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SOUTH INDIAN SAND CAYS

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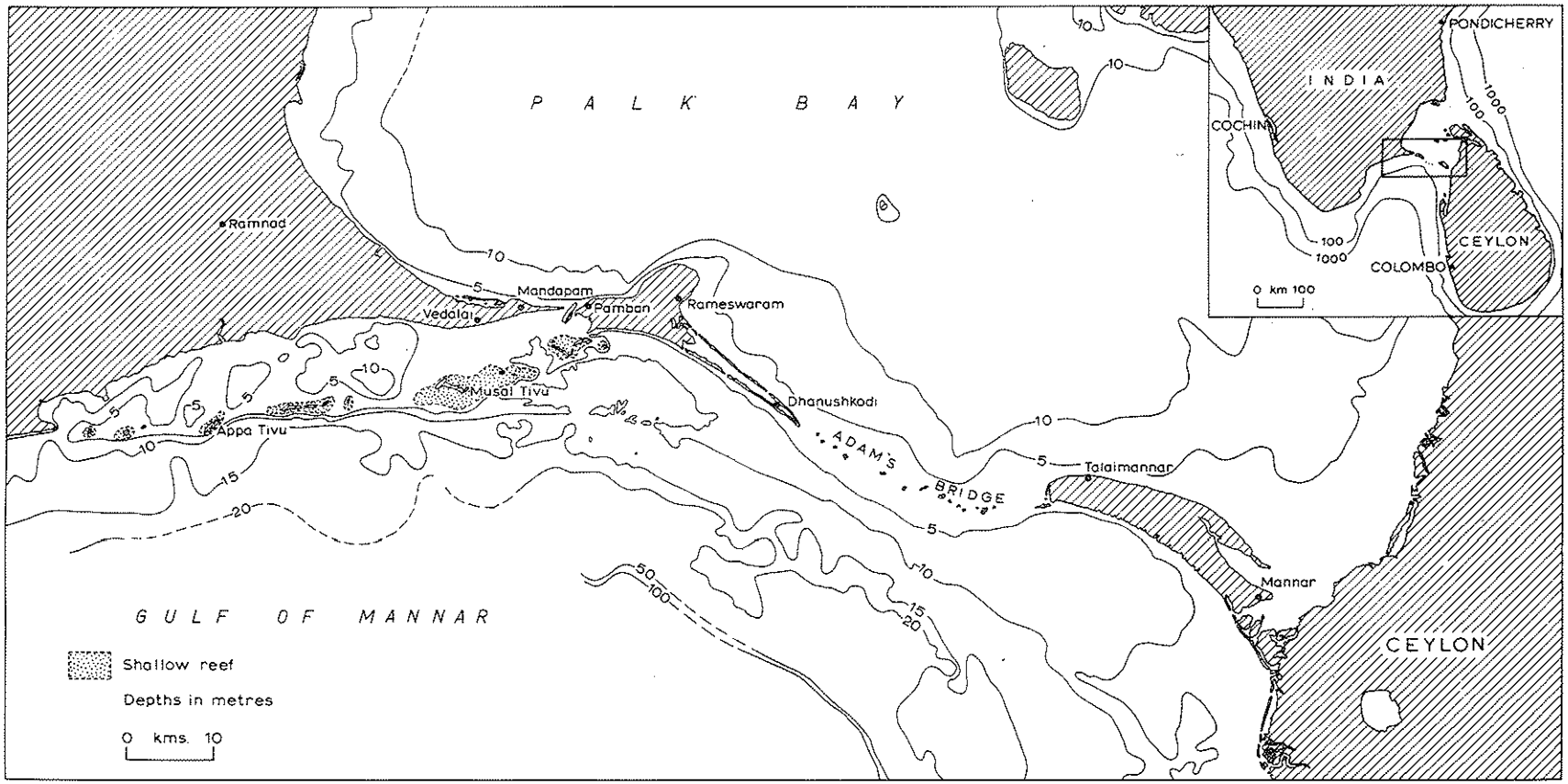

Figure 1. Adam's Bridge, between India and Ceylon, showing the location of the Gulf of Mannar reefs

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INTRODUCTION

Adam's Bridge and associated islands between India and Ceylon separate Palk Bay to the north, a shallow expanse of water 11-13 m deep, from the Gulf of Mannar to the south. A discontinuous barrier reef, here termed the Mannar barrier, parallels the mainland coast of India, round the northern side of the Gulf of Mannar, from Tuticorin to Pamban, a distance of 140 km. This barrier reef rises from a shelf less than 35 m deep but up to 25 km wide, from the edge of which the Gulf floor slopes steeply to depths of more than 300 m (Figure 1).

The barrier reef consists of intertidal reef flats 1.5-4 km wide and up to 15 km long, aligned parallel to the mainland coast, enclosing a shallow shelf or lagoon with depths generally less than 10 m. Sand cays, the subject of this paper, are located on the reef flats. We here describe the easternmost islands (Fig.2) of Musal Tivu or Hare Island; Manauli; a small islet west of Manauli; New Island; and, more briefly, Krusadai Island or Kurisadi Tivu and Shingle Island. Other islands extending westward to Tuticorin were not visited.

There has been little previous work on these islands or their terrestrial biota. R.B. Foote (1883, 1888, 1890) described the adjacent coast and coral reefs, as did J. Walther (1891) and R.B. Seymour Sewell (1932; 1936, 474-477). Only Walther (1891, 18-21) spent any time on the cays, visiting Krusadai and Shingle Islands. Early work by E. Thurston (1887) on the marine fauna of the islands was extended following the establishment of a small marine station on Krusadai by the Government of Madras (Gravely et al. 1927) and of the Central Marine Fisheries Research Institute at Mandapam Camp by the Government of India. Detailed studies have appeared on the sponges (Burton 1937), Foraminifera (Daniel 1949a, 1949b), and corals (Pillai 1967) of the area. Since Gravely's work on the land fauna and flora, only outline guides have appeared on the land biota (Chacko et al. 1955). Stoddart and Pillai (1972) have described recently raised reefs on the mainland coast near Mandapam and Pamban and have considered their geological implications.

ENVIRONMENT

The environment of the Mannar barrier reef is dominated by the seasonal monsoonal wind reversal. Winds show a considerable annual variation (Fig. 3), from the north and northeast from November to February, and from the south in May to October. Mean wind speed is 6-11 knots (3-5.6 m/sec). The area with which we are concerned differs from most of mainland India in that, because of the rainshadow effect of the south Indian mountains, the summer (southwest) monsoon is dry and the winter (northeast) monsoon wet. Mean annual rainfall at Pamban, averaged over 62 years (1891-1936, 1938-1950, 1952-1954, in *Rainfall of India* (1891-1914) and *Monthly Rainfall of India* (1916-1954)) is 915 mm, of which 688 mm falls in October-December. Extreme annual totals were 353 mm in 1945 and 1772 mm in 1896. There is a

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considerable probability of no rain at all falling in all months except October-January, and rainfall totals during the summer months of July-August are extermely low (Fig. 4). Table 1 gives some indicators of rainfall variability.

Table 1. Rainfall data for Pamban

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean monthly rainfall in mm	64.3	20.2	19.8	47.0	24.0	4.0	11.0	12.9	25.4	208.1	289.1	190.3	915.3
Number of years during the period of record with less than 2.5 mm reported in the month	2	29	26	10	21	43	31	34	20	1	0	0	
Number of years with less than 2.5 mm in the month as percentage of total length of record	3.2	46.8	41.9	16.1	33.9	69.4	50.0	54.8	32.3	1.6	0	0	
Highest monthly total mm	282.7	120.4	126.7	267.0	217.2	70.1	174.0	103.6	133.1	548.1	692.2	839.7	
Lowest monthly total mm	0	0	0	0	0	0	0	0	0	0	32.8	6.1	

Period of record: 62 years (1891-1936, 1938-1950, 1952-1954).
Source of data: *Rainfall of India* (1891-1914), *Monthly Rainfall of India* (1916-1954).

Temperatures are high, with a mean daily maximum over the year of 31.1°C and minimum of 25.6°C (the highest and lowest monthly means being in May, 34.4°C, and December, 22.8°C, respectively). The absolute maximum temperature recorded at Pamban over 30 years is 37.2°C and the absolute minimum 18.9°C (Meteorological Office 1958, 34; Hydrographic Department 1961, 46).

A striking result of these general high temperatures, low and often unreliable rainfall, and constant wind is the appearance of aridity in the vegetation; Spate (1954, 731) refers to the "Red Sea aspect" of the Gulf of Mannar coastlands by contrast with the green littoral of Ceylon. The impression of aridity is reinforced by the presence of high dunes, part fixed (terai) and part mobile, built by southerly winds on south-facing coasts. These dunes are unimportant on northern shores, partly because of the shorter duration of the northeast monsoon but also because it coincides with heavier rainfall. High mobile dunes are found well inland west of Rameswaram on Rameswaram Island, and again west of Mandapam, and have to be cleared from houses, railways and roads. The vegetation is also much affected by the pressure of dense human and animal populations.

Tropical cylones occasionally occur, and because of the configuration of the coast may be accompanied by high storm surges. A major storm with high surge and much loss of life occurred in the Pamban-Rameswaram area in December 1964 (Bhaskara Rao and Mazumdar 1966a, 1966b).

Tides are mixed, mainly semidiurnal, becoming rather irregular and briefly diurnal at neaps. *Indian Tide Tables* predict a maximum range at springs of 0.81 m and at neaps of 0.2 m, but wind conditions influence tidal behaviour considerably in the Gulf of Mannar and Palk Bay area.

GENERAL CHARACTERISTICS OF THE CAYS

Several general observations may be made about the south Indian cays. With the exception of Shingle Island, standing on a small reef patch, they are sand structures with gravel forming a minor component and boulders rare. Though some, such as Musal Tivu, are large, they occupy a very small proportion of the reef-flats on which they stand. Except for the fact that they are located closer to the leeward (northern) than windward (southern) sides of the reefs, their location on the flats appears largely random; they are not associated, as are most sand cays, with gaps or prominent angles on the reef. The islands themselves have very irregular outlines, with spits and partially enclosed bays, and often higher sandy beach ridges enclose areas of mud flats and standing water within the cay. Crescentic, often unvegetated, sand bars are common offshore on the south sides of the islands.

These features suggest a sediment supply insufficient for major land accumulation on such exceptionally wide reef flats (up to 4 km wide compared with a more usual reef-flat width elsewhere of 1 km), even in conditions of low tidal range. Since cyclones do occur, it is remarkable that boulders and coarse debris are not more significant as island-anchors near the seaward reef edges. Mainly sand-size sediments are thus transported across exceptionally wide flats by waves which are unable to carry them to the leeward edges of the reefs, but the deposited sediments are inadequate in quantity, when deposited, to form more than irregular scattered sand bars and islands.

Except where sand dunes have been built on Musal Tivu, the islands are all extremely low, probably all less than 3 m above the level of high water springs. No beachrock or other cemented sediments outcrop on the islands. This is surprising in view of the raised reefs and cemented current-bedded sediments prominently outcropping on the adjacent mainland Indian coast, indicating local uplift at about 4,000 years B.P. (Stoddart and Pillai 1972): how the Mannar barrier relates to these features is not clear, but there is no evidence to suggest that the cays are other than recent formations. Beachrock is found on neighbouring Ceylon shores (Cooray 1968) and its absence on the Mannar cays has no obvious explanation.

DESCRIPTION OF THE CAYS

Musal Tivu or Hare Island (Fig. 5)

Musal Tivu is the largest island on the barrier reef, with a length of about 4 km, width ranging from 250 to 1800 m, and a total area of about 160 ha. It differs considerably from the other cays in its vegetation, probably because of the amount of human interference and the numbers of cattle, goats and donkeys kept there. In general aspect, with such species as *Borassus, Acacia, Calotropis* and *Cissus,* it closely resembles the adjacent Indian mainland.

The narrow central part of the cay is covered with a dense coconut woodland, with trees 20-25 years old in rows, cleared beneath, and with rows of *Borassus* palms, clearly planted, on both seaward and lagoonward sides. The lagoon shore is sandy and clearly prograding, 1.5-2 m high, with a pioneer vegetation of sedges and grasses *(Fimbristylis, Dactyloctenium)* and an interrupted line of shrubby trees slightly inland from the beach crest. These are mainly trees of *Thespesia populnea* up to 5 m tall, with some *Acacia; Scaevola taccada* is notably rare in what appears to be a very suitable habitat, and only a single shrub of this species was seen on the lagoon shore.

Towards the east on the lagoon shore the littoral hedge becomes more continuous, with *Acacia* and *Thespesia* dominant, while towards the end of the island the prograding beach is replaced by spits of sand and fine gravel, covered with *Pemphis acidula,* with beds of marine phanerogams offshore and enclosing wide flat meadows of grazed *Salicornia* and *Arthrocnemum* within. Grasses and sedges colonise slightly higher ground, and a few clumps of *Avicennia* grow in some channel openings. The vegetation of the cay interior is very open, with scattered trees of *Acacia* and *Thespesia* and herds of goats and cattle.

Most of the south coast has a wide beach about 3 m high from low-water level, with incipient sand dunes colonised by *Spinifex* and *Cissus,* with *Thespesia* and *Acacia* further inland. *Scaevola* and *Tournefortia* are both absent.

The western end of the island is wider, with an open woodland of *Acacia* and *Calotropis,* with *Cassia,* and lower areas are covered with a *Salicornia* sward. Open pools are surrounded by sparse *Avicennia* and open *Pemphis* woodland.

Apart from the *Pemphis* and *Thespesia* woodland, and the *Spinifex* and *Salicornia* areas, the vegetation of Musal Tivu differs considerably from that of the other islands. Mangroves are also poorly represented, though there is some evidence of cutting.

West Island (Manauli) (Fig. 6)

West Island is a small recent island west of Manauli; it is 740 m long, 150–190 m wide, and has an area of 10.7 ha. It consists of sand and fine gravel rising 1.5 to 2 m above low water level. The vegetation consists of herbs, vines and grasses, with some scattered trees and shrubs of *Thespesia* and *Pemphis,* and a belt of *Avicennia* and *Lumnitzera* mangrove woodland at the eastern end. Apart from a small area in the centre dominated by *Sporobolus virginicus,* the ground cover is a mixture of grasses *(Dactyloctenium, Apluda),* sedges *(Bulbostylis, Cyperus, Fimbristylis), Dolichos lablab,* and *Ipomoea pes-caprae.* Climbing *Ipomoea macrantha* covers the trees. *Launaea, Spinifex* and *Sesuvium* are common on the south shore, *Suaeda* on the north.

Manauli (Fig. 7)

Manauli is a cay of rather complex topography, 1 km long, 350 m wide, and with an area of 24 ha. The northern and southern beach ridges are separated by an area of *Thespesia* woodland up to 6 m tall, and lower scrub of *Pemphis acidula,* with pools and open mud flats. The south coast vegetation, on a flat, irregular, prograding beach, is dominated by *Spinifex, Sesuvium* and *Suaeda,* with *Atriplex* on the north shore, all forming rather discrete assemblages. There are scattered mangrove trees *(Lumnitzera, Rhizophora, Bruguiera, Ceriops),* especially along the north shore, but only *Avicennia* forms a closed woodland round the mudflats. In addition to *Thespesia* there are trees of *Cordia subcordata* and *Clerodendrum inerme* shrubs. Tall trees approach close to the sea on the north coast, where a slightly retreating beach faces a reef flat about 9.5 km wide, whereas on the south coast, facing a reef flat 2 km wide, there is a wide zone of pioneer grasses and herbs on the beach crest, and isolated patches of similar vegetation on low sand banks seaward of the main beach. Protected mudflats are colonised by swards of *Salicornia* and *Arthrocnemum.*

New Island (Fig. 8)

New Island, east of Manauli, has a similarly complex topography with interior open mud flats; it is 1100 m long, 120-500 m wide, and 30 ha in area. There is a wide *Avicennia* woodland on the north side, but other mangroves are less common *(Rhizophora, Lumnitzera* and *Ceriops* are also present). Much of the interior is covered either with *Thespesia* woodland with shrubs such as *Clerodendrum,* or with a high grassland of *Sporobolus,* with other grasses, such as *Dactyloctenium,* and sedges. Colonizers on the south shore include *Spinifex, Sesuvium, Ipomoea,* and *Suaeda,* with a fairly continuous hedge of *Pemphis* on the beach crest.

Kurisadi Tivu or *Krusadai Island*

Krusadai was visited but not mapped: a sketch map made in July 1924 is given by Gravely et al. (1927) but is on a very small scale. Seaward beach ridges have a diverse vegetation of grasses *(Dactyloctenium),* sedges *(Fimbristylis), Euphorbia* species, *Dolichos lablab,* and *Ipomoea pes-caprae,* with *Thespesia* woodland inland. Mangrove woodland is extensively developed on the north coast. Many ornamental species have been planted round the scientific station. A list of plants from Krusadai was given by Parthasarathy Iyengar (1927).

Shingle Island

A landing was made on Shingle Island but no collections were made. It has higher steeper beaches, or coral gravel, than the other islands. According to a sketch map in Gravely et al. (1927) it consisted of two separate islands in 1878, and these coalesced to form the present single island by 1920-27.

MAIN FEATURES OF THE VEGETATION

The vegetation of these south Indian sand cays differs so considerably from that of western and central Indian Ocean reef islands that it is useful to review its main characteristics for comparative purposes.

Marine grass meadows

Marine grass meadows are extensive on the reef flats, in this resembling Indian Ocean continental coasts and the reefs of the southwest Indian Ocean (e.g. Aldabra) rather than the more isolated reefs of the open ocean (e.g. Chagos). The flora includes two species of *Cymodocea,* one of *Halodule,* one of *Syringodium,* one of *Thalassodendron,* one of *Enhalus,* two of *Halophila,* and one of *Thalassia.*

Mangrove woodland

Mangrove woodland is less extensive on the cays than might be expected from the presence of *Bruguiera, Ceriops, Rhizophora, Lumnitzera* and *Avicennia;* it is absent from the adjacent mainland coasts, where it is replaced by tropical salt-marsh vegetation. On the cays *Avicennia* is the most common mangrove, forming a woodland less than 5 m tall. Other genera are often represented only by scattered trees on protected shores.

Salt-marsh vegetation

Extensive mud-flat areas enclosed by sand spits are covered with meadows of *Arthrocnemum* and *Salicornia,* genera apparently absent from central Indian Ocean atolls. The meadows are often surrounded on slightly high ground by banks of *Suaeda maritima,* as in temperate salt-marshes, with *Sesuvium, Bulbostylis,* and *Fimbristylis* on flat but drier ground.

Beach vegetation

Pioneer and beach crest vegetation on the cays is variable. Common pioneers are *Sporobolus virginicus* and *Cyperus conglomeratus* on advancing coasts. In established vegetation, *Spinifex squarrosus* and *Sesuvium portulacastrum* seem to be more common on windward (southern) shores, and *Atriplex repens* on leeward shores. Beach-crest shrub vegetation is dominated either by *Thespesia populnea*, where interior woodland reaches the beach, or by the very common *Pemphis acidula*. The unimportance of common reef-island species in this community is remarkable: *Tournefortia argentea* and *Sophora tomentosa* have not been recorded, *Suriana maritima* though recorded in 1927 was not seen during the present survey, and *Scaevola taccada* is very uncommon except on Shingle Island. *Pemphis*, which grows to a height of 6 m, is more common on leeward shores, and on retreating beaches. Incipient dunes, common only on Musal Tivu, are covered with *Spinifex* and *Acacia*, as on the adjacent mainland.

Interior woodland

It seems likely that the ultimate vegetation of these cays is a woodland of *Thespesia populnea*, with trees up to 6 m tall. Few other trees are recorded *(Cordia, Premna, Salvadora, Calotropis)* and some are probably introduced. *Acacia* is common only on Musal Tivu, subject to much greater human disturbance than the other islands, and both coconuts and Palmyra palms are important only on this island. Again the absence of common atoll trees in the interior woodland is very noticeable (e.g. *Hernandia, Calophyllum)*.

Interior mixed grass and herb vegetation

Woodland covers only a small proportion of the cay surface, the rest being covered with low shrubs, herbs, vines and grasses. *Dactyloctenium, Sporobolus, Trachys* and *Apluda* are the most common grasses. *Ipomoea macrantha* is widespread on shrubs and low trees, while *Ipomoea pes-caprae* is more common on the ground. *Dolichos lablab* is particularly abundant.

LIST OF VASCULAR PLANTS

Plants of Krusadai Island were listed by Parthasarathy Iyengar (1927), who found 31 species. Some additional records of marine phanerogams are given by Den Hartog (1970). Species listed by both are included in the following list of plants collected in December 1968 and January 1969 and determined by F.R. Fosberg. The area lies within that covered by Gamble's (1915-36) Flora of Madras, though no island localities are given in that work. 84 species are now recorded from the cays (Musal Tivu or Hare, 34; Manauli, 54; West Island, 24; New Island, 25; Krusadai, 42).

PANDANACEAE

Pandanus odoratissimus Forsk.
Krusadai: listed by Parthasarathy Iyengar (1927).

POTAMOGETONACEAE

Cymodocea rotundata Ehrenb. and Hempr. ex Aschers.
Manauli: *Fosberg 51281.*
Krusadai: listed by Parthasarathy Iyengar (1927); collected in 1944 by Parthasarathy Iyengar and D. Daniel, in Den Hartog (1970).

Cymodocea serrulata (R. Br.) Aschers. and Magnus.
Musal Tivu (Hare): collected in 1928 by F. Børgensen, in Den Hartog (1970).
Krusadai: listed by Parthasarathy Iyengar (1927); collected, no date, by J. Gopelstao, in Den Hartog (1970); *Fosberg 51234.*

Halodule sp.
Manauli: *Fosberg 51280.*

Syringodium isoetifolium (Aschers.) Dandy
Musal Tivu (Hare): collected in 1928 by F. Børgesen, in Den Hartog (1970).
Krusadai: listed as *Cymodocea isoetifolia* by Parthasarathy Iyengar (1927).

Thalassodendron ciliatum (Forsk.) d. Hart. [*Cymodocea ciliata* (Forsk.) Koen.]
Manauli: *Fosberg 51282.*

HYDROCHARITACEAE

Enhalus acoroides (L. f.) Royle
Krusadai: listed as *Enhalus koenigii* by M.O. Parthasarathy Iyengar (1927); collected in 1944 by S.V. Parthasarathy and D. Daniel, in Den Hartog (1970).

Halophila ovalis (R. Br.) Hook. f.
Musal Tivu (Hare): collected in 1928 by F. Børgesen, in Den Hartog (1970).
Krusadai: listed by Parthasarathy Iyengar (1927); collected in 1928 by M.O. Parthasarathy Iyengar, in Den Hartog (1970).

Halophila stipulacea (Forsk.) Aschers.
Krusadai: listed by Parthasarathy Iyengar (1927); *Fosberg 51233.*

Thalassia hemprichii (Ehrenb.) Aschers.
Manauli: *Fosberg 51279.*

GRAMINEAE

Apluda mutica L.
West Island: *Stoddart 1519.*
Manauli: *Stoddart 1544, 1548; Fosberg 51270* (det. T.R. Soderstrom).
New Island: *Stoddart 1604.*

Dactyloctenium aegyptium (L.) Beauv. *s. l.*
West Island: *Stoddart 1504.*
Musal Tivu (Hare): *Stoddart 1563.*
Manauli: *Stoddart 1541; Fosberg 51267.*
New Island: *Stoddart 1605* (or undescribed species), *1606.*
Krusadai: *Fosberg 51222* (somewhat like *D. sindicum).*

Eragrostis tenella (L.) Beauv.
Musal Tivu (Hare): *Stoddart 1582.*

Eragrostis tenella var. *insularis* Hubb.
Musal Tivu (Hare): *Stoddart 1579.*
Manauli: *Fosberg 51251.*

Haplopyrum mucronatum (L.) Stapf
West Island: *Stoddart 1510.*
Manauli: *Fosberg 51254.*

Spinifex littoreus (Burm. f.) Merr.
Musal Tivu (Hare): *Stoddart 1575.*
West Island: *Stoddart 1524.*
Manauli: *Stoddart 1528.*
New Island: *Stoddart 1594.*
Krusadai: listed as *Spinifex squarrosus* by Parthasarathy Iyengar (1927).

Sporobolus sp.
West Island: *Stoddart 1517.*

Sporobolus fertilis (Steud.) Clayt.
New Island: *Stoddart 1601.*

Sporobolus maderaspatanus Bor
Manauli: *Stoddart 1542; Fosberg 51252.*

Sporobolus marginatus Hochst. ex Rich.?
Manauli: *Fosberg 51263.*

Sporobolus tremulus (Willd.) Kunth
Manauli: *Fosberg 51271.*

Sporobolus virginicus (L.) Kunth
West Island: *Stoddart 1522.*
Manauli: *Stoddart 1543; Fosberg 51250.*
New Island: *Stoddart 1596.*

Trachys muricata (L.) Pers.
Musal Tivu (Hare): *Stoddart 1566.*
Manauli: *Stoddart 1532; Fosberg 51253.*
Krusadai: *Fosberg 51223.*

CYPERACEAE

Bulbostylis barbata Kunth
Musal Tivu (Hare): *Stoddart 1569, 1589.*
West Island: *Stoddart 1514.*
Manauli: *Fosberg 51255, 51269.*
New Island: *Stoddart 1602.*

Cyperus arenarius Retz.
Krusadai: listed by Parthasarathy Iyengar (1927).

Cyperus aristatus Rottb.
Manauli: *Fosberg 51276, 51277.*

Cyperus bulbosus Vahl
Manauli: *Stoddart 1538; Fosberg 51256.*
New Island: *Stoddart 1603.*

Cyperus conglomeratus Rottb.
West Island: *Stoddart 1503.*
Manauli: *Stoddart 1527; Fosberg 51265.*
New Island: *Stoddart 1592.*
Krusadai: possibly listed as *Cyperus* "big species" by Parthasarathy Iyengar (1927).

Cyperus cuspidatus H.B.K.?
Manauli: *Fosberg 51278.*

Fimbristylis cymosa R. Br.
Musal Tivu (Hare): *Stoddart 1568, 1586.*
West Island: *Stoddart 1507.*
Manauli: (?) *Stoddart 1540; Fosberg 51273.*
New Island: *Stoddart 1590.*
Krusadai: *Fosberg 51224.*

Fimbristylis polytrichoides R. Br. ?
Musal Tivu (Hare): *Stoddart 1580.*
Manauli: *Stoddart 1539.*

PALMAE

Borassus flabellifer L.
Musal Tivu (Hare): seen by Stoddart, January 1969.

Cocos nucifera L.
Musal Tivu (Hare): seen by Stoddart, Jan. 1969.
Krusadai: seen by Stoddart, Jan. 1969.

LILIACEAE

Iphigenia sp. [cf. *I. indica* A. Gray or *I. pallida* Bak.]
Krusadai: *Fosberg 51230.*

CHENOPODIACEAE

Arthrocnemum sp.
Manauli: *Fosberg 51244.*

Arthrocnemum indicum (Willd.) Moq.
Krusadai: listed by Parthasarathy Iyengar (1927).

Arthrocnemum fruticosum var. *glaucum* Moq.
Krusadai: listed by Parthasarathy Iyengar (1927).

Atriplex repens Roth
Manauli: *Stoddart 1536, 1549; Fosberg 51241.*
New Island: *Stoddart 1600.*
Krusadai: listed by Parthasarathy Iyengar (1927).

Salicornia sp.
Musal Tivu (Hare): *Stoddart 1585* (seedling).
Manauli: *Stoddart 1547* (seedling).

Salicornia brachiata Roxb.
Manauli: *Fosberg 51243, 51245.*

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Suaeda maritima Dum.
West Island: *Stoddart 1520.*
Manauli: *Stoddart 1537; Fosberg 51264.*
New Island: *Stoddart 1591.*
Krusadai: listed by Parthasarathy Iyengar (1927).

Suaeda monoica Forsk.
Manauli: *Fosberg 51272.*
Krusadai: listed by Parthasarathy Iyengar (1927).

AMARANTHACEAE

Aerva tomentosa Forsk.
Musal Tivu (Hare): *Stoddart 1564.*
Manauli: *Stoddart 1533; Fosberg 51257.*
Krusadai: *Fosberg 51228.*

AIZOACEAE

Sesuvium portulacastrum (L.) L.
West Island: *Stoddart 1506.*
Manauli: *Stoddart 1531; Fosberg 51266.*
New Island: *Stoddart 1607.*
Krusadai: listed by Parthasarathy Iyengar (1927), also listed as var. *repens.*

LAURACEAE

Cassytha filiformis L.
Krusadai: listed by Parthasarathy Iyengar (1927).

LEGUMINOSAE

Acacia sp.
Musal Tivu (Hare): seen by Stoddart, Jan. 1969.

Caesalpinia sp.
West Island: *Stoddart 1511.*

Caesalpinia bonducella (L.) Flem.
Krusadai: listed by Parthasarathy Iyengar (1927) [= *C. bonduc.* (L.) Roxb. ?].

Cassia acutifolia Del.
Musal Tivu (Hare): *Stoddart 1559.*

Dolichos lablab L.
West Island: *Stoddart 1512.*
Manauli: *Stoddart 1545; Fosberg 51246.*
New Island: *Stoddart 1597.*

Indigofera oblongifolia Forsk.
Musal Tivu (Hare): *Stoddart 1561.*
Krusadai: *Fosberg 51226.*

SURIANACEAE

Suriana maritima L.
Krusadai: listed by Parthasarathy Iyengar (1927).

EUPHORBIACEAE

Euphorbia indica Lam.
West island: *Stoddart 1523.*
Manauli: *Fosberg 51260.*

Euphorbia microphylla Heyne?
Musal Tivu (Hare): *Stoddart 1562.*
Krusadai: *Fosberg 51231a* (glabrous form), *51231b.*

Excoecaria agallocha L.
Manauli: *Fosberg 51236.*
Krusadai: listed by Parthasarathy Iyengar (1927).

Phyllanthus maderaspatensis L.
Manauli: *Fosberg 51268.*

SALVADORACEAE

Salvadora persica L.
New Island: *Stoddart 1593.*

SAPINDACEAE

Dodonaea viscosa L.
Krusadai: *Fosberg 51229.*

RHAMNACEAE

Zizyphus mauritiana Lam.
Musal Tivu (Hare): *Stoddart 1578.*

VITACEAE

Cissus quadrangularis L.
Musal Tivu (Hare): *Stoddart 1584.*

MALVACEAE

Thespesia populnea (L.) Sol. ex Correa
Musal Tivu (Hare): *Stoddart 1565.*
West Island: *Stoddart 1518.*
Manauli: *Stoddart 1526.*
Krusadai: listed by Parthasarathy Iyengar (1927); *Fosberg 51232, 51235.*

Thespesia populneoides (Roxb.) Kostel.?
New Island: *Stoddart 1598.*

LYTHRACEAE

Nesaea lanceolata Koehne
Manauli: *Fosberg 51275.*

Pemphis acidula Forst.
Musal Tivu (Hare): *Stoddart 1577.*
West Island: *Stoddart 1508.*
Manauli: *Stoddart 1535; Fosberg 51237.*
New Island: *Stoddart 1609.*
Krusadai: listed by Parthasarathy Iyengar (1927).

RHIZOPHORACEAE

Bruguiera cylindrica W. and A.
Manauli: *Stoddart 1555; Fosberg 51239.*
Krusadai: listed as *Bruguiera caryophylloides* by Parthasarathy Iyengar (1927).

Ceriops tagal (Perr.) C.B. Rob.
Manauli: *Stoddart 1554; Fosberg 51238.*
New Island: *Stoddart 1613, 1616.*
Krusadai: listed as *Ceriops candolleana* by Parthasarathy Iyengar (1927).

Rhizophora mucronata Lam.
Manauli: *Stoddart 1552; Fosberg 51248.*
New Island: *Stoddart 1611.*
Krusadai: listed by Parthasarathy Iyengar (1927).

COMBRETACEAE

Lumnitzera racemosa Willd.
West Island: *Stoddart 1516.*
Manauli: *Stoddart 1551; Fosberg 51240.*
New Island: *Stoddart 1612.*
Krusadai: listed by Parthasarathy Iyengar (1927).

GENTIANACEAE

Enicostema hyssopifolium (Willd.) Veldk.
West Island: *Stoddart 1513.*
Manauli: *Fosberg 51261.*
New Island: *Stoddart 1599.*

ASCLEPIADACEAE

Calotropis gigantea (Ait.) Ait.
Musal Tivu (Hare): *Stoddart 1560.*
Krusadai: listed by Parthasarathy Iyengar (1927).

CONVOLVULACEAE

Ipomoea macrantha R. and S. [*I. tuba* (Schlecht.) G. Don]
Musal Tivu (Hare): *Stoddart 1574.*
West Island: *Stoddart 1502.*
Manauli: *Stoddart 1530.*
New Island: *Stoddart 1595.*

Ipomoea pes-caprae (L.) R. Br. subsp. *pes-caprae*
Musal Tivu (Hare): seen by Stoddart, Jan. 1969.
West Island: *Stoddart 1505.*
Manauli: *Stoddart 1529.*
Krusadai: listed as *Ipomoea biloba* by Parthasarathy Iyengar (1927).

BORAGINACEAE

Cordia subcordata Lam.
Manauli: *Stoddart 1556.*

VERBENACEAE

Avicennia marina L.
West Island: (?) *Stoddart 1515.*
New Island: (?) *Stoddart 1614.*
Manauli: *Fosberg 51242.*
Krusadai: listed as *Avicennia officinalis* by Parthasarathy Iyengar (1927).

Clerodendrum inerme (L.) Gaertn.
Manauli: *Stoddart 1553; Fosberg 51247.*
New Island: *Stoddart 1615.*

Premna obtusifolia R. Br.
Musal Tivu (Hare): *Stoddart 1571.*

Premna wightiana Schauer?
Manauli: *Stoddart 1550.*

LABIATAE

Leucas stricta Benth.?
Musal Tivu (Hare): *Stoddart 1581.*

SOLANACEAE

Physalis angulata L.
Manauli: *Fosberg 51258.*

PEDALIACEAE

Pedalium murex L.
Musal Tivu (Hare): *Stoddart 1573.*

RUBIACEAE

Hedyotis sp. [*Oldenlandia umbellata* L., *non Hedyotis umbellata* Walt.]
Musal Tivu (Hare): *Stoddart 1587.*
Manauli: *Fosberg 51259.*

Hedyotis herbacea L.
Manauli: *Fosberg 51274.*

Spermacoce articularis L. f.
Musal Tivu (Hare): *Stoddart 1570.*

CUCURBITACEAE

Coccinea indica W. and G.
Musal Tivu (Hare): *Stoddart 1567.*

Cucumis melo var.
West Island: *Stoddart 1501.*
Manauli: *Stoddart 1534; Fosberg 51249.*
New Island: *Stoddart 1608.*

GOODENIACEAE

Scaevola taccada (Gaertn.) Roxb.
Musal Tivu (Hare): *Stoddart 1572.*
Krusadai: listed as *Scaevola lobelioides* by Parthasarathy Iyengar (1927).

COMPOSITAE

Blumea amplectens DC.
Krusadai: *Fosberg 51227.*

Eclipta alba (L.) Hassk.
Musal Tivu (Hare): *Stoddart 1583.*
Manauli: (?) *Stoddart 1558.*

Lactuca intybacea Jacq.
Manauli: *Fosberg 51262.*

Launaea sarmentosa Sch.-Bip. ex O. Ktze
Musal Tivu (Hare): *Stoddart 1588.*
West Island: *Stoddart 1520.*
Manauli: *Stoddart 1546.*
Krusadai: listed by Parthasarathy Iyengar (1927) as *Launaea pinnatifida.*

Vernonia cinerea (L.) Less.
Musal Tivu (Hare): *Stoddart 1576.*
West Island: *Stoddart 1509.*
New Island: *Stoddart 1610.*
Krusadai: *Fosberg 51225.*

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NOTE

The flora of Hare and Church Islands off Tuticorin, by D. Daniel Sundararaj and M. Nagarajan, J. Bombay Nat. Hist. Soc. 61: 587-602, 1964(1965), concerns another Hare Island, located well to the southwest of Adam's Bridge, opposite Tuticorin.

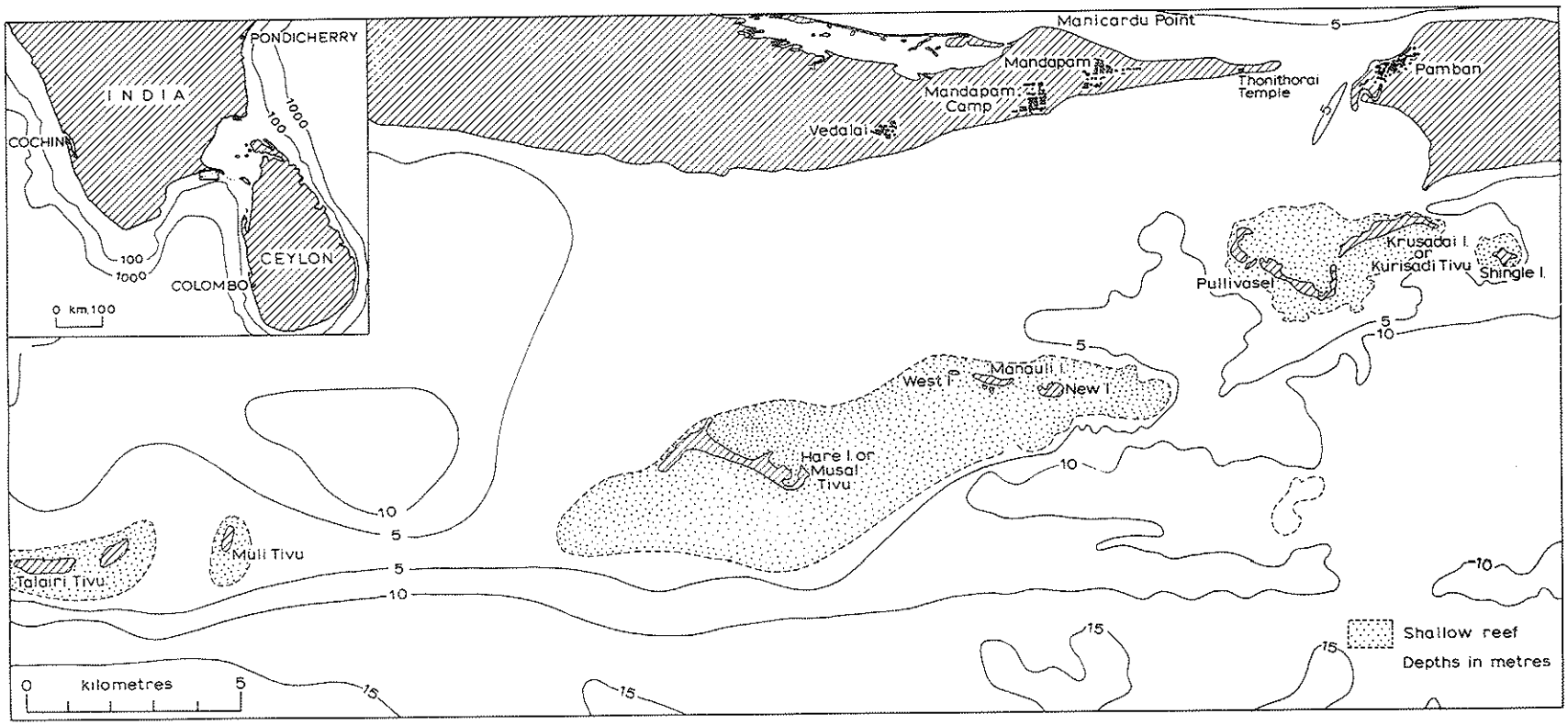

Figure 2. Reefs and sand cays south of Mandapam, Gulf of Mannar

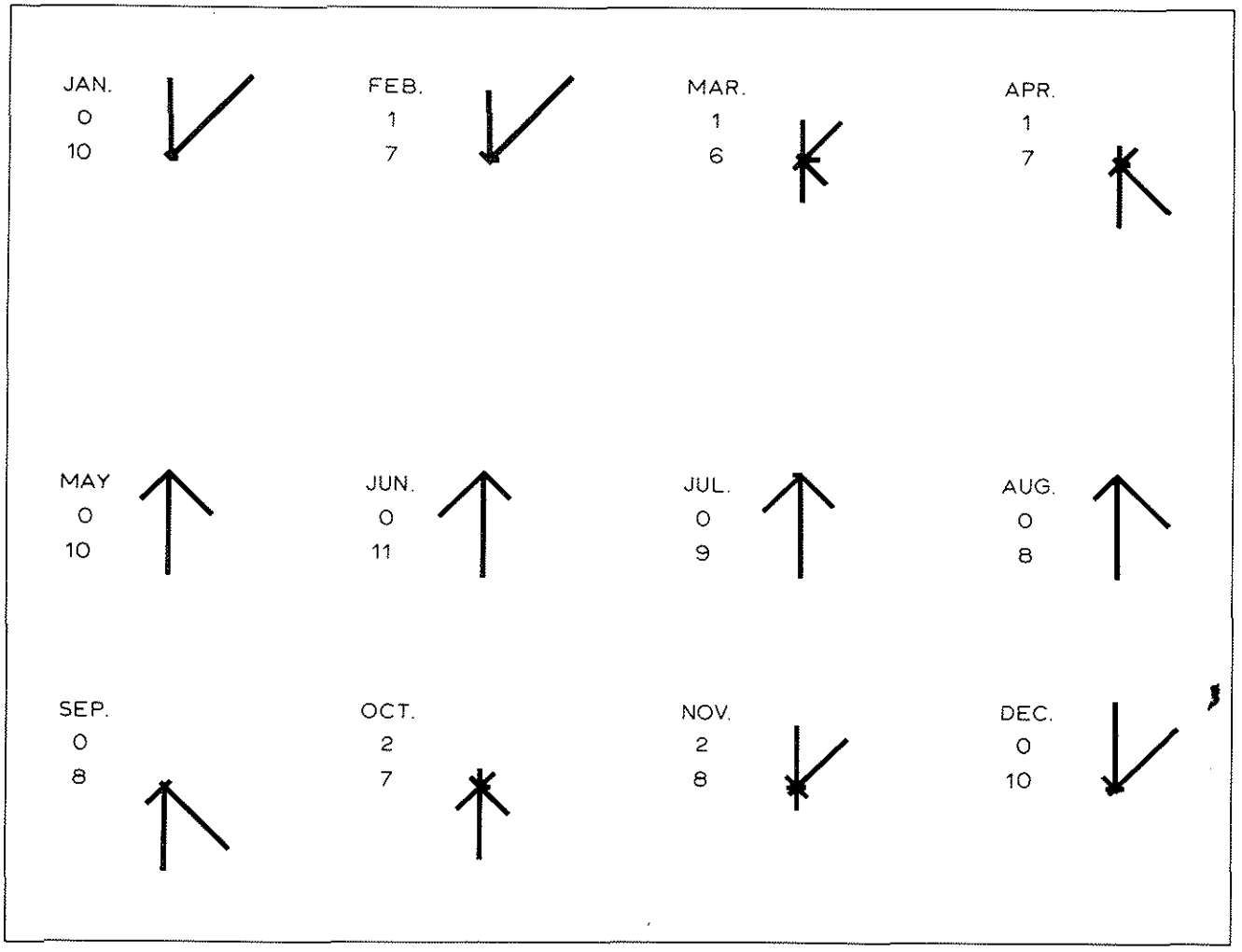

Figure 3. Monthly wind roses for Pamban (percentage of observations at 1730 hours, 5 year data). Upper figure shows percentage calms and lower figure mean wind speed in knots. Source of data: Hydrographic Department (1961, p. 46)

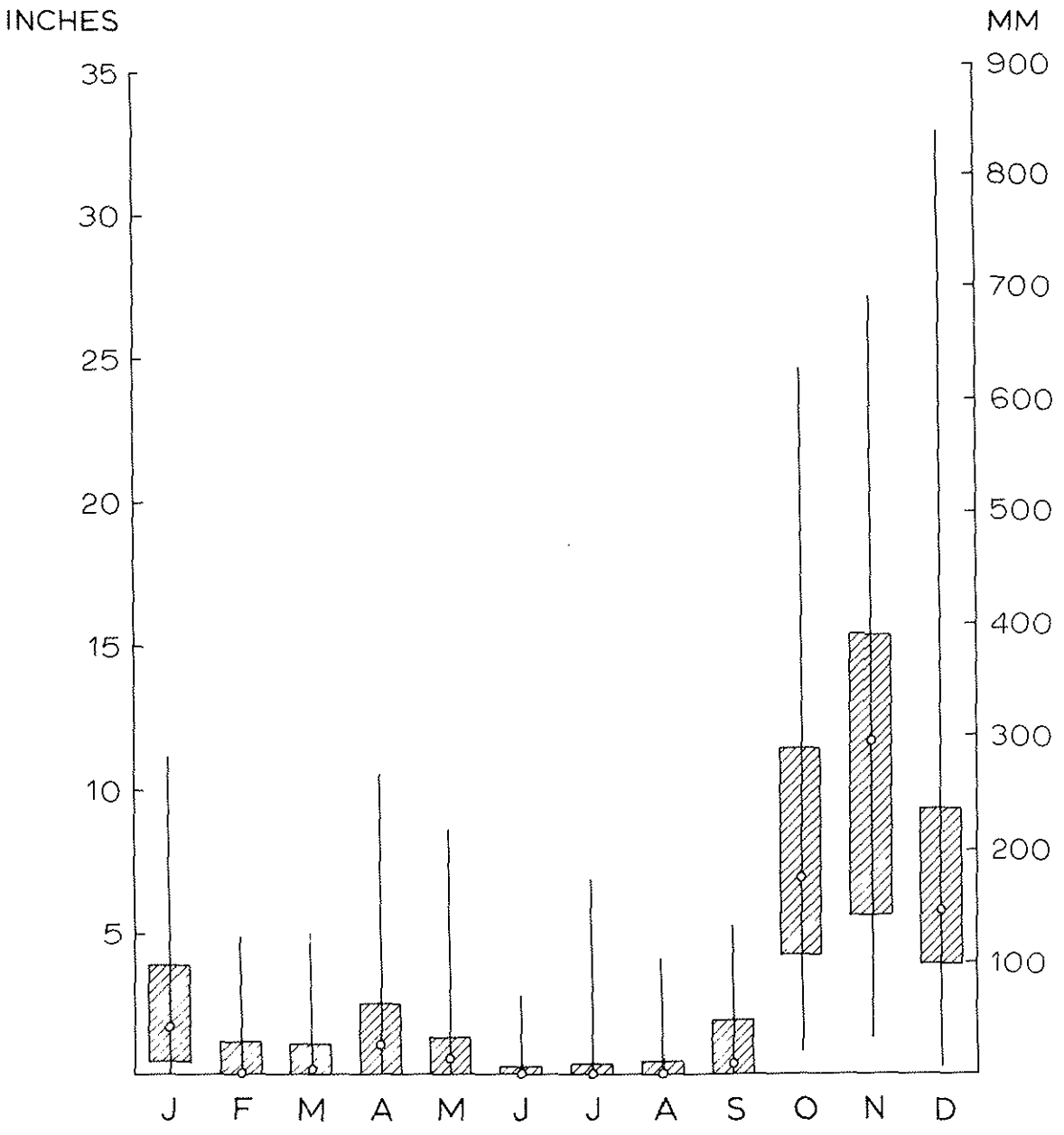

Figure 4. Mean monthly rainfall, monthly extremes, and monthly quartile ranges for 62 years of record at Pamban. Source of data: Meteorological Department, Government of India (1891-1954).

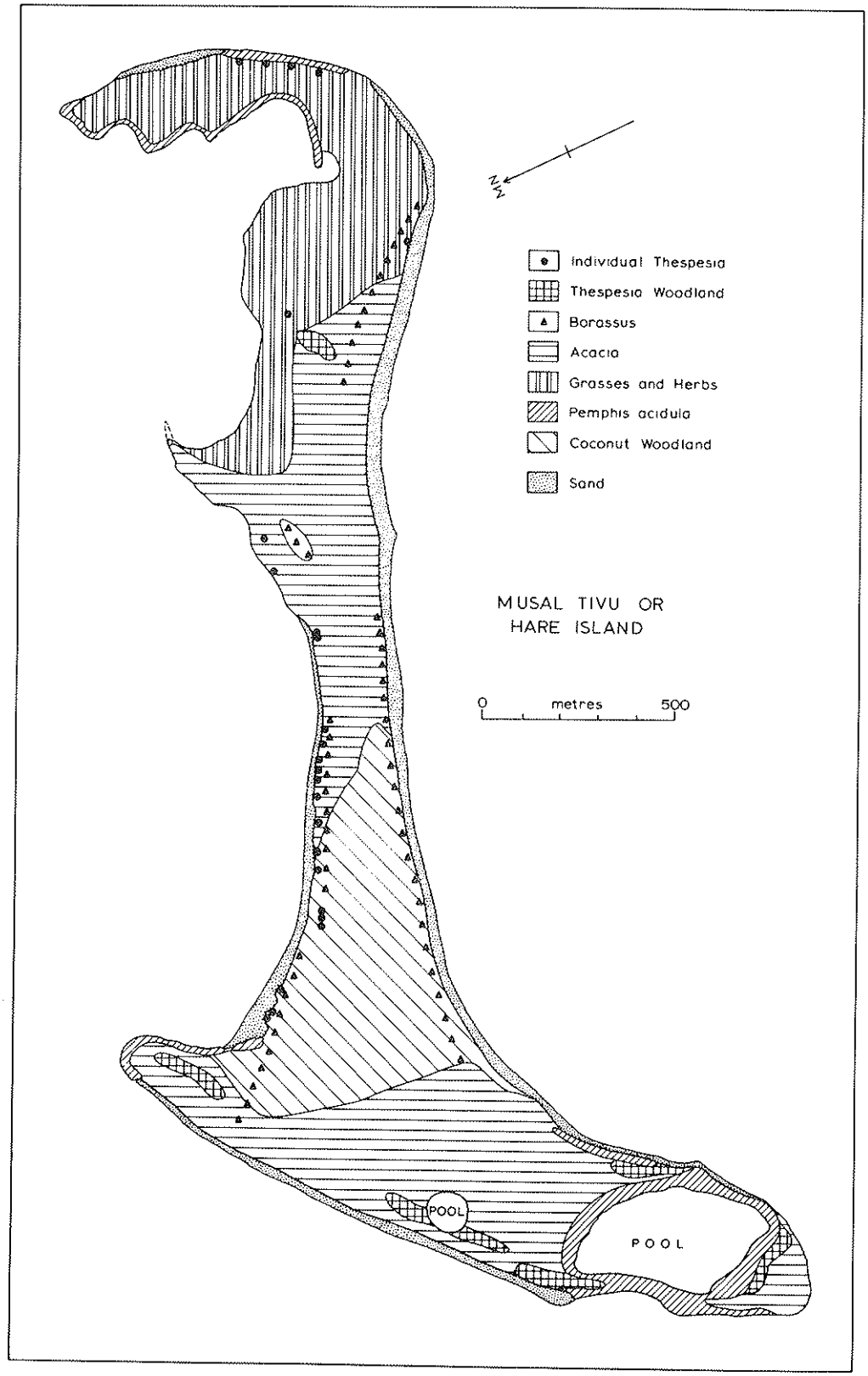

Figure 5. Musal Tivu or Hare Island. This and the following figures based on prismatic compass and pacing surveys

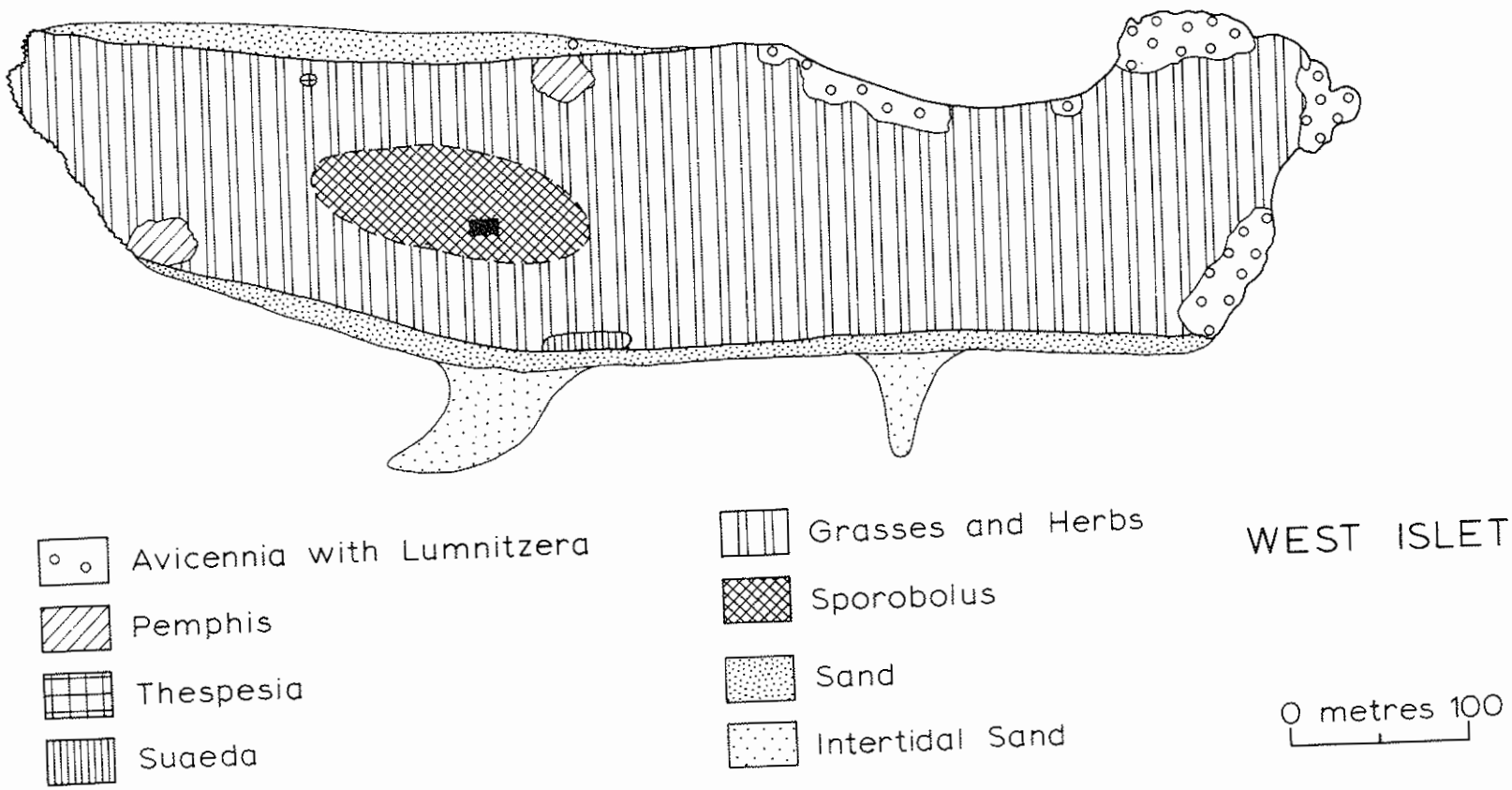

Figure 6. West Island

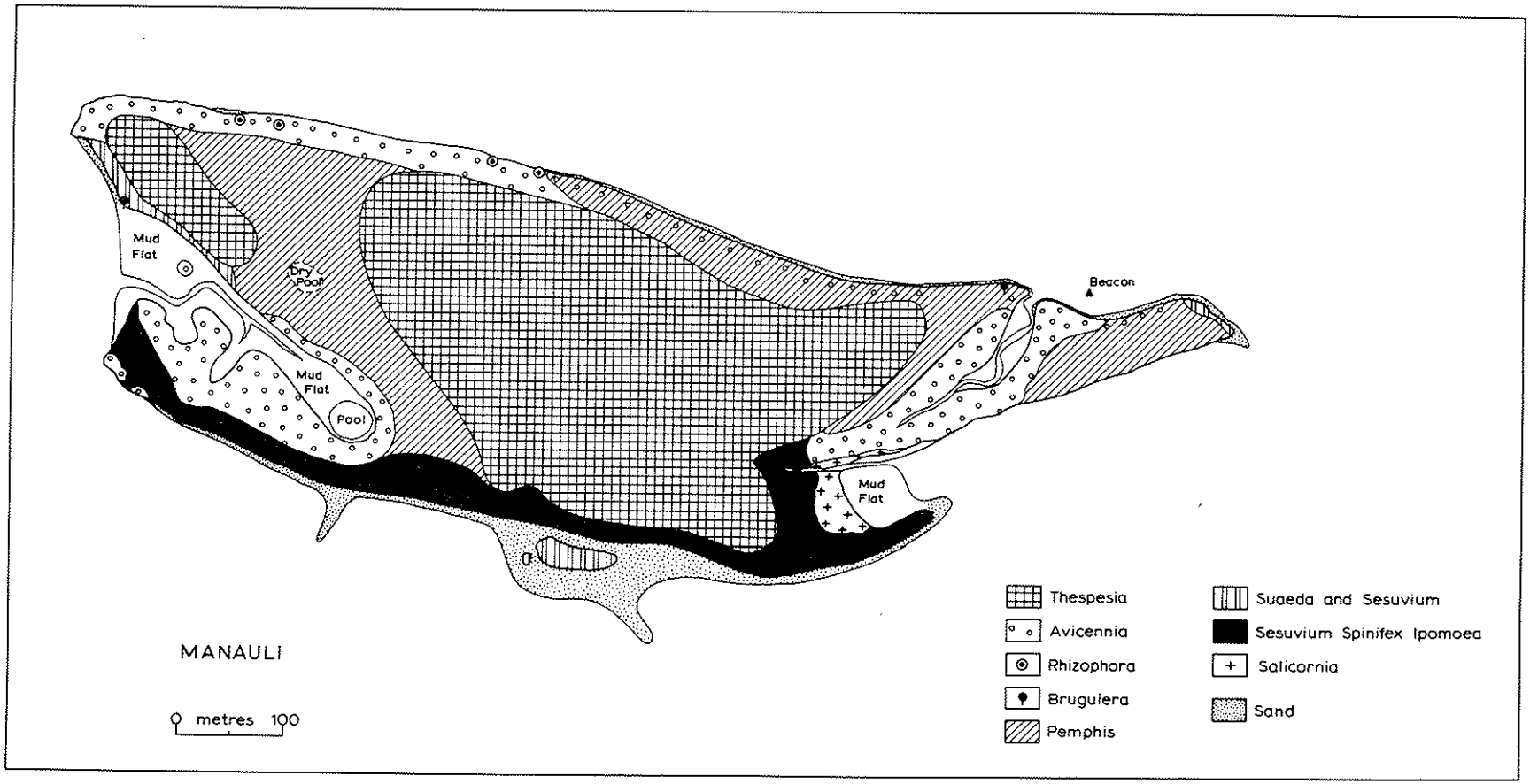

Figure 7. Manauli

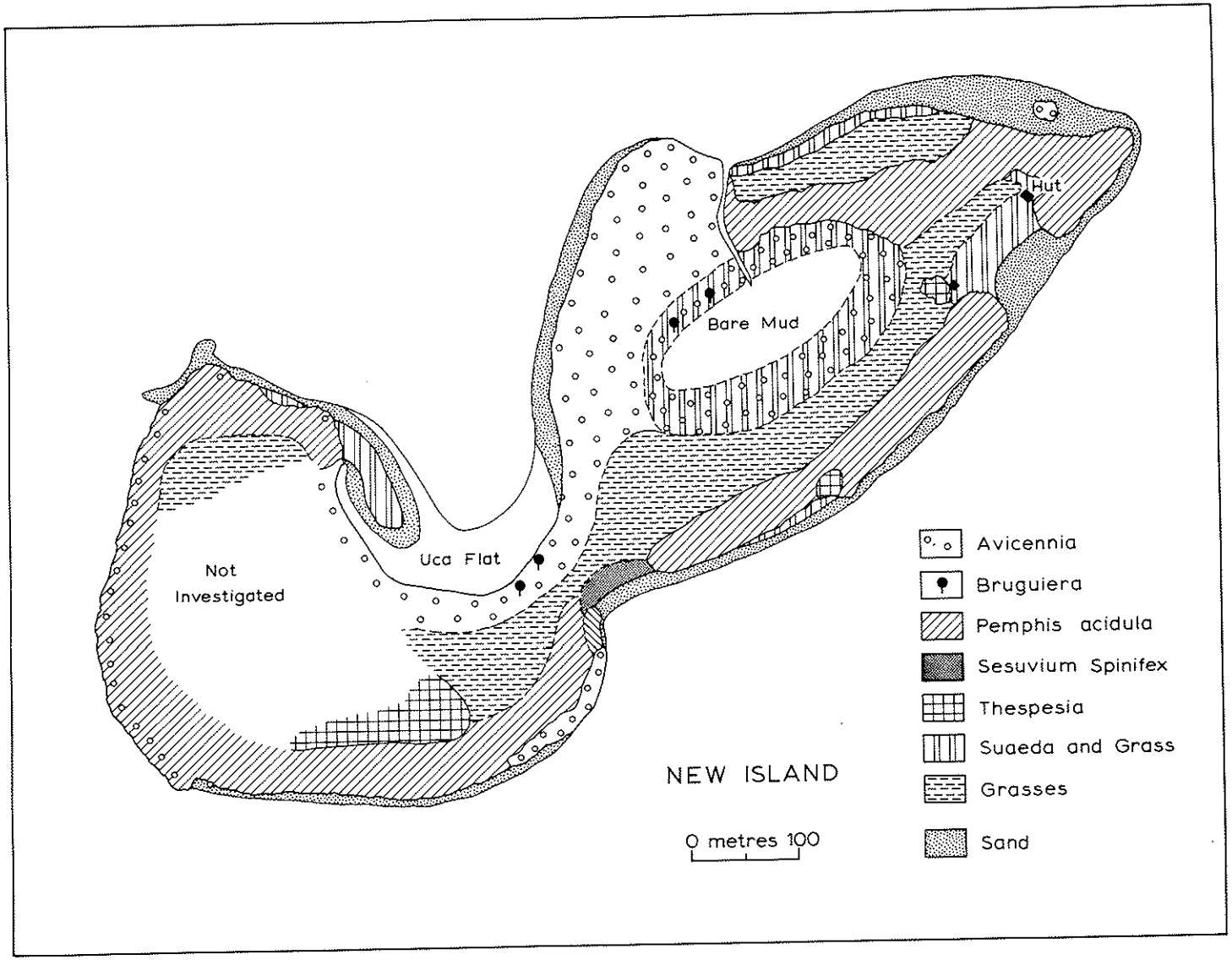

Figure 8. New Island