except when a supply ship comes from Apia. During 1981 there was approximately one ship every 2 months.

Life in Tokelau is organized around kinship groups known as kāiga. Daily activities involve various forms of fishing and the harvesting of food crops, including coconuts that are dried into copra for export.

Groups of men must regularly travel to the outlying uninhabited motu of the atoll to gather coconuts. The majority of the food consumed is obtained locally from the atoll and the surrounding ocean. In addition to coconuts, other basic food crops are breadfruit, pandanus, and pulaka, Cyrtosperma chamissonis. Pigs and chickens have been introduced to the village motu and provide supplemental sources of animal protein, usually reserved for special occasions.

Tokelau society is traditionally egalitarian in ethic and cognatic in terms of descent and inheritance. Each atoll is governed by a Council of Elders (taupulega) representative of the kāiga groups. In addition, a village commissioner (faipule) and mayor (pulenuku) serve as elected officials. Close family ties exist in Tokelau and there is great respect for the aged.

Comprehensive information on the ethnology of Tokelau has been assembled by Burrows (1923) and Macgregor (1937). Detailed studies of the demography, kinship relations, and other cultural aspects of Tokelau have been published during recent years by Huntsman (1971, 1977), Hooper and Huntsman (1973), and Huntsman and Hooper (1975, 1976). An enlightening popular account of life in Tokelau has been produced by the New Zealand Department of Education (Keen 1976).

Sea Turtles

Very little information has been published on the status and ecology of sea turtles in Tokelau. The available material can be summarized as follows.

In a consultancy report on turtle resources of the South Pacific, Hirth (1971), based on an interview with Dr. J. Huntsman, stated that "Green turtles [Chelonia mydas] and to a much lesser extent hawksbills [Eretmochelys imbricata] still nest in the Tokelau Islands (September - October) but their numbers are said to be rapidly decreasing." Wodzicki (1972) indicated that "Five species of marine turtles lay their eggs on the beaches [of Tokelau], and in the past used to be an important food item for the islands but unfortunately have lately been very low in numbers." In a later paper, Wodzicki (1973) again briefly mentioned five species being present, and added that "turtle nesting grounds in the Tokelau require further study and protection." The five species were not listed and no other details were given. Yaldwyn and Wodzicki (1979) stated that four marine turtles have been identified from local reports, and that the green turtle appears to nest but is subjected to considerable human predation. In a short interview with Mr. N. Walters at the Office for Tokelau Affairs in 1977, I was told that turtles of undetermined species nest along the ocean beach of Taulagapapa, a motu on the east side of Nukunonu (Balazs 1982a). During early 1980, correspondence pertaining to Tokelauan turtles was sent to me by the resident school principals on Nukunonu and Atafu, and the former school principal of Fakaofo now serving as the Director of Education. These letters revealed that three kinds of turtles are known to nest in Tokelau: the green turtle and, far less frequently, the hawksbill and loggerhead, Caretta caretta. The breeding season was said to extend from June through December, with the peak months being September, October, and November. Large numbers of turtles were clearly not involved, but those present were valued by the people. These facts, along with other background information contained in the letters, provided me with a sound basis for planning field research in Tokelau.

The ethnologic information on Tokelau assembled by Macgregor (1937) contains several references to sea turtles involving such aspects as fishing, cooking, ceremony, fishhooks, and folklore. Huntsman (1969) provided a description of the preparation and ceremonial distribution of two turtles captured at Nukunonu in 1967. Huntsman (1977) also recorded and translated into English the Tokelauan tale of "Hina and the turtle" which had been published earlier by Burrows (1923) in a different version.

STUDY METHODS

My study visit to Tokelau was carried out from 17 to 27 October 1981 in conjunction with a scheduled visit of the 58-m supply vessel, MV Frysna, chartered by the Office for Tokelau Affairs. The principal methods used to collect information on sea turtles consisted of 1) personal interviews, especially with village elders, fishermen, and other Tokelauans identified as having special knowledge; 2) firsthand surveys of beach and ocean areas at each atoll; 3) firsthand observations of the preparation and ceremonial distribution of turtles captured at Fakaofo; and 4) photographic documentation of pertinent aspects of the visit. Dossiers containing photos and drawings of the different sea turtle species were assembled for use during the interviews. These and other educational materials were left with village authorities and schools on each atoll. Many of the interviews were conducted with the aid of a translator to ensure an accurate understanding. Mr. Semu Uili, Officer for Agriculture and Fisheries, served admirably in this capacity and was of invaluable assistance as my guide and gracious host. A list of the people interviewed appears in the Appendix.

It was possible to spend 4 consecutive days and nights at Fakaofo because a general council meeting (fono) of all three atolls was held at this occasion in conjunction with the vessel's arrival. This convergence of a large number of people at Fakaofo enhanced my opportunities to gather information. The time I spent aboard the MV Frysna traveling between Apia and Tokelau, and back and forth between the three atolls, also afforded good opportunities to talk with people about sea turtles.

FINDINGS

Status and Ecology

Species present

The green turtle is the most common sea turtle at all three atolls of Tokelau, and is a seasonal breeder present mostly from September through November. During this time, mating pairs appear a short distance off the ocean side of the reef, and nesting occurs on certain sand beaches. For the rest of the year adults are far less frequently seen, but immature turtles about 40 to 60 cm in carapace length continue to be present in the lagoon and along the outer reef. The hawksbill is also known at all three atolls; however, Nukunonu is the only site where nesting occurs, and then only on rare occasions.[1] Most of the hawksbills seen are of an immature size that, like the young green turtles, appear to live throughout the year both in the lagoon and immediately outside the reef. The loggerhead is a third species known in Tokelau (exclusively from Nukunonu), but it is an uncommon nester. My informant from Nukunonu, 84-year-old Palehau Leone, who is an outstanding authority on all aspects of Tokelauan life, told me that "this reddish turtle comes from far away to nest, and when it does a greater number of green turtles can be expected." Vaughan (1981) mentioned a related belief at Santa Ysabel in the Solomon Islands where the capture of a loggerhead, a rare species not known to nest, is a good omen for the prospects of catching green turtles. Photographs and descriptions that I provided of the leatherback, Dermochelys coriacea, revealed that this turtle is totally unknown in Tokelau, although great interest was shown in its size, body form, and pelagic life habits.

Tokelauans call the green turtle "fonu," a general name for sea turtles also used in several other areas of Polynesia, including Samoa and Tonga. In Tahiti and Hawaii, green turtles are called "honu," and in Fiji (Melanesia), "vonu." The hawksbill in Tokelau is called "fonu una" (literally "scale turtle") because of its thick scutes. Two less common names used for this species in Tokelau are "fonu puhi" and "kea puhi," which refer to the hawksbill's beak being elongated like an eel's. Other than fonu, there is no special name for the loggerhead turtle. The name "tuahivivalu" (literally "eight backbones") was also given to me as a type of turtle. However, after considerable discussion among my informants, it was decided that this refers to an exceptionally large turtle measuring eight human hands laid along the carapace. This would be a length of at least 140 cm, the upper limit of the largest green turtles ever recorded in the scientific literature. No "tuahivivalu" are known to have been caught or seen in Tokelau during this generation. In Pukapuka the largest green turtles

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[1] Small numbers of green turtle and the hawksbill are known to nest at Olosega. The small human population is reported to take turtles and eggs from the beaches whenever possible.

are called "mataweo," while the ordinary ones are "wonu" (Beaglehole and Beaglehole 1938).

A female turtle in Tokelauan is called "ika fua" and the male "ika tane." Two turtles joined together copulating are called "ulugaafonu." The word used when referring to any small or young turtle was repeatedly given to me as "kea." Similar words are used solely for the hawksbill in the Tuamotuan (tīfai-kea) and Hawaiian (honu'ea) languages of Polynesia.

Nesting habitat

The nesting habitat on all three atolls is somewhat limited by extensive shoreline areas of beachrock (limestone) and coral shingle. Fine coral sand beaches suitable for nesting are interspersed along these inhospitable shores, and probably make up not more than 25 per cent of the existing coastline on the ocean sides of the motu. Nesting is not common on the lagoon sides, even though there are some suitable sand beaches. The ocean-side beaches where nesting takes place at each atoll are shown in Figures 2 and 3. Many of these are on the east-northeast sides which are generally more windward and farthest from the motu where the villages are situated.

Most of the beaches I examined had thick vegetation growing almost to the high tide line. Nearly all of the beaches are inaccessible to nesting turtles during periods of low tide because the seaward approach over the fringing reef becomes bare and exposes jagged coral rocks. A turtle that finishes nesting at such times is completely stranded until the tide rises.

Abundance and trends

The number of adult males and females captured in recent years during each breeding season has been approximately 20 at Nukunonu, 10 at Fakaofo, and 15 at Atafu. Not much effort seems to be directed at catching the immature turtles, except on special opportunities. Based on interviews and my firsthand surveys of beaches, I estimate the number of nesting females present each season to be approximately 70 at Nukunonu, 30 at Fakaofo, and 20 at Atafu (total: 120). This initial estimate will need to be refined as more information becomes available.

I asked my elder informants to give me some idea of how many adult turtles were captured during each season when they were young men. Palehau Leone was 18 years old in 1915 and he estimated that "3-4 turtles per day" were taken at that time, or about 90-120 per season. Nemia Tuvala, 65-year-old expert fisherman of Fakaofo, recalled that at least 20 turtles were caught each season in the 1930's. Kalolo Mika, 78-year-old expert fisherman and the son of Mika, Macgregor's (1937) principal informant, stated that about 80 per season were taken at Atafu in the 1920's. This information seems consistent with Macgregor's (1937) general appraisal for Atafu in 1932 that "many turtles are caught" during the mating and nesting period.

In considering the above catch data, it is important to note that turtles can now be located and taken far more efficiently than before due to the widespread use of outboard motors and more sophisticated capture methods. Even with this increased efficiency, it is still not possible to catch as many turtles as before.

Species description

It was only possible to examine specimens of the green turtle. A male and female seen captured at Fakaofo had carapace lengths of 91 and 105 cm, respectively. I was told that females are almost always bigger than males. The shell colorations and other dorsal surfaces of the two turtles at Fakaofo differed significantly. The female was mostly black and reddish-brown with yellowish streaks. The male was basically olive and had black flecks. The plastrons of both turtles were whitish-yellow. Recently excised shells from a 103-cm female at Fakaofo, and a 104-cm female at Nukunonu, were black and olive. A 102-cm shell at the home of Luciano Perez in Nukunonu was also black and olive. Turtle shells are not commonly used for decoration in Tokelau. Instead, they are either cut up and eaten or thrown away.

At the home of Mrs. Siniua Sosene on Fakaofo, I examined a 35-cm turtle that had been raised as a pet for about 2-1/2 years. The turtle was hatched from one of four eggs she had received as part of a clutch shared among the village. The shell had radiations of reddish-brown, with cream-colored infusions and some black streaks. The plastron was whitish-yellow. This healthy, fine-looking animal was being held in a small container of sea water next to the house where it was fed fish and coconut. Every so often village children took it for a swim in the lagoon. Several turtles raised by other families from the same clutch of eggs have escaped during similar outings.

Food sources

My informants told me that the green turtle's main food source is green algae. Algae are seldom, if ever, used for human food in Tokelau, and consequently there was not a great familiarity with the species present. The hydrozoan, *Velella velella* (called "hehema"), was also mentioned as a food item sometimes found in the stomach of green turtles. This was reported to be a common invertebrate in Tokelau. I saw a number of them on the beach at Nukunonu, as well as aggregations floating at the sea surface as we motored through calm waters between Apia and Tokelau.

I was able to thoroughly examine the gut contents of the two turtles caught at Fakaofo. The female's digestive tract was completely empty except for a single piece of blue polyethylene plastic about 15 cm long. The male, however, had algal food material throughout its entire tract. The fresh contents of the stomach consisted mostly of the green alga, *Valonia aegagropila*, and lesser quantities of the brown alga, *Turbinaria ornata*. The only other material found was a small bird feather in the large intestine.

Epizoics and diseases

Numerous small barnacles, Platylepas hexastylos, were present on the tail and neck regions of the two adults caught at Fakaofo. In addition, the male had patches of red alga (probably Polysiphonia tsudana) growing in these same areas. The juvenile turtle being raised by Mrs. Sosene also had red alga growing on its shell.

A small number of the turtles captured in Tokelau are reported to have an abnormal condition described as "watery and shrunken flesh." Turtles with this disorder are not emaciated and cannot be recognized by any external signs. These turtles are usually not used for food, but on the rare occasions when they have been eaten, no sickness resulted. Sister Juliana, a Tokelauan serving at the Catholic Mission on Nukunonu, told me that it is traditional on her island to sing and talk in the presence of turtles that have been captured to keep their meat from becoming watery and shrunken. At times when turtles are caught late in the afternoon, it is necessary for this ritual to continue throughout the night until the next morning when butchering takes place.

The tumors or fibrous growths that are sometimes seen in Hawaiian (Balazs 1980) and other populations of green turtles are unknown in Tokelau.

Natural predators

I was unable to find any direct evidence of predation on turtles or eggs, except for human predation. Nevertheless, there are a number of species in Tokelau that constitute potential threats and undoubtedly take turtles.

In the terrestrial environment there are hermit crabs, Coenobita spp., ghost crabs, Ocypode spp., Polynesian rats, Rattus exulans, two species of frigate birds, Fregata ariel and F. minor, and reef herons, Egretta sacra. All of these are known predators of hatchlings and eggs at certain other breeding areas. Except for rats, none of the above appeared abundant at the time of my visit. However, large predator aggregations may build up at other times of the year.

In the marine environment, sharks and other carnivorous fish can prey on hatchlings, especially during the vulnerable time when they cross over a shallow reef to reach deep water. Large groupers, Epinephelus spp., sometimes prey on immature turtles up to about 30 kg, and large sharks are known to eat turtles of all sizes, including the largest adults. The tiger shark, Galeocerdo cuvier (called "mokoha"), an important predator of sea turtles throughout the tropics, occurs in Tokelau but apparently not in great numbers. At Fakaofo I saw the jaws of a 3-m tiger shark hooked earlier in the year by villagers fishing from a small boat at night just outside the reef. The stomach did not contain any remains of turtles. It was my impression that such large sharks are not common, or at least not commonly encountered, in

Tokelau. Shark attacks on humans are reported to be very rare, but this may be because Tokelauans seldom dive or swim at night.

Many people that I talked to told me of the Tokelauan belief or rumor that the mother turtle returns to the waters near her nesting site when the eggs hatch so she can eat her young. No one has actually witnessed this event or recovered hatchlings from the stomach of a turtle. Possibly such predation was indeed documented at some time in the past, since there are a few records from other areas of adult turtles (leatherbacks) eating hatchlings (ridleys).

High-seas migrations

The green turtles that breed in Tokelau are absent for most of the year. There can be little doubt that they are coming from, and returning to, some distant feeding pasture. The actual location of this resident area (or areas) is unknown, but must be many hundreds of kilometers away. Green turtles breeding at other sites in the Pacific are known to make similar migrations (see Balazs 1982b). At Scilly Atoll in French Polynesia, green turtles tagged while breeding have been recovered at foraging areas to the west all across the Pacific, including Tonga, Fiji, Wallis Island, New Caledonia, and Vanuatu.

None of my informants had ever heard of a tag being found on a turtle in Tokelau. In addition, no traditional knowledge seems to exist on where the turtles may go when they are not in Tokelau. Although admittedly speculative, I believe that a likely possibility where the turtles may go would be the coastal waters of Western Samoa. Immature and adult green turtles are found in Western Samoa, but nesting does not take place. Green turtles nesting at tiny Rose Atoll (14°33'S, 168°09'W), the geologically oldest site in the Samoan Archipelago, may also use feeding grounds in Western Samoa. However, no recoveries have thus far been made of the turtles I tagged at this site in November 1980 and October 1982.

The origin of the few loggerheads and hawksbills that nest in Tokelau is also unknown. Hawksbills could, however, be permanent residents, as is suspected for certain other areas. Loggerheads are not common in the Pacific islands, although sizable numbers occur in New Caledonia and on the Great Barrier Reef, and at least some occur in Fiji.

In considering the migrations of Tokelauan turtles, it is interesting to note that in the tale of "Hina and the turtle," Hina rides on the back of the turtle (Kea) to Fiji and Tonga, but only ventures ashore when they arrive at Vavau. I have been unable to determine if Vavau refers to the group of islands by that name in Tonga, or to Bora Bora in French Polynesia which had the ancient name of Vavau. In other Tokelauan tales, there are clear references made to the Vavau in Tonga (J. Huntsman, personal communication in April 1982).

Human Usage

Methods of capture

Most turtles captured in Tokelau are taken while they are copulating in waters just outside the reef. There is some evidence to suggest that the leeward sides of the atolls are preferred mating areas, and the lagoon waters are not usually used.

When a mating pair is sighted from land, men from the village either swim out or launch their small outboard-powered aluminum boats and cautiously approach the turtles. Using skill and strength, the turtles are physically restrained by hand or with the aid of a rope. This is essentially the same method of capture described by Macgregor (1937). In recent years, however, the use of an iron hook and line to snag turtles has become popular. Fewer turtles are lost by this technique and not as many men are needed. A hook and line also increases the chances of catching mating turtles that are accidentally encountered at night when villagers are fishing for other species. A turtle caught at Nukunonu a week before my arrival was taken under these circumstances.

A traditional belief in Tokelau is that a man whose wife is pregnant will frighten off a pair of turtles if he is involved in the attempted capture. Consequently, these men are forbidden from joining the hunting party. A woman at Fakaofo in her eighth month of pregnancy was one of several people that related this belief to me.

Another one of my informants, Hosea Kirifi, told me an interestng story about an accident that happened many years ago at Fakaofo during an attempt to catch a large turtle. One of the men became entangled in a rope he had tied to the turtle. The turtle dove and pulled the man down to a great depth. The last thing the man remembered before losing consciousness was hearing a high-pitched noise (probably from pressure against his eardrums). The other men in the hunting party thought he had surely drowned and was lost. However, a few minutes later the turtle, in a state of exhaustion, and the unconscious man still tangled in the line, rose to the surface. The man recovered and lived to an elderly age, but could never hear again.

A second method used in Tokelau to catch turtles is to find the females while they are nesting. This method is used on overnight visits to the motu to gather coconuts, or when the Council of Elders sends a special party of men to a particular motu where turtle is likely to nest. When a turtle is found nesting, it is either tied to a pole and carried or dragged upside down back to the boat.

The use of outboard motors and aluminum boats is now widespread at Fakaofo and Nukunonu and has almost completely replaced the traditional outrigger canoes made from kanava trees. In past years, these canoes were powered exclusively by sail or paddle. During my visit I only saw one such sailing canoe at Fakaofo and the few others present had outboard motors.

Greater time and effort were once required to travel to the outlying motu, some of which involve round trips of 10-22 km. Although it is now far easier to reach the motu, I was unable to determine if this has influenced the number of overnight visits being made during expeditions to gather coconuts. If fewer stays now occur because of increased mobility (e.g., the men are returning to the village to spend the night at home), then there would be less opportunity to encounter nesting turtles. However, a turtle's tracks and fresh nesting site would be found when the men return the following morning. Most of the time the eggs would be taken, and eventually the turtle if it returns to this same site to nest again.

The current ability to travel faster and easier with outboard motors does not mean that freedom exists to visit all of the motu at any time. As a traditional means of conserving the coconut resource, the Council of Elders decides which motu may be visited during a certain time period. All others are off-limits, except by special permission. This control by the Elders applies to motus owned in common by the village, as well as land held by the kāiga groups that collectively make up most of the atoll. To some extent, these restrictions have probably also served as a conservation buffer for nesting turtles.

Although seldom used, another method of catching turtles in Tokelau is to harpoon them from the reef flat at low tide when they swim in close to feed on algae. Porpoises are also occasionally taken by this technique.

The least common method of taking turtles in Tokelau is to simply find them stranded on the reef flat at low tide. Such strandings are apparently rare, or at least not often seen by the people. The two turtles captured while I was at Fakaofo were found stranded by a group of children. Nemia Tuvala of Fakaofo told me that some years ago he found an adult female stranded on the reef between Fenua Fale and Fenua Fala, the two nearly adjacent motu where the villages are located. This capture was said to be significant for the following reason. Nemia's "grandfather's grandmother" had the name of Fonu. Within this family, there is the belief that a turtle will be captured a day or two after the death of a family member. Nemia's aunt died shortly before he found the turtle. Emory (1947) reported a similar belief at Napuka in the Tuamotu Archipelago, where the spirit of a deceased person was thought to lead a turtle to land 1 year after death.

Egg collection

Clutches of turtle eggs are dug up and taken whenever they are found at Fakaofo and Nukunonu. At Atafu the Council of Elders has placed a ban on the taking of eggs, except for a few that are allowed to be removed from each nest. According to Tokelauan custom, all eggs taken at each atoll must be given to the Elders for distribution among the village. The Elders also determine when the turtle will renest by careful inspection of the opaque disk that forms on each egg and becomes progressively larger as the embryo develops. Knowing that a turtle will usually nest again at 2-week intervals, the Elders compute an estimated date for the turtle to return based on the age of the eggs from the previous clutch. Men are then sent to the motu on this date to catch the turtle when it comes ashore. The technique assumes that a turtle renests on the same motu, and this indeed happens most of the time. The same reliable method of calculating the renesting date is also used in the Solomon Islands (Vaughan 1981), Palau (Pritchard 1977), and elsewhere throughout the Pacific.

Another method used at some islands to determine the renesting date involves counting the number of eggs in the clutch. There is no known scientific basis for this practice, and it is highly unlikely that meaningful results are obtained. Johannes (1981) mentioned that this technique is used in Tokelau, when actually the literature he cited pertained to Pukapuka in the northern Cook Islands where the counting method is known to have been used (Beaglehole and Beaglehole 1938).

There is no indication in the traditional history of Tokelau that the taking of turtle eggs was ever prohibited. Macgregor (1937) does not mention turtle eggs, although he lists "birds' eggs" as one of the ancestral foods of Tokelau. Bans on the taking of turtle eggs are known to have existed within a number of other Pacific island cultures, and some are still in effect (Johannes 1978, 1981). The taking of eggs at Pukapuka was not allowed in the past (Beaglehole and Beaglehole 1938). The people of Pukapuka attribute the lifting, or cultural breakdown, of this ban as being responsible for the decline of turtles at their atoll.

The ban on taking turtle eggs at Atafu was put into effect during the early 1970's. This action appears to have resulted in part from the advice of American Peace Corps Volunteer, Alan Banner, and the South Pacific Commission's Fishery Advisor, Val Hinds. The suggestion to implement this conservation measure was probably made to all three atolls, but Atafu is the only site where it was adopted as a continuing policy.

Turtle eggs that are taken and distributed among the village may be eaten or sometimes reburied for the purpose of hatching a pet turtle. According to Kalolo Mika, turtles raised as pets in captivity are not eaten because they have an unpleasant taste. They are also not raised to a large size because of an absence of adequate holding facilities.

At Fakaofo turtle eggs are described as watery and not considered palatable if they are more than 4 days old. At Nukunonu, I was told that eggs less than 10 days old are preferred. A method of cooking turtle eggs is to roast them directly in a fire.

Ownership and restrictions

In the Tokelauan culture sea turtles along with swordfish, sailfish, porpoise, and whales,[2] are classified as "sacred fish" (ika ha). The significance of this designation is that such animals are owned collectively by the entire village, and cannot be taken for personal use. When a turtle is captured, it is ceremonially shared with everyone through an intricate and equitable procedure known as "inati." Huntsman (1969) describes the inati system as "the reflection of the Tokelauan ideology of equality, whereby each individual receives from or contributes to the village or moiety his fair share."

In past years anyone who kept a sacred fish for his own use was punished by having his house burned and his property and canoe broken up (Macgregor 1937). At the present time, a person violating this traditional code would be severely rebuked by the Council of Elders. As a result, the family would be humiliated and the stigma could last for years. I was told of an incident that happened two generations ago involving a man who caught and ate a turtle on an outlying motu. Even now this man's descendants are sometimes the subject of ridicule by other villagers as the result of this incident.

In Tokelau all of the inhabitants, including women and children, are permitted to eat turtles if they so desire. No restrictions seem to have existed in the past, although certain portions such as the head were reserved for the chief. In a number of other Pacific island cultures, turtles could formerly only be eaten by select groups, usually limited to chiefs or adult men.

Macgregor (1937) indicated that certain forms of animal life, including turtles, used to be revered as family spirits or gods. The animal so designated was never caught, injured, or eaten by members of that family. I found no evidence that this belief still exists, although certain individuals within families will not eat turtle. Possibly this involves the small number of people who have recently converted to the Seventh Day Adventist Church, some members of which will not eat turtle for religious reasons (see the Bible Leviticus 11 and 19, Deuteronomy 14).

Huntsman and Hooper (1975) mentioned that women within the Tokelauan culture are perceived as having "close links" with spirits, as well as fish, turtles, and birds. This may be the reason why no women at Fakaofo were involved in any aspect of the butchering and distribution of the two turtles I witnessed. When I inquired about this matter my informants confirmed that women are never involved, but the cultural basis for exclusion was not known.

At Atafu I was told that the green turtle and the hawksbill (though now rarely caught) are both eaten and taste equally good. The

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[2]Whales are sometimes found washed up along the windward sides of the atolls.

females of both species are always preferred over the males. No restrictions have ever existed on eating hawksbills, and the poisoning that occasionally happens elsewhere in the Pacific has never been known in Tokelau. However, a fatality recently resulted from eating a balloonfish (Tetraodontidae or Diodontidae) at Fakaofo, and symptoms indicative of ciguatera poisoning have occurred at Nukunonu from eating a fish called "fagamea" (probably the red snapper, Lutjanus bohar).

Distribution

When a turtle or other sacred fish was caught in the old days, it was carried to the village meeting ground (malae) for ceremonial prayers of thanks offered to the god Tui Tokelau. The turtle was put on display for all to view, and later killed and cut up by a specially appointed man (tauvaega) who divided it among the people (Macgregor 1937).

Considerable ceremony and socialization are still associated with the distribution of a turtle. The tauvaega, or inati supervisor, presides over a team of men and boys that systematically divide the turtle into portions assigned to each family in the village. The entire turtle is consumed, except for the bile, scales, gut contents and, occasionally, the shell. While at Fakaofo, I was able to watch the full procedure of processing and distribution of the two turtles found stranded on the reef. The tauvaega of Fakaofo, Kalepo Mativa, as well as Nemia Tuvala and other participants, were most accommodating in allowing me full access to the work area and permission to take photographs. The following is a descriptive account of this event, starting when the turtles were first captured at about noontime on 22 October 1981.

The two turtles were transported from the reef by boat to the village motu of Fenua Fale, where they were placed on their bellies in the shade close to the lagoon shore. Although the turtles were not injured in any way, they exhibited very little activity or alertness, unlike the green turtles I am familiar with in Hawaii. They made no attempt to crawl to the water, even though it was in clear view just a few meters away. Furthermore, none of the villagers seemed concerned that they would try to escape. The only explanation I can offer for the turtles' lethargic behavior is that their earlier mating activity had left them in an exhausted state. This would be consistent with the fact that they did not swim off the reef when they sensed the tide receding, but rather allowed themselves to become stranded.

An interatoll rugby tournament was scheduled to take place that day, so after considerable discussion it was decided to postpone processing the turtles until the next morning. The turtles were eventually turned over on their backs where they remained unattended throughout the night.

Starting at about 8 p.m. and lasting until after midnight, traditional singing and dancing took place at the village meetinghouse as part of the festivities of the general council meeting. The turtles were well within hearing distance of this merriment, but not in the immediate vicinity. In keeping with the Tokelauan spirit of pride and friendly competition, people from Nukunonu later told me that turtles at their atoll are much better looked after, and never left alone, when they have to be held overnight. Ateli Perez, an elder at Nukunonu who was quoted by Huntsman (1977), provided some interesting insight on this tradition in a speech he gave at the Nukunonu meetinghouse on 10 October 1967:

> "We are all singing here in keeping with the ancient custom to which we still adhere. When a pair of turtles are captured in the late afternoon and are not used, old ladies come and guard over the turtle couple, sitting at the side and sing songs to cause them to stay awake. So we are sitting here at the side of the turtles and we sing. Because of another ancient belief, we come and sit beside the turtles lest a bush spirit (gaveve) steal them in the night. This is an ancient custom to which we still hold to this very night. This is the meaning of our joy-making and singing here."

The processing of the two turtles at Fakaofo started at about 8 a.m. A number of people, including many children, were gathered in the area. The turtles were first stunned in the traditional Tokelauan manner of delivering five to six heavy blows to the ventral neck and pectoral regions using a blunt instrument, in this case the hammer side of a long-handled axe. This causes massive internal hemorrhaging but very little external bleeding. When I first heard of this method, I was admittedly apprehensive from a humane standpoint. However, after seeing it take place, I am convinced that it is actually less cruel than many of the techniques employed elsewhere throughout the world. Sea turtles are simply not easy animals to kill or render unconscious by any method.

Immediately after striking the turtles, the plastron was removed by cutting along the border with a sharp knife. While this was still in progress, other workers were reaching into the turtle and ladling out all of the blood that had collected in the body cavity. Still other workers were busy building a number of small fires on coral stones for use as cooking stoves. Two of these sites were used to stew the blood in large metal pots.

The eggs in the female were carefully separated from the oviduct and counted into baskets woven from palm fronds. A total of 300 was present. All of them were immature and there was no sign of shelling.

After being separated from the body, the flippers, head, tail, and plastron were singed in the fires to loosen the keratinous epidermal scales. Each piece was then meticulously peeled clean of this inedible material. The four front flippers with the meaty pectoral regions still attached were each taken and presented as gifts to the visiting people from Atafu, Nukunonu, and Apia, and the general council meeting delegates.

The stomach and intestines were removed in one piece and carried a short distance into the lagoon where they were cut open lengthwise and washed clean. Along with the other viscera, this material was cut up into sections and combined with the remaining pieces of meat, bone, and cartilage.

The two shells were not cut up because they were initially intended to be saved as decoration for the village meetinghouse. This plan was later changed when offers were made to the Council of Elders to buy the shells. As a result, one was sold to a Tokelauan living in Apia, and the other to a Tokelauan residing on Fakaofo who eventually returned to New Zealand where he has lived for some years. According to Kalolo Mika, turtle shells have traditionally been cut up and eaten after removing the horny scutes. It was explained that the shell, which is mostly bone, is usually given to the young men because their teeth are strong enough to chew on it. On the other hand, the plastron, which has less bone and more cartilage and therefore is easier to chew, is given to the older people whose teeth may not be as good.

When the processing was completed, Kalepo supervised the other workers in assembling the proper allotment for each family or inati group. To serve as a guide, he had a list of the 76 family names for Fakaofo and the number of people in each unit. The quantity and composition of the shares seemed to be very carefully considered before a decision was reached. Because a sizable amount of the turtle meat had been given to the visitors, it was necessary to incorporate portions of a village-owned pig so that each share would be adequate. When the apportionment was finally completed, all of the shares rested on palm frond mats spread out neatly on the ground. A call was then given throughout the village signifying that children from each family should come to the area. After everyone had arrived, Kalepo read off each name and the children came forward with a bowl or basket to claim their share. At that time, a few immature eggs were also added by the workmen. The food was subsequently taken back to each family home where it was prepared for the afternoon meal. Methods of cooking include wrapping the meat in leaves and baking it under fire-heated rocks, or grilling the meat directly on the rocks. The stewed blood, along with small pieces of meat and viscera that had been added, were not distributed but instead eaten by the workers when their duties were finished. The entire butchering and distribution process ended at about 11:30 a.m. and took 3-1/2 hours.

The activities that I observed at Fakaofo differed in a few respects from the information supplied by Macgregor (1937) for Atafu, and by Huntsman (1969) for Nukunonu. Macgregor (1937) mentioned that the person who first sighted a turtle was entitled to claim a larger share. None of my informants indicated that this practice is followed at the present time. Huntsman (1969) stated that at Nukunonu the parts of the male and female turtles were kept separate and used in equal quantities whenever possible to make up the shares. I saw no evidence of this at Fakaofo; however, the large portions of the meat that were given as gifts may have influenced the distribution procedure. For Nukunonu, Huntsman (1969) also indicated that the head, heart, liver, and kidneys, were allocated to either the Mission personnel, the doctor, the oldest man in the village, or the workers that processed the turtle. My informants at Fakaofo told me that until recently the head was presented to the oldest man in the village as a token of respect. Although this custom was not being followed at the time of my visit, there were plans to ask the Council of Elders to have it reinstituted. According to Kalolo Mika, the head of a turtle is always given to the oldest man at Atafu. Luciano Perez explained to me that the traditional "head portion" at Nukunonu incorporates some of the neck and a nice piece of adjoining meat from the pectoral area.

Based on the shell lengths, I estimated that the total edible weight of the two turtles distributed at Fakaofo was not less than 190 kg, or 280 g (0.62 lb) for every man, woman, and child that lives on the atoll. Using the same estimate for edible weight, and the data previously presented on human population and number of turtles captured, it is possible to compute the approximate average amount of turtle consumed per person during each breeding season. The resulting values would be 1.4 kg (3.1 lb) for Fakaofo, 5.4 kg (11.9 lb) for Nukunonu, and 2.5 kg (5.5 lb) for Atafu. These quantities make a distinct contribution to the protein nutrition of the Tokelauans. However, to be accurately appraised, the values must also be viewed in light of the enjoyment that is derived from eating this highly prized and savory food.

Other cultural aspects

During the course of my visit to Tokelau, and my literature search, a number of miscellaneous cultural components involving sea turtles were identified.

The school principal at Atafu, Tenise Atoni, told me that the uneaten bone scraps from the shares received by each family are usually thrown into the ocean in the belief that they will attract turtles to the atoll. In Hawaii the opposite view is held, at least for raw turtle parts and blood, and discarding such material into the sea is believed to drive turtles away.

There is a Tokelauan expression called "hila fonu" for a particular red sunset. Hosea Kirifi told me that when a hila fonu is observed a turtle is likely to come ashore in the evening. Macgregor (1937) also mentioned this expression, which he wrote as "la sila fonu" and translated as "the sun like a turtle's breastplate." This was listed as a descriptive Tokelauan phrase for an "orange reflection of the sunset in the clouds, common near the equator."

Macgregor (1937) stated that in the old days the ear lobes of all babies were perforated shortly after birth, and that earrings of turtle shells or bone were sometimes inserted later in life. Although a number of people that I encountered had a pierced ear, none of them had this type of earring. Macgregor (1937) also described the ancient use of turtle bones made into tattoo puncturing instruments (pakiau) and thatching awls for splitting pandanus leaves. I found no indication of these items being currently used. Tattooing is reported to have been banned when the missionaries first arrived.

Throughout the Pacific islands the thick horny scutes from the shell of the hawksbill turtle were formerly a premium material for making fishhooks. Two types were crafted in Tokelau: the one-piece hook used for line fishing with bait, and the composite hook used for trolling from a canoe or casting from shore (Macgregor 1937). Iron hooks and plastic lures have now replaced these traditional products, mostly because they are convenient to obtain, but also due to the present scarcity of adult hawksbills. I did, however, learn of a possible renewed interest in making the traditional hooks and teaching this skill to the younger generation. In this regard, I was even asked if I knew of a source where hawksbill scutes could be bought for such a purpose.

Tokelauan handicrafts are recognized as being among the finest in the Pacific islands. The most commonly produced items are woven baskets, fans and mats, and small boxes with tightly fitting lids carved from kanava wood. Two other crafted items also of superb quality, but less commonly seen, are carved wooden turtles and authentic-looking turtle shells. The shell replicas are usually made from Tournefortia ("tausunu") wood. Iere Kirifi of Fakaofo is a master woodcarver of these fine objects.

Since the willing conversion of the people to Christianity, there has been no form of worship to the ancient god Tui Tokelau, even though a portion of this coral-rock image is still present in the meeting-house at Fakaofo. An invocation said to Tui Tokelau in the old days asked that the heavens send down the necessities of life to their small atolls--rain, calm, light, coconut blossoms, fish, and among other things, "he tai fonu" (plenty of turtle).

Singing and dancing continue to be an integral part of the Tokelauan culture. One of the traditional songs for dancing that Macgregor (1937) recorded from Kalolo Mika's father in 1932 tells of a turtle hunt in which Tinilau, a mischievous character of Polynesian mythology, allows the turtle to escape. The title of this short composition is "Song of catching the turtle," and the translated words are as follows:

> "The turtle of the deep sea,
> The turtle of the deep sea is hunted.
> Chase away the young children.
> Who congratulates Tinilau
> Alas! there is nothing.
> Tinilau continues to dance."

RECOMMENDATIONS FOR CONSERVATION

The information brought together in this paper should give the Tokelauans a better perspective of the nature and limits of their sea turtle resource. As the first document of its kind dealing with the turtles of Tokelau, the report should also be a stimulus for discussions within the Council of Elders at each atoll. I am hopeful that this increased awareness and focus of attention will result in steps to strengthen the survival outlook of turtles and their traditional role in the Tokelauan culture.

The available evidence strongly suggests that there has been a long-term decline in the number of turtles breeding in Tokelau. There has also probably been a reduction in the size of the adults, considering that much larger turtles (tuahivivalu) are known to have existed in past years. The most probable major cause of this deterioration is the biological inability of the turtle stock to remain stable against the levels of harvesting of adults and eggs that have been carried out over the years. Although these excessive harvesting levels may be partially caused by hunting pressures at the distant (and unknown) feeding areas, it is likely that the greatest impacts result from catching too many turtles and digging up too many eggs in Tokelau where breeding occurs. All sea turtles are known to be particularly vulnerable at their breeding site. This is because the reproductively mature and ecologically more valuable adults converge at relatively small areas where they are more susceptible to capture due to their density, high visibility, preoccupation with mating, and excursions on land to nest. When these same adults are at their distant feeding areas, they are usually distributed over many miles of coastal waters, are not readily visible, and almost never go ashore. In the feeding areas they are simply much more difficult to find and catch.

In the past, the mechanisms used by certain Pacific islanders to protect turtle stocks from overharvesting included prohibitions on taking eggs or taking adults while they are on the beach, establishing certain motu as inviolate sanctuaries, permitting only a certain number of turtles to be captured, and restricting the consumption of turtles to chiefs. None of these practices seem to have existed in Tokelau, although possibly at one time there was a total ban on taking eggs, such as the one known at the closest neighboring atoll to the east, Pukapuka. Even without such a ban, I suspect that turtles in Tokelau were fairly well buffered during the old days because of the greater difficulties in traveling to the outlying motu and outside the reef to catch them. Also, a greater percentage of the turtles pursued may have evaded capture in the past when the iron hook-and-line technique was not employed, and outboard motors were not available. The fact that special rules governing the taking of turtles apparently were not imposed in Tokelau suggests to me that a very large supply of turtles may have existed in relation to the human population. If this was true, as it may very well have been, the governing elders and chiefs would not have felt any need to limit the number of turtles captured. In the resource-limited atoll environment of Tokelau, the appearance of large numbers of turtles at a certain time of the year, and their departure just a few months later, could understandably motivate the small human population to catch as many as their hunting capabilities and rate of consumption would allow. Under these fruitful conditions, which undoubtedly continued year after year with little perceptible change, there would have been no reason to believe that this particular resource actually did have limits. McCoy (1974) described such a philosophy in the Caroline Islands where the seasonal coming and going of breeding turtles have falsely engendered "a faith in their perpetual return."

Whereas fewer turtles now nest in Tokelau, they have by no means vanished altogether. However, if the downward trends continue, this unfortunate outcome could very well take place. There are a number of examples of this pattern at other Pacific islands to support such a prediction. Because of our present inadequate understanding of the population dynamics and life history of sea turtles, there are no proven or guaranteed methods for rebuilding a depleted stock. Nevertheless, there are a number of conservation practices that can reasonably be expected to aid in the restoration. Green turtles living in the wild may take many years, even decades, to grow to maturity, so the implementation of these practices cannot be expected to produce quick results. Instead, any sacrifices made by this generation of Tokelauans, by taking fewer turtles and foregoing egg collection, must be regarded as an investment to benefit their grandchildren and subsequent generations. This may be a difficult challenge for people living in a remote atoll environment. However, some action is essential if the turtle resource in Tokelau is to be sustained. From information I received during my visit, it would appear that the survival problems confronting turtles are similar to the difficulties being experienced by the kanava tree, which also takes many years to reach a large size. I therefore believe it is necessary for Tokelauans to consider turtles from the same judicious perspective as they now view the kanava tree. Both of these components of the environment require special management and planning for the future.

In conclusion, I will offer a list of conservation recommendations for the Council of Elders to consider at each atoll. In this list I have purposely only presented a basic framework. If the decision is made to adopt some of these measures, which I hope it will be, then the details must of course be worked out by the Elders themselves to ensure compatibilty with Tokelauan ideals and way of life. My suggested conservation measures or options to aid sea turtles in Tokelau are as follows:

1. The collection of eggs should be stopped at all three atolls. Eggs should be left in their nests on the beaches to incubate naturally and produce hatchlings that can replenish the turtle stock. Atafu has already initiated such a measure, and the other two atolls should follow this example. The collection of one or two egg clutches each season under the Elders' supervision would be appropriate to meet the needs of villagers who want to raise a few turtles for pets.

2. All hawksbill and loggerhead turtles should be granted full protection for at last 10 years in an effort to prevent these species from becoming extinct as a breeding stock in Tokelau.

3. At each atoll, some limit or quota should be placed on the number of green turtles that are captured. Currently, there are no limits and as many as possible are taken. Consideration should be given to taking more males than females, since each male is capable of fertilizing several females. In setting quotas, as many females as possible should be permitted to escape capture so they can lay eggs to replenish the stock. The females that are allowed to be taken should be captured later in the breeding season (November and December) after they have had the chance to lay eggs.

4. Any female taken on the beach should be allowed to first nest and lay her eggs.

5. Certain motu, or defined sections of known nesting beach at each atoll, should be designated as "turtle sanctuaries" for the purpose of replenishing the stock. No turtles or eggs should be taken from these sites.

6. The use of more efficient and so-called modern methods of catching turtles in the water should be discouraged. The traditional manner of catching turtles should be encouraged because it involves challenge, strength, skill, pride, and a sense of accomplishment.

7. Tokelauan sea turtles or their parts should not be sold for money. The turtles are simply too valuable of a resource to the culture. The selling of such a native resource, once started, is difficult to stop and is a proven social and ecological disruption.

8. The schools should include information in their teaching program that covers the interesting cultural, biological, and conservation aspects of sea turtles. The teaching program should especially focus on young children.

9. A special effort should be made to strengthen or restore any appropriate cultural aspect that involves sea turtles (i.e., songs, dances, folklore).

10. Consideration should be given to teaching the young people the skill of making traditional fishhooks for fishing purposes from the scutes of the hawksbill turtle. An ample quantity of the raw scutes needed for this purpose can probably be obtained at no cost from confiscated stock being held by U.S. Government officials in Hawaii. Under no circumstances should hawksbill scutes be bought from a commercial source, since this species is seriously endangered with extinction throughout most of its range.

11. Records should be kept of the shell length, sex, capture location, and number of turtles taken during each season. Also, if interest exists, tags should be used at each atoll to try to find out where the turtles go when they are not in Tokelau.

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I would like to express my sincere gratitude to the Council of Elders, the Faipule, and the Pulenuku of Fakaofo, Nukunonu, and Atafu for allowing me to visit their atolls to undertake this field study. I am also particularly grateful to Hosea Kirifi who originally encouraged me to pursue this work, and to John Larkindale, Official Secretary of the Office for Tokelau Affairs, for endorsing my research proposal and coordinating all aspects of the trip. Along with the people listed in the Appendix, everyone that I met in Tokelau displayed warm hospitality and made special efforts to answer my many questions. I am appreciative of their interest and assistance. As previously mentioned, Semu Uili was my principal translator, guide, and host. I want to thank Semu and his family for their help. Without Semu's direct involvement, it would not have been possible to achieve my objectives within the limited time available.

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Appendix: Persons interviewed in Tokelau

Nukunonu

Palehau Leone	- 84-year-old Elder
Lucianno Perez	- Fisherman and Principal of Matiti School
Henry Joseph	- Fisherman and Tokelau Public Service
Sister Juliana Perez Soln	- Catholic Mission
Niko Pule	- Fisherman
Kalolo Perez	- Tokelau Public Service

Atafu

Kalolo Mika	- 78-year-old Master Fisherman and son of Mika, Macgregor's (1937) principal informant
Amusia Patea	- Faipule
Tema Nouata	- Pulenuku
Tenise Atoni	- Principal of Matauala School
Aleni Viliamu	- Tokelau Public Service

Fakaofo

Nemia Tuvala	- 65-year-old Master Fisherman
Kalepo Mativa	- Tauvaega
Hosea Kirifi	- Tokelau Director of Education
Siniua Sosene	- Owner of captive-reared turtle
Elizabeth and John Pereira	- Fisherman and resident
Moana Rimoni	- Resident
Mr. and Mrs. Fetalaiga Uili	- Fisherman and resident
Senitu Iasona	- Participant in inati ceremony
Sakaria Petelesio	- Tokelau Public Service
Janeta Siaon	- Resident

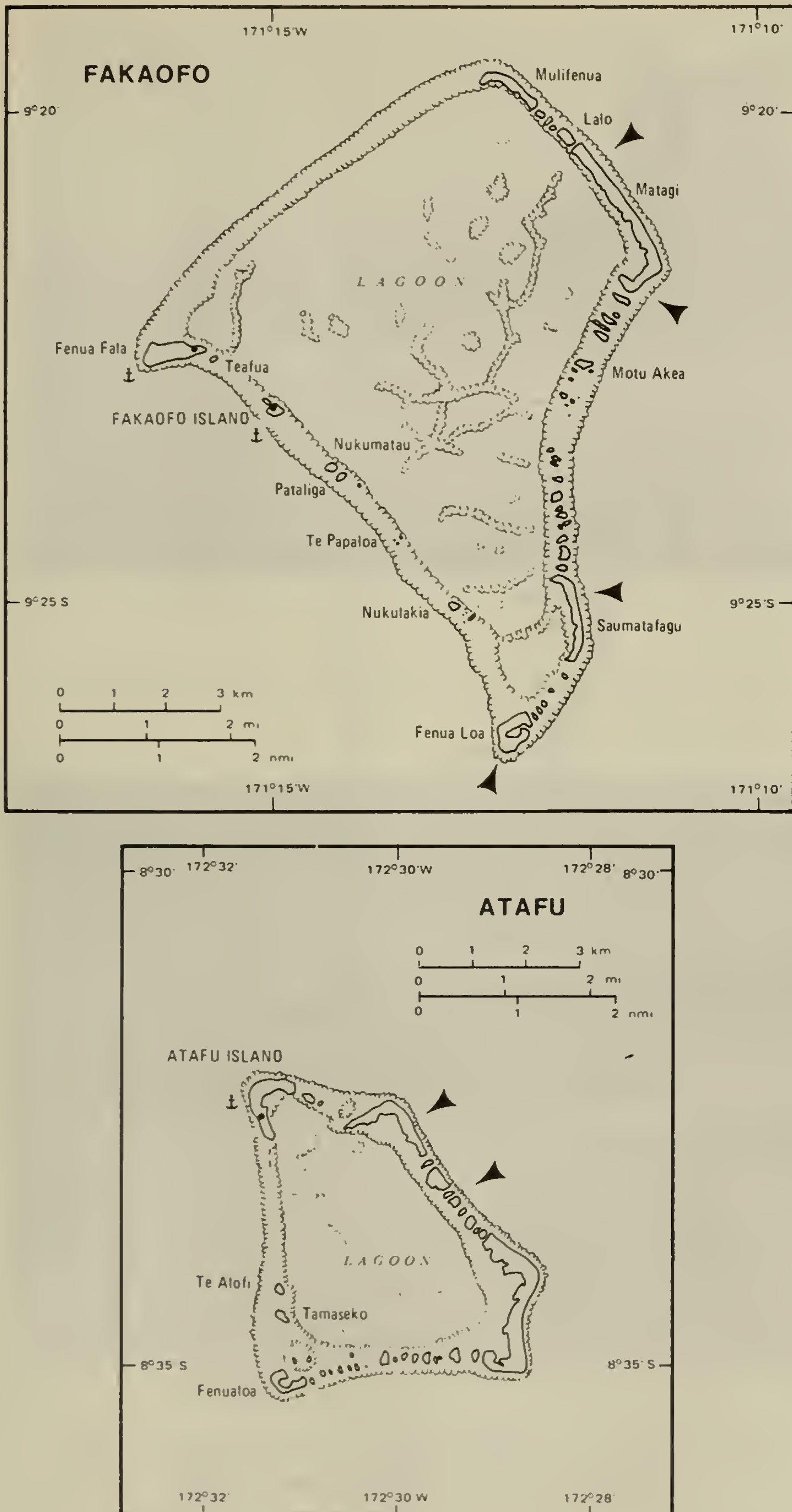

Fig. 2. Principal nesting areas at Atafu and Fakaofo

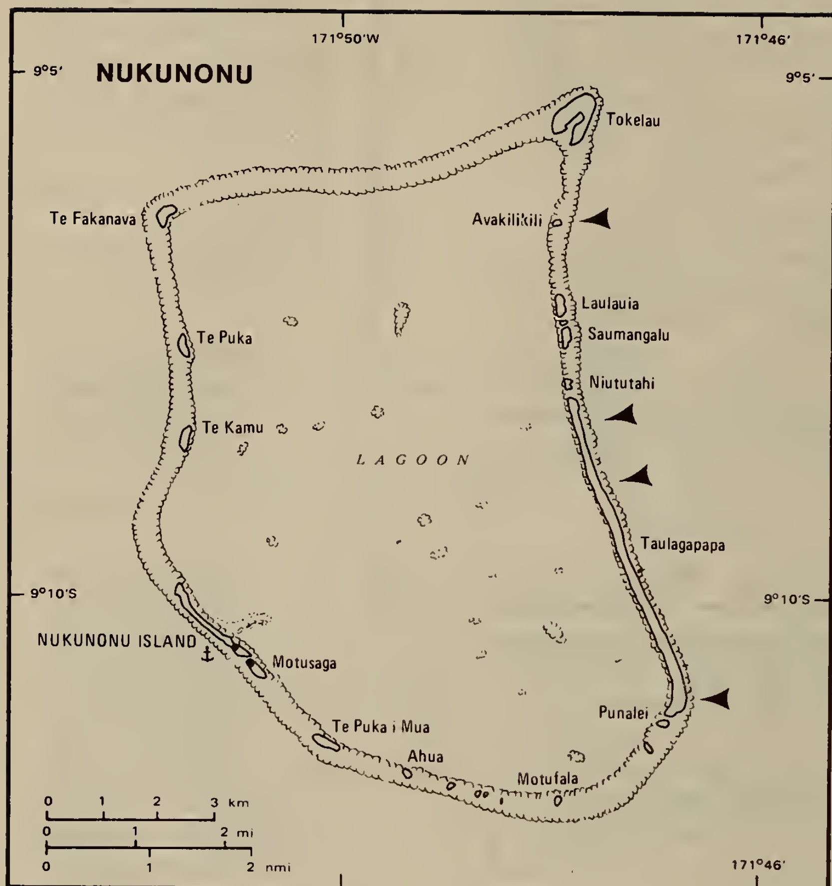

Fig. 3. Principal nesting areas at Nukunonu

1. Nesting beach at Nukunonu at low tide

2. Ocean shoreline at Atafu showing jagged coral rock and wrecked Taiwan fishing vessel

3. Henry Joseph with the 104-cm carapace of a green turtle caught at Nukunonu

4. Adult female green turtle caught while stranded on the reef at Fakaofo

5. Adult male green turtle caught at Fakaofo

6. Siniua Sosene at Fakaofo with her captive-reared pet green turtle

7. Kalepo Mativa, the tauvaega of Fakaofo, presiding over the distribution of turtle

8. Village children at Fakaofo after receiving their family share of turtle meat and immature eggs

9. Village landing and small boat channel at Fenua Fale, Fakaofo; the MV Frysna is offshore

10. Village landing at Nukunonu

11. Master Fisherman Kalolo Mika and relatives in their family home at Atafu

12. Fleet of aluminum boats with outboard motors anchored off Fenua Fala at Fakaofo

ATOLL RESEARCH BULLETIN

No. 280

A PRELIMINARY SURVEY OF THE VERTEBRATES OF CABARITA ISLAND, ST. MARY PARISH, JAMAICA

BY

RONALD I. CROMBIE, DAVID W. STEADMAN AND JOHN C. BARBER

ISSUED BY

THE SMITHSONIAN INSTITUTION

WASHINGTON, D. C., U.S.A.

DECEMBER 1983

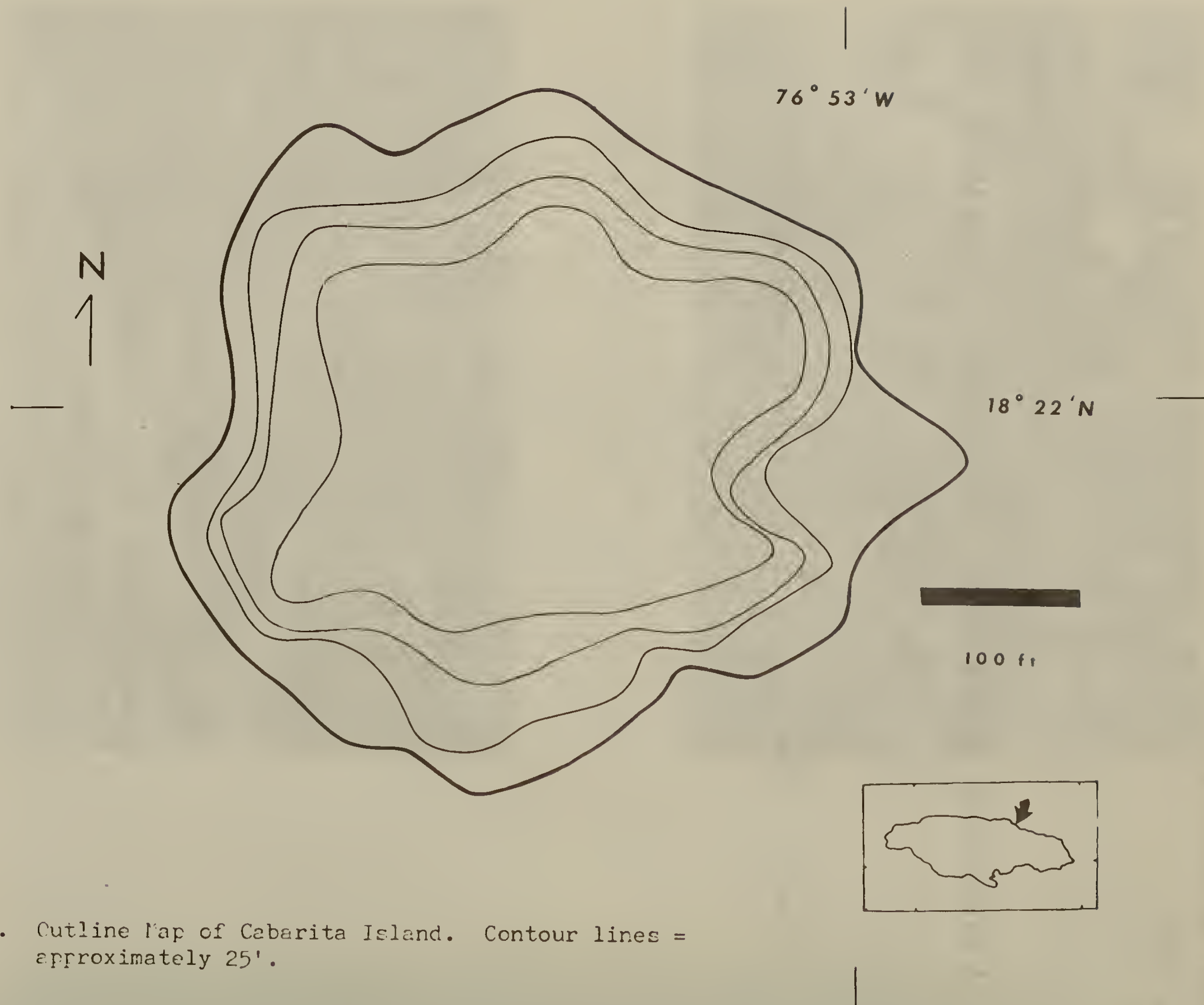

Fig. 1. Outline Map of Cabarita Island. Contour lines = approximately 25'.

A PRELIMINARY SURVEY OF THE VERTEBRATES OF CABARITA ISLAND, ST. MARY PARISH, JAMAICA

BY

RONALD I. CROMBIE, DAVID W. STEADMAN AND JOHN C. BARBER *

Introduction

Jamaica is unusual among Greater Antillean Islands for its paucity of offshore cays and islets. The Pedro and Morant Cays are 50-100 km off the south coast and consequently too far offshore to show strong Jamaican influences. Their terrestrial faunas, while poorly known, appear depauperate and consist of waif species, both Cuban and Jamaican in origin. Closer inshore there are a number of other low cays along the south coast, particularly in Portland Bight and off the Palisadoes Peninsula (the Port Royal Cays). Several of these islets were discussed and their vegetations mapped by Steers (1940), Steers et al. (1940), and Asprey and Robbins (1953); their faunas have never been documented. Even more poorly known are the two north shore islets, Navy Island, off Port Antonio (Portland Parish) and Cabarita Island, off Port Maria (St. Mary Parish). As its name indicates, the former is occupied by a Navy installation and the natural habitats are considerably altered. Cabarita Island, however, is a steep-sided speck of land of no special commercial importance, despite its proximity to the city of Port Maria.

Elsewhere in the Antilles, satellite islands are well known as centers of endemism or as refugia from mainland habitat destruction (see lists in Maclean et al. 1977, Honegger 1981, Lazell 1967, Schwartz 1970). With this in mind, we spent 23 hours surveying the fauna of Cabarita Island. Although we do not tout this list as being absolutely complete, we nonetheless feel it valuable to document these preliminary data, particularly considering the rapidity with which small insular faunas can be changed or destroyed.

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Materials & Methods

We left Paggee Beach, Port Maria in a fishing dinghy on 16 April 1978 at approximately 1000 hours. We circumnavigated Cabarita Island, which is approximately 0.6 km north of Port Maria, and landed at the one ascendable slope on the southwest end of the island, directly opposite the beach. We set up camp on the north, windward side in a semi-open area between the edge of the woods and the sea cliff. In clearing the camp area we each carefully sorted through the leaf litter on hands and knees, collecting any organisms found. We then did a general walking survey of the island; rocks, logs, and other ground cover were turned, dead palm fronds and bark were stripped from trees, cultivated plants were examined and tree holes were inspected. Three mist nets were set (60 total net hours), two in the woodland and one at the ecotone between the garden plot and the forest. Later in the afternoon we spent approximately four man-hours carefully searching additional litter plots (1 x 1 m) in an undisturbed area of the forest about 5-10 m west of camp. A few hours before dark we waded and swam around the base of the island, collecting on the accessible slopes and setting mist nets at two small sea cave entrances. A large cave (Fig. 6) was also examined but no traces of bats were seen or smelled. Several mammal snap traps were also set, on horizontal tree trunks in the forest and on the ground in the garden. After dark, we re-walked the entire plateau using headlamps to search for nocturnal organisms.

We returned to the mainland at approximately 0900 hrs on 17 April. Collections for comparative material on the mainland were made 11-12 and 15 April and additional distributional records for the area were taken from the literature. Faunal samples from the four major habitats on Cabarita (forest, natural clearings, garden, slopes) were kept separate. All vertebrate specimens were identified and deposited at the National Museum of Natural History (USNM). Invertebrate material was also collected and deposited at the Florida State Museum, University of Florida.

In the following species accounts, we use currently accepted systematics: Schwartz & Thomas (1975) for amphibians and reptiles, Bond (1980) for most birds, and Varona (1974) for mammals. Since common names for amphibians and reptiles are not standardized, we have used the Jamaican local term first for each species, then an English common name in parentheses, if one exists.

Description of the Island

Cabarita Island (Fig. 1) is shown as "Coral Reef--Quaternary" on the 1:250,000 Geological Map of Jamaica (Geol. Survey Dept. of Jamaica, 1959). It is a steep-sided plateau (Fig. 2), roughly 0.01 km^2 in area and 30 m above sea level. The southwest side of the island is sandy and slightly less steep, affording access to the plateau. The vegetation on the slope consists of sea grape, palmetto, ferns, and scrubby vegetation. At the top of the trail, the natural vegetation had been cleared and a garden had been planted (Fig. 3). Active clearing and burning was still going on and most of the destruction did not look more than a year old. The layer of soil was thin and distributed in pockets but beans, corn, and plantain had been planted wherever possible.

Beyond the cleared area the rest of the plateau is covered mainly with a canopied (8-10') hardwood forest (Fig. 4). This woodland is well shaded and open with very little undergrowth except at the ecotone. Leaf litter is thick, particularly in solution holes. The forest thins on the northeast side where it is replaced by a thick growth of a low, windblown, shrub with occasional stunted palms (Fig. 5). There is a small bay on this side with an offshore promontory, connected to the island by a barely inundated reef. The north and west sides are vertical cliffs for 10-15 m, with slightly less precipitous lower slopes that support sparse growths of palms.

Our survey of the island yielded records for twenty-two species of vertebrate (2 mammals, 13 birds, 5 reptiles, 2 amphibians), as outlined below.

AMPHIBIANS AND REPTILES

Bufo marinus (Linnaeus, 1758)--Bullfrog (Marine Toad)

Although no toads were found by day, at least four individuals (2 adult males, 2 adult females) were seen after dark. All were in the garden area or in the forest immediately adjacent to it but one individual appeared at our camp at about 0400 hours on 17 April, indicating mobility across the whole plateau.

These toads are not native to mainland Jamaica, having been introduced in 1844 (Gosse 1851:425-431). Undoubtedly the Cabarita population was also intentionally introduced, probably by the person who planted the garden. The motivation for the introduction is unknown, but the toads' efficiency in controlling insect pests is well documented. There is also considerable belief in Jamaica that B. marinus can control rat populations (Gosse 1851:431).

Nonetheless, the introduction cannot sustain itself since B. marinus requires standing water to breed. Cabarita has no fresh surface water and although sinkholes could accumulate pools during heavy rain, this water would percolate away before metamorphosis could be achieved (30-60 days; Zug & Zug 1979:11).

We collected one specimen (USNM 233927), a unicolor, keratinized male with nuptial pads and enlarged testes. The other male also had well-developed nuptial pads but neither of the females was obviously gravid (i.e., no substantial egg masses were palpable).

Eleutherodacytlus c. cundalli Dunn, 1926--Toad

Of the four species of Eleutherodactylus on the adjacent mainland, E. cundalli was least expected on Cabarita. However, one call of this species was heard an hour after dusk as we checked the net at the garden/forest border. No additional calls were heard but E. cundalli is not an extremely vocal species. The quiet, twittering, insect-like call is typical of frogs of the ricordii group (Schwartz 1958, Crombie 1977) and often is not audible at any distance.

Later in the evening, a 22.7 mm adult male (USNM 233872) was collected as it sat silently on a dead palm frond at the edge of the forest on the west side, from very near where we estimated the call had come earlier. This is a typical calling site but the habitat is somewhat unusual. Eleutherodactylus c. cundalli is a semi-arboreal frog that is most abundant and widely distributed in the wet limestone forest (terminology of Asprey and Robbins 1953) of western and central Jamaica (Schwartz & Fowler 1973, Stewart 1977). It is poorly adapted to hot, dry conditions (Pough et al. 1977), but it is found in some coastal areas of dry limestone scrub forest. This is a peripheral habitat, however, and the species is not as abundant there.

It is possible that a single frog or perhaps several individuals were unintentionally introduced on plants in the garden but only a few small banana trees were not grown from seed. Eleutherodactylus cundalli does occasionally use banana axils for a diurnal retreat (Schwartz & Fowler 1973:73; Crombie, pers. obs.);

Anolis g. grahami Gray, 1845--Tree Lizard (Graham's Anole)

Five specimens were collected (3 males and 2 females, USNM 233888-92), primarily around the agricultural area, where it was much more common than A. lineatopus merope. Only a few females were seen in the forested part of the island.

Underwood and Williams (1959:29) comment that Cabarita Island grahami were slightly more yellow-green dorsally than typical for the nominate subspecies and our observations confirm this. Both females were bright lemon yellow ventrally with dull orange in the dewlap area. Dewlaps of males were bright orange with faded yellow scales.

Intergradation with A. g. aquarum occurs ca. 6-7 km east of Cabarita on the mainland.

Anolis lineatopus merope Underwood & Williams, 1959--Tree Lizard (Anole)

Three adult males and five females (USNM 233893-900) were collected in the forested section of the island. They were much less common at the edge of the woods and almost absent from the portion that had been cleared for a garden. A. lineatopus was replaced by A. grahami at the ecotone and more exposed areas.

Underwood & Williams (1959) reported A. l. merope from Cabaritta (sic) Island and commented that males from the island have "a strong orange center to the throat fan in contrast to the more western specimens." In our three males, both USNM 233893 and 233895 had very pale yellow dewlaps with a concentrated bright yellow-orange central blotch. USNM 233894, however, had a faint, diffuse smudge of orange in the middle of the dewlap. Females had bright orange chins and undersides of tails.

Anolis l. merope occurs along the north coast of Jamaica from Hanover Parish to eastern Saint Mary parish, almost invariably in coastal areas but extending inland along the Wag Water River drainage.

Underwood & Williams (1959:37) felt that this species was characteristic of exposed dry coastal areas but the Cabarita Island population definitely preferred the shaded, interior of the island.

Aristelliger praesignis (Hallowell, 1856)--Croaking Lizard

These large geckos were found primarily in the forested part of the island. One large adult male, four females, one subadult and one juvenile were collected (USNM 233873-79); two of the females were gravid but no eggs were found. Most individuals were found under bark on dead trees but the one large male was found under a large flat limestone slab in an open area at the top of the bay slope on the southeast promontory.

Although A. praesignis is normally a very vocal species, we heard no calls at dusk or after dark. Several individuals were observed emerging from tree holes at dusk but they moved toward the tops of the trees without vocalizing.

Sphaerodactylus argus argus Gosse, 1850--Pawli Lizard

This species was only seen on the steep slopes of the island, where two individuals (USNM 233880-81) were collected under limestone rubble and palm trash. Both were strongly spotted with the ocelli irregularly arranged (see Thomas, 1975). Several hatched eggshells were found but neither of our specimens was reproductively active.

Although S. argus is an ecological generalist and is abundant in virtually all available habitats on the mainland, it was absent from the plateau of Cabarita. Extensive collecting in the forest and the cleared areas yielded only Sphaerodactylus sp.

Sphaerodactylus sp.--Pawli Lizard

This is a new species of the goniorhynchus group, currently under study by Richard Thomas. It is abundant in the forested part of the island, but is apparently absent from disturbed areas and the dry, steep slopes. We collected 6 specimens (USNM 233882-87). They were active in the leaf litter during the day and could also be found under small rocks in leaf litter. One individual was seen under a large rock near the edge of the forest but it escaped down a land crab hole, closely followed by the crab. Several communal nests (30-40 hatched egg shells) were found inside rotten logs but no viable eggs were seen, nor were any of the collected specimens gravid.

On the mainland, this species is widely distributed in primarily coastal areas. Although most of the localities where it has been collected are xeric, the lizards occupy the most moist microhabitats within the area.

BIRDS

Phaethon lepturus Daudin, 1802--White-tailed Tropic bird

One individual was seen at 1100 on 16 April, flying on the south and west sides of the island.

Fregata magnificens Mathews, 1914--Magnificent Frigatebird

One adult male was seen at 0900 on 17 April, soaring directly over the island.

Nyctanassa violacea (Linnaeus, 1758)--Yellow-crowned Night Heron

Fifteen individuals, at least twelve of which were adults, roosted during the day in the trees on the steep slopes of the southwest corner of the island. They were heard often throughout the night on 16-17 April.

Cathartes aura (Linnaeus, 1758)--Turkey Vulture

One to five individuals were usually in evidence both days, soaring above the island throughout the day. On 17 April Crombie found a nest with a clutch of two eggs being incubated by an adult. The nest, at an elevation of 8 m, was on the south side of the island, on a protected ledge of the steep slope. It was a circular depression (25 cm in diameter) in leaf litter, containing no foreign material other than several of the adults' feathers. The adult remained nearby during the investigation of the nest, which was photographed by Barber.

Falco peregrinus Tunstall, 1771--Peregrine Falcon

One individual was seen flying between the island and the mainland at 1100 on 16 April. From its size and color of the back, it was probably an adult male.

Sterna maxima Boddaert, 1783--Royal Tern

One individual was seen flying between the island and the mainland at 0800 on 17 April.

Columba leucocephala Linnaeus, 1758--White-crowned Pigeon

Two individuals were seen flying across the agricultural area the morning of 17 April. No vocalizations were heard.

Zenaida macroura (Linnaeus, 1758)--Mourning Dove

Three different individuals were calling simultaneously on both days, one near the east-northeast side of the island, one near the west edge of the island, and one in the central or south central part of the island. The former two were in the canopy of undisturbed forest, whereas the latter may have been in or near the agricultural area. Lack (1976:219) records this species in Jamaica only from the relatively arid southern coastal area. We did not find *Z. macroura* anywhere else on the northern coast of Jamaica.

Zenaida aurita (Temminck, 1810)--Zenaida Dove

Two different individuals were calling simultaneously on both days, one near the east edge and the other near the southwest edge of the island. Both were in or near the agricultural area. Two individuals were seen in the agricultural area at 0730 on 17 April.

Hirundo rustica Linnaeus, 1758--Barn Swallow

Two individuals at 1200 on 16 April and three individuals on 17 April were seen flying over the island. In both cases they were feeding with larger numbers of *Hirundo fulva*.

Hirundo fulva Viellot, 1807--Cave Swallow

Approximately 50 individuals roosted and nested in a sea cave on the southwest side of the island (Fig. 6). The cave's opening was 4 m high, and approximately 6 m wide, with a maximum depth of about 6 m. Many cup-like mud nests were attached to the ceiling and walls. Although two nests at lower heights in the cave contained no eggs or young birds, our presence in the cave flushed about 25 individuals from their nests, suggesting nesting activity. Cave Swallows foraged about the island and surrounding water throughout both days.

Vireo altiloquus (Viellot, 1808)--Black-whiskered Vireo

One individual was heard singing, but was not seen, on the northeast side of the island at 1300 on 16 April and at 0720 on 17 April.

Mniotilta varia (Linnaeus, 1766)--Black-and-White Warbler

One individual was taken in a mist net in the forest near the center of the island at 0900 on 17 April. It was preserved as a skeleton, USNM 553107, male, not quite in full breeding plumage, left testis 5x3 mm, fat moderate.

MAMMALS

Glossophaga soricina antillarum Rehn, 1902--Nectar Feeding Bat

Six pregnant females (USNM 534887-92) were netted, five at the edge of the agricultural area, and the other within the forest.

Rattus cf. rattus (Linnaeus, 1758)--Black Rat

Rats were extremely abundant on the island, but we were unsuccessful in trapping any. Rat traps, especially those set on tree limbs or or horizontal trunks, were sprung during the evening but the rodents escaped, often leaving tufts of hair.

Nocturnal surveys revealed dozens of rats, usually in the canopy of the forest but several were seen near the garden plot. Throughout the night, our bodies and gear were subjected to intense investigation by adult and juvenile rats.

DISCUSSION AND SUMMARY

With the possible exceptions of Anolis g. grahami and Zenaida macroura, the vertebrate fauna of Cabarita Island is a depauperate subset of that found on the immediately adjacent mainland, with no indications of endemism or differentiation. Anolis grahami on Cabarita differs slightly in coloration from those on the adjacent mainland, but this is not necessarily due to evolution in situ (see below). Zenaida macroura is known only from the arid portions of southern Jamaica but it may be becoming more widespread as habitats are opened up.

The fauna of Cabarita Island consists of forms that arrived by natural means and some that received human assistance, intentional or otherwise. The toads and rats are undoubtedly the result of human introduction. The rats may have been accidentally brought to the island on ships that docked in Port Maria harbour, either recently or with early Antillean explorers. The toads, however, are a recent, intentional introduction. The other frog (Eleutherodactylus cundalli) may also have been an introduction; if so, it was accidentally brought over from the mainland, probably on agricultural material. Since Eleutherodactylus are too small to be of commercial importance, most intentional West Indian introductions of the genus involves species with an aesthetically pleasing call. These "whistling frogs", "bo peeps", or "coquis" have been transported to several Antillean islands where they are not native. Eleutherodactylus cundalli has a quiet, insect-like call that few people would find aesthetic and, considering that nobody resides on Cabarita, E. cundalli is an unlikely candidate for intentional introduction.

Eliminating these "non-natural" elements of the fauna, the problem remains as to how the other 19-20 species arrived on the island. This is simply explained for the volant forms (birds and bats), given the short distance (approximately 0.6 km) to the mainland. In fact, many of the birds and the bat may not be permanent residents on the island. Its small size and limited food resources would make it difficult for Cabarita to support anything more than very small populations. However, since the island is (or was) somewhat difficult of access, it may have offered a refuge from human-related disturbances on the mainland, thereby explaining the heron roost and vulture nest.

No species of bird endemic to Jamaica was found on Cabarita; the thirteen species we recorded are all widespread in the Greater Antillean region. Two species (Cathartes aura and Hirundo fulva) definitely nest on Cabarita and four species definitely do not (Falco peregrinus, Hirundo rustica, Mniotilta varia are migrants; suitable habitat is lacking for Sterna maxima). We found no nests of Nyctanassa violacea but their roosting area contained possible nesting sites. Phaethon lepturus nests on cliffs facing the sea and Fregata magnificens on low trees near the water's edge, habitats found in abundance on Cabarita. F. magnificens usually nests in conspicuous colonies and we found no traces of them. The remaining four species (Columba leucocephala, Zenaida macroura, Z. aurita, Vireo altiloquus) are all "land birds" (as defined by Lack, 1976) and limited suitable habitat for each is present on Cabarita. It is not surprising that this group contains three species of columbids, which are known to be wanderers and good colonizers. The cleared agricultural area may be partially or wholly responsible for the two smaller columbids, Zenaida macroura and Z. aurita, which feed solely on the ground (Lack 1976:248). Vireo altiloquus occurs in a wide variety of habitats. The presence of Hirundo fulva is explained by the existence of the cave and is largely or completely independent of the island's flora.

Colonization of the island by nonvolant forms is somewhat more problematical, since the dominant wind and current patterns are from the northeast (i.e., from the island towards the mainland), making rafting difficult under normal conditions. Storms could have brought the original propagules to the island since many storm tracks in recorded times have been from the southeast towards the northwest. Hurricanes proceeding across the island in that direction could easily have driven trees, logs or driftwood containing adults and/or eggs of any of the lizards across the narrow channel from the mainland to Cabarita. An equally similar scenario could result in colonization from farther east (i.e., Portland Parish). Storms would swell the streams in the Blue Mountains, causing a rise in the level of the many rivers that drain the northeast coast (Rio Grande, Wag Water, Swift, Spanish, and Buff Bay Rivers). Floating islands of vegetation often result under such conditions (King 1962) and vertebrates can be carried along on these rafts. Upon reaching the coast, currents would carry the islands west or northwest and those that were pushed close to the coast would be caught in the natural trap of Port Maria Bay and Cabarita Island. This could explain the apparent (slight) trend of Cabarita Anolis grahami towards the eastern subspecies, A. g. aquarum, when the adjacent mainland is pure A. g. grahami.

Sphaerodactylus sp., Aristelliger praesignis, and both species of Anolis appear to have been resident on Cabarita for some time, since they occupy the more "natural" habitats and have relatively dense populations. _S. argus_, however, seems to be a recent, and probably natural, arrival. Its peripheral, sparse distribution on the slopes of Cabarita and the lack of even slight differentiation from mainland populations makes it a very likely recent adventive. Since _S. argus_ has a calcareous egg that is relatively impervious to sea water and it is found commonly in driftwood of the supratidal zone in Port Maria, it is hard to imagine that the species would _not_ have reached the island.

Although a great deal of distributional data on West Indian vertebrates has been accumulated in recent years, much still needs to be done and little time remains to do it. The burgeoning human populations of West Indian islands and their efforts to become economically self-sufficient have put a prime importance on space for development. Entire islands and their faunas can be erased in a span of months; the Bogue Islands off Montego Bay are a good example. Since every piece of the puzzle is important in determining the overall Antillean zoogeographic picture, we cannot afford to lose even small pieces like Cabarita Island without documenting its fauna.

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Fig. 2. View of Cabarita Island from Paggee Beach, Port Maria.

Fig. 3. Agricultural area near southwest side of Cabarita Island, showing selected clearing of natural forest.

Fig. 4. Windblown scrub on northeast slope of Cabarita Island.

Fig. 5. Trail through hardwood forest, interior of Cabarita Island, near camp.

Fig. 6. Sea cave southwest side of Cabarita Island, nesting site for a population of cave swallows (Hirundo fulva).

ATOLL RESEARCH BULLETIN

No. 281

CORAL ASSEMBLAGES OF REEF FLATS AROUND PULAU PARI, THOUSAND ISLANDS, INDONESIA

BY

B. E. Brown, M.C. Holley, L. Sya'rani and M. Le Tissier

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CORAL ASSEMBLAGES OF REEF FLATS AROUND PULAU PARI, THOUSAND ISLANDS, INDONESIA

BY

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Abstract

A spectrum of physical influences, resulting from the reversing monsoons, governs the distribution of corals on reef flats around the Pulau Pari complex of islands in the Java Sea, Indonesia, with greater diversity in the relatively sheltered southern reefs and reduced diversity on the more physically exposed northern reefs. A total of 74 species were recorded on southern reefs as compared with 43 species on the exposed northern reef flats.

The outer reef flats at all sites were dominated by *Acropora* species which showed a distinct zonation pattern. *Acropora pulchra/aspera* species dominated the unconsolidated landward section of the outer reef flat, *Acropora digitifera* occupied the mid-seaward section, while *Acropora hyacinthus* colonised the seaward edge.

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INTRODUCTION

Umbgrove (1929) was the first scientist to study the reefs of the Java Sea in detail. In these early studies Umbgrove recognised the important role of physical factors both in governing the morphology of the islands and the structure of benthic communities or "facies" comprising the reef flats. In 1975 Rosen proposed a similar scheme for reefs in the Indian Ocean, with different coral assemblages reflecting exposure to varying levels of wave energy and light. Other workers have recently shown the importance of exposure to wave energy in controlling reef development (Bradbury & Young 1981, Brown and Dunne 1980, Chappel 1980) and reef diversity (Grigg and Maragos 1974, Dollar, 1982).

Clearly then wave energy may be paramount in determining both reef type and resulting community structure in shallow waters. The present study presents data on the influence of reversing monsoons on the composition and zonation of reef flats in the Java Sea, an area little studied since the extensive work of Umbgrove in the early part of the century.

MATERIAL AND METHODS

a) Study site

The Pulau Pari complex of islands is situated at the southerly end of a chain of more than a hundred islands, commonly known as the Thousand Islands, which extends NNW - SSE across the Java Sea towards the Sunda Straits, Indonesia (Fig. 1).

The island complex is composed of Pulau Burung, Pulau Tikus, Pulau Kongsi and Pulau Tengah, the islands being separated from each other by a system of lagoons (Fig. 1). The islands are surrounded by well developed fringing reefs with prominent shingle banks on the north east and east rim.

The dominant physical influence in the area is the reversing monsoon wind. Umbgrove (1929, 1930) related the monsoons to be geomorphology of coral islands in the Thousand Islands and concluded that the more southerly islands of the group were subject to a strong wind effect from the north west quarter (the westerly monsoon which prevails from December-April) and an even stronger wind from the east (the easterly monsoon which prevails from May-November).

The Thousand Islands are also strongly influenced by the effects of reversing currents - Umbgrove noted that the reefs and islands of the group were aligned in the direction of their long axes and attributed this to the erosive effects of a current which runs along the north coast of Java, eight months westward and four monts eastward. The latter current is described as twice as fast as the westward current and Umbgrove quotes figures of 28 and 17 cm sec^{-1} for currents in the open sea of the region during the west and east monsoons respectively.

The tidal cycle for Jakarta shows a range of approximately one metre between high and low tide levels throughout the year. Salinities in the area vary between 31 - 33%.

b) Reef surveillance

Five areas were chosen for study (Fig. 1) using methods adopted by Loya (1978). After plotting a species/area curve, 10 m long measuring tapes were place at 5 or 10 m intervals across the inner reef flat and the percentage coral cover of individual colonies noted. Measuring tapes were placed at 2 m intervals across the outer reef flat areas. All observations were made by snorkelling.

RESULTS

The reef flats around the islands of Pulau Pari are characterised by an extensive sand flat (up to 500 m in extent), an inner reef flat, a shallow moat, an outer reef flat (varying from 10 - 20 m in width) and on the north east and east rim of Pari Island prominent shingle ramparts.

a) Species composition

A total of. 88 coral species from 28 genera were recorded (Table 1) on transects across reef flats at all sites, with southern reef flats showing greater diversity in terms of number of species than northern reefs. A total of 74 species was recorded on southern reef flats, while only 45 species were noted on northern reef flats.

b) Species distribution

Figure 2 illustrates the percentage living and dead cover of all corals and also the distribution of the dominant genera with respect to distance across the reef flat at all sites.

In almost all cases coral cover generally increased across the inner reef flat to reach a maximum in the moat area with dead coral cover reaching a maximum on the landward edge of the outer reef flat. After this point living coral cover rapidly increased up to and beyond the reef front.

Montipora ramosa occupied the inner reef flat at all sites, being particularly conspicuous at site 1, where it accounted for about 80% of the total coral cover. In addition it was abundant in the moat areas of sites 2, 3 and 5. Micro atolls of Heliopora coerulea were also conspicuous in the moat at site 3.

Stands of Porites species (Porites lutea, Porites attenuata, Porites nigrescens, Porites andrewsi and Porites (Synaraea) iwayamaensis) were obvious only on the southern reefs, particularly at site 5 where they accounted for more than 50% of the total cover.

All the outer reef areas were dominated by Acropora species and only at site 1 was Montipora foliosa abundant. At site 2 encrusting and branching Montipora species (Montipora informis, Montipora composita, Montipora levis and Montipora tortuosa) accounted for 35% total midway across the outer reef flat.

Figure 3 illustrates a distinct zonation pattern for Acropora species on the outer reef flat which was particularly marked at sites 1, 2, 3 and 4. At these sites the number of Acropora species recorded varied between 3 - 6, the common dominant species being Acropora aspera/pulchra (these species being included together because of the difficulty in separate identification on the reef flat (Wallace 1978)). Acropora digitifera and Acropora hyacinthus with Acropora formosa occurring abundantly at site 2. The relatively limited number of Acropora species recorded at these sites contrasted markedly with the more diverse outer reef flat at site 5 where 14 Acropora species were identified.

Generally Acropora aspera/pulchra species favoured the unconsolidated landward edge of the outer reef flat where broken coral fragments survived the breaking waves to the exclusion of other species. Acropora digitifera successfully colonised the mid-seaward edge of the outer reef flat while plates of Acropora hyacinthus dominated the reef edge. At site 5 this zonation pattern was not as clear as that described at other sites. The cover of each individual species was low being less than 12% of the total transect, compared with individual covers of between 30-60% for Acropora aspera/pulchra at site 2 and 35% for Acropora hyacinthus at site 1.

DISCUSSION

There is a very clear resemblance between the reefs described in this paper and those described to the south in the Bay of Batavia by Umbgrove (1939). The wind rose described for reefs in the Bay of Batavia, with the greatest "wind effect" on the northern reefs and the least influence on the south western reefs appears to hold in the Pari Island complex. The wind rose actually proposed (Umbgrove 1929) for islands in the southern sector of the Thousand Island group with the greatest "wind effect" on north west and south east reefs and relatively little influence on the north east sector certainly does not fit observations made in the present study. Features noted at Pari Island such as the Montipora ramosa dominated moat, the northerly located shingle ramparts and the abundance of Montipora foliosa on the north west side of the island complex are all characteristics of reefs described by Umbgrove in the Bay of Batavia.

There are however important differences to be noted between the reefs of the Bay of Batavia and the Pari Island complex in the southerly Thousand Islands. Firstly the shingle ramparts of Pari Island are restricted to the north east and eastern sectors of the complex and do not extend along the entire northern border as described for reefs in the Bay of Batavia. Secondly Umbgrove describes the reefs of the south west sector of the islands of the Bay of Batavia as showning an impoverished reef facies because of the strong sedimentation effect in this area. Within the Pulau Pari complex the reefs of the south west sector constitute a much more diverse coral assemblage than any other encountered in the present study. Table 1 and Figure 3 reflect the diversity of corals at site 5 with 57 species recorded here compared with between 20-27 noted for the northern reefs; the outer reef flat at site 5 exhibiting a particularly high diversity of Acropora species.

The relatively high diversity observed at site 5 may be explained by two factors - protection from severe wave action and the greater depth of water (40 cm) covering the reef flat at low water when compared to the depths (5 - 10 cm) recorded at sites 1 - 4 (Sya'rani - unpublished). The southern reefs (sites 4 and 5) appear to be relatively protected from monsoon influences since Porites assemblages, characteristic of sheletered waters (Rosen 1971, 1975) are found at both sites.

Clearly the degree of physical exposure is critical and it may be that a reversing monsoon influence where certain sites are exposed to strong physical influences for only part of the year provides suitable conditions for coexistence of numerous coral species. Species capable of withstanding heavy wave surge such as Acropora aspera/pulchra with high growth rate (Yap and Gomez 1981 and reproduction by fragmentation (Bothwell 1981 [1982]) colonise the outer reef flat together with more fragile platelike species in a characteristic high energy Acropora assemblage which includes encrusting and branching Montipora, Porites, Pavona and faviid species. In this way high diversity and high cover is maintained in the shallow and well illuminated waters of the outer reef flat.

Although several workers (Grigg and Maragos 1974; Porter 1974) have described observed differences in diversity and cover of reef communities in terms of Sanders stability-time hypothesis, Sanders (1968) himself states that there is no such thing as a "pure" physically controlled or biologically accommodated community. The reefs surrounding the Pulau Pari complex are the result of both physical and biological influences and so represent intermediates on the gradient between these extreme types of community; reefs to the north showing a tendency towards physically controlled systems while the more diverse southern reefs reflect a bias towards more biologically accommodated communities. It is perhaps significant that biological interactions involving Acanthaster attack (Aziz and Sukarno 1977) and agressive overgrowth by diademnid ascidians (Brown unpublished) have been noted only on corals at the most diverse reef (site 5) studied in the present investigation.

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Table 1. Coral species recorded on reef flats at sites 1 - 5.

	Site number				
	1	2	3	4	5
Order· SCLERACTINIA Bourne					
Suborder: ASTROCOENIIDA Vaughan & Wells					
Family: POCILLOPORIDAE Gray					
Genus: STYLOPHORA Schweigger					
S. pistillata Esper	+	+		+	+
Genus: SERIATOPORA Lamarck					
S. hystrix Dana					+
Genus: POCILLOPORA Lamarck					
P. damicornis Linnaeus		+	+		+
P. verrucosa Ellis & Solander	+				
Family: ACROPORIDAE Verrill					
Genus: ACROPORA Oken					
A.robusta (Dana)		+			
A. grandis (Brook)				+	
A. abrotanoides (Lamarck)					+
A. intermedia (Brook)	+				+
A. formosa (Dana)	+	+		+	+
A. splendida Nemenzo		+			
A. vaughani (Wells)					+
A. pulchra/aspera (Brook)/(Dana)?	+	+	+	+	+
A. hyacinthus (Dana)	+		+	+	+
A. cytherea (Dana)					+
A. palifera (Lamarck)		+			+
A. millepora (Ehrenberg)				+	
A. aculeus (Dana)					+
A. delicatula (Brook)		+			+
A. nasuta (Dana)					+

		1	2	3	4	5
	A. cerealis (Dana)	+				+
	A. diversa (Brook)	+	+			+
	A. variablis (Klunzinger)					+
	A. humilis (Dana)					+
	A. digitifera (Dana)	+	+	+	+	+
	A. clathrata (Brook)	+				
	A. divaricata (Dana)					+
	A. subglabra (Brook)	+				
	A. carduus (Dana)					+
	A. microphthalma (Verrill)					+
	A. squarrosa (Ehrenberg)					+
	A. cymbicyathus (Brook)					+
	A. surculosa (Dana)					+
Genus:	ASTREOPORA de Blainville					
	A. myriophthalma (Lamarck)					+
Genus:	MONTIPORA de Blainville					
	M. tortuosa (Dana)	+	+	+	+	+
	M. minuta Bernard					+
	M. informis Bernard		+			
	M. ramosa Bernard	+	+			+
	M. composita Crossland		+			
	M. levis (Quelch)		+			
	M. foliosa (Bernard)	+				+
	Suborder: FUNGIIDAE (Duncan)					
	Superfamily: AGARICIICAE (Gray)					
Family:	AGARICIIDAE Gray					
Genus:	PAVONA Lamarck					
	P. danai (Milne-Edwards & Haime)					+
	P. varians Verrill	+	+	+	+	+
	P. venosa (Ehrenberg)			+		

	1	2	3	4	5
P. decussata (Dana)					+
Genus: COELOCERIS Vaughan					
C. mayeri Vaughan			+	+	+
Superfamily: FUNGIICAE (Dana)					
Family: FUNGIIDAE (Dana)					
Genus: FUNGIA Lamarck					
Subgenus: FUNGIA Lamarck					
F. (Fungia) fungites (Linnaeus)					+
Subgenus: CTENACTIS Verrill					
F. (Ctenactis) echinata (Pallas)					+
Superfamily: PORITICAE (Gray)					
Family: PORITIDAE (Gray)					
Genus: GONIOPORA de Blainville					
G. stokesi Milne-Edwards & Haime				+	+
Genus: PORITES Link					
P. lutea Milne-Edwards & Haime		+	+		+
P. matthaii Wells				+	
P. attenuata Nemenzo	+			+	+
P. mayeri Vaughan				+	
P. nigrescens .Dana				+	+
P. andrewsi Vaughan		+		+	+
Subgenus: SYNAREA Verrill					
P. (Synarea) iwayamaensis Eguchi				+	+
Suborder: FAVIINA Vaughan & Wells					
Superfamily: FAVIICAE Gregory					
Family: FAVIIDAE Gregory					
Subfamily: FAVIINAE Gregory					
Genus: FAVIA Oken					
F. pallida (Dana)		+	+	+	
F. favus (Forskaal)				+	+

		1	2	3	4	5
	F. lizardensis Veron, Pichon & Wijsman-Best				+	
	F. matthai Vaughan			+	+	
Genus:	FAVITES Link					
	F. chinensis (Verrill)	+	+	+	+	
	F. abdita (Ellis & Solander)		+		+	
	F. halicora (Ehrenberg)	+		+		
Genus:	OULOPHYLLIA Milne-Edwards & Haime					
	Oulophyllia sp.					+
Genus:	CAULASTREA Dana					
	C. tumida Matthai				+	+
Genus:	GONIASTREA Milne-Edwards & Haime					
	G. retiformis (Lamarck)		+	+	+	
	G. edwardsi Chevalier				+	+
	G. aspera (Verrill)				+	
	G. favulus (Dana)		+		+	
	G. pectinata (Ehrenberg)				+	
Genus:	PLATYGYRA Ehrenberg					
	P. pini Chevalier	+		+	+	+
	P. sinensis Milne-Edwards & Haime	+		+		
	P. daedalea (Ellis & Solander)		+		+	+
	P. verweyi Wijsman-Best			+	+	+
Genus:	HYDNOPHORA Fischer de Waldheim					
	H. exesa (Pallas)	+				
Genus:	MONTASTREA de Blainville					
	M. magnistellata Chevalier					+
	M. valenciennesi (Edwards & Haime)					+
Genus:	LEPTASTREA Milne-Edwards & Haime					
	L. pruinosa Crossland		+			

	1	2	3	4	5
Genus: CYPHASTREA Milne-Edwards & Haime					
C. microphthalma (Lamarck)				+	
C. serialia (Forskal)				+	
Genus: ECHINOPORA Lamarck					
E. horrida Dana					+
Family: OCULINIDAE Gray					
Subfamily: GALAXEINAE (Vaughan & Wells)					
Genus: GALAXEA Oken					
G. fascicularis (Linnaeus)		+		+	+
Family: MERULINIDAE Verrill					
Genus: MERULINA Ehrenberg					
M. ampliata (Ellis & Solander)					+
Genus: SYMPHYLLIA Milne-Edwards & Haime					
S. nobilis (Dana)					+
Suborder: CARYOPHYLLINA Vaughan & Wells					
Superfamily: CARYOPHYLLIICAE Gray					
Family: CARYOPHYLLIIDAE Gray					
Subfamily: EUSMILIINAE Milne-Edwards & Haime					
Genus: EUPHYLLIA Dana					
E. glabrescens (Chamisso & Eysenhardt)					+
Order: COENOTHECALIA Bourne					
Family: HELIOPORIDAE Moseley					
Genus: HELIOPORA de Blainville					
H. coerulea (Pallas)		+	+	+	+
Class: HYDROZOA Huxley					
Order: MILLEPORINA Hickson					

		1	2	3	4	5
Family:	MILLEPORIDAE Blainville					
Genus:	MILLEPORA Linnaeus					
	<u>M. exaesa</u> Forskal		+	+		+
	<u>M. platyphylla</u> Hemprich & Ehrenberg			+		
	<u>M. dichotoma</u> Forskal					+
	TOTAL NUMBER OF CORAL SPECIES:	21	28	20	38	57

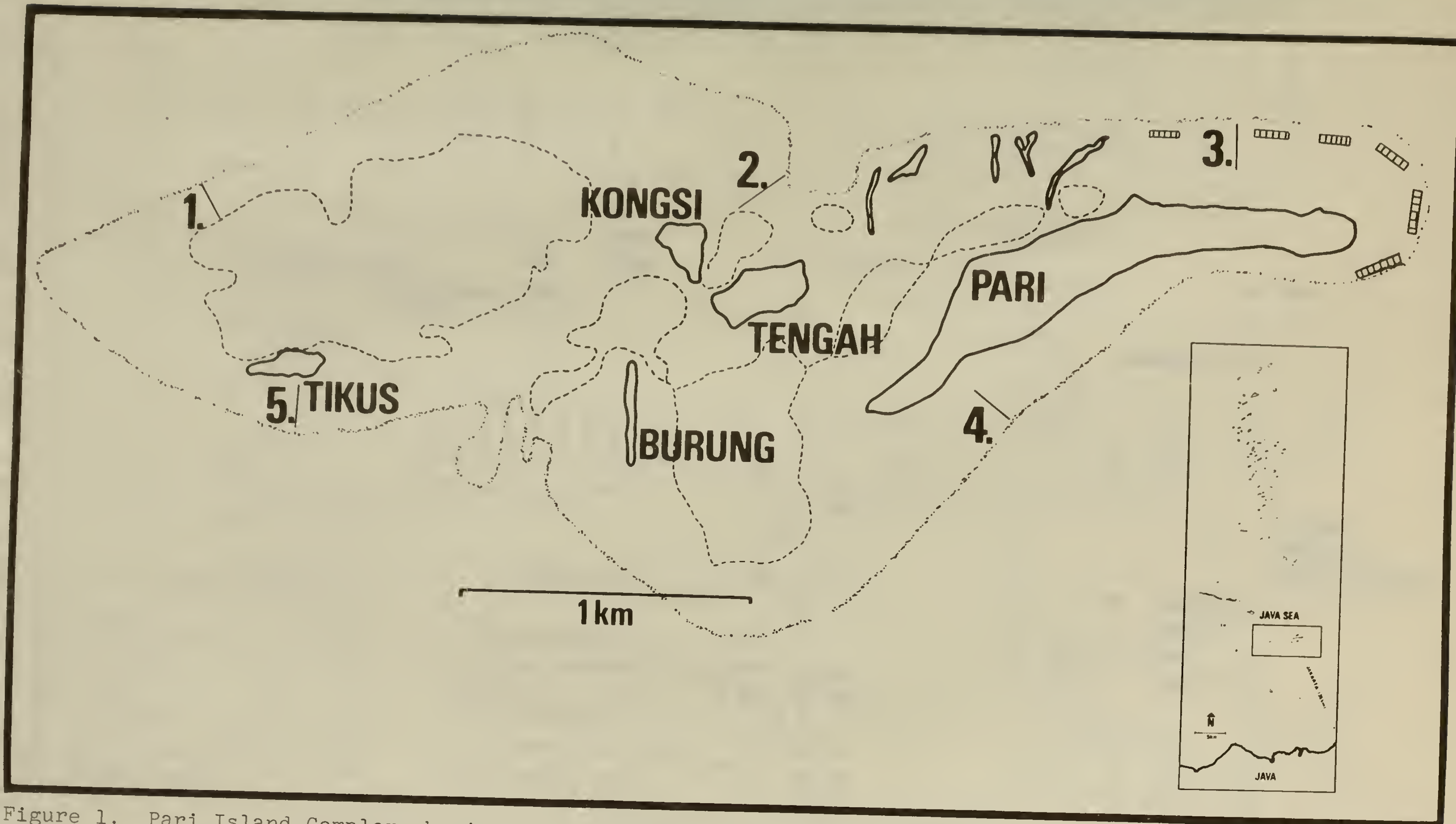

Figure 1. Pari Island Complex showing study sites and position of shingle ramparts (▭▭▭) and its location within the Java Sea (inset).

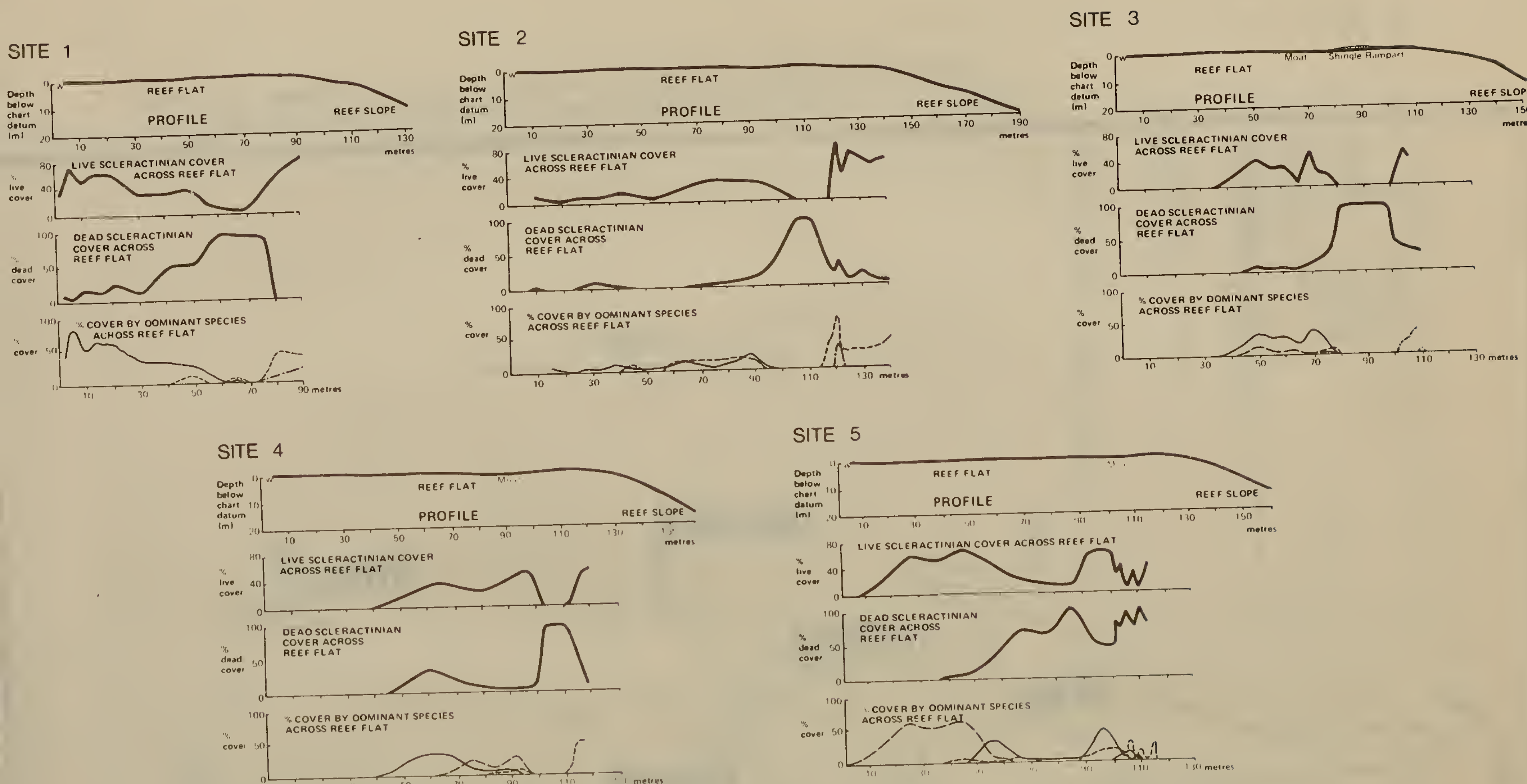

Figure 2. Distribution of living and dead coral across the reef flats at sites 1 - 5.

a) Profile of reef
b) Live scleractinian cover
c) Dead scleractinian cover
d) Dominant species cover

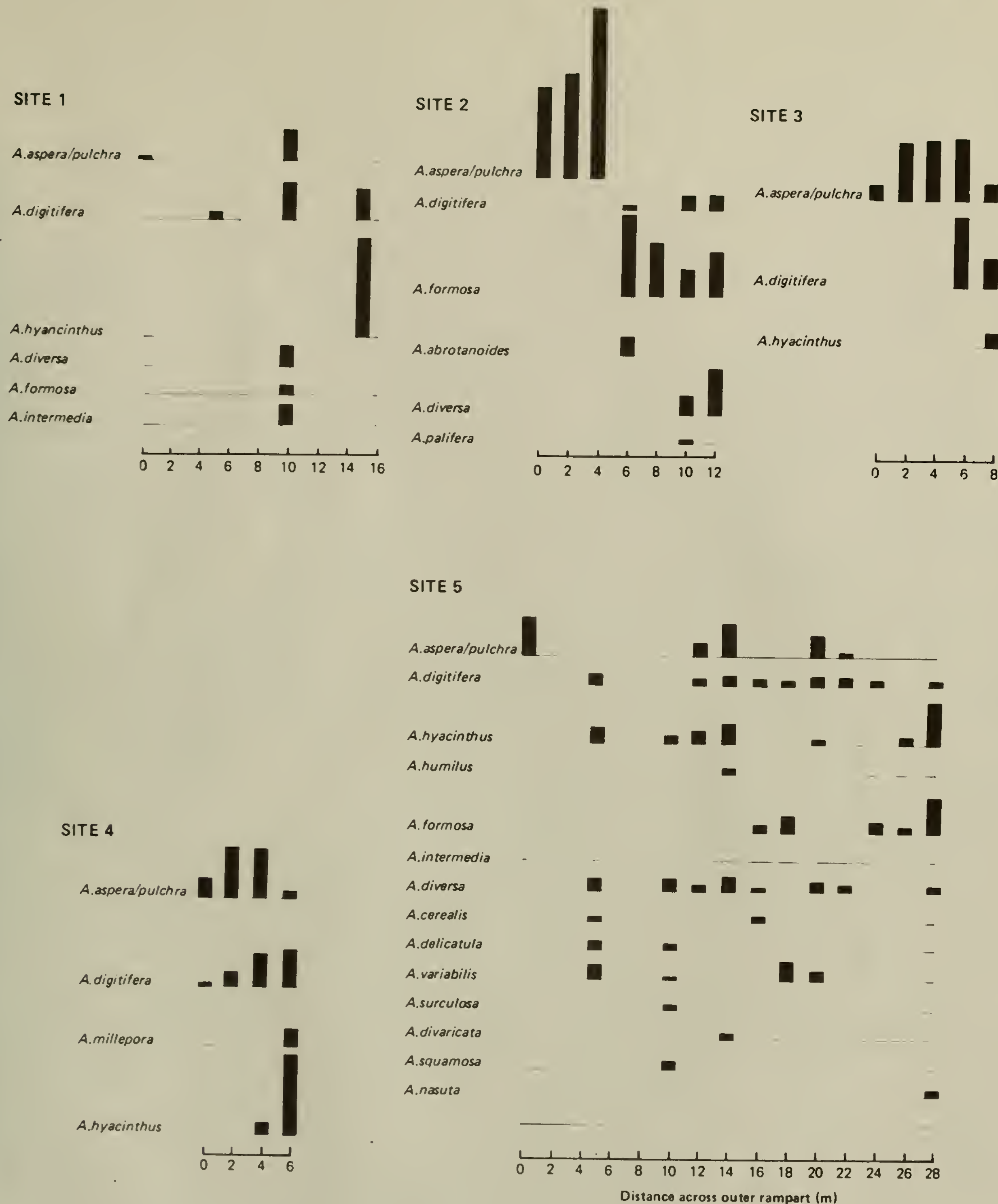

Figure 3. Zonation of Acropora species across the outer reef flats at sites 1 - 5.

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