The effects of habitat domination by invasive Melastomataceae

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Abstract: The structure of habitats dominated by *Clidemia hirta* and *Memecylon caeruleum* in Seychelles are described and their development between 1990 and 1994 reported. *Clidemia hirta* dominated areas have changed dramatically from low closed canopy to a higher, more open structure, correspondingly there has been an increase in plant diversity in the area. The *Memecylon caeruleum* dominated area remains stable, but an area cleared of this plant is changing slowly, with a notable decrease in *M. caeruleum* seedling abundance. This indicates that *M. caeruleum* dominates habitats through slow growth in deep shade, exposure reduces its growth rate. Animal life in *M. caeruleum* litter is very sparse and of low diversity, *C. hirta* litter supports a similar fauna to that of equivalent natural habitats. An association between coccoid bugs and ants is reported, with evidence of selective fruit abortion.

Introduction

The presence of habitats dominated by introduced Melastomataceae species in Seychelles was first reported in 1990 (Oxford University Silhouette Expedition 1990) when *Clidemia hirta* (L.) D.Don was found in almost pure stands on Silhouette. An area dominated by *Memecylon caeruleum* Jack (= *M. floribundum* Bl.) was located on Mahé in 1992 (Gerlach 1993). In 1992 both areas had obviously low plant diversity and appeared to have depauperate faunas (Gerlach 1993). Since then both sites have been monitored on a semi-annual basis, changes in structure have been detected during this period and are described below. In both habitats quantitative measures of plant and animal diversity and abundance have been carried out for comparison with natural habitats.

Memecylon caeruleum dominates an area of $3km^2$ at Beau Vallon, Mahé. Its presence on Mahé has been reported since 1931 (Robertson 1989) and it occurs at low density throughout the northern third of the island (Fig. 1.) (Gerlach 1993). In July 1994 its presence on Praslin was detected for the first time where it occured as isolated mature plants under the shade of *Cinnamomum verum* J.Presl. trees (Fig. 1.), many of these were flowering but few fruiting. The area at Beau Vallon is a low mountain ridge extending from sea level to 386m, *M. caeruleum* dominates this ridge up to approximately 100m where it forms a complete, dense canopy. A small number of isolated trees of *Cocos nucifera* L. and *Casuarina equisetifolia* L. emerge from this canopy. No seedlings other than *M. caeruleum* occur in this area, these are present at a density of $105m^{-2}$.

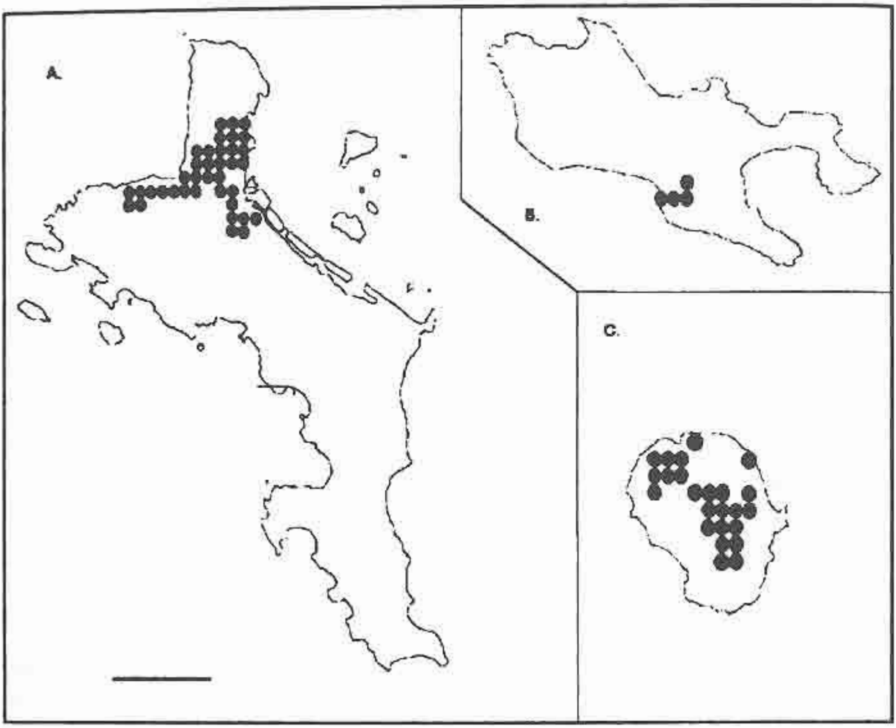

Fig. 1. The distribution of introduced Melastomataceae. Scale bar = 5km.
A. Mahé (*Memecylon caeruleum*). B. Praslin (*M. caeruleum*).
C. Silhouette (*Clidemia hirta*)

Measurements of numbers of seedlings and mature plants, canopy cover and canopy height were made in 1992 and repeated in 1994. In addition ten 5×5m areas were cleared in June 1993. In these patches all plants were felled to ground level, the soil and seedlings were left largely undisturbed. The number of mature plants and seedlings of all plant species were recorded one month after clearance and these counts repeated in December 1993 and June 1994. The number of seeds present in $1m^2$ was recorded. Repeat observations were made in January 1996.

Animals in the area were recorded by casual observation and quantitative counts on 100 plants in each observation period. $1m^2$ of leaf litter was collected in July 1994 and the animals present in it extracted by means of a Tullgren funnel, providing an estimate of animal abundance for comparison with data from other habitats (Gerlach 1995).

In Seychelles *Clidemia hirta* is primarily restricted to Silhouette, a single seedling was found at Le Niol, Mahé in 1993 and removed, none have been reported subsequently. On Silhouette it dominates two areas: Mon Plaisir ($2000m^2$) and the central part of Mare aux Cochons ($50m^2$). Scattered plants are present throughout the northern half of the island, where in 1990 it was restricted to areas above 400m. In 1991 small isolated plants were found down to 200m above sea level. These had matured by 1993 but remained small, a single mature plant was found in that year at sea level. No change in distribution was detected in 1994. The current distribution is shown in Fig. 1.

The Mon Plaisir site has been the main focus of monitoring studies due to its accesibility. This population is at an altitude of 570-590m. At this site records have been made of numbers of mature *C. hirta* plants, seedlings and other plants, canopy cover and height in 10 $1m^2$ quadrats in August 1990, July 1991, July 1993 and December 1993. The number of fruits set per plant and the number of seeds per fruit were counted and compared to similar records from plants at different altitudes. Leaf litter was collected from $10m^2$ and animals extracted using a Winkler apparatus in December 1993. The residue from this was subsequently kept damp in warm conditions to germinate any seeds present within it.

Memecylon caeruleum

Structure

The mean values of numbers of stems and seedlings, and canopy cover and height are shown in Table 1. Comparisons of these with a Model III (repeat-measures) analysis of variance (Anovar) does not detect any statistically significant difference. In the cleared areas there was no regrowth of the cut stems, data from these sites are shown in Table 2., using mean values. T-tests of the means of the data for each of the two years sampled show that there has been a significant increase in the abundance of *Asystasia* sp. No significant differences are detectable in *Ipomoea venosa* (Desr.) Roem. & Schultes or *Passiflora suberosa* L. as these occur in very low numbers. *Litsea glutinosa* (Lour.) C.B. Robinson numbers have increased but are still not significantly different. Most importantly the abundance of *M. caeruleum* has not increased, there is a non-significant decrease in numbers of mature plants and a significant decline in seedling numbers. This indicates that colonisation of exposed areas by *M. caeruleum* is a slow process and that seedling germination or survival is enhanced by shading. In 1994 there were 650 *M. caeruleum* seeds per square metre on the ground and only 3.4 seedlings per square metre, indicating that a major component of the seedling decline is due to very low rates of germination in exposed areas (possibly as a result of overheating or insufficient soil moisture). By January 1996 the cut area had reached the 3m height of the surrounding vegetation.

Table 1. Means of *M. caeruleum* factors recorded at Beau Vallon

Date	stems	seedlings	canopy %	height (m)
1992	0.6	0.5	100	3.5
1993	0.8	0.4	99	3.4
1994	0.4	0.6	100	3.8

Table 2. Mean numbers for the cleared *M. caeruleum* area, significant differences are marked with asterisks (* P<0.05, ** P<0.01)

Date	*Asystasia* sp.	*Ipomoea venosa*	*Passiflora suberosa*	*Listea glutinosa*	*Memecylon* seedlings	*Memecylon* plants
1993	0.30	0.10	1.00	0.30	13.60	0.80
1994	2.30	0.00	0.00	1.30	3.40	0.40
t	3.86**	1.00	1.00	1.67	3.13 *	1.34

Fauna

The only animals observed on the *M. caeruleum* plants were ants (*Technomyrmex albipes* Smith), coccoid bugs (*Icerya seychellarum* (Westwood, 1855)) and their introduced coccinelid beetle predator *Chilocorus nigritus* (Fabricius). There were significant correlations between the presence of ants, coccoids, the presence of ant nests in the apical cap of the fruit and fruit colour (see Table 3.). The presence of ant nests in fruit caps and *I. seychellarum* presence are correlated with ant presence, which is correlated with fruit colour. Ants are present on 63% of purple (mature) fruit and 80% of pink (immature) fruit, indicating that immature fruits are predominantly inhabited by ants and either that purple fruit are less suitable or that vulnerable fruit do not develop to maturity.

When ants are present 97% of pink fruits and 88% of purple fruit have *I. seychellarum* infestations. All ant nests are built in purple fruit, all assoicated with *I. seychellarum* (this is not significant due to the low total number - 5), suggesting that the association of *I. seychellarum* with ants is a significant fruit mortality factor, resulting in the abortion of immature *I. seychellarum*-ridden fruit. This would result in a lower frequency of infestation of ripe fruit. The association of nest development and fruit maturity is probably due to the time required for nest development exceeeding the immaturity period of fruit.

Only four individulas of the predatory beetle *Chilocorus nigritus* were observed. This species was deliberately introduced to prey on coccoids, however, as *I. seychellarum* is rarely eaten and predator abundance is known to decline with ant presence (Hill & Blackmore 1980) it is not a significant component of ant-coccid associations.

Table 3. Pearson's rank correlation coefficients for animals on *M. caeruleum* fruits (* P<0.05, ** P<0.01)

n=57	Ants	Nests	*Icerya*	Colour
Ants	-			
Nests	0.253*	-		
Icerya	0.287*	0.198	-	
Colour	0.372**	0.019	0.123	-

Litter fauna - No data from natural lowland forests are avialable for comparison with *M. caeruleum* litter. The samples collected reveal a low diversity fauna containing five species of mite ($75.0m^{-2}$), one cosmopolitan isopod (*Aphiloscia annulicornis* (Budde-Lund, 1885)) ($75.0m^{-2}$), two dipteran species ($5.0m^{-2}$), one unidentified scolytid beelte ($5.0m^{-2}$) and ants (*Technomyrmex albipes* and *Anoplolepis longipes* (Jerdon, 1851)) ($20.0m^{-2}$). Observations of natural lowland habitats suggest that this fauna is unusually species poor, particularly in its absence of molluscs.

Clidemia hirta

Structure

The mean values of the density of plants, stems and canopy height are shown in Table 4. Model III (repeat-measures) analysis of variance of these data show that there are significant decreases in the canopy cover ($F_{0.05(2)3,27}$=6.39, P<0.005), increases in canopy height ($F_{0.05(2)3,27}$=15.03, P<0.001) and a decline in the number of stems 1m above ground ($F_{0.05(2)3,27}$=11.17, P<0.001). There is a marked, but statistically insignificant, decline in *C. hirta* seedling numbers after 1993. Temporal changes in canopy cover, height and stem number can be described by statistically significant regressions. However, these have very low R^2 values (<0.23) due to the high variance of the data and are thus of little predictive value. These comparisons show that between 1990 and 1994 the *C. hirta* plants increased their height by 76%, resulting in an opening out of the vegetation structure and canopy thinning. Accompanying this the number of seedlings of other plants increased (especially ferns and *Roscheria melanochaetes* (Wendl.) Wendl. ex Balf.), however the numbers recorded are too low for statistical significance to be tested.

Fruiting and seed germination

Ripe fruit and open flowers have been observed in all seasons. The numbers of flowers, green (unripe) fruit, blue (ripe) fruits and seeds at different sites in July 1993 are shown in Table 5. There are significant differences between each site in the number of flowers (Anovar $F_{0.05(2)2,18}$>6.20 P<0.02), green fruit ($F_{0.05(2)2,18}$>4.82, P<0.05) and blue fruit ($F_{0.05(2)2,18}$>5.89, P<0.05) demonstrating that there is a relationship between reproductive output and altitude. The number of seeds per fruit is does not demonstrate any clear pattern but is greatly reduced at

Table 4. Means of *C. hirta* data from Mon Plaisir

Date	Canopy (%)	Height (m)	Seedlings	Stems
7.90	89.9	2.1	1.7	3.9
7.91	76.4	2.4	2.2	3.9
7.93	68.0	3.0	2.0	1.6
1.94	56.0	3.7	0.6	1.1

Table 5. Numbers of flowers, fruit and seeds per *C. hirta* plant

Site	Altitude (m)	Flowers	Green fruit	Blue fruit	Seeds per fruit
Mon Plaisir (n=10)	500	3.6	37.6	20.2	527 (n=10)
Jardin Marron (n=10)	300	5.1	18.2	5.7	458 (n=10)
Baie Cipailles (n=1)	0	4	3	1	35 (n=1)

sea level. This altitude effect may result from the higher humidity of upland sites and the strong effects of coastal salt-laden winds.

Seedlings were germinated from $10m^2$ of leaf litter collected in July 1993 (litter kept damp at 18°C for one year), these numbered 881 *C. hirta*, 8 *Dillenia ferruginea* (Baillon) Gilg, one *Northea hornei* (Hartog) Pierre and 1 *Mapania seychellarum* Simpson. This predominance of *C. hirta* is not surprising given the abundance of fruit but is in marked constrast to the numbers of seedlings in the study site ($2.0m^{-2}$). The low numbers of seedling recorded in the field is in accordance with data on other Melastomataceae demonstrating that germination is more successful beneath gaps in the canopy (21% emergence) than in the understory (4% emergence) and that seedling survival is low (0.1-0.4% surviving to one year) (Ellison *et al*. 1993). The Mon Plaisir data give seedling emergeance as 2.0% which is comparable to the understory value given by Ellison *et al.* (1993). The survial rate at Mon Plaisir also appears to be very low as indicated by the large number of seedlings germinated under artifical conditions being eaten by litter inhabiting beetles prior to development of the characteristic epidermal hairs.

Seedlings were also observed growing in rat (*Rattus rattus* (Linnaeus, 1753)) faeces suggesting that rats may act as significant dispersal agents.

Animal life

Leaf litter inhabiting animals were sampled from $10m^2$ at Mon Plaisir using a Winkler apparatus. Data from a comparative site on Mahé (Congo Rouge) were used in comparison in Table 6. The numbers of each animal taxon were compared using a t-test for samples with unequal variance, only significant results are shown. These data show that the faunas are similar. There are some significant differences, specifically more Isopoda, Araneae and Hemiptera at Mon Plaisir and more Diptera at Congo Rouge. Such differences are difficult to explain at present but it appears that most of the fauna is not significantly affected by *C. hirta* dominance.

Table 6. Faunal comparison of Mon Plaisir and Congo Rouge

taxon	Mon Plaisir	Congo Rouge	T-test value	P
Mollusca	0.40	6.75		
Annelida	0.80	1.50		
Amphipoda	0	0.25		
Isopoda	10.60	1.25	3.07	0.01
Araneae	2.70	0	3.95	0.003
Pseudoscorpiones	0.40	0.25		
Opilones	0.10	1.75		
Schizomida	0	0.25		
Myriapoda	1.80	3.25		
Thysanura	0.30	0.25		
Psocidae	0	0.25		
Dyctioptera	0.60	0.25		
Mallophaga	0	0.25		
Hemiptera	13.20	0.25	3.88	0.004
Orthoptera	0.10	0.25		
Lepidoptera	0.20	0		
Diptera	1.10	3.75	-2.53	0.026
Coleoptera	7.60	8.50		
Hymenoptera	10.20	25.75		
Reptilia	0.10	0		
Amphibia	0.20	0.25		

Discussion

Introduced Melastomataceae species have been reported as causing major conservation problems in many parts of the world, including the western Indian Ocean (Cadet 1989; Gueho 1988). In Seychelles they have only recently been identified as a threat to natural habitats. Study of their fauna and flora demonstrate that both *Memecylon caeruleum* and *Clidemia hirta* dominated areas have low plant diversity but that *C. hirta* areas support a largely natural fauna. The animals inhabiting the *M. caeruleum* area are mainly cosmopolitan taxa, the most abundant being part of the *Technomyrmex albipes* - *Icerya seychellarum* association parasitising the plants. An association between *I. seychellarum* and ants has been described previously (Hill & Blackmore 1980). All *I. seychellarum* populations observed were tended by ants, thus preventing the build up of honeydew and the infection of the plant by capnodiacean sooty mould (Hill & Blackmore 1980). The ability of *M. caeruleum* to withstand this parasitism is shown by the selective abortion of heavily parasitised fruits.

Monitoring of the areas concerned suggests that *M. caeruleum* dominance is stable and that it is achieved through rapid growth of seedlings in dense shade. Exposed areas are unsuitable for *M. caeruleum* seedling growth. Although it has spread slowly to date and is not reported from other localities *M. caeruleum* is becoming an increasingly important component of the vegetation of Mahé. Its recent colonisation of Praslin is a cause for concern (althoug a brief search in January 1996 failed to locate the plants noted in 1994).

In contrast the well known threat posed by *C. hirta* appears to be a temporary phenomenon, on Silhouette at least. Growth is rapid both in shade and sunlight. Low humidity and/or high levels of salt-spray appear to depress growth and reduce fruiting levels. It does reach a dominant state in open areas but with time develops an open structure. This allows high levels of light penetration and consequent high rates of seedling survival. There is no evidence of any competitive advantage of *C. hirta* seedlings in natural habitats so, despite the abundance of *C. hirta* seeds in the leaf litter, a high canopy allows a natural process of succession to occur. On Silhouette this process is resulting in reduction in *C. hirta* dominance and a return towards a natural high-altitude flora.

The changes reported here will continue to be studied. The results of the monitoring that has been undertaken to date identify *M. caeruleum* as a significant threat in the degraded habitats of Mahé and Praslin but indicate that *C. hirta* is a temporary problem in natural areas. The best means of managing *C. hirta* may be to adopt a non-interventionist approach where the surrounding habitats are in good health and are robust. Direct control may be required where habitat degradation has reached such a degree that natural processes are inoperative. This must be approached very carefully as *C. hirta* appears to be a pioneer species that would actually benefit from most of the available management options.

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