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PLANT COLONIZATION OF A RUBBLE BANK ON HERON ISLAND, GREAT BARRIER REEF, AUSTRALIA

BY

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ABSTRACT

Plant colonization of a rubble bank deposited on Heron Island was followed for over four years, ending when a cyclone destroyed much of the site. Two years elapsed before any plants were found, but after four years 30 species had been found, including 14 species native to Heron Island or other islands in the Capricorn group. A population of about 50,000 individuals was present by the end of the four years. Although most plants were weeds, the species which naturally dominate such sites were present and prominent. The number of species present on the site was related to logarithm of time since establishment, and the logarithm of the number of individuals present was also related to time since deposition of the rubble. Rapid colonization by native species is significant for management of coral cays.

INTRODUCTION

Coral cays are, by nature, small and often isolated patches of land subject to severe disturbance from such factors as tropical cyclones and other violent storms. Since a cay is composed entirely of material of biological origin, the vast bulk of it calcium carbonate from algal and coral skeletons, the substrate is an unusual and rather severe one (Wiens 1962). The soil has unusual chemical properties, and is especially high in calcium carbonate, which tends to limit the availability of phosphates. The physical structure of the substrate is also difficult for many plants.

The processes of plant colonization on such an apparently inhospitable place are of considerable interest. The angiosperm flora of Heron Island has been reported on a number of times

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(Chaloupka & Domm 1986, Walker 1991a), permitting a study of invasion of the cay by weeds (Chaloupka & Domm 1985). The colonization of Lady Musgrave Island, another cay in the Capricorn Group south of Heron Island, has been reported by Walker 1991b. The plant species diversity of Lady Musgrave Island increased linearly from 1927 to 1989, but this was apparently an artifact of management procedures in that period, diversity varying as goat populations rose and fell.

In October 1987 a large quantity of rubble and silt excavated from the basin of the harbour at Heron Island was deposited on the south-western side of the cay, and built up until the surface was at about the level of the adjacent terrestrial vegetation, and well above spring tide levels. The upper surface was flat, with a total area of about 150m x 40m and more or less lens-shaped in outline. A rubble beach with a low bank of coarse coral fragments formed around the edge of the reclaimed area. The materials in the bank have been discussed by Gourlay (1991).

No attempt was made to vegetate or otherwise stabilize this deposit of coralline rubble. Vehicular traffic skirted the landward edge of the deposit, but an area approximately 70m long, and with an area of about 700m^2 was subject to little traffic: natural colonization of this area commenced about two years after the rubble was deposited. This colonization provided an opportunity to study the successional process on what amounted to an extension of a coral cay. Such an opportunity is not common, and offers the chance to explore the processes of vegetation development on a cay, processes of scientific and applied interest as exploitation of cays by tourists increases.

In March 1992 a cyclone eroded a large portion of the bank, and inundation with salt-water killed almost all the plants, bringing the study to an end.

METHODS

Heron Island was visited at intervals from December 1987 until March 1992, during which time vegetation records were made. In December 1987, December 1988, September and December 1989, March, June September and December 1990, and March and July 1991 it was practicable to count all individuals of all species on the vegetated portion of the rubble bank. In September and December 1991 it was necessary to estimate numbers of the more common species by placing two lines of quadrats at five metre intervals systematically across the area. The numbers of less common and more prominent species were, however, counted.

RESULTS

The first plants appeared on the rubble bank in December 1989, morethan two years after the bank was deposited, when a total of 12 small and rather badly sand-blasted individuals of *Sisymbrium orientale* L were counted. The numbers of plants large enough to identify and found within the area is shown in Table 1, reaching a maximum of about 50,000 individuals in a total of 30 species, 14 of which were either native to Heron Island, or native to other similar islands in the Capricorn group.

The plants which colonised the rubble bank accumulated a mass of sand about themselves providing locations which were apparently particularly favourable sites for germination and establishment. The grasses, in particular *Lepturus repens*, built long-lasting sand mounds up to 30 cm high on the otherwise flat rubble surface. Sea birds, especially terns, frequented the area in large numbers.

Two of the *Casuarina equisetifolia* plants which were first noticed in November 1990 had reached heights of 75cm and 133cm respectively by September 1991. *Tournefortia argentea* plants which appeared at the same time had canopies ranging from 145cm tall and 140 cm wide to 25cm tall and 50 cm tall in September 1991: the larger plants had flowered and fruited. The root systems of one *Casuarina equisetifolia* were exposed by the storm which destroyed much of the rubble bank, and showed that root nodules were common.

The total number of identifiable plants was logarithmically related to days since creation of the rubble heap (fig. 1)

$$\text{Ln } N = -6.682 + 1.47\ D \times 10^{-2}.\ (r^2 = 0.903,\ p < 1\%,\ F=55.6,\ 6 \text{ df})$$

where N is the total number of plants and D is the number of days since the rubble bank was deposited.

The total number of species colonizing the rubble (N) was related to logarithm of time since deposition (D) (fig. 2)

$$N = -316 + 47.3 \ln D \quad (r^2 = 0.966,\ p < 1\%,\ F = 173,\ 6 \text{ df})$$

Table 1

Numbers of plants recorded on various dates from a rubble bank deposited at Heron Island in October 1987. Seedlings too small to identify are listed at the foot of the table. Species numbers refers to the cumulative number of native species, introduced species and total species reported to the given date on the rubble bank. Introduced species are indicated with an asterisk. No plants were present in September 1989. Dates indicate month and year.

Date	12.89	6.90	9.90	12.90	3.91	7.91	9.91	12.91	
Species									
Abutilon asiaticum					3	1	1	1	
Achyranthes aspera*						1	1	1	
Amaranthus viridis*				1	1	0	0	0	
Argemone ochroleuca*						10	24	10	
Boerhavia tetrandra		2	2	5	30	160	560	330	
Cakile edentula		10	49	37	75	62	16	30	
Capsella bursa-pastoralis*		5	0	1	3	1	0	1	
Casuarina equisitifolia					7	6	5	4	
Cenchrus echinatus*					4	5	2	0	
Conyza bonariensis*		10	60	207	250	210	50,000	30,000	
Coronopus didymus*		3	0	0	1	20	30	100	
Digitaria ciliaris*					2	2	0	0	
Eleusine brevifolia*						45	420	0	
Eleusine indica*			5	11	12	100	120	220	330
Gnaphalium luteoalbum				2	1	11	16	33	
Ipomoea pes-caprae					2	1	1	1	
Lepturus repens			1	3	100	100	500	550	
Lycopersicum esculentum*							1	0	
Poa annua*			40	3	1	1	900	1	
Portulaca oleracea			1	14	15	1	1200	690	
Sesuvium portulacastrum				2	8	16	7	6	
Sisymbrium orientale*	12	18	100	8	80	250	260	630	
Sonchus oleraceous*					2	24	500	250	
Solanum americanum*							1	0	
Sporobolus virginicus						4	10	10	
Stenotaphrum micranthum*						1	0	0	
Thuarea involuta					1	11	11	60	90
Tournefortia argentea					8	13	20	14	18
Tribulus cistoides		1	0	3	15	35	30	30	
Wollastonia biflora							1	1	1
Total numbers of plants									
Identified plants	12	54	264	307	700	1115	51,358	48,000	
Native plants	0	13	52	59	264	417	1205	1071	
Seedlings (unidentified)						30,000	4,000		
Total Plants	12	54	264	307	700	31,000	55,000	48,000	
Total numbers of species									
Native species	0	3	4	8	10	14	14		
Introduced species	1	5	7	8	12	16	16		
Total species	1	8	11	16	22	30	30		

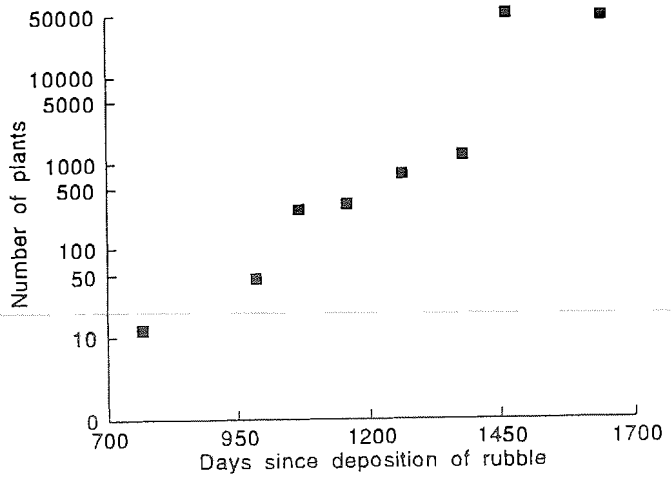

Figure 1. Number of individual plants on a rubble bank on Heron Island compared with the number of days since deposition of the rubble.

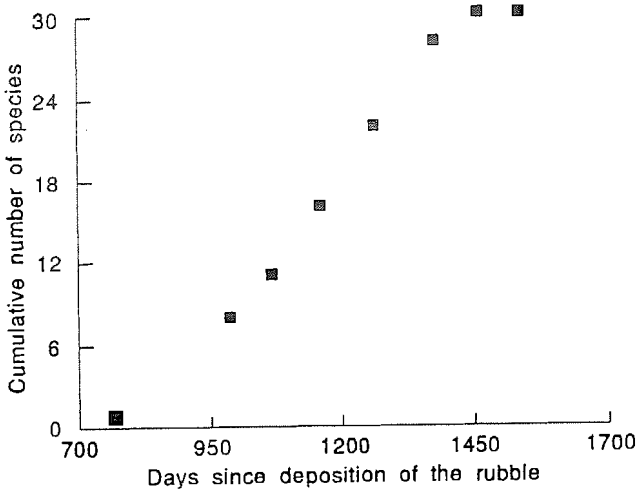

Figure 2. Cumulative number of species colonizing a rubble bank on Heron Island compared with the number of days since deposition of the rubble.

The number of native species (N) fitted a similar relationship

$$N = -158 + 23.5 \ln D \quad (r^2 = 0.940, p<1\%, F = 94.0, 6 df)$$

as did the number of introduced species (N)

$$N = -157 + 23.7 \ln D \quad (r^2 = 0.973, p<1\%, F = 217, 6df)$$

The more common species occurring on the site (*Boerhavia repens, Conyza bonariensis, Cakile edentula, Eleusine indica, Sisymbrium orientale)* also showed a statistically significant relationship ($r^2 > 0.70$, $p < 1\%$, $F > 55$ in each case) between time since deposition of the rubble and logarithm of total number of individuals on the site.

Of the species reported on the bank two, *Eleusine brevifolia* and *Sesuvium portulacastrum,* have not been reported previously from the island.

Discussion

The colonisation of the rubble bank was initially slow, but the number of individuals increased rapidly and logarithmically throughout the period. The number of individuals of the more common species also showed a logarithmic increase with time, none reaching a clear plateau stage or even showing a well defined drop in growth rate resulting in a logistic curve which might be expected if resources became limiting and competition for resources increased (Harper 1977). It is apparent that while the presence of some of the earlier colonizers may have facilitated the establishment of other species, succession had not proceeded to the extent that the later arrivals had begun to exclude the initial species. The appearance of long lived woody species and of perennial grasses, however, suggests that given more time displacement of populations of weedy species would proceed.

The number of species increased rapidly once colonization commenced, but slowed so that it decreased with the logarithm of time. This is entirely consistent with a logistic relationship between species richness and time available for colonization. Several species which are common on the margin of the strand had not appeared by termination of the study. *Scaevola taccada* is common on exposed shores, as is *Pandanus heronensis*, neither of which were discovered. *Scaevola taccada*, like *Tournefortia argentea* has a fleshy fruit and both are apparently bird dispersed: why only *T. argentea* has succeeded in colonising the rubble is unclear. There is no apparent biological agent to move about the large, aromatic, fleshy fruits of *Pandanus tectorius* which appear simply to fall at the base of the plant: those which fall onto a beach may then be dispersed in the sea, and fruits of *Pandanus* often found in the beach drift on Heron Island.

While the vast bulk of plants present are weeds (table 1), the native flora was well represented. Of the 30 native plants presently on the island, 13 were present on the rubble four years after deposition. *Sesuvium portulacastrum*, while not previously recorded from Heron Island is known from other Islands in the Capricorn Group, and, given the high rate of introductions and extinctions from such Islands (Chaloupka & Domm 1985) is treated as native to the Island. *Ipomoea pes-caprae* was reported on the rubble bank after a long absence from the Island (Chaloupka and Domm 1985). However, although both *Sesuvium portulacastrum* and *Ipomoea pes-caprae* appeared in an to be natural introductions to the rubble area, their recent absence perhaps being the result of a lack of appropriate natural habitats on Heron Island in recent years, both were subsequently observed growing as ground-cover plants in the gardens of the Heron Island Resort.

The three native grasses which characterize Heron Island (*Sporobolus virginicus*, *Lepturus repens*, and *Thuarea involuta*) were present and formed an extensive cover, accumulating substantial sand mounds. The long-lived perennials *Tournefortia argentea* and *Casuarina equisetifolia* which are prominent in the vegetation immediately behind the beaches of Heron Island were well established. The elements of a structured natural vegetation were, therefore, in place after about three years after the deposition of the rubble bank, and quite visually prominent after four years.

Weed populations in the disturbed area were high, and almost all of the weedy species reported from the island were found growing on the rubble bank. The appearance of numbers of *Argemone ochroleuca* on the bank was surprising, as although reported for the island by Chaloupka and Domm (1986) it has not been observed in recent years. Although no specimen was permitted to grow to maturity, young plants were found in July, September and December 1991, and in March 1992. A population in excess of 50 seeds was somehow introduced to the rubble bank, and scattered across it. It is likely that as the perennial native grass cover increased and sand accumulated on the bank, that the dominance of the short-lived weedy dicots would have decreased.

The speed with which plants recolonized such an inhospitable environment, and the diversity of species developing, has implications for the management of coral cays. Rehabilitation of a damaged cay using native species is likely to be rapid and relatively easy, provided that the source of disturbance is removed. The native species which dominate shore-lines (*Casuarina equisetifolia* and *Tournefortia argentea*) establish easily in apparently inhospitable conditions, and make rapid growth. That the native vegetation shows a rapid redevelopment is consistent with a vegetation which has evolved in a severe and periodically disturbed environment, such as a coral cay.

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