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PISONIA ISLANDS OF THE GREAT BARRIER REEF

**PART I. THE DISTRIBUTION, ABUNDANCE AND DISPERSAL BY SEABIRDS
OF PISONIA GRANDIS
BY T. A. WALKER**

PISONIA ISLANDS OF THE GREAT BARRIER REEF

**PART II. THE VASCULAR FLORAS OF BUSHY AND REDBILL ISLANDS
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PISONIA ISLANDS OF THE GREAT BARRIER REEF

**PART III. CHANGES IN THE VASCULAR FLORA OF LADY MUSGRAVE ISLAND
BY T. A. WALKER**

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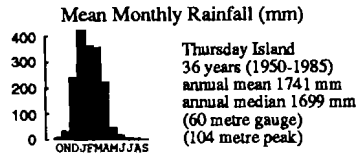
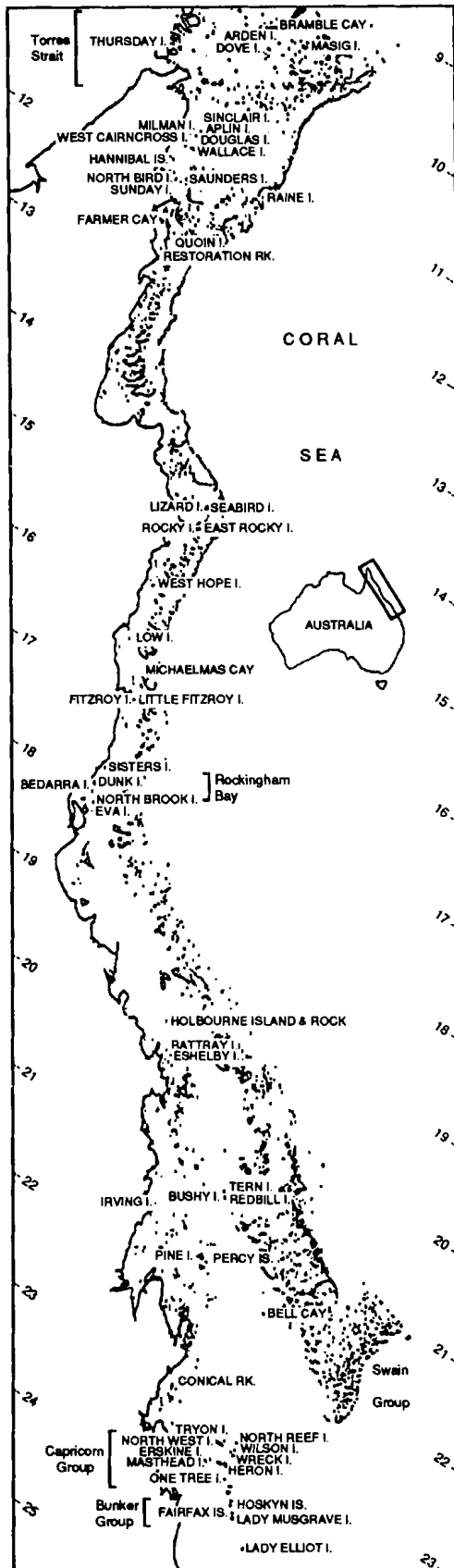
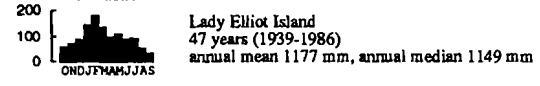
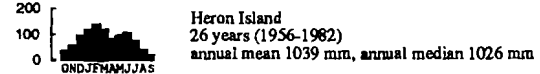
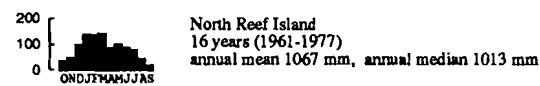
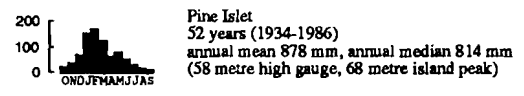
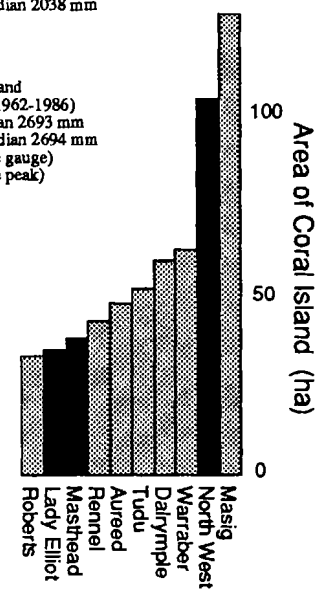
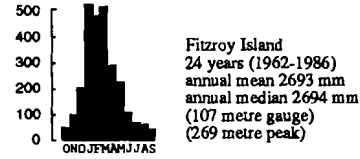
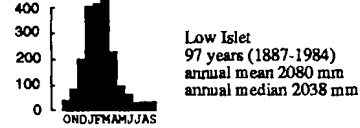
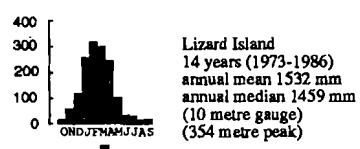


Figure 1-1. The Great Barrier Reef showing localities referred to in the text. Mean monthly rainfall data is illustrated for the four cays and the four rocky islands where records are available. Sizes of the ten largest cays on the Great Barrier Reef are shown below - three at the southern end (23 -24S) and seven at the northern end (9-11S).



PISONIA ISLANDS OF THE GREAT BARRIER REEF

PART III. CHANGES IN THE VASCULAR FLORA OF LADY MUSGRAVE ISLAND

BY

T. A. WALKER

ABSTRACT

The flora of Lady Musgrave Island has progressed from a belt of small strand trees surrounding a central scrub less than a metre high in 1843 to a mature *Pisonia grandis* forest in the 1980s. This succession was interrupted by phosphate mining and severely retarded over seventy years by grazing goat herds. Seven plant species lists recorded between 1927 and 1989 illustrate the changes occurring from natural and anthropogenic processes. 45% of the flora are naturalised alien species. There has been an eight-fold increase in human visitation in recent years but this has not resulted in a significant increase in colonisation by weeds.

INTRODUCTION

Lady Musgrave Island is the second most southerly island (23°54'S, 152°23'E) on the second most southerly reef of the Great Barrier Reef. It is the first island in the Bunker Group and consists of 13 ha (above high tide) of coral shingle, sand and phosphate rock. Lady Musgrave Island is the best example of a Great Barrier Reef island where advancing *Pisonia grandis* forest is displacing other vegetation (Figure 1-1). Substantial areas of vegetation and soil were cleared for phosphate mining in the 1890s and the vegetation was stripped bare by goats released by the miners in 1898 (Ellis 1936).

Over twenty thousand seabirds, primarily Wedge-tailed Shearwater *Puffinus pacificus* and Black Noddy *Anous minutus*, nest on the cay during summer. Less abundant species of ground-nesting terns have been partially displaced by tourists visiting the cay. The island experienced a progressive eight-fold increase in human visitation between 1984 and 1989 elevating it to the position of sixth most heavily visited cay on the Great Barrier Reef. The potential impact of tourists on the vegetation is primarily that of introduction of weeds and other alien species. Summer and winter floristic surveys were carried out on 12 January (dry conditions) and 3 June 1989 (following extensive rain) in order to evaluate vegetation changes that have occurred since previous surveys.

FLORISTIC HISTORY

The earliest description of the island and its flora is that of Jukes (1847) who landed on 7 January 1843: "The beach was composed of coarse fragments of worn corals and shells, bleached by the weather. At the back of it a ridge of the same materials, four or five feet high, and as many yards

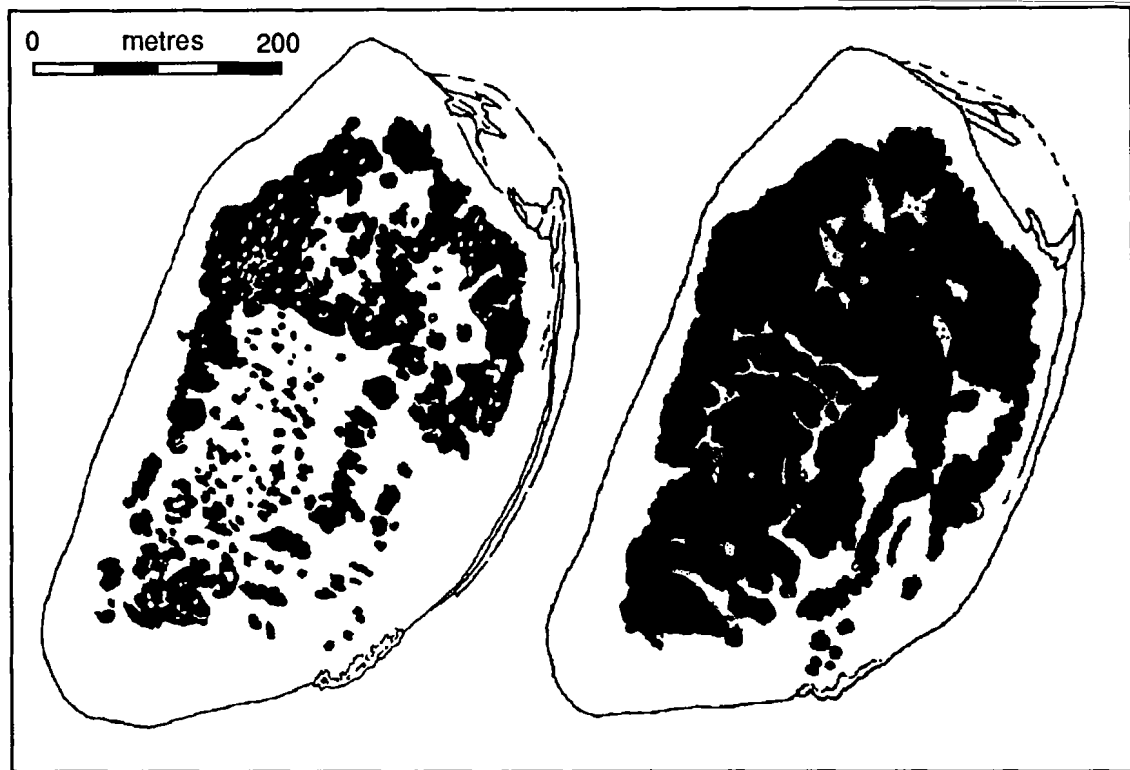


Fig. 3-1. Lady Musgrave Island in 1967 and in 1987 showing the increase in cover by *Pisonia grandis* over twenty years. A few isolated trees were not identifiable from the aerial photography.

across, completely encircled the island, which was not a quarter of a mile in diameter. Inside this regular ridge were some scattered heaps of the same stuff, the whole encircling a small sandy plain. The encircling ridge was occupied by a belt of small trees, while on the plain grew only a short scrubby vegetation, a foot or two in height. The materials of the encircling ridge were quite low and thinly covered with vegetable soil among the trees; but the sand of the central plain, which was dark brown, was sufficiently compact to be taken up in lumps, and a little underneath the surface it formed a kind of soft stone, with imbedded fragments of coral. Some vegetable soil also was found, a few inches in thickness in some places, the result of the decomposition of vegetable matter and birds' dung." Jukes also noted that the trees were "loaded" with the nests of Black Noddies and that shearwaters were abundant.

More recently, floristic surveys have been carried out on seven occasions commencing in 1927 (TbIs. 3-1 3-2; Fig. 3-2). The first survey in November 1927 reported only eleven species growing (MacGillivray and Rodway 1931). At that time up to 300 goats (23 per ha) had removed all small trees, shrubs, herbs and grasses with the exception of a few sessile plants growing too close to the ground to be grazed (Nebe 1928, Napier 1928, MacGillivray 1928, MacGillivray and Rodway 1931). The four species of trees were browsed clear to a height of 120 cm and the goats had started to eat bark from *Pisonia grandis*. Only two "miserable specimens" of *Tournefortia argentea* were

Notes to Table 3-1: 1 - not on the incomplete 1966 list but possibly present; 2 - seeds of *Caesalpinia bonduc* but no plants; 3 - inferred to be still present by Cribb but not seen by Belmont & Lentfer with the exception of an unidentified Asteraceae (possibly *Conyza bonariensis*); 4 - species not identified with certainty; 5 - seen by Belmont & Lentfer but not by Cribb; 6 - species uncertain, variously referred to *B. albifrons*, *B. diffusa* and *B. tetrandra*; 7 - seen by Cribb but not by Belmont & Lentfer; 8 - not seen by Belmont & Lentfer but noted as *Panicum* sp. by Cribb; 9 - not recorded by Chaloupka and Domm but almost certainly present.

Table 3-1. Vascular plant species recorded at Lady Musgrave Island in different years.

	1927	66	69	75	82	84	89	Status in 1989
NATIVE SPECIES								
<i>Casuarina equisetifolia</i>	+	+	+	+	+	+	+	common, south-western margin
<i>Ficus opposita</i>	+	+	+	+	+	+	+	common, throughout cay centre
<i>Pandanus tectorius</i>	+	+	+	+	+	+	+	common, north and east strand
<i>Pisonia grandis</i>	+	+	+	+	+	+	+	dominant forest over cay
<i>Portulaca oleracea</i>	+	-1	+	+	+	+	+	widespread, not abundant
<i>Caesalpinia bonduc</i>	-2	+	+	+	+	+	+	large thickets, south-eastern side
<i>Tournefortia argentea</i>	+	+	+	+	+	+	+	common, north and east strand
<i>Hydrocotyle acutiloba</i>	+	-1	+	+	+	+	+	
<i>Abutilon asiaticum</i>		+	+	+	+	+	+	common in forest clearings
<i>Achyranthes aspera</i>		-1	+	+	+	+	+	widespread, not abundant
<i>Canavalia rosea</i>		+	+	+	+	+	+	common, south half periphery
<i>Ipomea pes-caprae</i>		+	+	+3	+	+	+	common, south-eastern herb fields
<i>Lepturus repens</i>		+	+	+	+	+	+	co-dominant ground cover
<i>Sesuvium portulacastrum</i>		+	+	+	+	+	+	pond meadow, rare elsewhere
<i>Solanum americanum</i>		+	+	+	+4	+	+	widespread, not abundant
<i>Sporobolus virginicus</i>		+	+	+	+	+	+	uncommon, south-eastern clearings
<i>Tetragonia tetragonioides</i>		+	+	+	+	+	+	rare, south-eastern strand only
<i>Thuarea involuta</i>		+	+	+	+	+	+	co-dominant ground cover
<i>Tribulus cistoides</i>		+	+	+	+	+	+	widespread, not abundant
<i>Boerhavia repens</i> ⁶		+		+7	+	+	+	uncommon
<i>Malvastrum coromandelianum</i>		+			+	+	+	dense patch in south-east clearing
<i>Ophioglossum vulgatum</i>		-1	+	?3				
<i>Ruppia maritima</i>		-1	+	?3				
<i>Oxalis perennans</i>		+						
<i>Ipomea macrantha</i>				+5	+4	+	+	uncommon, mainly ground cover
<i>Euphorbia tannensis</i>				+7	+	+	+	widespread, not abundant
<i>Spinifex sericeus</i>					+	+	+	rare
<i>Ipomea sp.</i>							+	one patch on herbs, camp area
NATURALISED ALIEN SPECIES								
<i>Oxalis corniculata</i>	+	-1	+	+	+	+	+	rare
<i>Coronopus integrifolius</i>	+						+4	rare
<i>Coronopus didymus</i>	+	-1	+	+3	+			
<i>Cyperus rotundus</i>	+							
<i>Amaranthus viridis</i>		-1	+	+	+	+	+	widespread, not abundant
<i>Bidens pilosa</i>		+	+	+	+	+	+	patchy abundance, southern half
<i>Cakile edentula</i>		+	+	+	+	+	+	common, north and eastern strand
<i>Cenchrus echinatus</i>		+	+	+	+	+	+	common but patchy
<i>Sonchus oleraceus</i>		+	+	+	+	+	+	uncommon, patchy, south half of cay
<i>Conyza bonariensis</i>		+	+	+3	?4	+	+	few, south-eastern clearings
<i>Cynodon dactylon</i>		+	+	+3	+	+	+	uncommon, patchy
<i>Eleusine indica</i>		+	+	+3	+	+	+	uncommon, patchy
<i>Euphorbia prostrata</i>		+	+	+3	+	+	+	rare
<i>Argemone ochroleuca</i>		+		+	+	+		
<i>Digitaria ciliaris</i>		+			+			
<i>Eragrostis minor</i>		+						
<i>Panicum maximum</i>				+8	+	+	+	one patch, northern strand
<i>Trachymene cussonii</i>					+	+	+	few, northern strand
<i>Ipomea indica</i>					+	+9	+	large patch near light tower
<i>Conyza sumatrensis</i>					?4		+	few
<i>Lepidium bonariense</i>					+			
<i>Lepidium virginicum</i>						+	+	rare, in clearings
<i>Raphanus raphanistrum</i>							+	rare
CULTIVATED SPECIES								
<i>Lycopersicon esculentum</i>		-1	+	+	+	?	+	small vines, camping area
<i>Cucurbita pepo</i>		-1	+	+3	+4	?	+	six vines, camping area
<i>Carica papaya</i>			+	?3				
<i>Allium cepa</i>				+7				
<i>Solanum tuberosum</i>				+7				
<i>Cocos nucifera</i>							+	seedling

Table 3-2. Non-cultivated plant species at Lady Musgrave Island in different years.

	1927	1969	1975	1982	1984	1989	All Years
Total species number	11	31	35	40	39	41	51
Native species number	7	20	22	23	23	24	28
Alien species number	4	11	13	17	16	17	23
Alien species %	36	35	37	42	41	42	45
Sea-dispersed species	3	14	15	17	17	17	17
Sea-dispersed species %	27	45	43	43	44	41	33

alive and MacGillivray and Rodway (1931) observed that the “animals seem now to be dependent upon the dead leaves that fall from the trees and the seaweed on the beach”. There was competition between goats and nest-building Black Noddies for every leaf that fell to the ground (MacGillivray and Rodway 1931, Nebe 1932). Nebe (1928) described the *Pisonia* trees as stunted whereas Napier (1928) referred to 40 foot (12 m) high trees. MacGillivray and Rodway (1931) reported that most of the centre of the cay was occupied by *Ficus opposita* from 15 to 20 feet (4.5-6 m) high and abundance of this species was previously inferred in the 1890s by Ellis (1936) who noted flocks of doves feeding on the “wild figs”.

Four years after the 1927 survey the goats had been greatly reduced by hunting and “much undergrowth, mostly *Abutilon* and coarse grasses” was present (Nebe 1932). Five years later the cay was “thickly wooded and the tangled undergrowth made direct levelling or cross-traverses impossible” (Steers 1938). A small holiday resort was built and operated at the southern side of the cay during the 1930’s and the last remnants and debris were removed in 1984. The extent of island habitat modification and garden importation associated with the resort is unknown but no cultivated vegetables or ornamentals survived at the time of the next floristic surveys with the possible but unlikely exceptions of *Lycopersicon*, *Carica* or *Cucurbita*.

Over the following forty years the goat herd fluctuated in size from hunting (surviving at least one eradication attempt in 1948) until they were eliminated in 1971 with the exception a single animal that escaped until 1974 (P. Ogilvie, pers. comm.). H. S. Curtis sketched a vegetation map in October 1965 and made an incomplete species collection in November 1966 (Queensland Forestry Department files). Floristic surveys undertaken in July 1967 and in April 1969 were combined into a vegetation list by A. B. Cribb (letter to the Forestry Department). The lists of Curtis and Cribb are shown under “1966” and “1969” respectively in Table 3-1 and demonstrate a large increase in native and alien plant species since the grazing-impooverished list of 1927.

In August-September 1975 twenty-eight plant species were recorded by Belmont and Lentfer (Heatwole 1984). Cribb also visited in July 1975 and listed seven new species in addition to species reported in 1969 (letter to the Forestry Department). Cribb noted that goat damage to *Casuarina* and *Pandanus* was repairing and that “removal of goats has led to a marked increase in ground cover of plants. Bare shingle ridges of conglomerate exposed by phosphate mining had been fairly conspicuous features of the cay during the 1969 visit but are now mostly obscured by ground cover plants.” Three new species established at the cay in the early 1970s. Four more new species were present in January 1982 when Elsol (1986) mapped the vegetation and analysed distribution patterns.

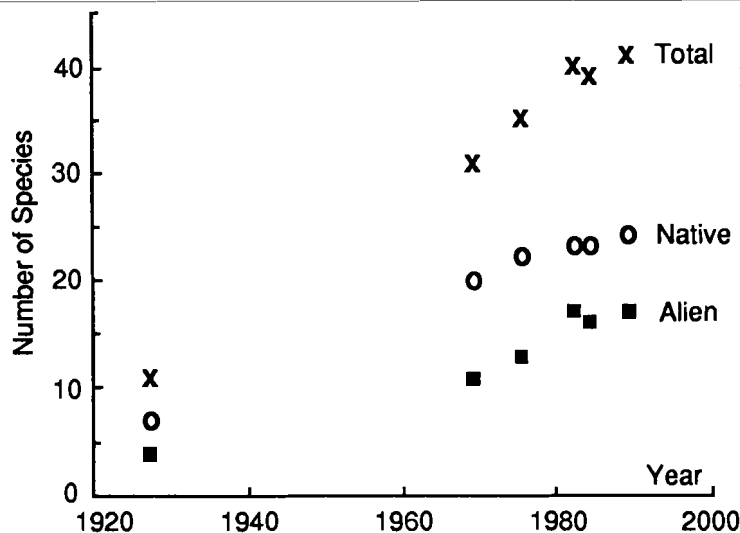


Fig. 3-2. Increase in species diversity at Lady Musgrave Island from 1927 to 1989. Strong linear correlations between species diversity and time ($r = 0.996$ total, 0.993 native, 0.975 alien) are misleading. Between surveys in 1927 and 1965 the plant density fluctuated with changing hunting intensity on the goats and diversity would also have fluctuated widely.

The 1982 floristic survey marks a turning point for the island vegetation. The last effects of destructive or selective grazing by goats had finally disappeared and subsequent floristic surveys in 1984 (Chaloupka and Domm 1986) and 1989 (Tables 3-1, 3-2) indicate that species diversity has stabilised. Neglecting the introduced food plants, four species disappeared between 1982 and 1989 and five new species appeared. The changes may be less if, as seems likely, there was confusion with identification or collection of the two species each of *Coronopus*, *Conyza* or *Lepidium* reported. *Ipomea indica* was almost certainly overlooked or dormant in the 1984 survey as it dominated the same site in 1982 and in 1989.

The vegetation is presently experiencing strong competition for space. Establishment of new species has become difficult and some established species are being displaced by expansion of others. Dense ground cover of *Thuarea*, *Lepturus* and other species inhibit establishment of *Casuarina* seedlings and the population is decreasing slowly as the old trees die (but seedlings have been planted in recent years by park staff). *Pisonia* stands have expanded vegetatively shading out all other species to cover an area in 1989 more than twice that covered in 1967 (Fig. 3-1). Displacement of previously dominant *Ficus opposita* has been accompanied by extinction of the frugiferous Bar-shouldered Dove *Geopelia humeralis* population since 1927. *Pisonia* forest permits no undergrowth and in the absence of destructive cyclones or other events will form the climax vegetation. *Pisonia* was presumably present at the time of phosphate mining although the description of Jukes (1847) indicates that *Pisonia* cover was not significant in 1842. Impenetrable thickets of *Caesalpinia bonduc* are presently expanding and displacing other species (Elsol 1982). In 1989 several *Pisonia* and *Pandanus* trees were severely overgrown by this woody vine which could pose a challenge to the dominance of *Pisonia*. *Ipomea indica* also blanketed a large area of ground vegetation and trees near the navigation light in June 1989. This vine spread rapidly from a small area in January as a result of unusually high rainfall throughout the first half of the year.

PLANT DISPERSAL AND COLONISATION

The method of a species' arrival at a cay can be partially inferred from diaspore adaptations for anemochory, hydrochory, epizoochory or endozoochory and from previous knowledge of dispersal events. Arrival mechanisms are unclear when species have more than one natural dispersal mode or when there has been introduction of garden soil, building materials or other materials likely to contain diaspores. Building materials were imported to Lady Musgrave Island for a shelter hut in

about 1930, for resort buildings in the late 1930s, for an automatic navigation light tower in 1974 and for camper toilets in 1987. Food plants including tomato, pumpkin, pawpaw, onion and coconut have been taken to Lady Musgrave Island by visitors from time to time. These were intentionally planted or have propagated from discarded seeds and are not considered in the following examination of plant colonisation.

About 15% of species recorded at Lady Musgrave Island have diaspores that are dispersed by wind but with one exception this is primarily a short-distance mechanism. Offshore winds are weak, infrequent and not often likely to transport seeds of grasses, weeds or *Casuarina* across 60 km of sea from the mainland. One exception is *Ophioglossum vulgatum* (presumably the same species reported as *O. lusitanicum* on adjacent Fairfax Island by Cribb 1986) which has the tiny fern spores capable of extended aerial buoyancy. The grasses and weeds with wind dispersal capability have alternative dispersal modes by birds or people which are the more probable routes of arrival at Lady Musgrave Island. *Casuarina equisetifolia* is assumed to have colonised by sea dispersal. Plants with diaspores dispersed by the sea make up 33% of the total species list and 54% of the native species (Table 3-2). There are two sea-dispersed alien species, *Trachymene cussonii* and *Cakile edentula*.

About 65% of all species appear to have dispersed to Lady Musgrave Island via birds or people. The corresponding proportions of native and alien zoochorous species are 43% and 91% respectively. It is often difficult to differentiate between dispersal of small seeds carried internally by birds and those carried externally by birds or by people. One can speculate that the bulk of the alien species were accidentally carried to the cay by campers and tourists but there is little direct evidence to support this. Weeds initially introduced to Australia by human agency have subsequently spread by natural means.

Chaloupka and Domm (1986) have argued that anthropochory is the primary determinant of colonisation of southern Great Barrier Reef cays by alien plants. Using data from the Capricorn-Bunker Islands they reported that the percentage of alien species on each cay was strongly correlated with the amount of human visitation. This correlation was attributed to inadvertent dispersal of diaspores attached to the clothing and footwear of the visitors (anthropochory). The conclusions of Chaloupka and Domm (1986) have been reviewed by Heatwole and Walker (1989) who showed that while anthropochory may be an important process, other factors including introduction of gardens and soil, habitat modification by human activities and avian zoochory could equally well account for the observed patterns of alien plants on the Capricorn-Bunker Islands.

The eight-fold increase in tourist visitation at Lady Musgrave Island between the 1984 and 1989 floristic surveys makes it an ideal location to observe the effects of anthropochory. Annual numbers of campers at Lady Musgrave Island increased from 212 in 1984 to 992 in 1985 and 1,475 in 1988 (Department of Environment and Heritage permit records). Prior to 1985 the island was closed to campers for six months each year but from 1985 camping was permitted year-round. Accessibility of the cay was greatly boosted in July 1985 by commencement of a large tourist catamaran service from the mainland. The vessel and its associated seaplane carried more than 11,000 day-visitors in 1988. In addition to this the mean numbers of cruising yachts and motor boats present at the reef increased from 2.1 and 2.3 respectively in 1984 to 3.8 and 3.8 respectively in 1988 (data from twice-weekly aerial surveillance flights by the Department of Environment and Heritage). Simple estimates from the camper, tourist and vessel records (assuming an average of two people go ashore from each private vessel which remains at the reef for an average of two days)

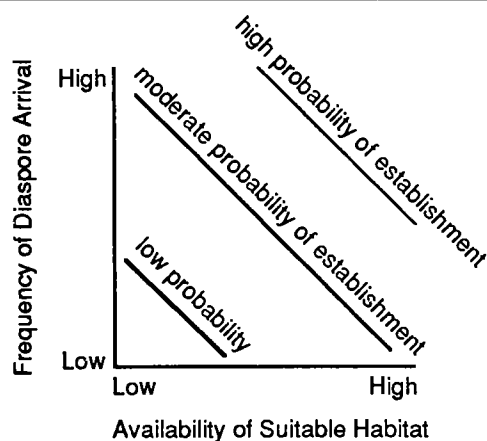


Fig. 3-3. The relationship between arrival and survival of a new plant species.

indicate that numbers of people visiting the cay increased from about 1,800 in 1984 to about 15,000 in 1988 (the most heavily visited cay on the Great Barrier Reef is Green Island which received about 240,000 tourists in 1988). The number of visitors in the four years from 1985 to 1988 is probably greater than the total number of visitors to Lady Musgrave Island during the preceding thirty year period.

Floristic differences between 1984 and 1989 involve only four species and are not consistent with a flora primarily influenced by anthropochory. *Argemone ochroleuca* disappeared (probably a seed-bank temporal) while *Raphanus raphanistrum*, *Conyza sumatrensis* and a new species of *Ipomea* appeared (the *Ipomea* resembles *I. indica* but is glabrous and may be an undescribed taxon). *Conyza sumatrensis* could have been present in 1984 but overlooked amongst the *Conyza bonariensis* (*Raphanus raphanistrum* was rare and might also have been overlooked previously). The floristic changes at Lady Musgrave Island from 1927 to 1989 indicate that habitat disturbance is more important to establishment of native or alien plants than anthropochory. This is a long-term evaluation because the relative importance of diaspore arrival undoubtedly fluctuates with respect to diaspore survival. There may at times be a surplus of immigrant diaspores but no suitable available habitat, or an excess of available habitat with an absence of immigrant diaspores. The situation most likely to occur is between these extremes with the probability of species establishment being directly dependent on the product of diaspore arrival frequency and habitat availability (Fig.3-3).

CONCLUSION

The floristic composition of Lady Musgrave Island is typical of the Capricorn-Bunker islands. The only species not recorded from the other islands of the group is the unidentified newly arrived *Ipomea* species. *Scaevola sericea* and *Wollastonia biflora* are notably absent from Lady Musgrave Island and from adjacent East Fairfax Island which was also defoliated by goat herds until recent years (Cribb 1986). These two sea-dispersed species may have difficulty colonising the strand which is excavated by nesting turtles during summer. Only 55% of species recorded at the island are native to Australia. The large increase in numbers of visitors to the cay between 1984 and 1989 has not been accompanied by significant change in the botanical species composition. If these visitors are transporting numerous diaspores to the cay then there can be little suitable habitat available for colonisation and trampling effects must be insignificant in creating such habitat.

Human interference with the vegetation has been severe particularly with respect to phosphate mining and release of goats but these effects should not obscure the fact that the flora of Lady Musgrave Island has progressed from scrubby vegetation less than a metre high in 1843 to a predominant cover of mature *Pisonia grandis* forest. Mining and grazing retarded this progression but, as with some other Capricorn-Bunker cays, the vegetation was notably less advanced last century prior to known European impact. Whether this is indicative of the youth of the cays or of a history interrupted by cyclonic destruction is unknown. The abundance of phosphate cay rock could be interpreted as evidence of a previous *Pisonia* forest (Fosberg 1957) but such rock might also form in the absence of *Pisonia* (Part I).

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Plate 1. *Pisonia grandis* with large double trunk (Cairncross Island, October 1988).



Plate 2. Shallow *Pisonia* root system uncovered by *Megapodius reinwardt* digging at Bushy Island (August 1989).



Plate 3. Soil profile in *Pisonia* forest at Heron Island (August 1988). Less than a metre of sand with *Pisonia* humus and roots overlying white coral sand.



Plate 4. Coppice shooting from a fallen *Pisonia* branch (Heron Island, August 1988).



Plate 5. *Pisonia* forest at Lady Musgrave Island (September 1986 photo from light tower).



Plate 6. Deciduous *Pisonia* forest (Douglas Island, October 1988).