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TERRESTRIAL AND MARINE ECOLOGY OF MARIE-LOUISE, AMIRANTES, SEYCHELLES

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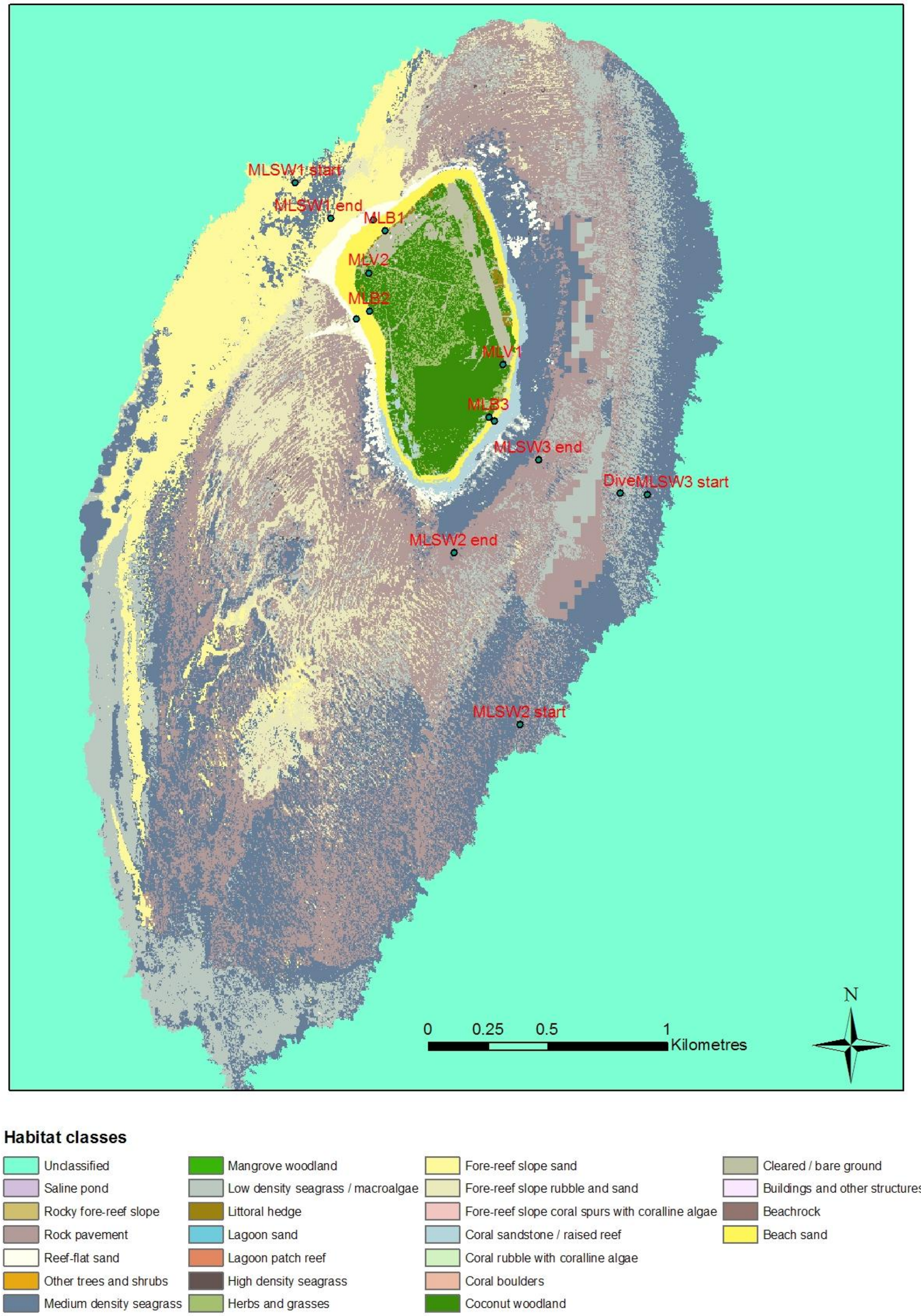

Figure 1. Location of vegetation Line Intercept Transects (MLV1 and MLV2), beach profiles (MLB1, MLB2 and MLB3), shallow-water transects (MLSW1, MLSW2 and MLSW3) and SCUBA dive survey at Marie-Louise, 24th January 2005. Habitat map from Spencer et al. (2009).

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INTRODUCTION

The Amirantes group, Seychelles, comprises 24 islands and islets lying between 5° and 6° south of the equator on the Amirantes Bank, western Indian Ocean. The islands were discovered by the Portuguese navigator Vasco da Gama on his second voyage to India in 1502, soon after acceding to the rank of Admiral, and the islands were subsequently named Ilhas do Almirante or Admiral's Islands (Lionnet, 1970). The group extends over a distance of 138 km, from African Banks in the north to Desnoeufs in the south. Marie-Louise lies at the southern end of the Amirantes group at 6°10′S, 53°08′E, approximately 13 km from Desnoeufs and 280 km south-west of the granitic island of Mahé (Wilson, 1983).

Marie-Louise was first sighted, and named, by Chevalier du Roslan in 1771 but remained uninhabited until the end of the nineteenth century (Ridley and Percy, 1958). In 1771 the island was reported to be densely wooded (Fauvel, 1908-9) but human settlement has greatly altered the natural vegetation. Marie-Louise was first leased in 1905, when the island had a population of 86 people. In 1905, two co-lessees ran the island, one overseeing the production of guano and the other developing agriculture (Wilson, 1983). Over 3,500 tons of guano were exported from the island in late 1905 but by 1906 it was reported that the economically workable deposits had been exhausted (Tonnet, 1906). In 1963, however, it was estimated that approximately 3,000 tons of guano remain on the island, of which half could be taken for local use without damaging agricultural potential (Baker, 1963). In recent times, it has been reported that guano for agricultural purposes has been imported from Desnoeufs (Wilson, 1983). The second lessee in 1905 was involved in establishing agriculture on the island. Eight hundred coconut palms (*Cocos nucifera*) and numerous casuarina trees (*Casuarina equisetifolia*) had already been planted on the west coast, holes were dug through the sandstone to increase planting effort and wells were sunk beneath the sandstone. Following the exhaustion of guano supplies, the island's main commodities turned to fishing and agriculture, supporting an island population of around 20 people. The island was

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neglected in 1969 and by 1979-1980 little change had occurred, although pigs, poultry, vegetables, maize, tortoiseshell and saltfish were produced for island use and to augment copra exports (Wilson, 1983). Space for an airstrip was cleared in the east of the island in the mid-1960s although the work was never completed. Since 1981, the lease of Marie-Louise has been taken over by the Island Development Company (a Seychelles government parastatal) and in 1983 it was reported that the island was permanently inhabited by approximately 15 agricultural workers and fishermen "based at a small settlement on the west coast above the beach and opposite the only safe anchorage" (Wilson, 1983:185). Copra production continued until 2004 but by 2005 there were no commercial activities at Marie-Louise, only island maintenance by 6 Island Development Company workers.

In 1882 the survey ship H.M.S. *Alert* found it unsafe to land because of the heavy surf (Coppinger, 1882) and the Percy Sladen Trust Expedition decided that the islands of Marie-Louise and Desnoeufs were best avoided "owing to their lack of suitable anchorage, the only one offering any protection having been ruined by a guano-steamer, which took fire and foundered" (Gardiner and Cooper, 1907:17). Landing by boat is difficult due to the swell coming directly from the open seas surrounding the small island and waves permanently breaking on the surrounding shelf and steep beach (Plates 1 and 2). Perhaps due to this access difficulty, scientific studies at Marie-Louise have been relatively limited.

Previous studies on the terrestrial environment of Marie-Louise include those of G. Auchinleck (November 1921), E.S. Brown (November 1952), M.W. Ridley and Richard Percy (May and July 1955), C.J. Piggott (November 1960) and J.R. Wilson (14 - 15 June 1979 and 10 - 11 July 1980). These studies resulted in brief accounts of the physical geography, vegetation and vertebrate fauna, especially the birds (Auchinleck, 1921; Brown – unpublished diary; Ridley and Percy, 1958; Piggott, 1969; Wilson,1983). The only mention of insect life was by Auchinleck (1921) regarding "the appalling prevalence of white scale [insects] (*Aspidiotus*)" (Order Hemiptera, suborder Homoptera Sternorrhyncha, superfamily Coccoidea, Family Diaspididae) on coconut palms. Fletcher (1910) mentioned two moths (Order Lepidoptera), that were apparently collected by Rivalz Dupont, Curator of the Seychelles Botanical Gardens, who had visited the "outer" islands in 1906 and 1909 (Dupont, 1929). Other visitors have looked at the marine environment of Marie-Louise: Jacques-Yves Cousteau and Gustave Cherbonnier stopped there onboard *Calypso* in May 1954 to survey the seabed (Cherbonnier, 1964); Jeanne A. Mortimer visited Marie-Louise in August 1981, December 1981 and December 1982, as part of her study of marine turtles (Mortimer, 1984).

A collaborative expedition between Khaled bin Sultan Living Oceans Foundation, Cambridge Coastal Research Unit and Seychelles Centre for Marine Research and Technology – Marine Parks Authority to the southern Seychelles was conducted onboard M.Y. *Golden Shadow*, from 10th – 28th January 2005. The primary aim of the expedition was to use a CASI (Compact Airborne Spectrographic Imager) sensor onboard a seaplane to conduct large-scale mapping of the southern Amirantes, Alphonse/St. Francois (Spencer et al., 2009) and Providence Bank. All surveys at Marie-Louise were conducted on 24th January 2005.

TOPOGRAPHY AND GEOLOGY

Of the seven reef types identified in the Seychelles by Stoddart (1984), three are present in the Amirantes: platform reef, atoll and drowned atoll. The platform reefs vary in their morphology; Spencer et al. (2009) identified three categories of platform reef. They defined Marie-Louise as a Type 2 platform reef, where the reef island is surrounded by a narrow peripheral reef but where both island and reef sit on an extensive and relatively shallow and gently sloping rock platform, covered in rubble, sand and seagrass beds, often incised by numerous small, sub-parallel and anastomosing channel systems (Plate 1). It is at its narrowest (approximately 30 m) off the northern tip of the island and at its widest (over 1 km) off the southwest of the island. Table 1 provides quantitative information on this morphology; it can be seen that the island accounts for less than 10% of the total reef platform surface area.

Table1. Morphometry of the platform reef at Marie-Louise.

Total reef platform area[1] (km^2)	Peripheral reef area[2] (km^2)	Land area[3] (km^2)	Land area as proportion of total reef platform area (km^2)
7.89	0.20	0.74	9.36

[1] area of terrestrial and shallow marine habitats classified by Spencer et al. (2009) from airborne imagery
[2] area between the breaker zone and island marginal sediments
[3] area of terrestrial habitats and coarse beach materials (including beachrock)

The island itself is oval in shape, measuring approximately 1 km by 0.5 km, with a long axis lying approximately north-south. The island area is 52.6 hectares and elevation is typically +5 to +6 m above sea level (Wilson, 1983).

It has been described as an uplifted cay, with calcareous sandstones dipping outwards from the centre, overlying and interbedded with gravels (Baker, 1963; Piggott, 1968, 1969). In the south of the island the rock is reported to be less well developed and younger in origin (Wilson, 1983). Jemo Series soils, phosphatic sandstone overlain by a horizon of organic matter (Stoddart and Fosberg, 1984), have formed on the island, with a phosphatised layer of guano above the sandstones, but much of the unconsolidated material has been removed through human exploitation of guano and rock is exposed on over three quarters of the island (Wilson, 1983). Shioya Series soils, calcium carbonate sediments with a darker surface horizon of higher organic content (Piggott, 1968) are present at the island's perimeter (Wilson, 1983). Observations of the coast of Marie-Louise in January 2005 confirmed the description by Wilson (1983). A wide beach exists in the north and north-west of the island, especially in front of the settlement where it approaches 100 m in width (Plate 3), but the southern half of the island generally exhibits low cliffs (*ca.* 1 m high) in massive beach sandstone (Plate 4) which are fronted by rocky pavement, exposed beachrock and rubbly storm beaches in the south and east (Plates 5 and 6).

METHODS FOR TERRESTRIAL SURVEYS

Terrestrial Flora and Fauna

Quantitative vegetation surveys were conducted using the Line Intercept Transect (LIT) technique over a horizontal distance of 30 m. By summing the intercept lengths for each plant species and dividing this value by the total length of the transect, percentage cover for each plant species was calculated:

$$\text{Percentage cover} = \frac{\text{Total length of plant species}}{\text{Length of transect}} \times 100$$

Two transects were laid at Marie-Louise, one in the southeast (MLV1) and one in the west (MLV2), close to the settlement (Fig. 1). Their positions were fixed by hand-held GPS units (horizontal resolution = ±10 m). Plants that could be not identified in situ were labelled and photographed with a high resolution (4.1 mega pixels) digital camera for later identification by local botanists Murugaiyan Pugazhendhi and Katherine Beaver.

A total of 13 dry-stored insect sample vials were collected at Marie-Louise. The species were identified by examination under low magnification and consultation of relevant taxonomic works, identification keys and specimens from other localities. General observations of the island and bird-life were also recorded.

Beach Surveys

Three beach profiles were conducted in the north-west (transect MLB1; 6°10.49´S, 53°08.51´E - 6°10.52´S, 53°08.53´E), west (MLB2; 6°10.76´S, 53°08.51´E - 6°10.77´S, 53°08.48´E) and southeast (MLB3; 6°10.94´S, 53°08.76´E) sides of the island (Fig. 1). Profiles were measured by Abney level and tape, in an offshore direction perpendicular to the beach, beginning at the terrestrial vegetation line and continuing to the offshore step (where the waves were breaking, typically marked by a downward step) or as far as safely possible into the water. Eight surface scrape sediment samples of *ca.* 200 – 350 g by weight were collected, typically at the start and end points of each beach profile. Hand-held GPS positions were recorded for the start and end of each beach profile and for the sites of the sediment samples. Sediments were dried, disaggregated and sieved using standard techniques at 0.25 phi intervals.

MARINE SURVEY METHODS

Shallow-water Transects

Shallow-water transects were undertaken at three sites around Marie-Louise. Transects ran NW-SE from a depth of 32 m to 3.8 m (MLSW1; 6°10.418´S, 53°08.345´E - 6°10.495´S, 53°08.430´E), SE-NW from a depth of 19.5 m to 3.8 m (MLSW2;

$6^o11.682'S$, $53^o08.870'E$ - $6^o11.290'S$, $53^o08.727'E$) and at 300^o in towards the island from a depth of 16.5 m to 3.8 m (MLSW3; $6^o11.162'S$, $53^o09.167'E$ - $6^o11.056'S$, $53^o08.884'E$) (Fig. 1).

Each time the boat was stopped a hand-held GPS position was taken and the water depth and bottom substrate (viewed through a glass-bottomed bucket) recorded. Eight substrate observations were recorded on MLSW1, 17 substrate observations were recorded on MLSW2 and 19 substrate observations were recorded on MLSW3.

Benthic Surveys

A single SCUBA survey took place on the south-east side of the island ($\sim 6^o11.157'S$; $53^o09.102'E$) as this was where the most coral had been observed when conducting the shallow-water transects. Quantitative surveys were conducted at water depths of 10 m and 15 m using the video transect method. This technique enables a large area of reef to be surveyed in a short time period as well as providing a permanent visual record of the reef at a specific time (Carleton and Done, 1995). A Sony digital DCR-SC100 video camera, positioned vertically 30 cm above the substrate, was used to conduct all video transects over a horizontal distance of 20 m following the depth contour of the reef. The video data recorded was a plan view of a rectangular section of benthic reef community measuring 20 m x ~ 0.3 m; by recording both sides of the transect, double the area was covered (or 20 m x ~ 0.6 m).

The video transect footage was analysed using the AIMS 5-dot analysis method, pausing the video at regular intervals and recording the substrate captured by each of the 5 dots (Christie et al., 1996; Osborne and Oxley, 1997). Ten major benthic categories were identified: sand, rubble, bare substrate, dead standing coral, pink calcareous algae on bare substrate, pink calcareous algae on dead standing coral, Scleractinia, non-Scleractinia, macroalgae and others (e.g. zooanthids, molluscs, bivalves). Scleractinia, non-Scleractinia and macroalgae were identified to genus level. Percentage cover for the 10 benthic categories was calculated as follows:

$$\text{Percentage cover} = \frac{\text{Total number of dot captures for single benthic category}}{\text{Total number of dot captures for entire transect length}} \times 100$$

In addition to the benthic video surveys, fish species observed at Marie-Louise were recorded during the dive. All fish species seen during a 35-minute period at depths of between 15 m and 5 m were recorded. A random search pattern was followed and both pelagic and demersal species noted.

RESULTS OF TERRESTRIAL SURVEYS

Flora and Fauna Surveys

Wilson's (1983) map of terrestrial habitats of Marie-Louise shows the island to be predominantly under a cover of coconut woodland (total area of coconut woodland = 321 m^2) with a strip of littoral scrub up to 150 m wide along the south-east coast and present as a narrow strip along the south-west coast (total area of littoral scrub = 98 m^2). Part of the southern end of the island is occupied by an area of herbaceous mat; this also characterizes the eastern and north-east coast along the line of the disused airstrip (total area of herbaceous mat = 45 m^2). In 2005, coverage by coconut woodland was found to be almost identical, but slightly greater than suggested by Wilson (1983) (total area of coconut woodland in 2005 = 346 m^2). However, the 2005 expedition island map (Fig. 1) displays a much greater area of herbaceous mat (total area = 100 m^2) but much smaller area of littoral scrub (total area = 10 m^2) (Plate 7).

The first transect on Marie-Louise (MLV1) was conducted 5 metres west of the southern end of the airstrip (Fig. 1), in an area classified by Wilson (1984) as littoral scrub. The vegetation under the transect was dominated by the white flowered *Catharanthus roseus* which occupied 32% of the total ground cover, followed by the ground creeper *Boerhavia* sp. at 27% cover (Fig. 2). The creeper *Passiflora suberosa* and the herb *Acalypha indica* were also common, occupying 17% and 13% cover respectively. Cotton (*Gossypium hirsutum*) covered 6% of the transect line and was mainly concentrated along the coast to the south-west of the airport with plants reaching several metres high. On both sides of the airstrip, an area which is routinely cleared, *Dactyloctenium ctenoides* was the dominant species. The first few metres on moving landwards on the east coast of the island was dominated by *Scaevola taccada*, as is the case with many of the low lying islands of the southern Seychelles (Sauer, 1967; Stoddart and Fosberg, 1984).

The second LIT (MLV2) was conducted on the west side of the island (Fig. 1), in an area which had previously been cleared of coconut woodland but which appears to have been left untouched for a number of years. Cotton (*Gossypium hirsutum)* was the dominant vegetation, covering 42% of the transect line (Fig. 2). *Stachytarpheta jamaicensis* was the second most dominant plant found along the transect, occupying 18% cover. Other common vegetation observed were the erect grass *D. ctenoides* (13% cover), *S. taccada* (12% cover), *P. suberosa*, *Boerhavia* sp. (6% cover) and *Cyperus aromaricus* (3% cover). The west side of Marie-Louise, at which the second transect was laid, is more shaded and less exposed to the wind compared to the south-eastern side of the island; this in turn has favoured the growth of more plant species. A total of 48 plant species were recorded at Marie-Louise, both during the LITs and through general observations. All plant species observed at Marie-Louise in January 2005 are listed in Table 2.

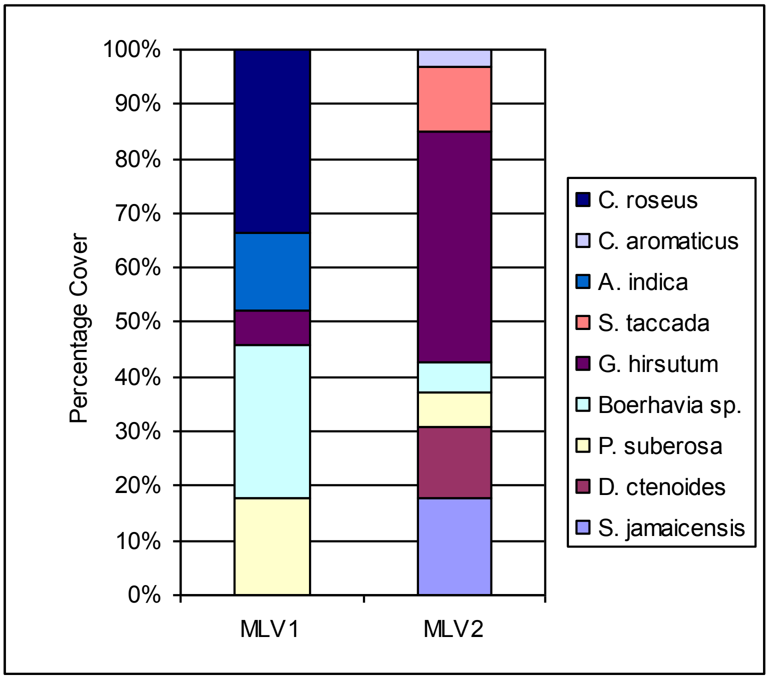

Figure 2. Percentage cover of plant species along two 30 m long LITs at Marie-Louise, January 2005 (see Figure 1 for locations of MLV1 and MLV2).

Table 2. Scientific and Creole / common names of plants observed at Marie-Louise, January 2005. Total number of plants observed = 48. Number of new records compared to Wilson (1983) = 12 (new records marked with *)

Family and Species	Creole / Common Name
Agavaceae	
Furcraea foetida	
Apocynaceae	
Catharanthus roseus	Roz enmer / Madagascar periwinkle
**Nerium oleander*	
Ochrosia oppostifolia	Bois sousouri
Araceae	
Alocasia macrorrhiza	Vya
**Colocasia esculenta*	
Arecaceae (Palmae)	
Cocos nucifera	Cocotier / Coconut palm
Asteracea (Compositae)	
**Synedrella nodiflora*	
Tridax procumbens	
**Vernonia cinerea*	
Boraginaceae	
**Ehretia cymosa*	Bois malagasche
Tournefortia argentea	Bois tabac

Table 2 (Con'td)

Family and Species	Creole / Common Name
Caricaceae	
Carica papaya	Papayer / Papaya
Casuarinaceae	
Casuarina equisetifolia	Cèdre / Pin / Casuarina
Combretaceae	
**Terminalia catappa*	Badamier / Bodanmyen / Indian almond
Convolvulaceae	
Ipomoea pes-caprae	Batatran / Goats foot creeper / Beach morning-glory
Crassulaceae	
Kalanchoe pinnata	
Cucurbitaceae	
Cucurbita moschata	Pumpkin
Cyperaceae	
**Cyperus aromaticus*	Sedge
Cyperus dubius	Sedge
Cyperus ligularis	Herbe bourique
Euphorbiaceae	
Acalypha indica	Herbe chatte / Lerb sat / Cat grass
Euphorbia prostrate	
Pedilanthus tithymaloides	
Phyllanthus amarus	
Ricinus communis	Tantan
Fabaceae (Leguminosae)	
**Desmanthus virgatus*	Wild tantan
Leucaena leucocephala	Kasi
Goodeniaceae	
Scaevola taccada	Scaevola
Hernandiaceae	
Hernandia nmyphaeifolia	Bois blanc
Lilaceae	
**Zephyranthes rosea*	
Lomariopsidaceae	
**Nephrolepis biserrata*	Fern
Malvaceae	
Gossypium hirsutum	Cotton
Hibiscus tiliaceus	Var / Mahoe
Moringaceae	
Moringa oleifera	Bred mouroun
Nyctaginaceae	
Boerhavia sp.	Pata covin / Patate cauvin
**Bougainvillea spectabilis*	Vilea / Bougainvillea

Table 2 (Con’td)

Family and Species	Creole / Common Name
<u>Passifloraceae</u>	
Passiflora suberosa	
<u>Poaceae (Gramineae)</u>	
Dactyloctenium ctenoides	Grass
Stenotaphrum dimidiatum	Grass
Unidentified grass sp.	Grass
<u>Portulaceceae</u>	
Portulaca oleracea	Kour pye / Pourpier / Morning glory
<u>Rubiaceae</u>	
Morinda citrifolia	Bois tortue / Indian mulberry
<u>Solanaceae</u>	
Datura metel	Wild aubergine
Solanum nigrum	
<u>Urticaceae</u>	
Laportea aestuans	
**Pipturus argenteus*	
<u>Verbenaceae</u>	
Stachytarpheta jamaicensis	Épi bleu

The centre of the island exhibits tall and dense vegetation with the top canopy comprising mainly tall *Cocos nucifera* (coconut palms) and *Carica papaya* (papaya) (Plate 8) but nearer the settlement, much of the low-growing vegetation has been cleared (Plate 9). Large *Ochrosia oppostifolia* trees were observed at the settlement and were being used by nesting *Gygis alba* (Fairy or White Terns). Other birds observed on Marie-Louise included: *Sterna fuscata* (Sooty Tern), *Anous tenuirostris* (Black or Lesser Noddy), *Fregata minor* (Greater Frigatebird) and *Gallus gallus* (Feral chicken). Increased numbers of birds come to Marie-Louise in the breeding season (July – August), but not as many as can be found on the neighbouring island of Desnoeufs, which is the only Seychelles island where seabird egg collection continues (Ministry of Environment, Seychelles, pers. comm., 2005). *Anous stolidus* (Brown or Common Noddy) were seen resting on patches of dried grasses close to the settlement. *Coenobita perlatus* (land hermit crab) were observed on the beach, green geckos (*Phelsuma sundbergi*) were observed on coconut palms and unidentified lagomorphs, most probably rabbits (*Oryctolagus cuniculus*), were observed in the undergrowth. Six species of insect were collected and identified as follows:

1. Unidentified cockroach. Order Blattodea.
There were four small, apparently immature, specimens (nymphs) of one species of cockroach. Further work is required to identify it. There was sand with the specimens, which suggests that this is a ground-inhabiting species.

2. *Cratopus adspersus* (Waterhouse, 1884). Order Coleoptera, family Curculionidae, subfamily Brachycerinae.
This herbivorous weevil, of which there were 4 specimens in the samples, belongs to a genus that has undergone massive radiation throughout the western Indian Ocean. This species occurs throughout the "outer", coralline, islands of Seychelles as well as in St Brandon (Cargados Carajos) and the Chagos. Interestingly, in coastal areas of the granitic islands of Seychelles it is replaced by *C. griseovestitus* (Linell, 1897).

3. Unidentified plume moth. Order Lepidoptera, family Pterophoridae. There were three specimens of this species, which has not yet been identified. The cosmotropical species *Megalorrhipida defectalis* (Walker, 1864) is known from elsewhere in Seychelles, including other islands in the Amirantes.

4. *Zizeeria knysna* (Trimen, 1862). Order Lepidoptera, family Lycaenidae, subfamily Zizeerinae.
This small butterfly, the African grass blue, occurs throughout Seychelles. Its world distribution is reported to extend from the Canary islands, southern Europe and Africa to the west to Japan and Australia to the East (Guillermet, 2004).

5. *Polistes olivaceus* (Degeer, 1773). Order Hymenoptera, family Vespidae, subfamily Polistinae.
This is the common yellow paper wasp distributed throughout the inner, granitic, Seychelles, and also known, in the Amirantes, from D'Arros and Desroches. Outside Seychelles it occurs elsewhere in the western Indian Ocean, in Asia and in Africa.

6. Unidentified ant. Order Hymenoptera, family Formicidae.
The samples included four workers of a species of ant that is yet to be identified. The considerable amount of coral sand with the specimens suggests that they were caught on the ground, probably on or close to a beach.

7. *Nephila inaurata* (Walckenaer, 1841). Order Araneae, family Tetragnathidae.
A young female of this spider, the red-legged golden orb-web spider, was together with the insect specimens. The species occurs throughout Seychelles. It ranges from South Africa to the western Indian Ocean. The western Indian Ocean form is sometimes considered to be a separate sub-species, *Nephila inaurata madagascariensis* (Vinson, 1863).

Beach Surveys

Beach widths vary from a maximum of 90 m at the west north-west margin of the island, where they grade into a 130 m wide area of reef-flat sand, to 25 m on the south-west, south and south-eastern coasts where they fronted by a 50-70 m wide rock pavement (Plates 5 and 6). As elsewhere on leeward reef coasts (Stoddart and Steers, 1977), beaches on the leeward side of Marie-Louise are wide and lie relatively high in the tidal frame. Beach sediments are generally composed of moderately well-sorted to very well-sorted coarse to very coarse sands (Table 3, Fig. 3). Textural groups are slightly gravelly to gravelly sand.

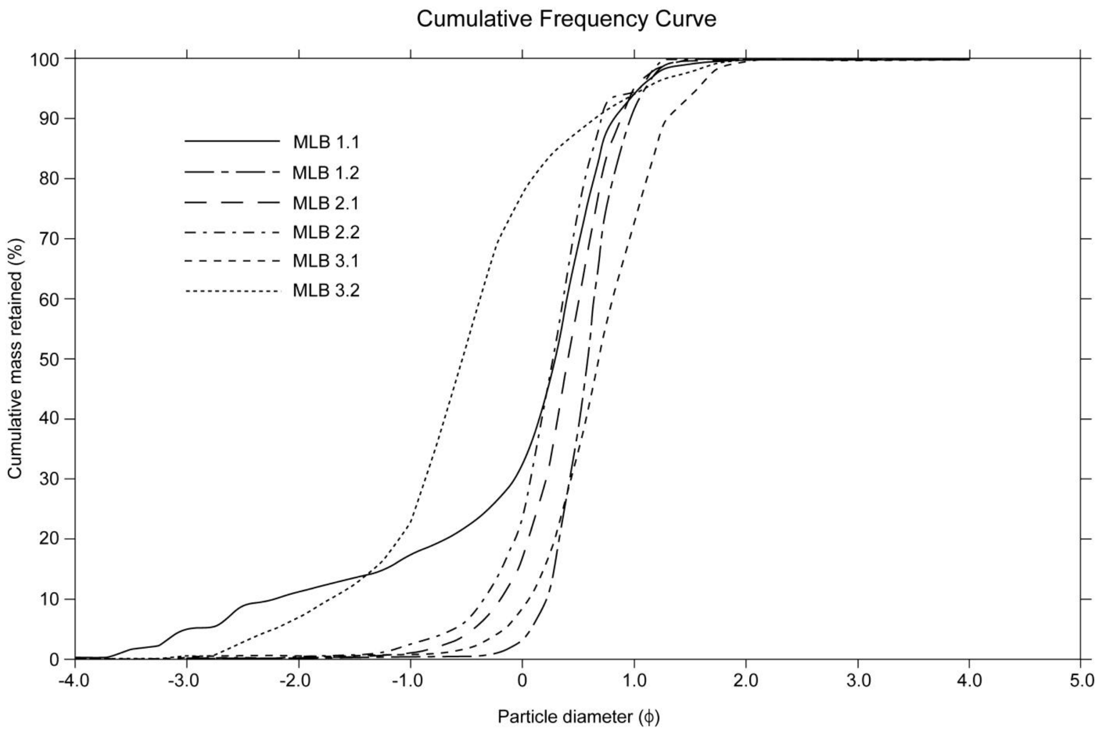

Figure 3. Cumulative frequency curves for sediment samples from upper and lower leeward beaches on Marie-Louise.

Table 3. Folk and Ward (1957) particle size distribution statistics for sediment samples from beach profiles. Units are given on the phi (ø) scale.

Sample	Environment	D_{50}	M_z	σ_1	SK_1	K_G	Description
MLB1.1	Upper beach	0.292	-0.049	1.062	-0.605	1.931	Very Coarse Sand, Poorly Sorted, Very Coarse Skewed, Very Leptokurtic
MLB1.2	Lower beach	0.584	0.587	0.300	0.019	1.188	Coarse Sand, Very Well Sorted, Symmetrical, Leptokurtic
MLB2.1	Upper beach	0.409	0.384	0.398	-0.141	1.126	Coarse Sand, Well Sorted, Coarse Skewed, Leptokurtic
MLB2.2	Lower beach	0.271	0.237	0.440	-0.105	1.451	Coarse Sand, Well Sorted, Coarse Skewed, Leptokurtic
MLB3.1	Upper beach	0.673	0.687	0.489	0.031	1.069	Coarse Sand, Well Sorted, Symmetrical, Mesokurtic

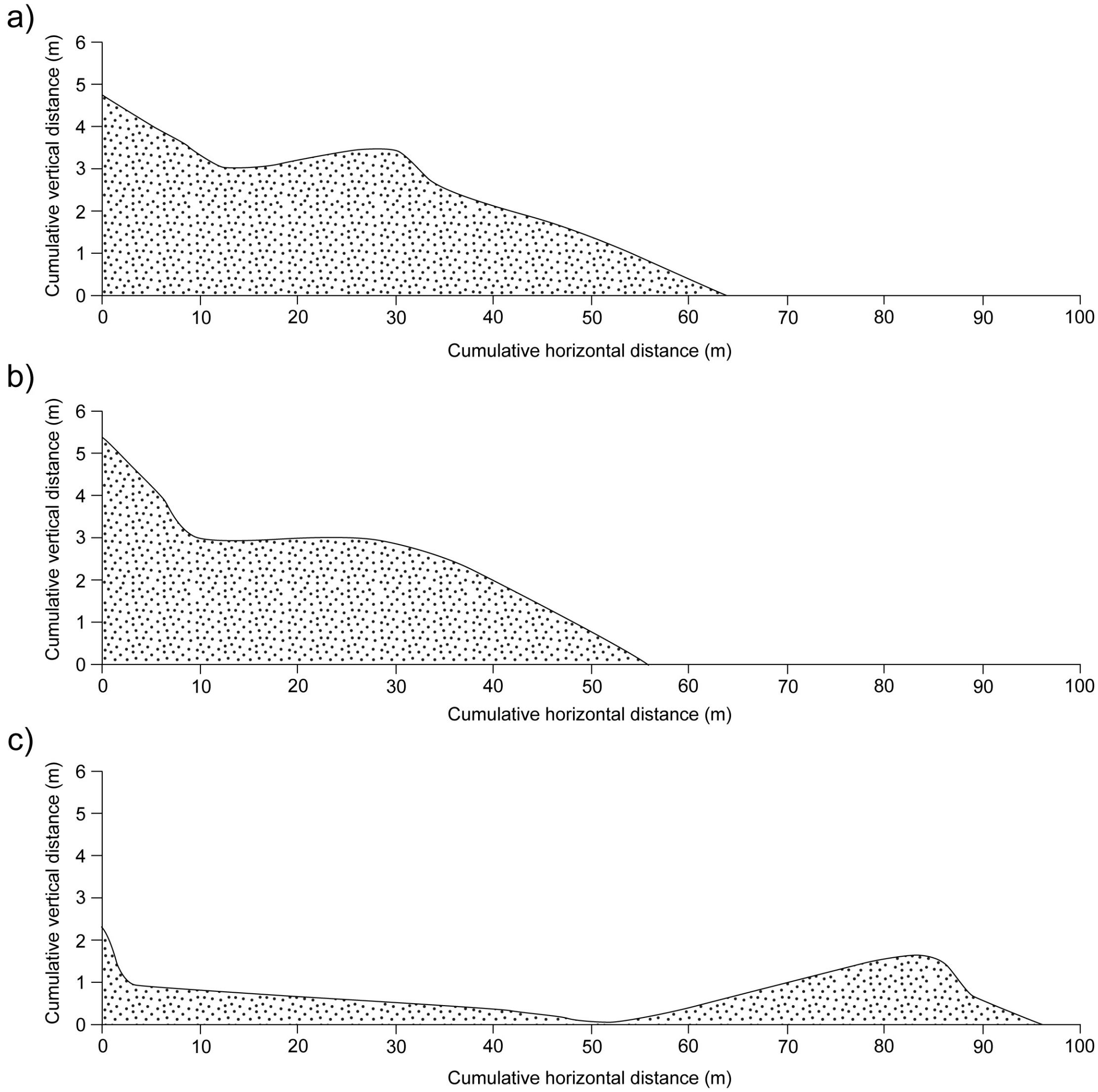

Figure 4. Beach profiles a) north-west side of the island at 06°10.492′S, 053°08.521′E - 06°10.516′S, 053°08.530′E; b) west side of the island at 06°10.756′S, 053°08.511′E – 06°10.768′S, 053°08.483′E; and c) on the south-east side of the island at 06°10.941′S, 053°08.762′E - 06°10.730′S, 053°08.552′E.

In the northwest, the beach is *ca.* 60 m wide and extends to *ca.* 3.5 m above mean water level, with typical beach angles of 5 – 8°. The base of the beach profile is composed of very well sorted coarse sand (MLB1.2; Table 3, Fig 3). The crest of the active beach is backed by a shallow trough and a ridge of poorly-sorted washover sands (Fig. 4a), composed of coarse to very coarse sand with a significant (18%) fine to medium sized gravel component (MLB1.1; Table 3, Fig. 3). On the western shoreline, the active beach is *ca.* 30 m wide and extends to 3.0 m above mean water level with beach angles of 4 – 7°; it is composed of well-sorted coarse sand (MLB2.1; Table 3, Fig. 3). The landward margin to the beach terminates in a 2 m high cliff with an upper beach scarped at angles of 12 – 14° (Fig. 4b).

On the south coast, beach sands lie within pockets surrounded by extensive slabs of smooth, fluted beachrock with a narrow rock conglomerate pavement at lower levels. This pavement reaches its greatest extent on south-east facing coasts, where it lies at up to 1.5 m above the base of the beach (Fig. 4c) and grades landwards into beachrock deposits, as described at Diego Garcia (Stoddart, 1971). On Marie-Louise it is backed by narrow, steep (5 - 9^{o}) beaches, characterized by extensive bands of gravel, cobbles and boulders, often stacked in imbricated structures. The base of the beach is characterised by noticeably coarser sands (MLB3.2; Table 2, Fig. 3) than at other sites on Marie-Louise, although the upper beach shows typical well-sorted coarse sands (MLB3.1; Table 3, Fig. 3). As on the western coast, the upper beach often terminates in a scarped profile, with beach angles of up to 15^{o} (Fig. 4c). Near the southern end of the airstrip, there is an outcrop of lithified and bedded "cay sandstone" (*sensu* Sewell, 1935; see also Bourne, 1888 and Stoddart, 1971; Plate 4); it is not clear whether or not these deposits indicate a relative change in sea level, as suggested by Gardiner (1936) at Diego Garcia.

RESULTS OF MARINE SURVEYS

Shallow-water Transects

On the south and south-east side of the island, the fore-reef slope is a very gently shelving rock platform, with small (~30 cm diameter) branching corals, most notably *Pocillopora* spp., and to a lesser extent *Acropora* spp., and dense macroalgal cover (*Halimeda* spp.) (Plate 10). Narrow sand channels, approximately 50 cm in width, bisect the reef, running perpendicular to the shoreline (Plate 11). Funnelling of wave motions in these channels causes short-lived re-suspension of sediment and loose clumps of *Halimeda* spp. were observed in traction in response to oscillatory water movements.

The fore-reef slope on the south-west side of the island is very gently shelving and extends to a much greater distance offshore before a distinct reef drop off is reached, compared to the southern and south-eastern slope aspects. The platform margin supports seagrass beds of medium density.

The edge of the rock platform is strongly delineated by a NNE – SSW trending boundary which intersects the north-western corner of the island. At water depths greater than 8 m, the substrate is sand and seagrass, identified as *Thalassodendron ciliatum,* and at depths of less than 8 m, the seabed is an unvegetated sand sheet. Five manta rays (*Manta birostris*) were sighted just off the north-west beach over the sandy seabed just in front of the settlement.

Benthic Surveys

At both 15 m and 10 m water depths on the south-east side of the island, the dominant benthic cover type was determined as macroalgae (31 – 36% cover; Table 4), with the most dominant genus being *Halimeda* (a single *Microdictyon* sp. and a single *Caulerpa* sp. were also observed). The second most prevalent category recorded was bare substrate (22 – 26% cover), followed by scleractinian cover (16 – 21% cover; Table 4). The rocky substrate often contained black boring sponges. The 15 m site displayed higher macroalgal cover and lower scleractinian cover compared to the 10 m site. Although some non-scleractinian corals were observed, these contributed very little to the overall benthic composition. The sand channels and sand patches contributed to 10% of total substrate coverage at both depths.

Calcareous algae were observed, but generally this cover type was thin and sparse. Nearly twice as much calcareous algal cover was found at the 10 m site compared to the 15 m site (Table 4). Little rubble was observed at either depth, but a higher percentage was observed at the deeper site compared to the shallower site. The categories of macroalgae, bare substrate and Scleractinia combined to account for 74% of the benthic community at 15 m depth and 78% of the benthic community at 10 m depth, with other categories making up roughly one quarter of the benthos (Table 3).

Table 4. Percentage benthic cover on fore-reef slope at 15 m and 10 m water depths, from video data analysis.

Benthic Category	Percentage Cover at 15 m depth	Percentage Cover at 10 m depth
Sand	10.4	9.6
Rubble	6.5	1.9
Bare Substrate	21.9	26.4
Pink Calcareous Algae on Bare Substrate	5.7	9.0
Pink Calcareous Algae on Dead Standing Coral	0.0	0.2
Scleractinia	21.1	16.1
Non-Scleractinia	2.4	0.3
Macroalgae	31.3	35.6
Others	0.7	0.8

Table 5 shows the percentage of each coral genus recorded at the two survey depths.

Table 5. Coral genera as a proportion of the overall coral community at 15 m and 10 m water depth, from video transect analysis.

Coral Genus	Percentage of coral community at 15 m depth	Percentage of coral community at 10 m depth
Scleractinia		
Porites	20.6	9.7
Favia	2.2	1.4
Favites	8.8	4.9
Galaxea	0.0	0.7
Goniastrea	0.9	0.0
Leptastrea	4.4	1.4
Astreopora	2.2	4.9
Pavona	0.9	2.1
Platygyra	0.4	0.0
Acropora	2.2	9.7
Pocillopora	40.4	61.1
Montipora	6.6	2.1
Fungia	0.4	0.0
Non-Scleractinia		
Sinularia	8.8	2.1
Dendronephthya	1.3	0.0

Figures 5 and 6 illustrate the proportion of individuals represented by each of the ten most dominant coral genera within the coral community at 15 m depth (Fig. 5) and 10 m depth (Fig. 6).

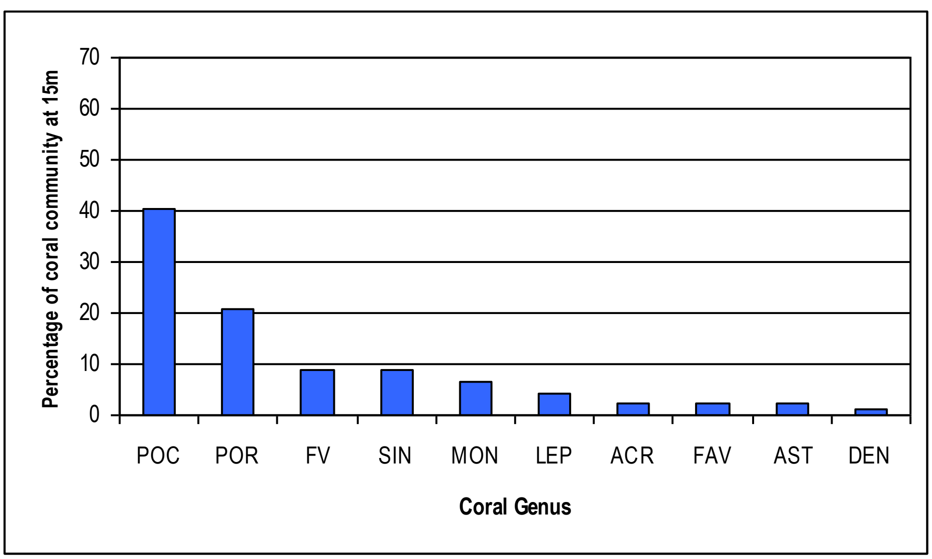

Figure 5. Percentage cover by different coral genera in order of dominance at 15 m depth, from video transect analysis. POC = *Pocillopora*, POR = *Porites*, FV = *Favites*, SIN = *Sinularia*, MON = *Montipora*, LEP = *Leptastrea*, ACR = *Acropora*, FAV = *Favia*, AST = *Astreopora*, DEN = *Dendronephthya*.

At 15 m depth, the coral community was dominated by *Pocillopor*a which represented 40% cover within the coral community. The second most dominant genus, *Porites*, represented half this amount (21% cover). All other genera contributed less than 10% to the overall coral community. The third ranking coral genus at this depth was *Favites* and the fourth was the non-scleractinian coral genus *Sinularia*.

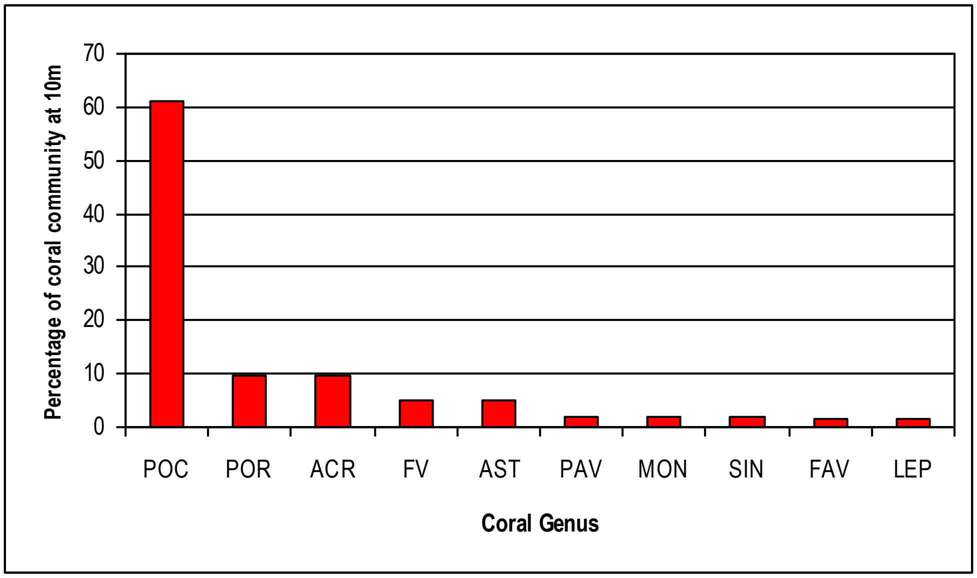

Figure 6. Percentage cover by different coral genera in order of dominance at 10 m depth, from video transect analysis. POC = *Pocillopora*, POR = *Porites*, ACR = *Acropora*, FV = *Favites*, AST = *Astreopora*, PAV = *Pavona*, MON = *Montipora*, SIN = *Sinularia*, FAV = *Favia*, LEP = *Leptastrea*.

At 10 m depth, the two most dominant coral genera, *Pocillopora* and *Porites*, were the same as for the 15 m site, but at this site the dominance of *Pocillopora* was greatly increased (61% cover). Here, the proportion of the second most dominant genus, *Porites*, was equalled by that of *Acropora*. Although *Acropora* did occur at the 15 m depth site, it was only the 7th most dominant genus and accounted for nearly 5 times less cover than it did at the 10 m site (Table 5). Non-scleractinian coral cover was minimal at the 10 m site and unlike at 15 m, *Sinularia* was only the 8th most dominant genus found at 10 m.

Fish Surveys

Forty-three fish species from 16 families were recorded. These varied in trophic group and size from large lethrinids, such as *Lethrinus olivaceus,* to small pomacentrids, such as *Dascyllus carneus*. Pomacentrids were the most speciose family recorded (9 species), followed by serranids (7 species). All fish species observed at Marie-Louise are listed, by family group, below.

Acanthuridae
Acanthurus leucosternon
Acanthurus nigrofuscus
Acanthurus tennenti
Ctenochaetus striatus
Zanclus cornatus

Balistidae
Melichthys indicus
Rhinecanthus aculeatus
Sufflamen chrysopterus

Carangidae
Caranx ignobilis

Chaetodontidae
Chaetodon guttatissimus
Chaetodon trifasciatus

Cirrhitidae
Paracirrhites arcatus
Paracirrhites forsteri

Holocentridae
Sargocentron caudimaculatus

Labridae
Coris frerei
Gomphosus caeruleus
Halichoeres iridus
Thalassia amblycephalum
Unknown sp.

Lethrinidae
Lethrinus obsoletus
Lethrinus olivaceous

Lutjanidae
Lutjanus gibbus

Monacanthidae
Cantherhines pardalis

Mullidae
Parupeneus cyclostomus

Pomacanthidae
Apolemichthys trimaculatus
Centropyge acanthops
Centropyge multispinis
Pomacanthus imperator
Amphiprion fuscocaudatus
Chromis dimidiata
Dascyllus carneus
Dascyllus trimaculatus
Pomacentrus caeruleus

Scaridae
Unknown sp.

Serranidae
Cephalopholis argus
Cephalopholis nigripinnis
Epinephelus fasciatus
Nemanthias carberryi
Pseudanthias evansi
Pseudanthias squamipinis
Variola louti

Sphyraenidae
Sphyraena barracuda

Synodontidae
Unknown sp.

The number of fish species recorded at Marie-Louise was lower than documented in previous surveys in the Seychelles (Jennings et al., 1995; Spalding and Jarvis, 2002), most probably due to the lower sampling effort. Fifteen species overlapped with the most common and abundant species found by Spalding and Jarvis (2002) in the southern Seychelles and 19 overlapped with Jennings et al.'s (1995) survey of the granitic Seychelles islands.

DISCUSSION

Terrestrial Surveys

Forty-eight plants were observed during the short visit (less than 2 hours) to Marie-Louise in January 2005. This is over two thirds the number described by Wilson (1983) who spent a total of 4 days on the island in 1979 and 1980 (Wilson (1983) identified 68 species in total). Twelve of the 48 plants observed in 2005 are new records. Thirty-five species were identified by both Wilson (1983) and the 2005 expedition but Wilson (1983) identified a further 33 species that were not observed by the 2005 expedition. The vegetation at Marie-Louise closely resembles that found at Poivre, but is less similar to that found at Desnoeufs. This could be attributed to the larger sizes of Marie-Louise and Poivre, and the presence of their extensive coconut groves which create microhabitats that enable a more diverse plant community to be maintained.

In view of the island's relatively recent formation (the sand cays on sea-level reefs in this region are probably less than 6,000 years old (Stoddart, 1984)) and its relatively simple structure, Marie-Louise would not be expected to have a large endemic insect fauna. It is not surprising, therefore, to find efficient widespread colonisers like the butterfly *Zizeeria knysna* and the wasp *Polistes olivaceus* present. Indeed, Marie-Louise has species like *P. olivaceus* and the weevil *Cratopus adspersus* in common with the Chagos Archipelago, some 1,900 km to the east. A further consideration is that much of the original natural vegetation of Marie-Louise was altered during the heyday of the coconut industry in the 20th century, with the planting of coconut palms on a commercial scale (Wilson, 1983) and the attendant accidental as well as deliberate introduction of non-native plant species; some native invertebrates may have been driven to extinction in the process.

Marine Surveys

The reefs of Marie-Louise are dominated by rock pavement and macroalgae, and the scleractinian community, which accounts for 16% of the benthic cover at 10 m water depth and 21% of the benthic cover at 15 m depth at one site in the south-east, is dominated by a small number of genera. The 1997-98 coral bleaching event, as a result of increased sea surface temperature, had a very severe impact on reefs of the Indian Ocean (Wilkinson, 2000). A high level of macroalgal cover and bare rock at Marie-Louise suggest that this recent bleaching event may have led to a benthic community with reduced scleractinian cover and increased macroalgal cover, as has been hypothesised elsewhere (e.g. Done, 1999). However, although the granitic Seychelles islands in the north suffered up to 90% coral mortality during the 1997-98 ocean warming, (Lindén and Sporrong, 1999) reefs surrounding the southern Seychelles islands, such as the oceanic atolls of Alphonse and Aldabra were less severely affected, with average mortality of around 60% (Spencer et al., 2000). Although the extent of the 1997-98 coral bleaching in the Amirantes is unknown, due to the relatively shallow nature of the Amirantes Bank (maximum depth ~70 m but typically 11 – 27 m) it is likely that the bleaching impact was more similar to in the grantics compared to Seychelles reefs further south which are surrounded by much deeper water. If the bleaching impact in the Amirantes was severe, it is therefore surprising that little rubble was exhibited on these reefs during the 2005 surveys, as coral rubble is a typical sign of recent coral mortality (Rasser and Riegl, 2002). The lack of rubble present suggests that, even in pre-1998, these reefs were most probably not dominated by a high coverage of branching corals.

The two most prevalent scleratinian genera at both depths surveyed were *Pocillopora* and *Porites*. *Pocillopora damicornis* has been described as an opportunistic species, due to its rapid reproductive cycle, widespread larval dispersal and fast growth rate on settling, enabling it to quickly occupy any newly available space (Endean and Cameron, 1990) such as that available following the 1997-98 coral bleaching event in the Amirantes group. *Pocillopora* spp. colonies at Marie-Louise typically measured 10-30 cm in diameter, sizes which could have been attained in the 7 years following the bleaching event. Conversely, the presence of *Porites* as the second most dominant genus at Marie-Louise may suggest that these slow-growing, massive colonies survived the 1997-98 bleaching event.

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PLATES

Plate 1. The island and reef platform of Marie-Louise looking from the west (photograph: Herb Ripley, January 2005).

Plate 2. Steep beach on western side of Marie-Louise (photograph: Jen Ashworth, January 2005).

Plate 3. View of Marie-Louise looking from the north. Note beach at its widest off the north-west point, feeding into a fore-reef sand sheet (photograph: Herb Ripley, January 2005).

Plate 4. Low cliffs (~1 m high) in blocky "sandstone" on the south-east coast (photograph: Martin Callow, January 2005).

Plate 5. Bevelled rock pavement, boulder beach and island margin, south-east coast (close to beach profile MLB3) (photograph: Martin Callow, January 2005).

Plate 6. Bevelled rock pavement, south-east coast (photograph: Martin Callow, January 2005).

Plate 7. *Scaevola taccada* forming a littoral hedge on the north-west coast of Marie-Louise (photograph: Jen Ashworth, January 2005).

Plate 8. Dense vegetation in the centre of the island showing *Cocos nucifera* and *Carica papaya* (photograph: Martin Callow, January 2005).

Plate 9. *Cocos nucifera* near the settlement in the north of the island (photograph: Martin Callow, January 2005).

Plate 10. Coral rock platform in the south-east, with scattered *Pocillopora* spp. colonies and macroalgae (*Halimeda* spp.) (photograph: Jen Ashworth, January 2005).

Plate 11. Anastomosing sand channels running through rock platform (photograph: Herb Ripley, January 2005).