ATOLL RESEARCH BULLETIN

NO. 223

D'ARROS AND ST. JOSEPH, AMIRANTE ISLANDS

by D. R. Stoddart, M. J. Coe and F. R. Fosberg

Issued by
THE SMITHSONIAN INSTITUTION
Washington, D. C., U.S.A.

September 1979

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Contributors

Dr M. J. Coe, Animal Ecology Research Group, Department of Zoology, University of Oxford, South Parks Road, Oxford, England.

Dr F. R. Fosberg, Smithsonian Institution, Washington, D.C. 20560, U.S.A.

Dr D. R. Stoddart, Department of Geography, Cambridge University, Downing Place, Cambridge, England.

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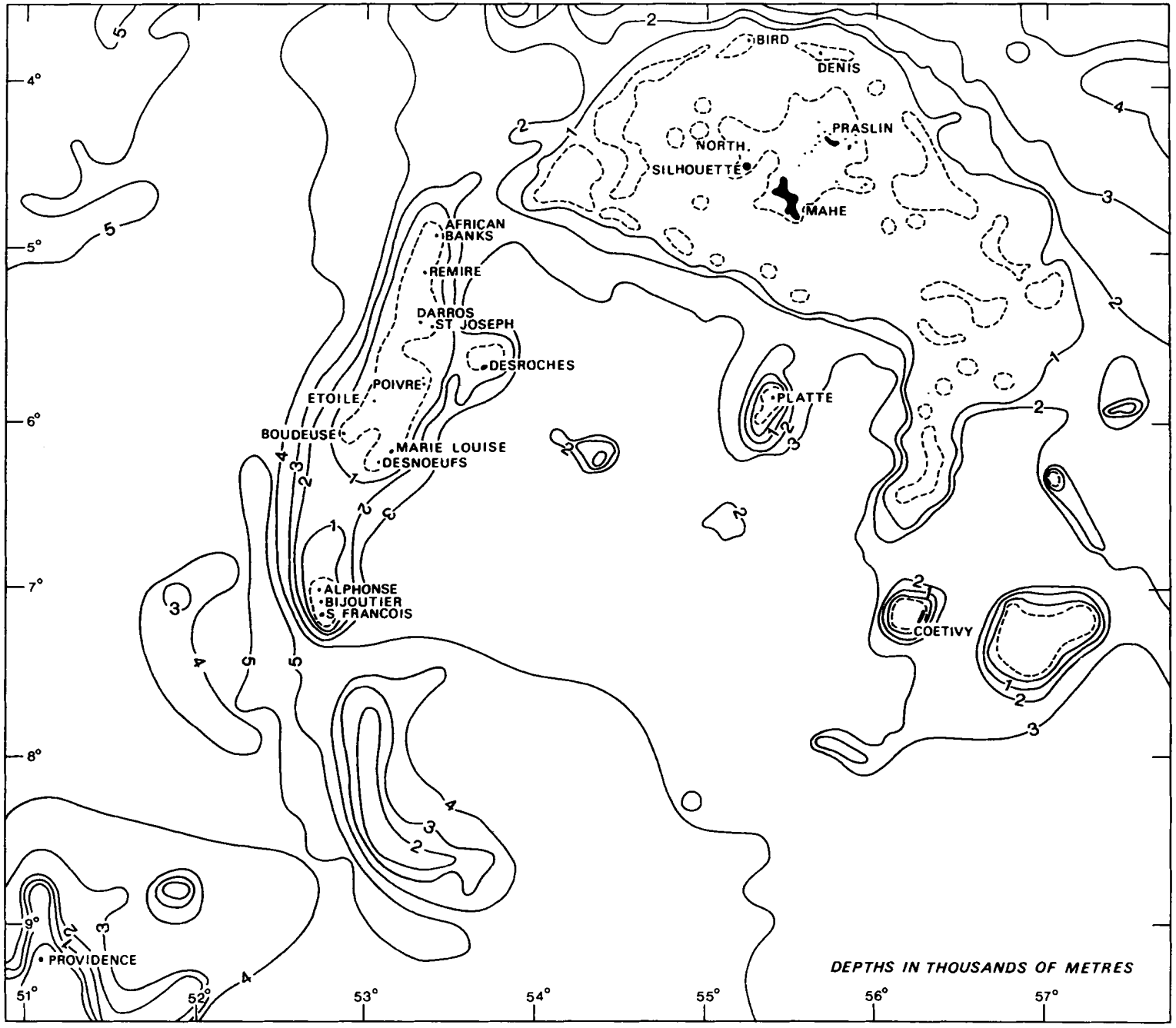

Figure 1. The Amirantes and the Seychelles Bank, western Indian Ocean. Produced from part of British Admiralty Chart No 4702 with the sanction of the Controller, H.M. Stationery Office and of the Hydrographer of the Navy

D'ARROS AND ST. JOSEPH, AMIRANTE ISLANDS

INTRODUCTION

D.R. Stoddart

This report results from a request by the then Governor of the former Colony of Seychelles, H.E. Mr. C.H. Allan, for advice on the ecology of D'Arros Island and St. Joseph Atoll in the Amirantes, recently acquired by H.I.H. Prince Chahram Pahlavi. Stoddart and Coe visited the islands on 5-8 April 1976. In addition to making specific recommendations, the following accounts of D'Arros and St. Joseph were prepared as summary papers incorporating scientific information on the islands previously obtained, mainly by the *Alert* and *Sealark* (Percy Sladen Trust) Expeditions, together with our own observations.

There is surprisingly little information available on most of the Amirante Islands, and the value of much of the published data is reduced by the lack of detailed locality records. This applies to early studies, such as that of Dufo (1840) on the marine molluscs, as well as to the reports of the Percy Sladen Trust Expedition. There are few recent accounts of the fauna and flora of islands in the group. This paper completes the coverage of the northern Amirantes - African Banks, Remire, Desroches - initiated in 1968 (Stoddart and Poore 1970a, 1970b, 1970c; Fosberg and Renvoize 1970a, 1970b, 1970c). The southern islands of the group - Poivre, Etoile, Boudeuse, Marie-Louise, Desnoeufs, Alphonse, St. François, and Bijoutier - have yet to be visited.

The present investigation was made possible through the assistance of William A. Pomeroy of Mahé. We are particularly grateful to Miss Jenny Furneau for hospitality and help on the islands, and to Capt. Marsh for the opportunity to see them from the air. C.W. Benson, Department of Zoology, Cambridge University, kindly commented on the sections on birds, and also made available his notes on Parker's collection of birds now in the National Museum of Kenya, Nairobi. G.E. Watson of the National Museum of Natural History, Washington,

kindly supplied details of the St. Joseph pelican. We are grateful to the following in the British Museum (Natural History) for determinations of collections: P. Freeman (insects), D. MacFarland (millipedes), F.R. Wanless (spiders), R.W. Ingle (crabs), and E.N. Arnold (reptiles); J.F. Peake assisted in many ways. F.R. Fosberg and M.-H. Sachet, National Museum of Natural History, Smithsonian Institution, Washington, D.C., undertook the work on the plant collections as part of their general project on the floras of western Indian Ocean coral islands. J.E. Böhlke, Academy of Natural Sciences, Philadelphia, supplied information on ichthyological work at both D'Arros and St. Joseph in March 1964.

We are grateful to H.I.H. Prince Chahram Pahlavi, through Mr. William A. Pomeroy, for contributing to the cost of publication of this report.

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Figure 2. D'Arros Island and St Joseph Atoll. Produced from part of British Admiralty Chart No 721 with the sanction of the Controller, H.M. Stationery Office and of the Hydrographer of the Navy

GEOGRAPHY AND ECOLOGY OF D'ARROS ISLAND

D.R. Stoddart and M.J. Coe

Introduction

D'Arros Island is situated in latitude 5°24½'S, longitude 53°18'E, in the Amirante Islands, western Indian Ocean, immediately to the west of the small atoll of St. Joseph. It is an oval-shaped sand cay (Plate 1), oriented NE-SW, with its major axis 1.9 km long and minor axis 1.0 km long. The island stands on a patch reef similarly orientated, with maximum dimensions of 2.8 and 1.4 km. The island stands on the northern sector of the reef; there are drying reef flats 250-400 m wide on its south side, but only a narrow fringing reef about 75 m wide on its north side. The total reef area at low water is about 270 ha; of this the island occupies 170 ha or 62 per cent; and of the island area (measured from the foot of the beaches) 160 ha are vegetated.

Previous work

Table 1 lists previous scientific visits to D'Arros. The island was discovered in 1771 by M. de la Biolière, during a voyage of exploration from Mauritius, and was named after Baron d'Arros, Commandant de la Marine at the Ile de France in 1770-71 (Froberville 1848, 111). The first hydrographic survey was carried out in 1822 by Lt. Russell under the direction of Capt. Fairfax Moresby and was mainly concerned with the establishment of accurate co-ordinates (Moresby 1842). The island was charted and the first scientific visit carried out during the visit of H.M.S. *Alert* during 20-23 March 1882. The chart by Capt. J.P. Maclear, though much corrected, is still the basis of the published chart (Admiralty Chart 724). R.W. Coppinger contributed a general description of the island and also collected marine invertebrates. The Percy Sladen Trust Expedition, with J. Stanley Gardiner and C. Forster Cooper, on board H.M.S. *Sealark*,

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spent 10-11 October 1905 on D'Arros, contributing general descriptions and collecting birds, reptiles and arthropods, especially insects.

Table 1. Previous work at D'Arros

Year	Investigator	Field of study	Main publication
1771	M. de la Biolière	Discovery	
1822	F. Moresby	Survey	Moresby 1842
1882	R.W. Coppinger J.P. Maclear H.M.S. *Alert*	Marine zoology Survey	Coppinger 1883
1892	W.L. Abbott	Birds	Ridgway 1895
1905	J.S. Gardiner C. Forster Cooper H.M.S. *Sealark*	Land and marine animals	Gardiner and Cooper 1907
1950s	J.L.B. Smith	Marine fish	Smith 1955, 1956
1960	C.J. Piggott B.H. Baker	Soils, coconuts Geology	Piggott 1968, 1969 Baker 1963
1964	J.E. Böhlke and others	Marine fish	Starck 1969, Tyler 1967, McCosker and Randall 1977.
1967	I.S.C. Parker M.D. Gwynne D. Wood M.F.R.V. *Manihine*	Birds, plants	Parker 1970 Gwynne and Wood 1969
1975	R.J. Campbell H.M.S. *Hydra*	Survey	
1976	D.R. Stoddart M.J. Coe	Fauna and flora	

Apart from occasional visits by Government economic entomologists and a visit by the ichthyologist J.L.B. Smith, no further information was collected until a survey in 1960, when C.J. Piggott described the soils and coconut plantation and B.H. Baker the geology; both were able, for the first time, to use an accurate map derived from aerial photographs at an approximate scale of 1:12,800 flown in June 1960 (Piggott 1968, 55; 1969, 33-34; Baker 1963, 54-56). Subsequently M.F.R.V. *Manihine* visited the island on 22-24 September 1967, when I.S.C. Parker (1970) studied birds and M.D. Gwynne and D. Wood (1969) collected vascular plants. H.M.S. *Hydra*, Cdr. R.J. Campbell, charted the island and adjacent waters, especially to the north, during a visit on 20-23 October 1975. Our own visit took place on 5-8 April 1976.

Geomorphology

The Amirantes (Figure 1) comprise a chain of small reef islands extending from African Banks in the north to Desnoeufs in the south, located on a bank 180 km long and 8-40 km wide; in addition to the main chain there are also islands on banks separated from the main bank, notably Desroches and Alphonse. Depths on the bank itself are mostly less than 40 m, with parts of the rim rising to 10-25 m, with occasional surface reefs. Immediately to the west of the bank the Amirantes Trench reaches depths of 5 km. The bank probably consists of a coral cap overlying volcanic rocks. Matthews and Davies (1966) suggested a basaltic foundation at a depth of 1 km or less from geophysical evidence, while near Alphonse basalts dredged from depths of 2430-3000 and 2400-2700 m have yielded a radiometric age of 82 ± 16 m yr, i.e. mid-late Cretaceous (Fisher, Engel and Hilde 1968).

The D'Arros reef itself (Figure 2) rises from the main bank surface at 30-60 m, near its eastern edge. The reef slopes are fairly gentle to the west and south, where the 30 m isobath lies 1-1.4 km from the reef edge, but they are more abrupt in the north and especially the east, where this contour is 100-300 m from the reef edge. The channel between D'Arros and St. Joseph is about 1100 m wide and 60 m deep. An un-named bank slightly smaller than the D'Arros reef is located 5 km due north of it, and has least depths of 2.7 m.

The windward reef flats are rocky pavements veneered with mobile sand and gravel, and with no living coral. There are no reef blocks on the reef edge, and no well-marked algal rim. Near the west point there is an accumulation of slightly lithified storm rubble, mostly composed of small whole *Acropora* colonies, forming a transverse tongue on the reef flat, and there are signs elsewhere on the reef flat of similar tongues now eroded. The leeward reef is irregular, with sea-grass swards and coral colonies.

The beaches of the island are all sandy (Plates 3 and 4). They are highest between Pavé Matin and Bois Blanc, where low coastal dunes are at present being eroded, leaving several lines of beachrock on the reef flat close inshore (Plate 5). No elevations were measured on the island, but the greatest height is probably not more than 7 m and much of the surface probably stands at about 2-3 m above sea-level. The interior of the island is flat and featureless; except for areas of phosphate rock the entire island is composed of carbonate sand. Piggott (1968, 55) describes the main soil as a well developed Shioya Series with an organic layer 45 cm deep; the phosphate rock he describes as a truncated Jemo Series soil with the superficial guano removed. The approximate area of the phosphate rock as mapped by Baker (1963) is shown in Figure 3. Most of the local surface irregularity on the island results from the excavation of holes through the rock during the planting of coconuts. The outcrop is either a

pavement with an irregular surface, or consists of angular irregular blocks; the extent to which the broken character of the blocks results from human activity is unknown. The thickness of the rock is usually about 1 m.

Climate

D'Arros is under the influence of the northwest monsoon from December to March, and of the southeast trades from April to November. During the trades the weather is dry, and months completely without rain are not infrequent. Most rainfall occurs during December and January (Figure 4). The mean annual rainfall for the period 1951-62 was 1497 mm; the highest annual total was 2486 mm in 1961, and the lowest 804 mm in 1958 (Table 2). The mean of 1497 mm compares with 1350 mm for Poivre (1949-62) 43 km to the south, which is the only other Amirantes station with a comparable record.

No other meteorological records are available for D'Arros. Temperatures probably vary from 25 to 30°C. Humidity is probably high, being greatest during the period of the northwest monsoon.

Marine fauna

The only collections of marine invertebrates from D'Arros are those of the *Alert* expedition in 1882. Smith (1884) lists 25 species of molluscs, mainly gastropods, Bell (1884) 18 species of echinoderms, including echinoids, ophiuroids and holothurians, Miers (1884) 16 species of crustaceans, mainly crabs, Ridley (1884a, 1884b) 7 species of sponges and a single alcyonarian. Monro (1924, 1926) also listed three species of polychaete from *Alert* material. Subsequently J.L.B. Smith (1955, 1956) listed three species of marine fish, and more species have been cited from J.E. Böhlke's collections in 1964 (Tyler 1967, Starck 1969, McCosker and Randall 1977). From these very patchy records the shallow water marine fauna appears characteristic of that of western Indian Ocean reefs generally, and of other islands in the Amirantes. According to Rosen (1971) 31 genera of reef-building corals have been recorded from the Amirantes as a whole but he predicts that the fauna probably comprises 57 genera.

Vegetation

D'Arros is presently covered with coconut woodland, but this is of comparatively recent origin. Coconut oil was being produced on at least some of the Amirantes early in the nineteenth century (Prior 1820, 59), but plantations came at a much later date. In 1882 Coppinger (1885, 221) on D'Arros noted "a large plantation of young cocoa-nuts, which in five or six years will doubtless be productive". As late as 1905, however, Gardiner and Cooper (1907, 153) gave a clear impression

Table 2. Monthly rainfall at D'Arros, 1950-1962

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1950	217	280	161	126	-	43	69	-	16	18	72	199	-
1951	157	57	97	170	97	0	17	58	88	290	159	288	1476
1952	212	252	84	236	111	149	0	22	0	8	13	135	1218
1953	410	71	193	111	196	0	11	12	22	244	130	348	1747
1954	194	107	196	84	125	0	0	109	25	0	0	211	1050
1955	422	245	23	70	203	0	0	0	51	74	89	365	1541
1956	193	175	259	117	180	36	51	15	0	53	188	267	1534
1957	366	173	163	164	79	39	49	19	0	167	158	299	1674
1958	28	118	46	166	112	90	85	15	0	19	64	61	804
1959	363	159	79	97	179	56	36	33	208	239	97	64	1610
1960	194	221	159	194	64	39	10	7	57	203	0	275	1423
1961	300	348	382	77	30	83	64	159	191	221	296	338	2486
1962	132	213	127	137	120	98	51	37	232	52	96	103	1398
Mean	245	186	151	134	124	49	34	40	68	122	105	227	1497

Original data in inches; converted to mm and rounded to nearest mm.

of rather sparse coconut growth: "Against the sea was a thick belt of the usual scrub with a few small coconuts behind; inside it had evidently been burnt. 'A thirsty and dry land where no water is'." On the other hand figures of nut production at this time (see below), which probably derive jointly from both D'Arros and St. Joseph, suggest a total planted area (assuming a yield of 2000 nuts/ha) of not less than 200 ha, or two-thirds of the combined land area of the two islands. It seems likely from this evidence that the present dense plantations are the product of the last 70-100 years. Both vegetation and flora have thus been greatly influenced by man.

The following vegetation units may be distinguished:

Coastal scrub

Most of the island is surrounded, especially on the south and west sides, by a monospecific hedge of *Scaevola taccada* about 50 m wide, 5-8 m tall, and almost impenetrable (Plates 2-4). This reaches the upper part of the beach, and consequently there is very little pioneer herbaceous vegetation on the beach crest. One or two small patches of *Lepturus repens* and clumps of *Cyperus ligularis* were seen. In addition to *Scaevola*, there are very occasional shrubs of *Suriana maritima* and *Tournefortia argentea*. *Pemphis acidula* has not been recorded from D'Arros.

Casuarina woodland

Casuarina litorea is extensive on the beach crest along much of the north and northeast shore, extending round the east end of the island to Pavé Matin (Plates 4 and 11). Coppinger noted "a handsome grove" of trees 25 m tall at the present settlement in 1882; they were then said to be nineteen years old and to have been introduced by a Frenchman named Hoyaeux (Coppinger 1885, 221, 226). Many of the present trees are very large, often more than 30 m tall (Plate 5); a few are being undermined by beach retreat, and others are being felled for timber.

Neisosperma groves

Medium-sized trees of *Neisosperma* (= *Ochrosia*) *oppositifolia* form a narrow but extensive belt between the road and the coastal *Scaevola* scrub in the southeastern part of the island east of Pavé Matin (Plate 8). Here, as well as elsewhere on the inland side of the *Scaevola*, there are mature trees of *Guettarda speciosa*.

Calophyllum groves

Between Dardanelle and Takamaka there are several discrete groves of tall *Calophyllum inophyllum* trees (Plate 7), presumably a relict of the indigenous woodland of the island. These form a dense canopy, and no other plants are found in the heavily shaded area beneath. The trees are about 25 m tall.

Other broadleaf groves

In the western part of the island there are occasional small groves, often of 2-3 trees, of *Cordia subcordata*, *Barringtonia asiatica* (Plate 6), *Guettarda speciosa* and *Pisonia grandis*. The *Cordia* and *Barringtonia* trees are particularly large; the latter is introduced.

Coconut woodland

Over most of the island the woodland canopy is formed by tall *Cocos nucifera* (Plate 9), interspersed with frequent tall but isolated trees of *Casuarina litorea*. An intermediate tree storey comprises trees 5-15 m tall of juvenile *Casuarina*, *Morinda citrifolia*, *Pipturus argenteus*, and *Leucaena leucocephala*, though these are largely replaced in the areas of phosphate rock by *Carica papaya*.

The ground layer of herbs and grasses is luxuriant and variable (Plate 10). *Kalanchoe pinnata* is the dominant tall herb, forming extensive dense stands up to 2 m tall. There are also frequent clumps of the fern *Nephrolepis biserrata* 1-2 m tall. The most common herbs are those typical of Indian Ocean coconut plantations: *Turnera ulmifolia*, *Passiflora suberosa*, *Euphorbia cyathophora*, *Phyllanthus maderaspatensis*,

Bidens pilosa, Asystasia bojeri, Boerhavia repens, Stachytarpheta jamaicensis, Striga asiatica and *Tridax procumbens*, with the sedges *Fimbristylis cymosa* and *Cyperus dubius* and the grasses *Cenchrus echinatus, Dactyloctenium aegyptium, Digitaria ciliaris* and *Eragrostis tenella*. There is one small area with clumps of *Panicum maximum* 3-4 m tall and of *Pennisetum polystachyon* reaching 2½m. *Achyranthes aspera* was curiously not recorded in 1976, nor has it been collected on D'Arros in earlier years, but it is almost certainly present.

Other cultivated and decorative plants

It will be apparent that most of the herbs of the coconut woodland are introduced weedy species. Much of the vegetation near the main settlements is also dominated by introduced species of more restricted distribution. These include massive trees at the main settlement of *Terminalia catappa* and *Hernandia sonora*, as well as *Casuarina litorea*, together with decorative plants (*Catharanthus roseus, Bougainvillea, Canna, Crinum, Hymenocallis*) and food plants (*Musa sapientum, Solanum nigrum, Moringa oleifera, Ricinus communis, Carica papaya, Vanilla mexicana, Cucurbita pepo, Capsicum frutescens*). Coppinger (1885, 221) noted that "many introduced plants - such as papaws, cotton, pumpkin, etc. - were growing in a neglected state over the island".

Flora

Gwynne and Wood (1969) in the only previously reported collection of plants from D'Arros record 42 species, based on the 53 numbers collected in 1967 (these included *Cynodon dactylon* L., not listed in their publication). 50 numbers were collected in 1976 and determinations are listed by F.R. Fosberg in the following section of this report. With sight records, the recorded flora of D'Arros is now 69 species, including two sea-grasses; this compares with 60 species for Desroches and 58 for Remire, the only other islands of a similar nature and with comparable information in the Amirantes.

Terrestrial fauna

Birds

Birds form the most conspicuous element in the land fauna of D'Arros. They are listed here in systematic order, and some effort has been made to incorporate all previously published records in this account.

Wedge-tailed Shearwater *Puffinus pacificus*

Noted as numerous by Parker (1970), though as a result of the level of human activities it is unlikely that any still breed on the island.

Audubon's Shearwater *Puffinus lherminieri*

Seen at sea 1.6 km north of D'Arros by Parker (1970); not recorded on either D'Arros or St. Joseph.

White-tailed Tropicbird *Phaethon lepturus*

Two birds seen flying round the crown of a coconut palm on 6 April 1976.

Brown Booby *Sula leucogaster*

Listed by Ridgway (1895) on the basis of three specimens collected by Abbott on 30 August 1892; no subsequent record.

Red-footed Booby *Sula sula*

Listed as *S. piscator* by Ridgway (1895); there is no subsequent record.

Greater and Lesser Frigatebirds *Fregata minor, F. ariel*

Frigates are recorded in sightings by Parker (1970). Up to 500 birds were seen over the north end of D'Arros on 7 April 1976. These are undoubtedly non-breeding birds which range widely from their main nesting site on Aldabra between November and July (Penny 1974). The lack of suitable nesting sites and the pressure of human activities make it unlikely that frigates breed on D'Arros.

Little Green Heron *Butorides striatus*

Seen by Parker (1970) and common on D'Arros in 1976. See the comments under this species on St. Joseph Atoll. Ridgway (1895) lists *B. atricapilla*.

Grey Heron *Ardea cinerea*

Seen roosting along the shoreline of D'Arros in 1976.

Cattle Egret *Bubulcus ibis*

Reported by Watson et al. (1963), and listed as *B. bubulcus* by Ridgway (1895).

Grey Francolin *Francolinus pondicerianus*

Coppinger (1885, 225) mentions in his account of Desroches Island a "partridge ... identical with that already seen at Eagle and Darros Islands"; this "small red-legged partridge", still common at Desroches, must be this species, introduced on several of the Amirantes. It was listed without identification by Ridgway (1895), but there is no other record of its occurrence on D'Arros.

Turnstone *Arenaria interpres*

Listed by Ridgway (1895). Common on D'Arros along the shoreline and in coconut plantations in April 1976, birds spending the night in small parties in the coastal scrub. In the early morning these small groups of up to 20 birds moved about together in a closed flock, but during the morning they broke up into small groups of up to 6 birds, regrouping again at sunset. One male and two females collected by Parker on 22 September 1967 are in the National Museum of Kenya, register numbers 20924-20926.

Greater Sand Plover *Charadrius leschenaultii*

Sight record by Parker (1970).

Grey Plover *Squatarola squatarola*

Sight record by Parker (1970).

Whimbrel *Numenius phaeopus*

Listed by Ridgway (1895) and by Watson et al. (1963). Very common on the shoreline and in coconut plantations in 1976, calling almost continuously.

Sanderling *Crocethia alba*

Sight record by Parker (1970).

Bridled Tern *Sterna anaethetus*

This species, seen by Parker (1970), is not recorded for the Amirantes by Watson et al. (1963). Penny (1974) records it as occurring in the Amirantes, and quotes Vesey-FitzGerald as finding nesting birds on Recif and Cosmoledo. This may be the species collected on D'Arros by Gardiner in 1905 and named *Sterna bernsteini* (Gadow and Gardiner 1907).

Common Noddy *Anous stolidus*

Sight record by Parker (1970). Two birds were seen off the northern end of D'Arros on 7 April 1976.

White Tern *Gygis alba*

Recorded as very common by Parker (1970). Very common in 1976 along the shore, but no nesting birds seen.

Turtledove *Streptopelia picturata*

Collected by Parker (1970). Two birds were observed on D'Arros,

7 April 1976; see the discussion under this species in the account of St. Joseph Atoll.

House Sparrow *Passer domesticus*

Recorded for D'Arros by Ridgway (1895), as *P. indicus*, and listed by Watson et al. (1963); recorded as a breeding species by Penny (1974). Parker found it very common (Parker 1970). Very common in 1976, and breeding freely. It is not clear when this species arrived in the Amirantes, but it was probably introduced from the African mainland (Penny 1974).

Madagascar Fody *Foudia madagascariensis*

This species has been introduced into many of the islands of the Amirantes, after an original introduction to the Seychelles about 1800. Parker (1970) found it numerous. Present on D'Arros in 1976, but numbers apparently reduced by the presence of the House Sparrow.

Seychelles Fody *Foudia sechellarum*

This species was introduced into D'Arros by the Bristol Seychelles Expedition in 1965, and it was recorded again there in 1968 (Penny 1974). Not seen in 1976.

Reptiles

Only two reptiles are recorded from D'Arros: the Green Gecko *Phelsuma madagascariensis* and the skink *Mabuia sechellensis* (Boulenger 1909). The skink was common on houses on D'Arros in 1976.

Insects

Only a very small number of insects has been recorded from D'Arros, mostly collected by the Percy Sladen Trust Expedition in 1905 (Table 3). Lepidoptera (8 species) and Coleoptera (6 species) are best represented. The mosquito *Aedes aegypti* (L.), recorded as *Stegomyia fasciata* by Theobald (1912), is very abundant; it has also been collected on the island by Mattingly and Brown (1955). These insects occur in large numbers in areas of overgrown plantation, but recent clearing operations have reduced their abundance in some parts. Piggott (1969, 34) also noted the Long-tailed Mealy Bug *Pseudococcus adonidum* and the Rhinoceros beetle *Oryctes rhinoceros* as pests of coconuts. We collected the pantropical cockroach *Pycnoscelus surinamensis* (L.) at the settlement.

Table 3. Insects collected on D'Arros

Orthoptera	Bolivar 1912, 1924	3 species
Dermaptera	Burr 1910	1 species
Neuroptera	Needham 1913	1 species
Lepidoptera	Fletcher 1910	8 species
Coleoptera	Arrow 1922 Champion 1914 Gebien 1922	6 species
Hymenoptera	Cameron 1907 Forel 1907	3 species
Diptera	Theobald 1912 Lamb 1922 Stein 1910	3 species

Other invertebrates

One species of spider was recorded by Hirst (1913).

Settlement and development

Very little is known of the history of the island. At the time of the *Alert* visit in 1882 the population of D'Arros was 11 (Coppinger 1885, 221). Magistrates' reports in 1905-6 put the total at 24 in September 1905, 35 in November 1905, and 42 in July 1906 (A. Tonnet, ms.). Census reports give totals of 56 in 1931, 57 in 1947, and 105 in 1960, with males exceeding females on each occasion.

Piggott (1969, 33) states that guano has been dug from the surface of the phosphate rock, though no details have been found of this activity. Baker (1963, 120) puts the amount of guano remaining at 2200 tons, and suggests it is only of value for local use.

As already stated, planting of coconuts began about 1880 on a commercial basis. In September 1905 the yield of the plantations on D'Arros and St. Joseph was 30,000 nuts per month, and in July 1906 it was 43,000 nuts per month (A. Tonnet, ms.). Both copra and oil (the latter 500 veltes, or 3400 litres) were exported at this time. Piggott (1969) took an optimistic view of the present state of the plantations.

In 1975 the lease of the island was taken over by H.I.H. Prince Chahram Pahlavi, and it is now managed by W. Pomeroy and Co. of Mahe. In 1976 an airstrip was constructed across the centre of the island

(Plate 11). There is a good anchorage immediately opposite the Settlement on the north shore (Plates 12-19), and during the northwest monsoon pirogues can be launched from a boathouse on the south shore.

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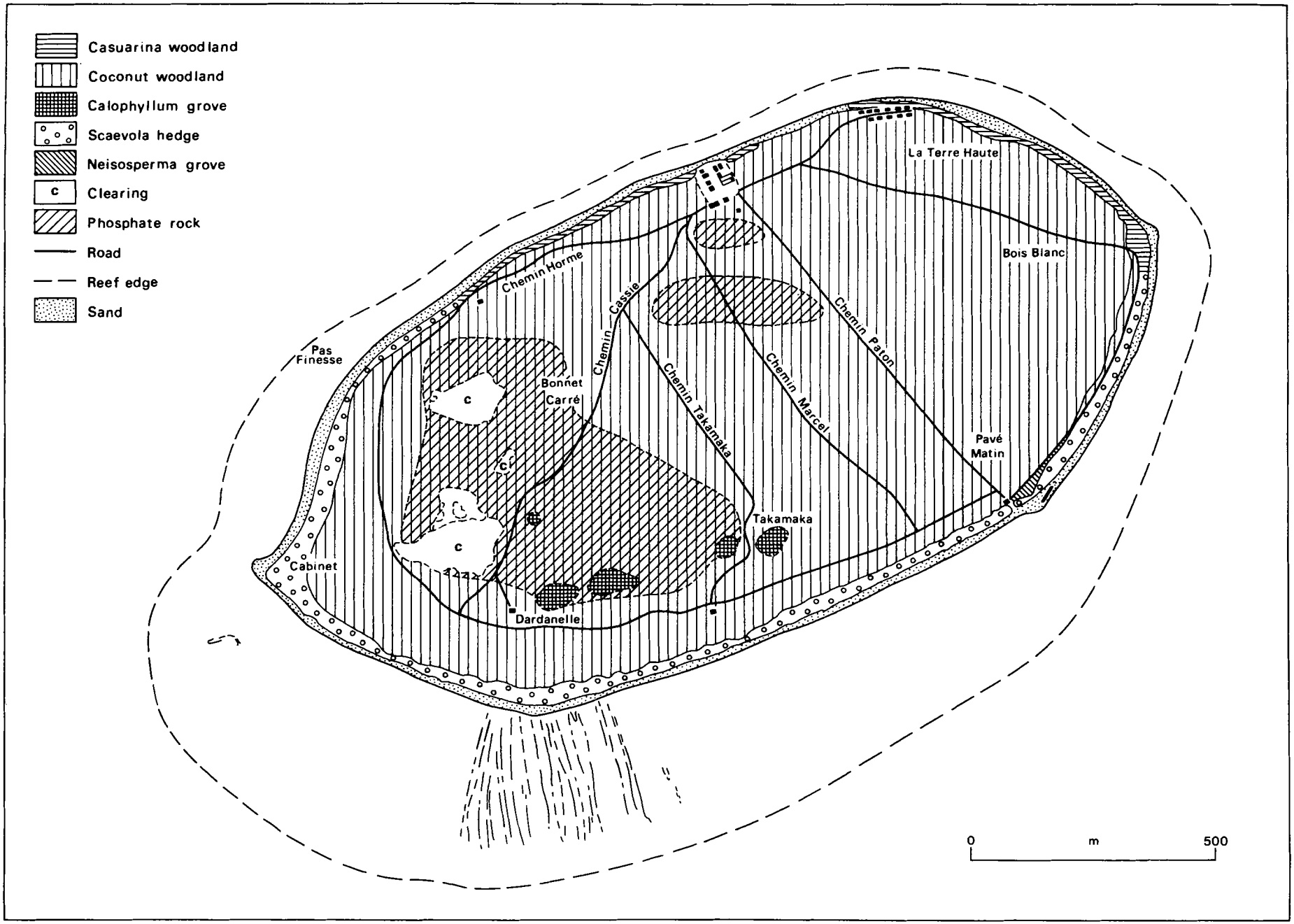

Figure 3. D'Arros Island. Based on aerial photographs with detail added from Baker (1963) and Piggott (1968)

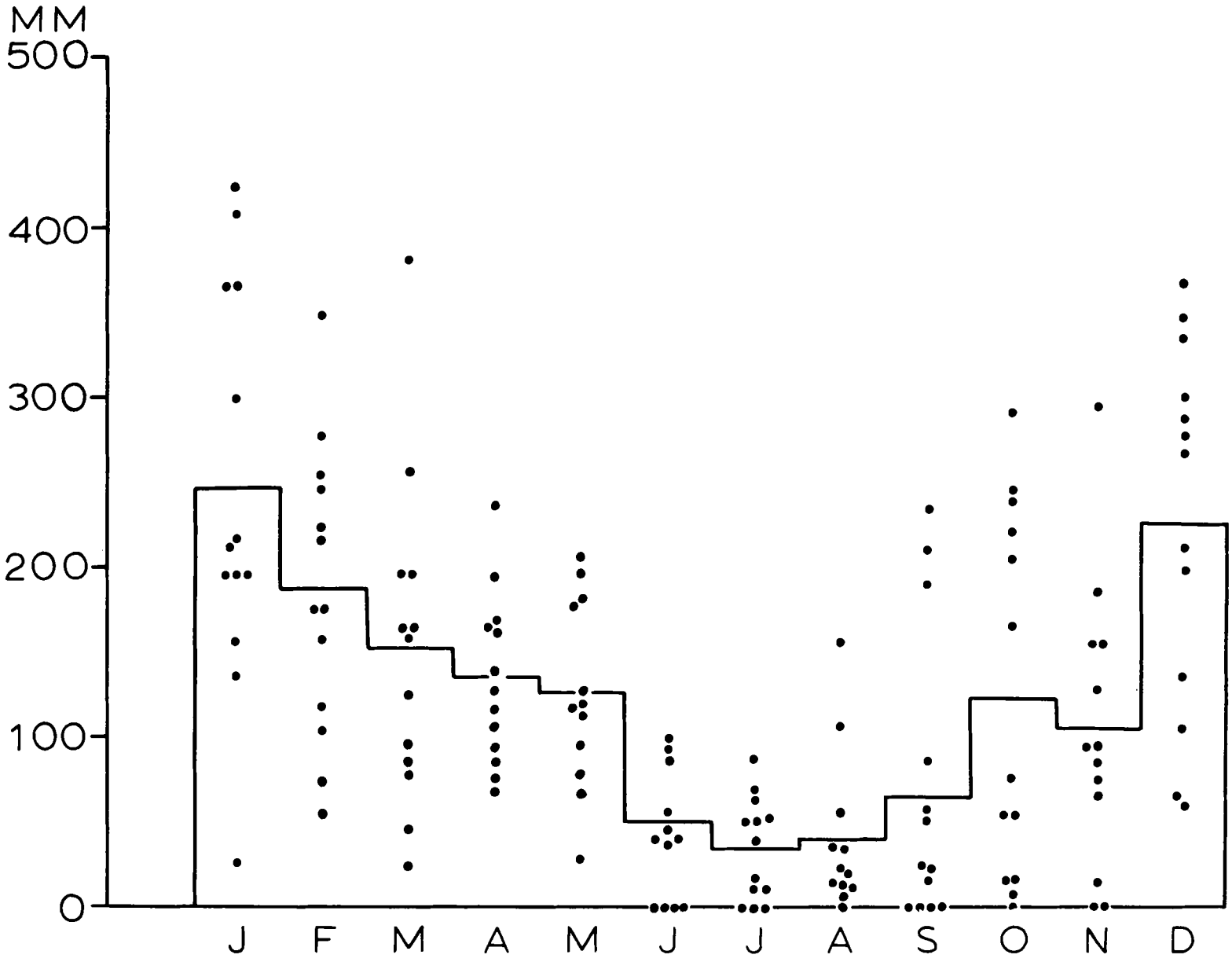

Figure 4. Monthly rainfall at D'Arros Island, 1950-62

late 1. D'Arros Island aerial photograph. Reproduced by permission of the Chief Surveyor, urvey and Lands Department, Republic of Seychelles

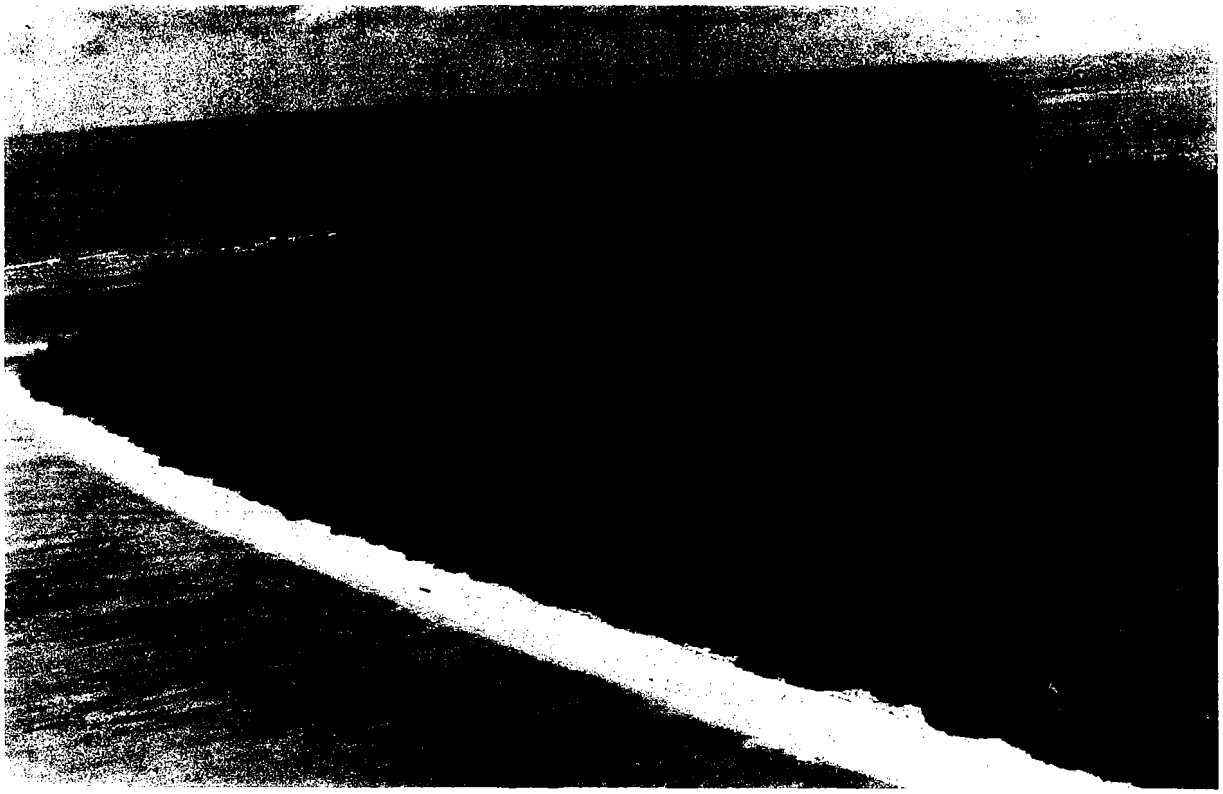

Plate 2. Southwest coast of D'Arros, showing *Scaevola* fringe, coconut woodland, and broadleaf groves

Plate 3. *Scaevola* and *Casuarina* at the southwest point of D'Arros

Plate 4. *Scaevola* and *Casuarina* at the northeast point of D'Arros

Plate 5. Tall *Casuarina* on the south coast of D'Arros Island

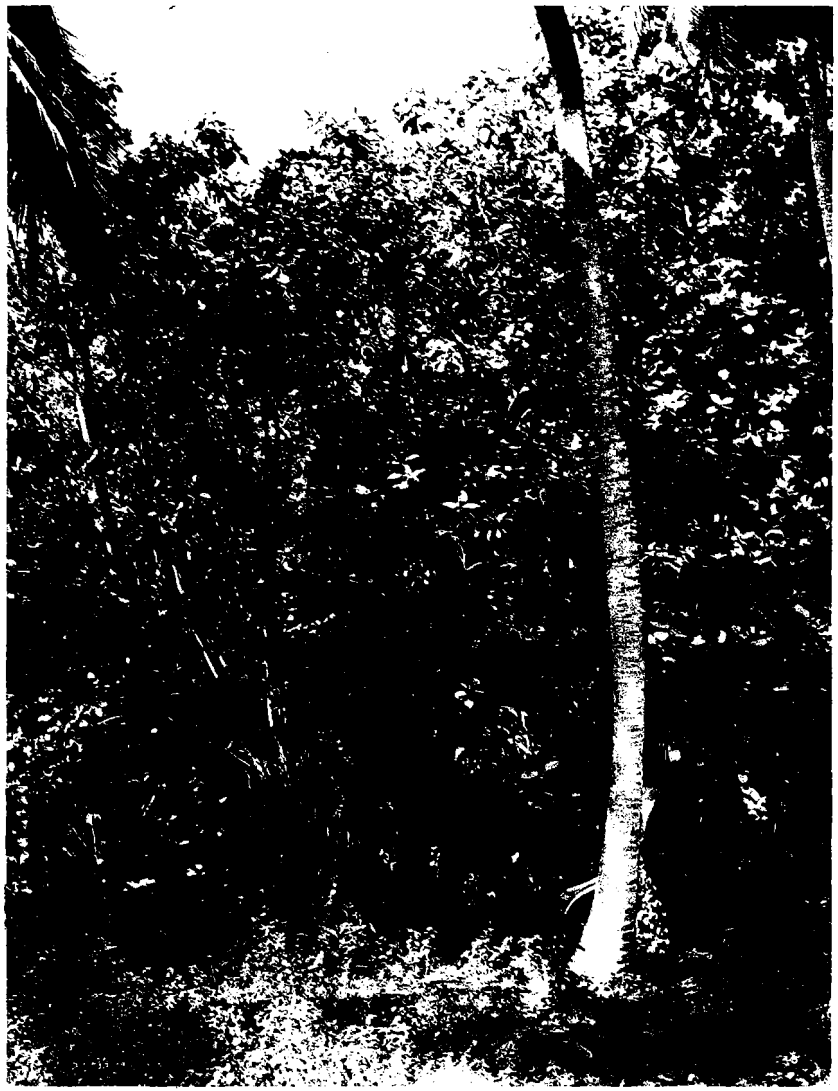

Plate 6. Mature *Barringtonia* within coconut woodland at D'Arros Island

Plate 7. Tall *Calophyllum* of inland groves at D'Arros Island

Plate 8. *Neisosperma* groves near the south coast of D'Arros Island

Plate 9. Coconut plantation near the north coast of D'Arros Island

Plate 10. Coconuts with undergrowth of *Kalanchoe*, northwestern part of D'Arros Island

Plate 11. New airstrip, western part of D'Arros Island

Plate 12. North shore of D'Arros Island showing tall *Casuarina* and the settlement

Plate 13. Centre of the settlement at D'Arros Island

Plate 14. Labourers' quarters at D'Arros Island

Plate 15. Manager's house at D'Arros Island

Plate 16. Copra works at D'Arros Island

Plate 17. Rainwater reservoir at D'Arros Island

Plate 18. Vegetable garden at D'Arros Island

Plate 19. Cemetery near the southeast shore at D'Arros Island

PLANTS OF D'ARROS ISLAND

F.R. Fosberg

POLYPODIACEAE

Nephrolepis biserrata (Sw.) Schott
Stoddart 7215 (US)

POTAMOGETONACEAE

Syringodium isoetifolium (Aschers.) Dandy
Gwynne and Wood 1007 (EA)

Thalassodendron ciliatum (Forsk.) den Hartog
Cymodocea ciliata (Forsk.) Ehrenb. ex Aschers
Gwynne and Wood 940 (EA)

GRAMINEAE

Cenchrus echinatus L.
Gwynne and Wood 936 (EA); Stoddart 7157 (US)

Cynodon dactylon (L.) Pers.
Gwynne and Wood 1011 (EA)

Dactyloctenium aegyptium (L.) Willd.
Gwynne and Wood 934 (EA); Stoddart 7161 (US)

Digitaria ciliaris (Retz.) Koel.
Stoddart 7162 (US), 7203 (US)

Digitaria horizontalis Willd.
Gwynne and Wood 946 (EA), 1025 (EA)

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Eleusine indica (L.) Gaertn.
Gwynne and Wood 925 B (EA), 1024 (EA)

Eragrostis tenella var. *insularis* Hubb.
Gwynne and Wood 925 A (EA), 928 (EA)

Lepturus repens R. Br.
Gwynne and Wood 926 (EA)

Lepturus repens R. Br. var. *subulatus* Fosb.?
Stoddart 7188 (US)

Panicum maximum Jacq.
Stoddart 7223 (US)

Pennisetum polystachion (L.) Schult.
Stoddart 7222 (US)

CYPERACEAE

Cyperus dubius Rottb.
Mariscus dubius (Rottb.) Fischer
Gwynne and Wood 1013 (EA); Stoddart 7158 (US)

Cyperus ligularis L.
Mariscus ligularis (L.) Urb.
Gwynne and Wood 960 (EA); Stoddart 7191 (US)

Fimbristylis cymosa R. Br. (s.l.)
Fimbristylis obtusifolia sensu auct.
Gwynne and Wood 924, 1004, 1008, 1009, 1010 (all EA);
Stoddart 7226 (US), 7163 (US)

PALMAE

Cocos nucifera L.
Gwynne and Wood, sight; Stoddart, sight

ARACEAE

Alocasia macrorrhiza (L.) Schott
Stoddart 7206 (US)

AMARYLLIDACEAE

Crinum sp.
Stoddart 7190 (US)

MUSACEAE

Musa sapientum L.
Stoddart, sight

ORCHIDACEAE

Vanilla mexicana Mill.
Vanilla planifolia Andr.
Gwynne and Wood 945 (EA); Stoddart, sight

CASUARINACEAE

Casuarina litorea L.
Casuarina equisetifolia L.
Gwynne and Wood 1026 (EA)

URTICACEAE

Laportea aestuans (L.) Chew
Fleurya aestuans (L.) Miq.
Gwynne and Wood 942 (EA); Stoddart 7220 (US)

Pipturus argenteus (Forst.) Wedd.
Stoddart 7197 (US)

NYCTAGINACEAE

Boerhavia repens L. var.
Stoddart 7219 (US); Gwynne and Wood, sight

Mirabilis jalapa L.
Gwynne and Wood 944A (EA), 1029 (EA); Stoddart 7208 (US)

Pisonia grandis R. Br.
Gwynne and Wood 931 (EA), 941 (EA), 947B (EA)

PORTULACACEAE

Portulaca oleracea L.
Stoddart 7200 (US)

LAURACEAE

Cassytha filiformis L.
Gwynne and Wood 943 (EA), 948 (EA)

HERNANDIACEAE

Hernandia sonora L.
Gwynne and Wood 922 (EA); Stoddart 7195 (US)

MORINGACEAE

Moringa oleifera Lam.
Stoddart 7224 (US)

CRASSULACEAE

Kalanchoe pinnata (Lam.) Pers.
Bryophyllum pinnatum Lam.
Gwynne and Wood 1014 (EA); Stoddart 7187 (US)

LEGUMINOSAE

Adenanthera pavonina L.
Gwynne and Wood 1031 (EA)

Leucaena leucocephala (Lam.) deWit
Leucaena glauca sensu auct.
Gwynne and Wood 919 (EA), 1016 (EA); Stoddart 7210 (US)

Sesbania sericea (Willd.) Link
Gwynne and Wood 1002 (EA)

SURIANACEAE

Suriana maritima L.
Gwynne and Wood 937 (EA); Stoddart 7186 (US)

EUPHORBIACEAE

Euphorbia cyathophora Murr.
Gwynne and Wood 1022 (EA); Stoddart 7209 (US)

Euphorbia hirta L.
Gwynne and Wood 1023 (EA)

Euphorbia prostrata Ait.
Stoddart 7207 (US)

Phyllanthus maderaspatensis L.
Gwynne and Wood 1030 (EA)

Ricinus communis L.
Stoddart 7212 (US); Gwynne and Wood, sight

TILIACEAE

Triumfetta procumbens R. Br.
Stoddart 7194 (US)

MALVACEAE

Gossypium hirsutum L.
Gwynne and Wood 935 (EA); Stoddart 7202 (US)

Sida parviflora DC.
Stoddart 7192 (US)

Sida rhombifolia L.
Gwynne and Wood 1027 (EA)

GUTTIFERAE

Calophyllum inophyllum L. var. *takamaka* Fosb.
Stoddart 7221 (US)

TURNERACEAE

Turnera ulmifolia L.
Gwynne and Wood 927 (EA), 950 (EA), 961 (EA); Stoddart 7213 (US)

PASSIFLORAE

Passiflora suberosa L.
Gwynne and Wood 962 (EA); Stoddart 7216 (US)

CARICACEAE

Carica papaya L.
Stoddart 7214 (US)

CUCURBITACEAE

Cucurbita pepo L.
Stoddart 7201 (US)

COMBRETACEAE

Terminalia catappa L.
Stoddart, sight

LECYTHIDACEAE

Barringtonia asiatica (L.) Kurz
Gwynne and Wood 920 (EA); Stoddart 7198 (US)

APOCYNACEAE

Catharanthus roseus (L.) G. Don
Vinca rosea L.
Gwynne and Wood 1028 (EA); Stoddart 7204 (US)

Neisosperma oppositifolia (Lam.) Fosb. and Sachet
Ochrosia oppositifolia Lam.
Gwynne and Wood 923 (EA); Stoddart 7193 (US)

CONVOLVULACEAE

Ipomoea macrantha R. & S.
Ipomoea tuba (Don) Schlecht.
Gwynne and Wood 929 (EA), 932 (EA)

BORAGINACEAE

Cordia subcordata Lam.
Gwynne and Wood 921 (EA), 947A (EA); Stoddart 7199 (US)

Tournefortia argentea L. f.
Messerschmidia argentea (L. f.) Johnst.
Gwynne and Wood 1019 (EA); Stoddart 7189 (US)

VERBENACEAE

Lippia nodiflora L.
Gwynne and Wood 1003 (EA); Stoddart 7159 (US)

Stachytarpheta jamaicensis (L.) Vahl
Stoddart 7160 (US); Gwynne and Wood, sight

SOLANACEAE

Capsicum frutescens L.
Stoddart 7225 (US)

Solanum nigrum L. (sensu lato)
Gwynne and Wood 1018 (EA)

SCROPHULARIACEAE

Striga asiatica (L.) O. Ktze.
Gwynne and Wood 939 (EA); Stoddart 7217 (US)

ACANTHACEAE

Asystasia bojeri Nees
Gwynne and Wood 1021 (EA); Stoddart 7205 (US)

RUBIACEAE

Guettarda speciosa L.
Gwynne and Wood 930 (EA), 944B (EA); Stoddart 7196 (US)

Morinda citrifolia L.
Gwynne and Wood 1020 (EA); Stoddart 7218 (US)

GOODENIACEAE

Scaevola taccada (Gaertn.) Roxb.
Scaevola sericea Vahl
Scaevola frutescens sensu auct.
Stoddart 7165 (US)

COMPOSITAE

Bidens pilosa L.
Gwynne and Wood 1005 (EA); Stoddart 7211 (US)

Tagetes patula L.
Stoddart, sight

Tridax procumbens L.
Stoddart 7164 (US)

GEOGRAPHY AND ECOLOGY OF ST. JOSEPH ATOLL

D.R. Stoddart and M.J. Coe

INTRODUCTION

St. Joseph is an atoll located in latitude 5°25'S, longitude 53°20'E, in the Amirante Islands, immediately to the east of D'Arros Island (Figure 2). The atoll is roughly oval-shaped, and measures 7 km in longer and 4.4 km in shorter dimensions (Plate 20, Figure 5). The windward (eastern) reef flat is exceptionally wide, reaching 2.8 km at the eastern point; the northern reef flat is 1-1.5 km wide, the southern 1 km, and the western 600-800 m. The main island, at the eastern end, is St. Joseph; Fouquet and Ressource are larger islets on the northern rim; and there are several small islets in the south. There is some confusion over the names of these islets, and Table 4 gives the names recorded on recently published maps.

Previous work

Table 5 lists the main investigations carried out at St. Joseph. It was discovered by M. de la Biolière, aboard the *Etoile du Matin*, in 1771, and named St. Joseph. Moresby (1842) fixed its position in 1822. Though charted by Capt. J.P. Maclear of H.M.S. *Alert* in 1882, it was by-passed by the scientists of that expedition. Abbott collected birds in 1892, but the first general scientific studies were those of J. Stanley Gardiner and C. Forster Cooper of the Percy Sladen Trust Expedition on 10-11 October 1905. Later Vesey-Fitzgerald worked there, and more recently it has been visited by C.J. Piggott and B.H. Baker in 1960, and by the *Manihine* expedition (with I.S.C. Parker, M.D. Gwynne and D. Wood) in 1967. The present chart (Admiralty Chart 724) is based on the 1882 survey by the *Alert*, but it was again charted by H.M.S. *Hydra* in October 1975. It was visited by the present authors on 5-8 April 1976. Air photograph cover at a scale of 1: 12,800 was flown in 1960.

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Table 4. Names of islets on St. Joseph Atoll

Alert 1882	Hydra 1885	Baker 1963
St. Joseph	St. Joseph	St. Joseph
Cascassaye	Cascassaye	-
-	-	Banc Ferrari
Benjamen	Benjamen	Chien
Pelican	Pelican	Benjamin
Chien	Chien	Paul, Pelican
-	Sand bar	Banc Sable
Poule	Poule	Banc Coco
Ressource	Ressource	Ressource
Fouquet	Fouquet	Fouquet

Geomorphology

St. Joseph lies on the eastern edge of the Amirantes Bank (Figure 1). To the west, on the bank surface, bottom depths are less than 50 m, except in the narrow channel between the atoll and D'Arros, where they reach 60-62 m. To the east depths of 500 m are found 1.5 km from the reef edge, and of 1000 m about 2.5 km from the reef.

The total area of the atoll is 2253 ha. Of this, 79 per cent or 1774 ha comprises peripheral reef flat, and 21 per cent or 480 ha the interior lagoon. Islets occupy 8 per cent of the peripheral reef flats, or 139 ha. The lagoon is completely enclosed by the surrounding reef; at low water it drains over a narrow sill, Passe Lerein Fin, at its western end. The greatest depth sounded by H.M.S. *Alert* within the lagoon was 6.4 m; other soundings ranged from 2.1 to 3.7 m.

The peripheral reefs, in addition to being exceptionally wide, are covered (except on the west side) with mobile sand. Intertidal sand sheets are encroaching on the margins of the lagoon on its windward side, which is marked for much of its extent by a discontinuous linear sandbar. There are no flourishing reefs in the lagoon. Transverse reef ridges, especially in the centre and west, mark the location of former flourishing reefs; but these are now sediment-capped ridges topped with sea-grasses, with massive poritid and faviid corals on their sides. At least at the time of our visit in 1976 the lagoon water was turbid and visibility poor, in marked contrast to the sea outside the atoll reefs.

Table 5. Previous work at St. Joseph Atoll

Year	Investigator	Field of study	Main publication
1771	M. de la Biolière	Discovery	
(1882)	F. Moresby	Survey	Moresby 1842
1892	W.L. Abbott	Birds	Ridgway 1895
1905	J.S. Gardiner C. Forster Cooper H.M.S. *Sealark*	Land & marine animals	Gardiner and Cooper 1907
ca 1940	L.D.E.F. Vesey-FitzGerald	Birds	Vesey-FitzGerald 1941
1960	C.J. Piggott B.H. Baker	Soils, coconuts Geology	Piggott 1968, 1969 Baker 1963
1964	A.J. Bruce R.V. *Anton Bruun*	Marine fauna	Bruce 1971
1964	J.E. Böhlke and others	Marine fish	Tyler 1966, 1967; McCosker and Randall 1977
1967	I.S.C. Parker M.D. Gwynne D. Wood M.F.R.V. *Manihine*	Birds, plants	Parker 1970 Gwynne and Wood 1969
1975	R.J. Campbell H.M.S. *Hydra*	Survey	
1976	D.R. Stoddart M.J. Coe	Fauna and flora	

The reef islets are of two types: longitudinal and transverse (Plates 21-24). The longitudinal islets are aligned parallel to the reef edge, e.g. St. Joseph and Fouquet. They are sandy islands, and because of the amount of sediment on the reef flats it is often difficult clearly to delimit the foot of the island beaches. These islands probably do not rise more than 2.5 m above the level of the reef flats. The transverse islands have a foundation of transverse rubble bars, as at Ile Poule and Ile Chien (Plates 25-27). These comprise narrow tongues of storm debris standing about 1 m above the level of the flats, and often widening seawards. Such bars are very common on the southern reef, and not all of them have sand spits or vegetated islets on them. They appear to be of similar age, and may represent a single phase of storminess.

There is some indication of considerable topographic change over the last century in the form of some of the smaller islets. Thus in 1882 Chien was charted as much larger than at present; Benjamen has apparently similarly decreased from a single large islet to a group of

small ones; Cascassaye, the southernmost section of St. Joseph, was then a separate islet. These interpretations rely on the accuracy of the survey during the brief visit by the *Alert*, but they are not inconsistent with the impression of considerable mobility of large amounts of sediment on the reef flats. Gardiner (1906, 457, 461; Gardiner and Cooper 1907, 154) gives photographs of beaches and beach rock on the eastern side of the atoll, and also speculates on topographic change.

Piggott (1968, 1969) emphasised the apparent recency of the islands, indicated by the absence of phosphatic Jemo Series soils and the dominance of immature sandy and gravelly Shioya Series soils. Baker (1963, 17), however, noted the existence of an area of phosphatic sandstone near Mare Frégate in the southern part of St. Joseph, but this area was not visited by us.

Marine fauna

There appear to be no records in the literature of marine animals from St. Joseph atoll, other than single species of pontoniinid shrimp recorded by Bruce (1971), and some species of fish collected by J.E. Böhlke in 1964 (Tyler 1966, 1967; McCosker and Randall 1977).

Vegetation

The larger islands of St. Joseph, notably St. Joseph itself, Fouquet and Ressource, are covered with coconut plantations which are at least as old as those of D'Arros. Probably because of the more isolated state of the atoll, resulting from the absence of a passage into the lagoon, the introduced weed flora is much more restricted than on D'Arros, and the whole aspect of the vegetation in the plantations is therefore very different. This paucity in the herb and grass flora also extends, however, to pioneer habitats, which are characteristically occupied by shrubs, and where much ground remains bare. Athough there can be little climatic difference between D'Arros and St. Joseph, the former therefore gives an impression of damp luxuriance, and the latter in many areas of much greater aridity; these differences undoubtedly reflect the differences in the nature and level of human activity on the two places.

Pioneer shrub community

A mixed community of shrubs on the sand islet of Poule includes *Pemphis acidula* up to 5 m tall (Plate 28), *Suriana maritima*, *Tournefortia argentea* (Plate 29) and *Scaevola taccada*. The ground surface is completely bare, except for a single tussock of *Lepturus repens*, one small patch of *Boerhavia*, and a pair of germinating coconuts. Similar areas of low shrubs with bare ground beneath are found on the islands south of St. Joseph.

Coastal scrub

Scaevola taccada is the typical shrub species of seaward beaches on the larger islands, as on D'Arros, together with occasional shrubs of *Tournefortia argentea* (Plates 30-33).

Coastal woodland

Guettarda speciosa is a very common beach crest tree, especially on lagoon shores (Plates 34-35), as on Fouquet and Chien. Both islands, and also Ressource, have coastal *Casuarina litorea* (Plate 36), both as individual trees and as groves. There is a single coastal tree of *Hernandia sonora* on Ressource.

Pemphis thicket

Most of the larger islands have extensive beach-foot thickets of *Pemphis acidula* on their lagoon shores, occupying locations where mangroves might be expected; these thickets are particularly extensive in the area of mud and sand flats at Cascassaye (Plates 28 and 37). A single tree of *Rhizophora mucronata*, fruiting abundantly, was found on the lagoon shore of Pelican (Plate 38), and it is not clear why mangroves are not much more common along lagoon shores.

Suriana thicket

A small pool at the eastern end of Fouquet is surrounded by a low scrub of *Suriana maritima* (Plate 39).

Coconut plantations

The coconut plantations are intensively managed on St. Joseph (Plate 40), but on the other islands they form a thicket with tall herbs and juvenile palms (Plate 41). *Kalanchoe pinnata* up to 1 m tall is common in these latter situations. Other common herbs in the plantations include *Achyranthes aspera, Boerhavia repens, Cassytha filiformis, Euphorbia hirta, Ipomoea macrantha, Passiflora suberosa, Phyllanthus maderaspatensis, Portulaca oleracea, Sida parvifolia, Stachytarpheta jamaicensis, Striga asiatica, Tridax procumbens, Turnera ulmifolia* and *Vernonia cinerea*; the grasses *Lepturus repens, Eragrostis ciliaris, Stenotaphrum micranthum, Sporobolus virginicus,* and *Dactyloctenium aegyptium;* and the sedges *Cyperus ligularis* and *Fimbristylis cymosa*.

Settlement vegetation

The small settlement at the western end of St. Joseph has a cluster of introduced trees: *Barringtonia asiatica* and *Terminalia catappa* 15 m tall, *Hernandia sonora* 10 m tall, and *Leucaena leucocephala*. There are cultivated trees of *Moringa oleifera, Carica papaya,* shrubs of *Capsicum frutescens,* and decorative *Hymenocallis, Crinum* and *Catharanthus*.

Flora

The first collection of vascular plants from St. Joseph was that made by Gwynne and Wood (1969). Their 40 numbers comprised 28 species (including *Pithecellobium unguis-cati*, omitted from their published list). The 44 numbers collected in 1976 comprise 39 species, bring the total number of plants recorded to 47 species, including two sea-grasses, listed in the following paper by F.R. Fosberg. The flora is noteworthy in comparison with that of neighbouring D'Arros by the presence of *Pemphis* and *Rhizophora*, and the absence of *Cordia* and of many of the common introduced weedy species of D'Arros.

Terrestrial fauna

Birds

Wedge-tailed Shearwater *Puffinus pacificus*

Recorded as *P. tenuirostris*, breeding in large numbers, by Gadow and Gardiner (1907). Gardiner and Cooper (1907, 153) also mention a "vast number" on Fouquet, as well as burrows on Pelican (ibid., p.154). It was recorded as breeding by Vesey-FitzGerald (1941), and as numerous, and breeding on Fouquet, by Parker (1970). One male and two females collected by Parker are in the National Museum of Kenya, registered numbers 20937-20940. Fouquet was still covered with large numbers of burrows in 1976, and local workers assured us that the birds were still common. No burrows were seen on Ressource, but they were said to be still found at the southern end of St. Joseph. They were also found on the southern end of Pelican. The restriction of clearing on Fouquet would doubtless ensure the survival of the nesting area on that island.

White-tailed Tropicbird *Phaethon lepturus*

Six were seen at Ressource by Parker (1970).

Pink-backed Pelican *Pelecanus rufescens*

W.L. Abbott collected a specimen of this species on 29 August 1892 and it was listed by Ridgway (1895, 516), with a note by Abbott referring to "a small colony - perhaps one hundred individuals ... the only colony of pelicans in these seas". The colony was again seen by Gardiner in 1905. "These large birds were found breeding in a colony in the coconut and other large trees of the eastern island of St. Joseph Atoll, Amirante Group. Young birds were seen in October 1905" (Gadow and Gardiner 1907, 110). No specimens were taken but the birds were identified as Dalmatian Pelican *Pelecanus crispus*. Gardiner and Cooper (1907, 154) state: "St. Joseph is covered with tall coconuts, some of which were weighted down and killed by the large nests of

Pelecanus crispus, of which there was a numerous colony. How far this bird is a wanderer we do not know". Both Betts (1940, 504) and Watson et al. (1963, 180) follow Gardiner in listing the species as the Dalmation Pelican, even though this is a ground-nesting species. *P. crispus* does not breed closer to the Amirantes than the Persian Gulf. Dr. G.E. Watson has located Abbott's original specimen and has confirmed its overlooked identification by Ridgway as *P. rufescens* (Stoddart 1977); the specimen is in the National Museum of Natural History, Washington. There are several records of this species from Madagascar and one from the Dahlak Archipelago, Red Sea, but otherwise none outside mainland Africa; its occurrence on St. Joseph is thus of some interest. Loustau-Lalanne (1963, 23) gives a hearsay report of two individuals of *P. crispus* on Bijoutier, Alphonse, southern Amirantes; if the presence of these birds is confirmed they may also be *P. rufescens*. The colony was not seen by Vesey-FitzGerald in the 1930s, has not been subsequently reported, and was not present in 1976. The fact that one of the islets on St. Joseph was charted as 'Pelican' by H.M.S. *Alert* in 1882 may indicate either that the species was present then, or that it had nested there sufficiently recently for the name to be recognised.

Brown Booby *Sula leucogaster*

Listed by Ridgway (1895) on the basis of Abbott's report. A nest with two eggs was recorded in November by Vesey-FitzGerald (1941). This species was not seen in 1976.

Red-footed Booby *Sula sula*

Abbott collected a single specimen of this species in 1892 (Ridgway 1895). Gardiner and Cooper (1907, 153-154) refer to "another common bird, likewise breeding, - the booby (*Sula piscator*), found so abundantly before at St. Pierre, and wandering daily from St. Joseph over every reef in the group". There is no later record of this species on the atoll.

Great Frigatebird *Fregata minor*

One immature was collected by Parker (1970). Up to 500 birds, either Great or Lesser Frigates, were seen over Fouquet on 6 April 1976. As on D'Arros, it is unlikely that they breed because of the lack of suitable nesting sites.

Lesser Frigatebird *Fregata ariel*

Sight record by Parker (1970). A male was taken by Abbott in August 1892 (USNM 128775) (Ridgway 1895).

Grey Heron *Ardea cinerea*

Recorded by Watson et al. (1963). Fifteen were seen by Parker (1970). Common on all the islands and the reef flats.

Little Green Heron *Butorides striatus*

Listed as *B. atricapilla* by Ridgway (1895). Noted as resident by Watson et al. (1963), and as common on all the islets by Parker (1970). The National Museum of Kenya has a female collected on the "reef between D'Arros and St. Joseph", 23 September 1967, by Parker, registered number 20931. Abundant in 1976 on all the islands. During the heat of the day and evening the birds commonly roost on palm fronds, landing and creeping close to the shelter of the crown with the body held horizontal. This bird is the subspecies *B. s. crawfordi* which is common from Aldabra to the Amirantes, being replaced in the Seychelles by *B. s. degens*. Although the latter subspecies may occur in the Amirantes (Penny, 1974), it was the former which was observed on the islands visited in 1976.

Cattle Egret *Bubulcus ibis*

Recorded by Ridgway (1895) (as *B. bubulcus*) and by Watson et al. (1963, 180).

Turnstone *Arenaria interpres*

Listed by Ridgway (1895) and as a non-breeding migrant by Watson et al. (1963); seen by Parker (1970). Common in 1976 along shorelines and in plantations.

Grey Plover *Squatarola squatarola*

Seen by Parker (1970). A single bird was seen on the reef flat on 7 April 1976.

Greater Sand Plover *Charadrius leschenaultii*

Seen by Parker (1970).

Whimbrel *Numenius phaeopus*

Listed by Ridgway (1895) and as a non-breeding migrant by Watson et al. (1963). Very common on the shoreline and in plantations in 1976.

Greenshank *Tringa nebularia*

Six seen by Parker (1970).

Common Sand Piper *Tringa hypoleucos*

Seen on the shorelines of St. Joseph and Ressource, 6-7 April 1976.

Sanderling *Crocethia alba*

One male collected on Ressource, 23 September 1967, by Parker, and now in the National Museum of Kenya, registered number 20923.

Crab Plover *Dromas ardeola*

Twelve seen by Parker (1970), who collected one female and two juveniles on 23 September 1967, now in the National Museum of Kenya, registered numbers 20932-20934. Three birds observed on St. Joseph and two on Ressource, 7 April 1976.

Black-naped Tern *Sterna sumatrana*

Recorded as nesting, without precise locality, by Vesey-FitzGerald (1941, 256), and noted as breeding in September-November by Watson et al. (1963, 181). One seen by Parker (1970) on Ressource. Several seen over the reef flats off Ressource and St. Joseph on 7 April 1976. Both Ressource and several of the small islets south of St. Joseph would seem to have suitable beaches for terns to nest.

Bridled Tern *Sterna anaethetus*

This species, seen by Parker (1970), is not recorded from the Amirantes by Watson et al. (1963). Penny (1974) records it as occurring in the group.

Sooty Tern *Sterna fuscata*

There is no previous record of this species from St. Joseph Atoll. A group of a dozen was seen on Ressource, 7 April 1976, settling on vegetation on the beach crest and fishing over the reef flat margin.

Crested Tern *Thalasseus bergii*

Two birds seen on the reef flat off Ressource, 7 April 1976.

Common Noddy *Anous stolidus*

Seen by Parker (1970). A small group flying with Sooty Terns seen on Ressource, 7 April 1976.

White Tern *Gygis alba*

Recorded as breeding by Vesey-FitzGerald (1941, 529-530), and noted as very common by Parker (1970). Very common along the shores of all islands in 1976, but no nesting birds seen.

Turtledove *Streptopelia picturata*

The endemic subspecies of the Madagascar Turtledove in the Amirantes is the vinous-headed *S. p. saturata*. Parker collected

two grey-headed females on 23 September 1967 on St. Joseph Island, and these are in the National Museum of Kenya, registered numbers 20927-20928. Benson (1970) has suggested that these specimens are hybrids resulting from an introduction of *S. p. picturata* from the Seychelles. Two birds were observed on D'Arros, 7 April 1976, and one on St. Joseph, 7 April 1976; all had typical grey heads and deep purple mantles.

House Sparrow *Passer domesticus*

First recorded as introduced by Abbott in 1892 (Ridgway 1895). Noted as very common on Ressource and St. Joseph by Parker (1970). He collected one female on Ressource on 23 September 1967, now in the National Museum of Kenya, registered number 20901. Very common in 1976 on St. Joseph Island, but not seen on Fouquet or Ressource.

Madagascar Fody *Foudia madagascariensis*

Noted as numerous on Ressource and St. Joseph by Parker (1970). One male collected on Ressource on 23 September 1967, now in the National Museum of Kenya, registered number 20900. Present on all the larger islands of the atoll, but the presence of the House Sparrow on St. Joseph Island seems to reduce its numbers there. Only seen in large parties on Ressource where the House Sparrow is apparently absent.

Reptiles

Madagascar Green Gecko *Phelsuma madagascariensis*

This species was common on all four main islands of the atoll. The presence of palm trees seems to favour their presence, and up to four animals were commonly seen on their trunks. Aggressive displays were observed in which the combatants faced each other and the bright red tongue was flashed across the face, having the appearance of a small red balloon momentarily inflated. This display was initiated usually by one of a pair after which the other gave way and retreated. Previously recorded from the atoll by the Percy Sladen Trust Expedition (Boulenger 1909).

House Gecko *Hemidactylus frenatus*

A specimen collected on St. Joseph is now in the British Museum (Natural History); this species has not previously been recorded from the atoll.

Seychelles Skink *Mabuia sechellensis*

Very common on all islands of the atoll. It occurs on tree trunks like *Phelsuma*, but it is also observed on the ground, unlike the Gecko. This species is restricted to the Seychelles and the Amirantes, although it is quite closely related to the widely distributed African species *M. maculilatris*.

Insects

We have found only a single species of insect previously recorded from St. Joseph Atoll, the Rhinoceros Beetle (Scott 1912). The caterpillars of the small arctiid moth *Utetheisa p. pulchelloides* Hampson were found defoliating *Scaevola* on Ressource, 8 April 1976. Also collected were specimens of *Euconocephalus* sp. (Tettigonioidea); *Icerya seychellarum* (Westwood); *Cardiophorus* sp. (Elateridae); *Dactylosternum* sp.? (Hydrophilidae); *Aedes (Stegomyia) albopictus* Skuse (Culicidae); and the following Staphylinidae: *Philonthus bisignatus* Boh., *Philonthus reinekis* Schab., *Philonthus* species (four not determined and one possibly new), *Gabronthus* sp., *Oxytelus varipennis* ssp. *Pharaohnum* Koch., and *Aleochara trivalis*.

Other Arthropods

Hirst (1913) records two spiders, including *Nephila madagascariensis*, from St. Joseph. We collected a specimen of a young huntsman spider (Heteropodidae) from Fouquet. The orb weaver *Tetragnatha* sp. is very common on all islands where it spins its golden webs in great numbers. Local children collect the thicker strands of these webs for fishing. Three millipedes were collected from a rotten palm trunk, and have been identified as follows:

Mystalides bivirgatus (Karsh), recorded from Tanzania, Pemba, Comoros, Aldabra, Madagascar.
Spirostrophos naresii (Pocock), recorded from Madagascar and Seychelles and widely distributed in the East and West Indies.
Orthomorpha coarctata (Sauss), cosmotropical distribution.

Recent clearing operations in the coconut plantations have removed many fallen trunks from the surface. However it is possible to measure the rate of decomposition of fallen palm trunks remaining. The dead trunks examined were probably not more than six years old, yet during this time the whole interior had been reduced to a broken powder comprised mainly of arthropod frass. In addition to the very large numbers of millipedes present there were also huge numbers of a small Entomobryoid-like Collembolan. At the time of our visit to the atoll recent rain had probably accelerated decomposer microorganism and detritivore activity, which must for much of the year be water-limited.

Borradaile (1907) records the land hermit crab *Coenobita rugosus* H. Milne-Edwards from St. Joseph. We did not, however, find these crustaceans to be common. One male and one female were collected on Ressource, together with three individuals of *Coenobita perlatus* H. Milne-Edwards. Only a single colony was found of the large crab *Cardiosoma carnifex* (Herbst), and this too was on Ressource, under *Pemphis* scrub on the west shore. One female of this species and the specimens of *Coenobita* are in the British Museum (Natural History).

Ocypodid crabs were abundant on virtually all the beaches visited. Their excavations for the small bivalve mollusc *Donax faba* were especially prominent on the lagoonward shores of St. Joseph, where a female *Ocypode ceratophthalmus* (Pallas) was collected. These crabs play an important role in adding to and reworking the sediments of the beaches, in some of which *Donax* shells form a dominant component.

The Lagoon

The lagoon, which has general maximum depths of about 3 m, is divided into a series of basins by parallel flat-topped reef ridges trending northeast to southwest and concentrated in its western half. The upper surfaces and edges of these ridges are emergent during lowest tides and do not support living corals. They are covered with thick growths of marine angiosperms, mainly *Thalassodendron ciliatum* and *Thalassia hemprichii*, with a molluscan infauna characterised by *Pinna*. *Syringodium isoetifolium* has been collected on the reef flat at D'Arros but not at St. Joseph, though it is common in shallow water on the north side of the lagoon. Massive faviid and poritid corals grow on the flanks of the ridges, especially on their eastern (windward) sides; but they are clearly adversely affected by siltation, and the coralla are heavily bored and deformed. Presumably because of the absence of any open channel to the sea, the lagoon acts as a sediment sink. Wide fans of sediment are advancing into the lagoon from the peripheral reefs, especially on the south and southeast sides, and during our visit the lagoon water was extremely turbid, in marked contrast to that outside the seaward reef margins. Shallow surfaces in the lagoon are covered with thick silty sand sheets up to 30 cm deep.

Large rays are extremely common on shallow sandy reef flats. In several cases they were seen swimming in pairs, raising their pectoral fins above the water and diving one above the other, and it seems probable that they were courting. Seychellois on the atoll say that rays are always common in the lagoon. Black-tipped and White-tipped sharks (*Carcharinus melanopterus, Triaenodon abesus*) are seen in all parts of the lagoon. No Green Turtles *Chelonia mydas* were seen, but up to a dozen Hawksbill Turtle *Eretmochelys imbricata* were seen on the D'Arros aspect of the atoll and around the islets south of St. Joseph.

The shallow nature of the lagoon and the low rate of water turnover leads us to suspect that it is in a low state of productivity. Thus suggestion would seem to be supported by the fact that few fish shoals were observed in the lagoon during our visit. The presence of storm beaches and the width of the reef flats may well inhibit the transport of reef-generated nitrogenous particulate matter into the lagoon.

Settlement

The only settlement on the atoll at present is on St. Joseph island, though there are remains of huts some years old on both Fouquet and Ressource. The plantations were well established by 1905, when Tonnet reported that there were more trees on St. Joseph than on D'Arros. At that time there were 4000 coconut trees on Fouquet and 2500 on Ressource, as well as the main plantation on St. Joseph; together with small plantations on Benjamen and Cascassaye. The population in September 1905 was 26, including 3 each on Fouquet and Ressource.

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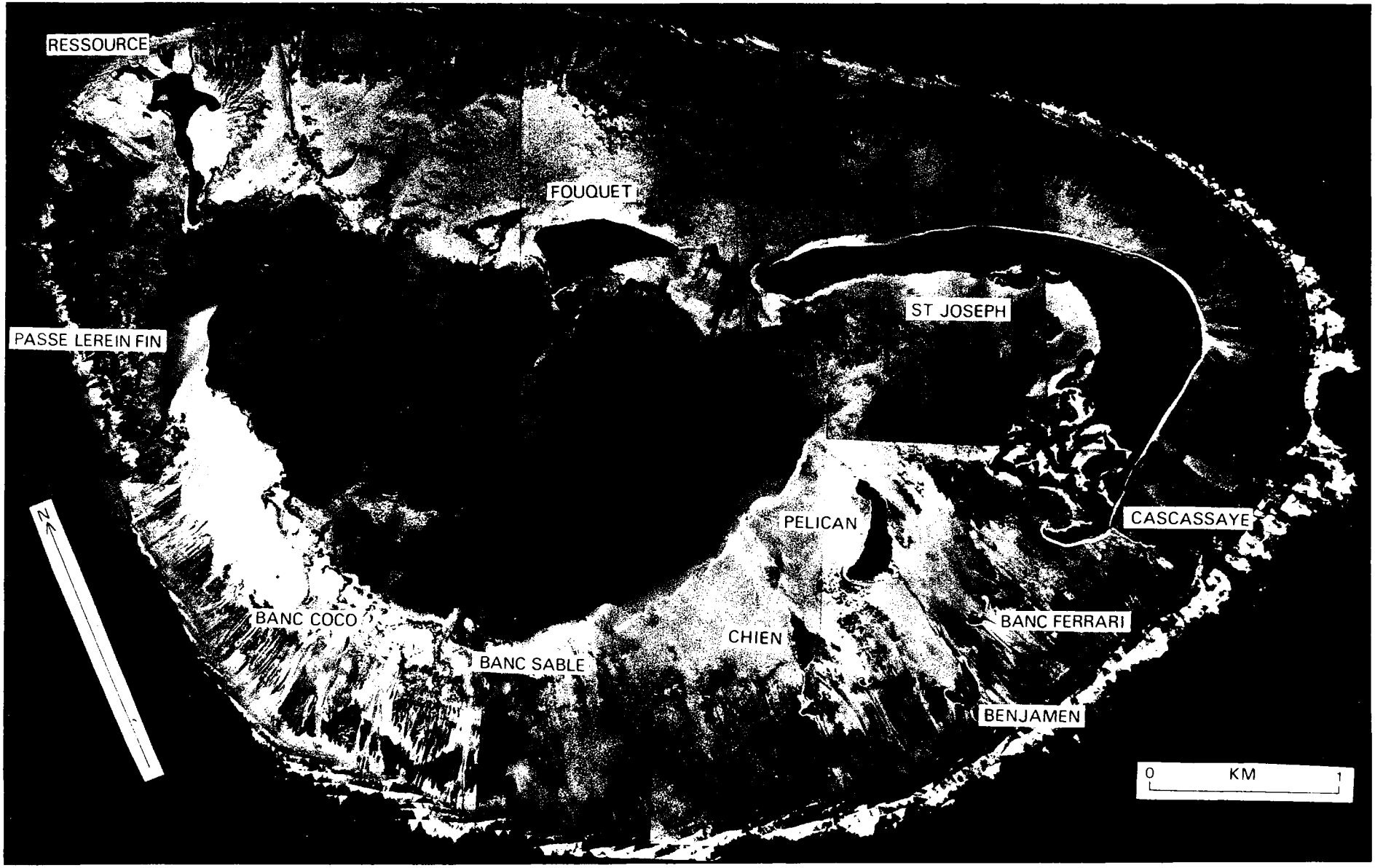

Plate 20. St Joseph Atoll: vertical air photograph mosaic. Reproduced by permission of the Chief Surveyor, Survey and Lands Department, Republic of Seychelles

Plate 21. St Joseph Atoll from the northeast; the island in the foreground is St Joseph Island

Plate 22. Southern reef of St Joseph Atoll, from the east. The islet in the foreground is Chien, and the large island in the background is D'Arros

Plate 23. Pelican Island from the south, with Fouquet in the background

Plate 24. The southern part of St Joseph Island (Cascassaye), from the east, with Pelican and other islets behind

Plate 25. Hammerhead shingle spit at Banc Coco, St Joseph Atoll

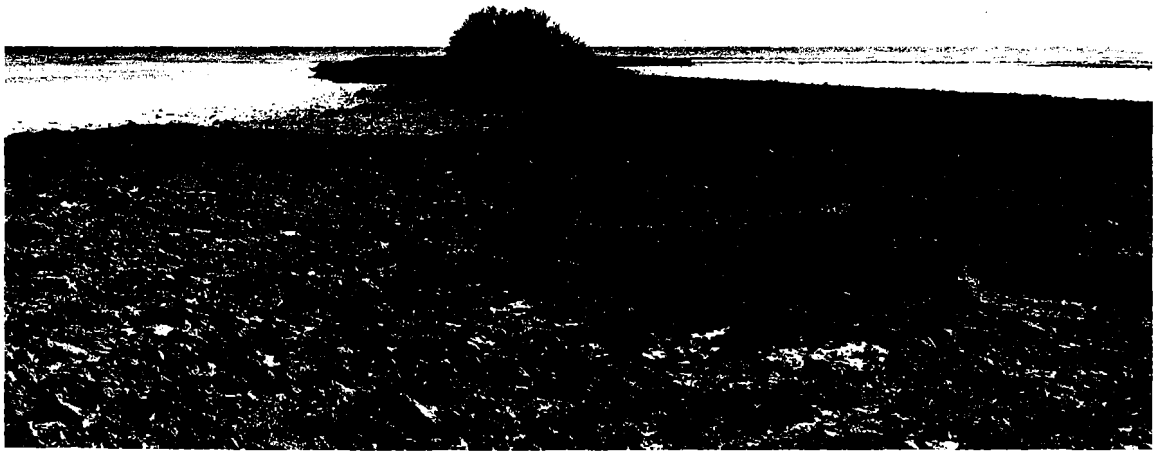

Plate 26. Banc Sable, St Joseph Atoll

Plate 27. *Scaevola* and *Suriana* shrubs on Banc Sable, St Joseph Atoll

Plate 28. Scrub of *Pemphis acidula* on Ile Poule, St Joseph Atoll

Plate 29. Scrub of *Tournefortia argentea* on Ile Poule, St Joseph Atoll

Plate 30. *Scaevola* scrub, seaward shore of Ile Fouquet, St Joseph Atoll

Plate 31. *Scaevola* scrub, coconuts and *Casuarina*, seaward shore of Ile Fouquet, St Joseph Atoll

Plate 32. *Scaevola* scrub, northern lagoon shore of Ile Fouquet, St Joseph Atoll

Plate 33. Pioneer *Scaevola*, southeast point of Ile Fouquet, St Joseph Atoll

Plate 34. Coastal *Guettarda* woodland, eastern seaward shore of Ile Fouquet, St Joseph Atoll

Plate 35. *Guettarda* woodland, west coast of Pelican Island, St Joseph Atoll

Plate 36. Coastal coconut and *Casuarina* woodland, lagoon shore of St Joseph Island, St Joseph Atoll

Plate 37. *Pemphis* scrub and cemented gravel on Ile Ressource, St Joseph Atoll

Plate 38. *Rhizophora* in *Pemphis* scrub, west shore of Pelican Island, St Joseph Atoll

Plate 39. Mudhole surrounded by *Suriana* scrub, with germinating coconuts, east end of Ile Fouquet, St Joseph Atoll

Plate 40. Mature coconut woodland, north end of St Joseph Island, St Joseph Atoll

Plate 41. Abandoned coconut plantation with juvenile coconuts, Ile Fouquet, St Joseph Atoll

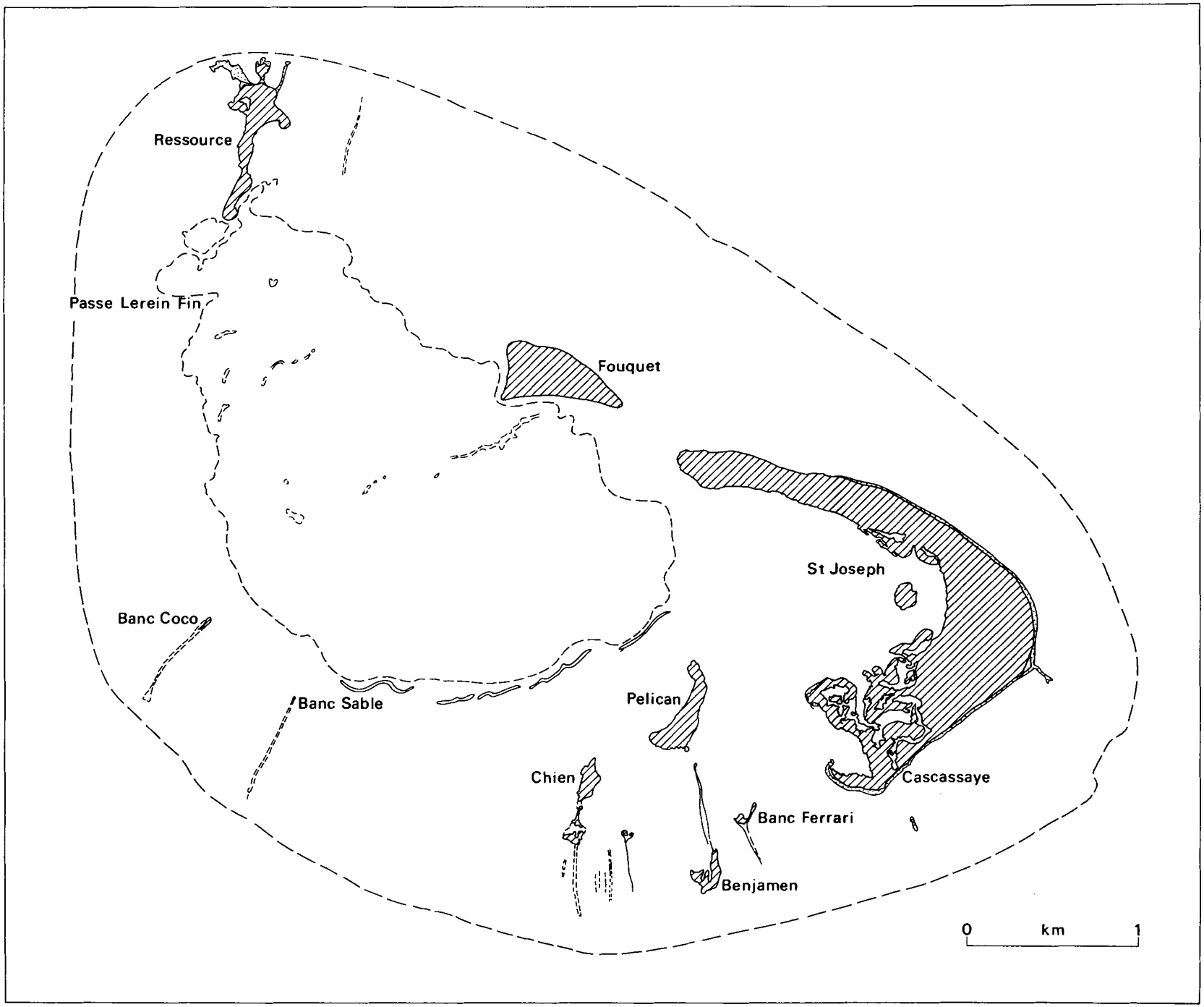

Figure 5. St Joseph Atoll. Based on aerial photographs with detail added from Baker (1963) and Piggott (1968)

PLANTS OF ST. JOSEPH ATOLL

F.R. Fosberg

POTAMOGETONACEAE

Thalassodendron ciliatum (Forsk.) den Hartog
Cymodocea ciliata (Forsk.) Ehrenb. ex Aschers.
Gwynne and Wood 1057 (EA) (Fouquet); Stoddart 7167 (US), 7170 (US) (St. Joseph).

HYDROCHARITACEAE

Thalassia hemprichii (Ehrenb.) Aschers.
Gwynne and Wood 1056 (EA) (Fouquet); Stoddart 7168 (US), 7169 (US); (St. Joseph).

GRAMINEAE

Dactyloctenium aegyptium (L.) Willd.
Gwynne and Wood 966 (EA), 987 (EA) (St. Joseph); 1059 (Fouquet)

Dactyloctenium sp.
Stoddart 7147 (US) (Fouquet)

Eragrostis ciliaris (L.) R. & S.
Gwynne and Wood 967 (EA)

Eragrostis tenella var. *insularis* Hubb.
Gwynne and Wood 981 (EA) (St. Joseph)

Lepturus repens R. Br.
Gwynne and Wood 982 (EA) (St. Joseph)

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Lepturus repens R. Br. var. *subulatus* Fosb.
Stoddart 7140 (US)

Sporobolus virginicus (L.) Kunth
Stoddart 7155 (US) (St. Joseph)

Stenotaphrum micranthum (Desv.) Hubb.
Stenotaphrum subulatum Trin.
Gwynne and Wood 973 (EA), 985 (EA) (St. Joseph), 1061 (EA) (Fouquet); Stoddart 7145 (US) (Fouquet)

CYPERACEAE

Cyperus ligularis L.
Mariscus ligularis (L.) Urb.
Stoddart 7141 (US) (Fouquet)

Fimbristylis cymosa R. Br.
Fimbristylis obtusifolia sensu auct.
Gwynne and Wood 958 (EA), 959 (EA), 983 (EA) (St. Joseph); Stoddart 7139 (US) (Fouquet)

PALMAE

Cocos nucifera L.
Gwynne and Wood, sight; Stoddart, sight

AMARYLLIDACEAE

Crinum angustum Roxb.
Gwynne and Wood 957 (EA) (St. Joseph)

Hymenocallis littoralis (Jacq.) Salisb.
Stoddart 7176 (US) (St. Joseph)

CASUARINACEAE

Casuarina litorea L.
Casuarina equisetifolia L.
Gwynne and Wood 963 (EA) (St. Joseph); Stoddart 7150 (Fouquet)

AMARANTHACEAE

Achyranthes aspera L. var. *mollis* (Moq.) Townsend
Gwynne and Wood 1060 (EA) (Fouquet); Stoddart 7148 (US) (Fouquet)

NYCTAGINACEAE

Boerhavia repens L. var.
Stoddart 7146 (US) (Fouquet)

Pisonia grandis R. Br.
Gwynne and Wood 986 (EA) (St. Joseph)

PORTULACACEAE

Portulaca oleracea L.
Stoddart 7177 (US) (St. Joseph)

LAURACEAE

Cassytha filiformis L.
Gwynne and Wood 965 (EA) (St. Joseph); Stoddart 7136 (US) (Fouquet)

HERNANDIACEAE

Hernandia sonora L.
Gwynne and Wood 954 (EA) (St. Joseph); Stoddart 7154 (US) (St. Joseph), 7227 (US) (Ressource).

MORINAGACEAE

Moringa oleifera Lam.
Stoddart 7174 (US) (St. Joseph)

CRASSULACEAE

Kalanchoe pinnata (Lam.) Pers.
Bryophyllum pinnatum Lam.
Stoddart 7135 (US) (Fouquet)

LEGUMINOSAE

Leucaena leucocephala (Lam.) deWit
Leucaena glauca sensu auct.
Stoddart 7173 (US) (St. Joseph)

Pithecellobium unguis-cati (L.) Benth.
Gwynne and Wood 953 (St. Joseph)

SURIANACEAE

Suriana maritima L.
Gwynne and Wood 979 (EA) (St. Joseph); Stoddart 7138 (US) (Fouquet)

EUPHORBIACEAE

Euphorbia hirta L.
Stoddart 7172 (US) (St. Joseph)

Phyllanthus maderaspatensis L.
Gwynne and Wood 975 (EA), 989 (EA) (St. Joseph); Stoddart 7178 (US) (St. Joseph).

MALVACEAE

Hibiscus tiliaceus L.
Stoddart 7181 (US) (St. Joseph)

Sida parvifolia DC.
Gwynne and Wood 972 (EA) (St. Joseph); Stoddart 7185 (Ile Paul) (US)

TURNERACEAE

Turnera ulmifolia L.
Stoddart 7180 (US) (St. Joseph)

PASSIFLORAE

Passiflora suberosa L.
Gwynne and Wood 968 (EA), 984 (EA) (St. Joseph) 1062 (EA) (Fouquet); Stoddart 7144 (US) (Fouquet)

LYTHRACEAE

Pemphis acidula R. Br.
Gwynne and Wood 955 (EA), 980 (EA) (St. Joseph), 1058 (EA) (Fouquet); Stoddart 7143 (US) (Fouquet).

RHIZOPHORACEAE

Rhizophora mucronata Lam.
Stoddart 7182 (US) (Ile Benjamin)

COMBRETACEAE

Terminalia catappa L.
Stoddart 7152 (US) (St. Joseph)

LECYTHIDACEAE

Barringtonia asiatica (L.) Kurz
Stoddart 7153 (US), 7166 (US) (St. Joseph)

APOCYNACEAE

Catharanthus roseus (L.) G. Don
Vinca rosea L.
Gwynne and Wood 951 (EA) (St. Joseph); Stoddart 7171 (US) (St. Joseph)

CONVOLVULACEAE

Ipomoea macrantha R. & S.
Ipomoea tuba (Don) Schlecht.
Stoddart 7184 (US) (Ile Benjamin), 7228 (US) (Ressource)

BORAGINACEAE

Tournefortia argentea L. f.
Messerschmidia argentea (L. f.) Johnst.
Stoddart 7137 (US) (Fouquet)

VERBENACEAE

Stachytarpheta jamaicensis (L.) Vahl
Stoddart 7142 (US) (Fouquet)

SOLANACEAE

Capsicum frutescens L.
Stoddart 7175 (US) (St. Joseph)

SCROPHULARIACEAE

Striga asiatica (L.) O. Ktze.
Gwynne and Wood 969 (EA) (St. Joseph); Stoddart 7156 (US) (St. Joseph), 7183 (US) (Ile Benjamin)

RUBIACEAE

Guettarda speciosa L.
Gwynne and Wood 964 (EA), 978 (EA) (St. Joseph); Stoddart 7151 (US) (Fouquet)

GOODENIACEAE

Scaevola taccada (Gaertn.) Roxb.
Scaevola sericea Vahl
Scaevola frutescens sensu auct.
Gwynne and Wood 977 (EA) (St. Joseph); Stoddart 7149 (US) (Fouquet)

COMPOSITAE

Bidens pilosa L.
Gwynne and Wood 956 (EA) (St. Joseph)

Tridax procumbens L.
Gwynne and Wood 974 (EA) (St. Joseph)

Vernonia cinerea (L.) Less. var. *parviflora* DC.
Gwynne and Wood 970 (EA) (St. Joseph); Stoddart 7179 (St. Joseph)