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Section A: Short Communication

Pollen Fertility Status in Coastal Plant Species of Rotuma Island

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Abstract

The Island of Rotuma is facing widespread destruction and degradation of its flora. This investigation was conducted to determine the pollen fertility status in thirty two species of economic and environmentally important coastal species, which are reproducing freely thus most suitable to rehabilitate coastal areas. Pollen fertility status in these species varied from as low as 38% in Canavalia cathertica to as high as 100% in Hernandia nymphaeifolia and Vigna marina. It was interesting to note that species within same genus showed wide range of pollen viability. However, most of the species investigated had high pollen viability especially in those species, which grow close to sea. It was recorded that pollen fertility was low in small fragmented populations. This showed the effect of population size on reproduction. Larger sized populations showed high percentage of pollen fertility.

1. Introduction

Rotuma is a small isolated volcanic oceanic island located 465 km to the northwest of the Republic of Fiji. Because of its relative isolation from the rest of the Fiji Group and its geographical remoteness from all the other Pacific Islands (the closest being Niulakita Island in Tuvalu, which is approximately 350 km to the northeast), it has been largely neglected in the botanical studies and surveys of the Pacific Islands and Fiji.

Rotuma also encounters widespread destruction and degradation of its flora. The clearing of forests for plantations and settlements has resulted in the loss of many species. For the better part of the 19th century, Dillon (1829) and Wood (1875) reported that the island was densely populated and that most of its interior was cleared for towns and settlements. Gardiner (1898) observed that the whole island, wherever practicable, was at one time tilled. There were signs of forest clearing even on the steepest slopes and food crops, such as bananas, were observed growing at the bottom of hills for a very long time (Gardiner 1998). At the arrival of European trading and whaling ships, the attraction of trade with foreigners lured the population away from the interior of the island to settle along the coast. Towards the end of 1800 (Gardiner 1898), the towns and settlements in the interior of the island were abandoned and the entire population was living along the coast (Russell 1942). The movement of population from interior to coastal areas resulted in the clearing of all coastal land suitable for agriculture and settlement and exposed the coastline to erosion during heavy rainfall and high tides.

Most Rotuman coastal plant species are of very high cultural utility (Thaman, 1992). The coastal plant species are used for food, clothing, construction, carving, medicine and cultural attire, to mention a few. The frequent removal of these species together with the lack of understanding of consequences and advantages of replanting led to serious coastal degradation and to the endangerment of a high proportion of littoral species. Therefore there is urgent need for conservation measures to rehabilitate coastal land and restore plant communities. Besides human activity, other factors have also contributed to the degradation of Rotuma's coastal littoral flora. Periodic natural disasters such as hurricanes and storms, although infrequent, caused enormous devastation and destruction to plants and animals (Dumont 1848, Boddam-Whetham 1876, Gardiner 1898, Bach 1924). More recently, in October 1972 Hurricane Bebe swept across the island, its strong winds and accompanying unusually high waves caused extensive damage to homes and vegetation (Walkley, 1973). The coastline was eroded considerably changing the configuration of a large proportion of it.

Pollen, which is a carrier of male gametes, includes three domains that are different in their chemical composition, morphological structure and their physiological and biological significance (Knox, 1984). The three domains of pollen-grain include exine, entine and nucleus. The complex exine structures of pollen are storage sites for carbohydrates, glycoproteins, lipids, terpenoids and phenolics (Wiermann and Gubatx, 1992). The pollen nucleus is rich in chromatin material and viable pollen stains pink to deep red with acetocarmine, while sterile (mostly shriveled) pollen does not take any stain and thus remains almost white and transparent (McKellar and Quesenberry 1992, Marutani *et al*. 1993). A viable or fertile pollen is one which, after landing on the stigma of the same plant or other plants of the same variety or species, under normal conditions would start growing a pollen tube and finally discharge its male gametes in the embryo sac effecting fertilization.

Pollen fertility, which can be determined using pollen viability tests *in-vitro* is very important in fruit and seed production in flowering plants. Therefore, the pollen fertility knowledge for any plant species is essential for plant breeders and commercial growers. The present study was undertaken to determine pollen fertility status using pollen viability tests *in vitro* by aceto-carmine staining technique in thirty-two species of economic and environmental importance. This investigation will also help in identifying coastal species, which are reproducing freely and are therefore most suitable for coastal reforestation and rehabilitation.

2. Materials and Methods

Thirty-two species (which were in flower during the time of this study) were tested for pollen fertility status by using the aceto-carmine staining method. The aceto-carmine method of determining viability in different species of plants is comparable to other methods such as pollen germination method on artificial medium (Tyagi *et al* 1992) and Flow Cytometry Reactivity (Tyagi *et al.,* 1995).

Flower buds, flowers or inflorescences of these species were collected from around the whole coastline and where possible their pollen was analysed for viability within one of collection or kept in the fridge at 4^{o}C for analysing the next day. The method followed that closely used by Marutani *et al.* (1993). Using dissecting forceps, scalpel and a needle, anthers of various species were opened to allow extraction and subsequent transfer of pollen dust (on to) a microscopic glass slide in a drop of aceto-carmine stain. Mature anthers were crushed and pollen grains mixed thoroughly with the aceto-carmine stain. Cover slips were gently placed (on to) different slides for each species. The slides were then observed under a light microscope. For each plant species flowers were collected from at least three different plants. For each plant, three slides were prepared. For each slide ten randomly selected fields were observed under the 10X objective (100 X magnification).

To determine pollen fertility, darkly stained pollen grains were recorded as fertile and viable, and unstained or very lightly stained ones were considered as sterile or non-viable. Pollen fertility range was recorded by taking lowest and highest values of pollen viability percentage. Pollen fertility was calculated by dividing the number of viable pollen grains by the total number of grains counted in the field of view and averaging them for all plants in that species. Pollen viability was expressed as percentage pollen fertility in each plant species. Standard error was calculated from original data to compare for significant differences among different plant species.

3. Results

Pollen fertility results obtained using the aceto-carmine method are presented in Table 1. Average pollen viability ranged from a low 38% ± 2.5 for *Canavalia cathartica* to 100% for *Dendrolobium umbellatum, Vigna marina* and *Hibiscus tiliaceus*. Out of the 32 species analysed for their pollen viability, only four species (12.5%), namely *C. cthartica, C. rosea, C. asiatica* and *P. pacifica* showed a pollen viability percentage lower than 50%. Sixteen species (50%) showed pollen viability of 50 – 80%. The remaining twelve species (37.5%) showed a pollen viability percentage of 80 – 100%.

Species within a single genus showed different pollen viability. For example, in the *Psychotria* genus, *P. fragrans* has an average pollen viability of 85%, ± 4.9 with a range of 81- 87% which is more than two times the pollen viability (41%) of *P. pacifica.*

Out of three species of genus *Canavalia, C. cathartica* (38%± 2.5) and *C. rosea* (40%±3.1) showed almost similar pollen fertility status. However, a larger difference was observed between these two and a third species of *Canavalia, C. sericea*, which had a much higher pollen fertility count of 75%± 4.2. Contrarily, the two species of *Ipomea, I. pes-caprae* and *I. littoralis* have the same pollen fertility percentage of 77 percent with almost similar standard error.

4. Discussion

In Table 1, the range and pollen fertility (viability) status of most species tested was high, especially species close to sea. Having evolved in such a harsh environment, all these plant species have structural and behavioural adaptations that provide protection of essential reproductive structures in the flower. For example, in *Scaevola taccada*, viable pollen grains can only be found in very young flower buds. After this stage, the pollen grains decrease in viability until the opening of the flower when only dead pollen can be found (personal observation).

Several factors contributed to the low number of species included in this pollen fertility count. Theoretically it was possible to analyse all coastal plant species. However, due to several factors it was not possible during the span of this study. Firstly, even though some tree species were in flower, they were usually too tall for easy flower collection. These included species such *as M. gillespieana, D. pruritivus* and *S. fanaiho*. Secondly, most tree species especially the rarer ones (and probably the most important one) such as *D. elliptica, D. gillespiei*, *S. inophylloides and S. leucanthum* were already in the fruiting season during the time of this survey. Thirdly, the flowers of coastal species were typically small having microscopic anthers. This made the extraction, crushing and counting of viable pollen grains a slow and tedious process. However, most of the species in this category were analysed for their pollen viability.

In view of the impoverished coastal littoral flora of Rotuma and the urgent need to reforest and replenish it, knowledge of the pollen fertility status of Rotuman coastal plant species would be very useful. Pollen fertility is a significant determinant of whether in a population there will be enough regeneration through sexual reproduction to ensure the survival of that species. Pollen fertility is also evidently reduced in small fragmented populations (Jennersten and Nilssen 1993). Byers (1995), Kerry (1995) and Kerry et al. (2000) investigated the effect of population size on reproduction of some angiosperms and found that reproduction was strongly reduced in small populations where plants produced fewer seeds per fruit per plant. They concluded that insufficient quantity and quality of pollen is the likely explanation for the reduced fecundity in small populations. Fischer and Mathies (1998) observed that fecundity was four-times higher in large populations of the rare *Gentianella germanica* than in small populations and that fitness is reduced in plants from small populations. Menges (1991) and Agren (1996) also observed low pollen fertility and reduced seed germination rates in small fragmented populations.

Table 1 Pollen fertility (viability) percentage in 32 coastal plant species of Rotuma Island.

Scientifc Name	Rotuman Name	Pollen Fertility Percentage	
		Range	Mean ± S.E.
Acalypha grandis	Karposi	87 – 99	95 ± 4.3
Barringtonia asiatica	hufu	76 - 90	86 ± 4.6
Calophyllum inophyllum	hefau	61 - 72	67 ± 3.7
Canavalia cathartica	fuholi	33 - 42	38 ± 2.5
Canavalia rosea	‘ai raorao	35 - 43	40 ± 3.1
Canavalia sericea	‘ai raorao	69 - 78	75 ± 4.2
Cassytha filiformis	lu ‘on ravak	76 - 85	82 ± 4.4
Cerbera manghas	giagia	68 - 77	73 ± 3.9
Colubrina asiatica	tartarmoana	38 - 49	45 ± 3.2
Cordia subcordata	man’ao	67 – 75	71 ± 3.8
Crinum asiatica	maliha	53 - 61	57 ± 3.2
Cuscuta campestris	lu ‘on ravak	48 – 56	52 ± 3.5
Dendrolobium umbellatum	jojo	100 –100	100 ± 0.0
Guettarda speciosa	hana	72 – 83	78 ± 4.7
Hernandia nymphaeifolia	popofo	71 – 79	76 ± 4.9
Hibiscus tiliaceus	hau	100 –100	100 ± 0.0
Ipomea littoralis	johea	72 – 81	77 ± 5.1
Ipomea pes-caprae	puka	74 – 79	77 ± 4.8
Morinda citrifolia	‘ura	58 – 65	63 ± 3.7
Mucuna gigantea	faga	68 – 73	70 ± 3.9
Pemphis acidula	‘ai ne peje	66 – 72	69 ± 4.2
Premna serratifolia	varvara	75 – 84	81 ± 4.6
Psychotria fragrans	soag koroi	81 – 87	85 ± 4.9
Psychotria pacifica	soag koroi kele	38 – 45	41 ± 2.9
Scaevola taccada	pulu	87 – 96	92 ± 5.6
Sophora tomentosa	not known	77 – 86	82 ± 4.7
Tacca leontopetaloides	mara	76 – 84	80 ± 4.3
Thespesia populnea	penau	62 – 70	66 ± 3.8
Tournefortia argentea	sumi	89 – 96	92 ± 5.1
Tylophora samoensis	fag fea	61 – 68	64 ± 4.1
Vigna marina	karere	100 – 100	100 ± 0.0
Wollastonis biflora	totoro	67 - 74	71 ± 4.5

As seed formation or regeneration information is not available, the main emphasis of this study is the concern that plants with low pollen fertility may become scarcer and could become endangered. Pollen fertility status of the coastal plant species of Rotuma is required further investigation to include all the littoral species. This will help identify all the littoral species with low pollen fertility, which would need replenishing.

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