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FLOWERING AND FRUITING IN THE FLORA OF HERON ISLAND, GREAT BARRIER REEF, AUSTRALIA

BY

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ABSTRACT

The plant species in flower and fruit on Heron Island, a sandy cay on the Great Barrier Reef, Australia, were observed at intervals of three months for three and a half years. At no time were less than 20 nor more than 36 of the 49 species monitored found to be in flower, nor were less than 20 nor more than 41 of the 50 species monitored found to bear fruit. Despite a strongly seasonal climate there was not a strong seasonal pattern evident in the number of species in flower or fruit, although some species were themselves strongly seasonal. A principal components analysis of all flowering records, however, demonstrated a seasonal polarity with March and September representing the two extremes. Fleshy fruited species, important for frugiverous birds such as silvereyes, bore fruit throughout the year.

INTRODUCTION

Temporal patterns in flowering and fruiting are significant attributes of vegetation, for these are attributes subject to selection as are any others. Variation in seasonal flowering patterns has proved to be significant in understanding of heathlands in Australia (Specht *et al.* 1981) and Europe (Woolhouse & Kwolek 1981), both in terms of ecophysiology, and in terms of the evolutionary derivation of the floras. The availability of flowers and fruit is manifestly important to those animals which depend on fruit, seed and nectar as food resources, and an interaction between plant phenology and the birds responsible for seed dispersal has been postulated (Herrera 1986).

There has been little previous study of the temporal variations in flowering and fruiting of the plants on the cays of the Great Barrier Reef, although Heatwole (1981) noted flowering times for a few species on One Tree Island. There has apparently been little if any study of seasonality on similar islands elsewhere. Opportunity to visit Heron Island on a regular basis was therefore used to collect information on the flowering and fruiting patterns of the flora of that island.

Heron Island is a small coral cay about 800 m x 300 m situated 70 km offshore from the Australian continent (Lat. 23°26' Long. 151°55'E). Much of the island is clad in a dense forest of *Pisonia grandis* trees, with some fringing grasslands (Fosberg 1961). The island has been the subject of extensive weed invasions during its recent history of intense human activity, and this has been documented in particular for a spoil dump established on the island in 1987 (Rogers 1993) and in more general terms by Chaloupka & Domm (1986).

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Heron Island has a strongly seasonal climate, with mean rainfall varying from as little as 20 mm in September to as much as 145 mm in February. The four months July to November receive in total less than 15% of the annual rainfall (Fig. 1). A consequence of this strong seasonality is that *Pisonia grandis* and *Ficus opposita* often lose many of their leaves by December, and the native grass cover of the island dies.

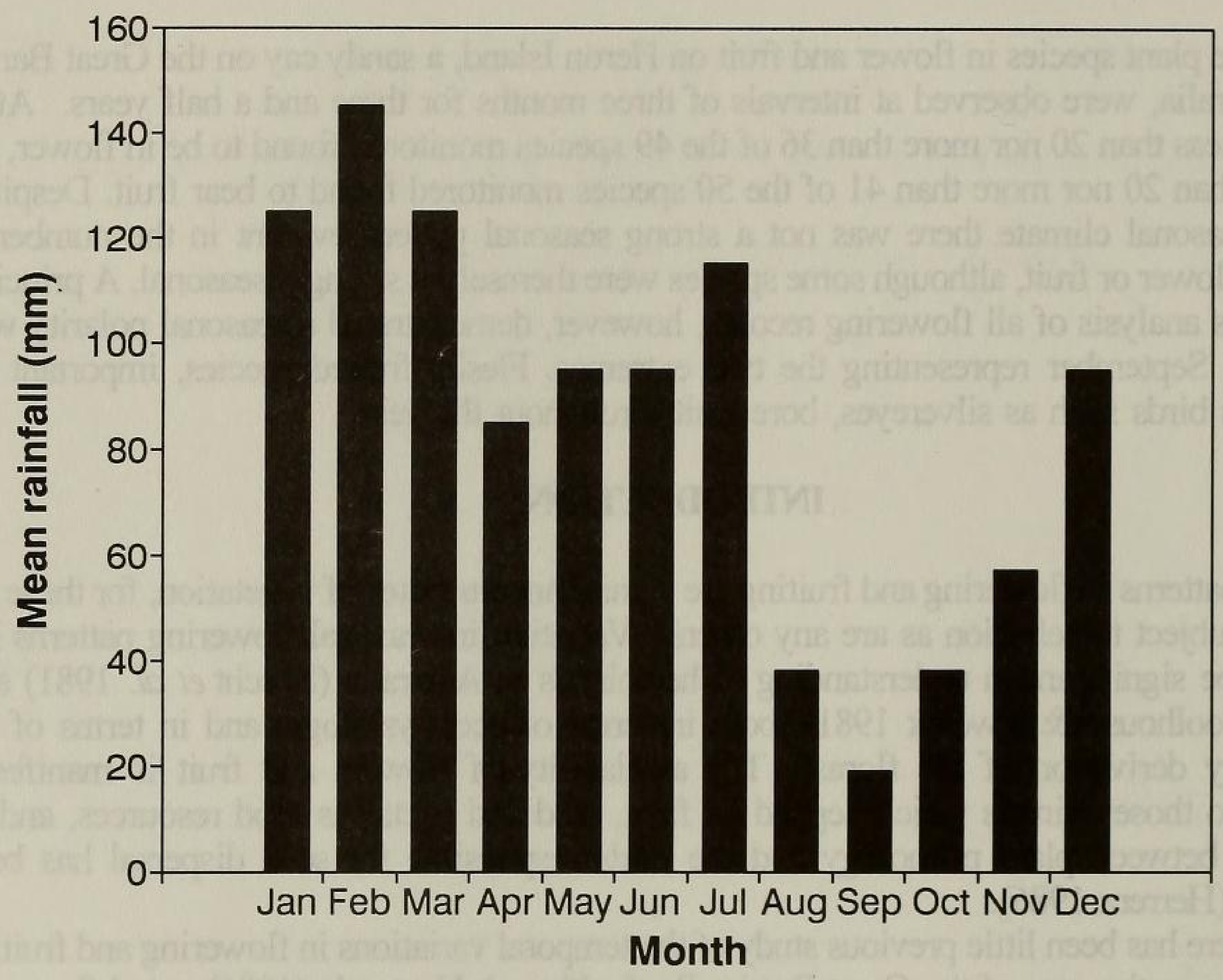

Figure 1 Distribution of mean monthly rainfall through the year for Heron Island (from Walker 1991a).

Methods

Heron Island was visited at intervals of about three months between September 1990 and December 1993, and the flora surveyed to determine which species were represented by individuals in flower or fruit at the time. These data were recorded and analysed in terms of total species in flower and fruit, native plants in flower and fruit, weedy plants in flower and fruit, native dicots in flower and native and weedy grasses in flower, and numbers of species bearing fleshy fruit.

Information was collected in September, December, March and July, for convenience referred to as spring, summer, autumn and winter. Records were made by walking a series of transects on the island which traversed all the vegetation types and the habitats of all the plant species known for the island.

To detect pattern in a multivariate system such as that studied here where it is proposed to detect seasonality of flowering in a system comprising 49 species requires a multivariate analysis. One such analysis which is suitable for the purpose is Principal Components Analysis, and in order to reveal underlying patterns in the data a principal components analysis was executed on the flowering data (Wilkinson 1990).

Table 1 Seasonality of flowering of plants on Heron Island, Great Barrier Reef, Australia, between September 1990 and December 1993. **N** = total number of plants in the category.

		Number of species in flower													
year		**90**	**90**	**91**	**91**	**91**	**91**	**92**	**92**	**92**	**92**	**93**	**93**	**93**	**93**
Month	**N**	**S**	**D**	**M**	**J**	**S**	**D**	**M**	**J**	**S**	**D**	**M**	**J**	**S**	**D**
All species															
natives	**26**	10	14	16	18	11	17	8	11	15	16	12	14	17	19
weeds	**23**	16	10	16	17	19	17	12	19	21	16	14	19	23	22
Total	**49**	28	24	32	35	30	34	20	30	36	32	26	33	40	41
Dicots															
Native	**22**	10	13	14	16	12	16	7	9	13	14	11	12	15	16
Weeds	**15**	12	7	9	11	12	11	7	13	14	10	10	12	15	15
Total	**37**	22	20	23	27	24	27	14	22	27	24	20	24	30	31
Grasses															
Native	**3**	1	1	2	2	0	1	1	2	2	2	1	2	2	3
Weeds	**8**	5	3	7	6	6	6	5	6	7	6	4	7	8	7
Total	**11**	6	4	9	8	6	7	6	8	9	8	5	9	10	10

Table 2 Seasonality of fruiting of plants on Heron Island, Great Barrier Reef, Australia, between September 1990 and December 1993. **N** = total number of plants in the category.

		Number of species in fruit													
year		**90**	**90**	**91**	**91**	**91**	**91**	**92**	**92**	**92**	**92**	**93**	**93**	**93**	**93**
Month	**N**	**S**	**D**	**M**	**J**	**S**	**D**	**M**	**J**	**S**	**D**	**M**	**J**	**S**	**D**
All species															
natives	**27**	13	17	19	20	17	19	12	14	17	19	17	18	19	21
weeds	**23**	16	9	17	16	19	21	8	16	20	17	12	19	21	20
total	**50**	29	26	36	36	36	40	20	30	37	36	29	37	40	41
Fleshy fruits	**7**	4	4	4	5	6	4	4	4	4	4	5	4	5	5

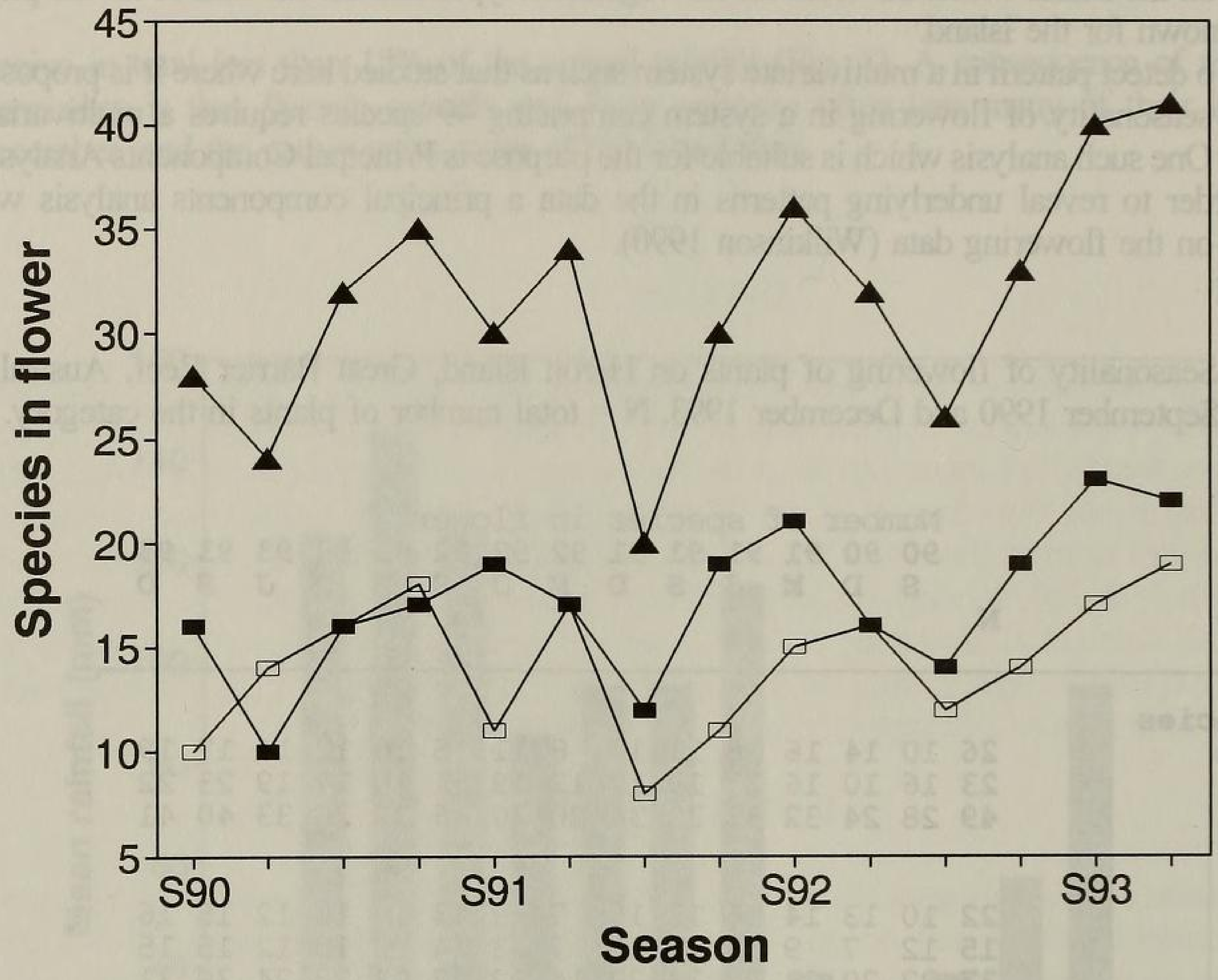

Figure 2. The total number of plant species in flower (▲), number of native species in flower (□), and number of introduced species in flower(■) Heron Island, Great Barrier Reef, Australia, at three month intervals from September 1990 until December 1993.

RESULTS

Flowering was recorded for 46 of the 49 species examined for flowers (appendix 1): *Ipomoea pes-caprae* and *Salsola kali* were not seen in flower, and flowering of *Ficus opposita* was not determined because of the syconium within which flowers are produced.
No distinct patterns of number of species in flower around the year was apparent (Fig. 2, Table 1), whether the flora was taken as a whole or divided into components. The patterns of variation shown by all groups of species are essentially the same. A depression in the number of species in flower is apparent in July (southern winter) of 1992 and 1993, but July 1991 shows a high number of species flowering.

Patterns can be detected in individual species (appendix 1). *Apium leptophyllum*, *Bromus catharticus* and *Wollastonia biflora* flower only in spring-summer, whereas *Cordia subcordata* may be found flowering in any season except summer. *Pisonia grandis* flowers in summer-autumn. The small herb *Gnaphalium luteoalbum* appears to flower in any season but autumn. Of the remaining species 17 were recorded flowering in 12-14 of the times surveyed, and 4 in three or less occasions.

The principal components analysis showed that over 50% of the variance in the flowering matrix was explained by the first two components (36.3% and 15.4% respectively), and that the replicate seasonal collections for March and September represented poles of an ordination, with the summer and winter collections (December and June) falling into an intermediate position (fig.2)

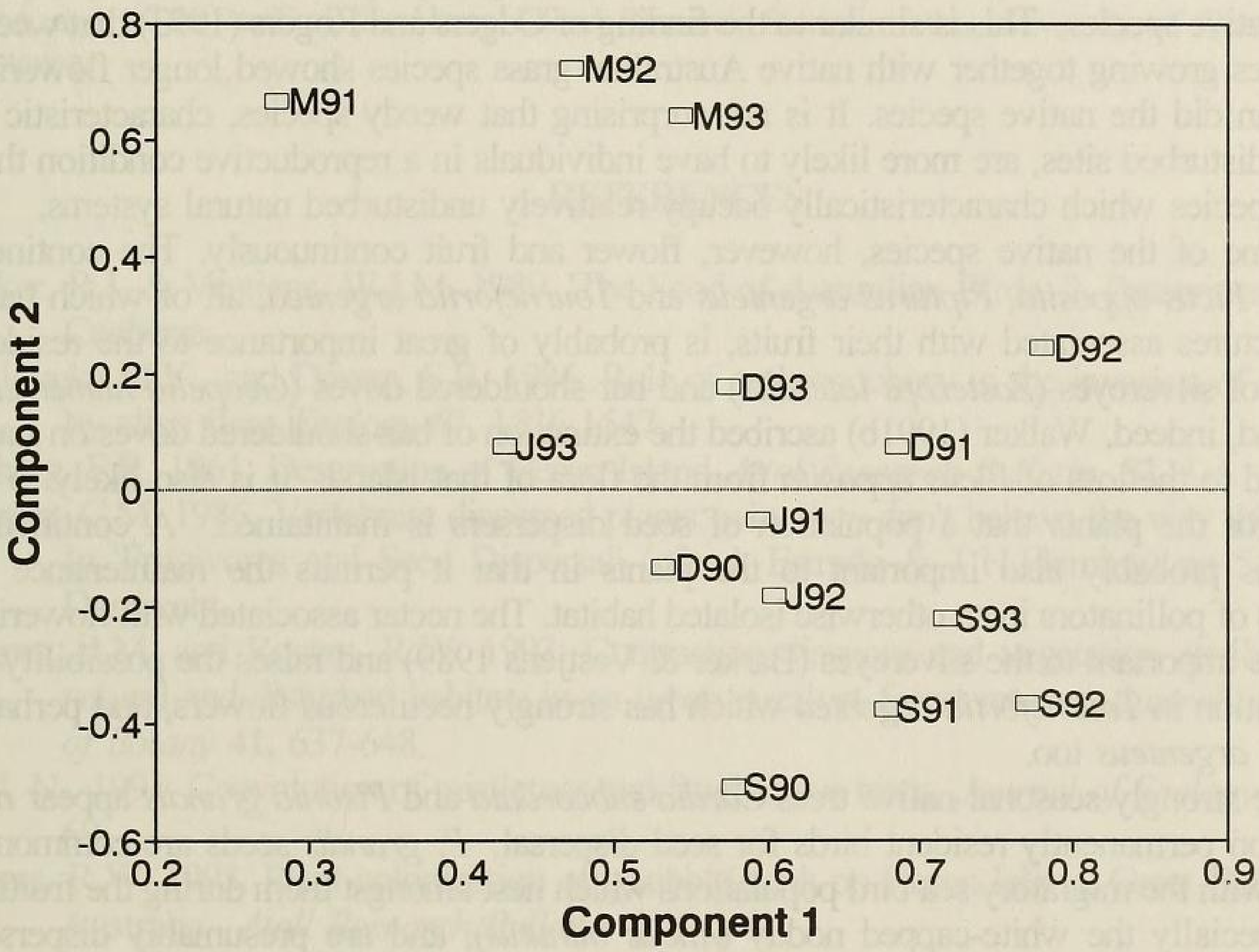

Figure 3. Plot of the first two components from a Principal Components Analysis of three-monthly flowering records from Heron Island. Each record is identified by month (M = March, J = July, S = September, D = December) and year.

Fruiting was observed in 47 of the 49 species (appendix 2), *Ipomoea pes-caprae* and *Salsola kali* not being observed in fruit during the study period: expanded syconia of *Ficus opposita* were treated as fruits. No distinct seasonal patterns were evident in numbers of species fruiting around the year, and the total number of species in fruit closely paralleled the number flowering (fig.3). At least four fleshy fruited species were in fruit at any time, and three of these, *Tournefortia argentea*, *Ficus opposita* and *Pipturus argenteus* bore fruit every time they were observed.

DISCUSSION

Observations made four times per year do not permit a study of seasonality of flowering in any great detail. However, it is sufficiently frequent to detect the more striking patterns which may be present. It is apparent that the very strong seasonality evident in the rainfall pattern for the Island is not reflected in the number of species in flower or fruit. The polarity demonstrated by the principal components analysis between March and September, however, is quite clear. Thus, although the seasonal differences are diffuse, involving numbers of species showing quite different patterns, the overall view is of well developed seasonality in flowering pattern.

At all times studied there was a higher proportion of weed species in flower than of native species, and at all times except December 1993 a higher proportion of weed species in fruit than native species. This is similar to the finding of Odgers and Rogers (1993) that weedy grass species growing together with native Australian grass species showed longer flowering seasons than did the native species. It is not surprising that weedy species, characteristic of frequently disturbed sites, are more likely to have individuals in a reproductive condition than are those species which characteristically occupy relatively undisturbed natural systems.

Some of the native species, however, flower and fruit continuously. The continual fruiting of *Ficus opposita*, *Pipturus argenteus* and *Tournefortia argentea*, all of which have fleshy structures associated with their fruits, is probably of great importance to the resident population of silvereyes (*Zosterops lateralis*) and bar-shouldered doves (*Geopelia humeralis*) on the island, indeed, Walker (1991b) ascribed the extinction of bar-shouldered doves on Lady Elliot Island to the loss of *Ficus opposita* from the flora of that island. It is also likely to be important for the plants that a population of seed dispersers is maintained. A continuous flowering is probably also important to the plants in that it permits the maintenance of populations of pollinators in an otherwise isolated habitat. The nectar associated with flowering may also be important to the silvereyes (Barker & Vestjens 1989) and raises the possibility of bird pollination in *Tournefortia argentea* which has strongly nectiferous flowers, and perhaps in *Pipturus argenteus* too.

The strongly seasonal native trees *Cordia subcordata* and *Pisonia grandis* appear not to depend on permanently resident birds for seed dispersal. *P. grandis* seeds are commonly associated with the migratory sea bird populations which nest amongst them during the fruiting season, especially the white-capped noddy (*Anous minutus*), and are presumably dispersed adhering to birds (Walker 1991a), although the noddies may suffer heavy fatalities from high *P. grandis* fruit loads in those years in which *P. grandis* fruiting is heavy. *Cordia subcordata* produces a large and rather corky fruit which is often found in drift along beaches and is apparently dispersed by flotation.

Boerhavia tetrandra is in the same family (Nyctaginaceae) as *Pisonia grandis*, but is a prostrate herb which bears sticky fruit similar to that of *P. grandis*, but displayed only a few centimetres above ground level. Seedlings of *Boerhavia tetrandra* are commonly observed in disturbed areas of Heron Island, whereas those of *Pisonia grandis* are seen very rarely, but then in very large numbers within the forest (e.g. March 1972 when several hundred could be found in a square meter). The sticky fruit of *Boerhavia tetrandra*, however, are more likely to be dispersed by ground feeding birds such as the doves and rails, in contrast to the dispersal of *Pisonia grandis* seeds by marine bird species.

The possibility of coevolution of the frugivorous birds and the flora cannot be dismissed, especially in terms of selection for plants which have an extended fruiting season, for Herrera (1986) has observed that changes in phenology are amongst those most likely to occur in response to frugivory and contingent dispersal. It is recognised that the silvereyes of the Capricorn Group are a distinct variety, differing from their mainland relatives. However, it is not possible to argue for any close co-evolution between the birds of the cays and the flora in the way in which Reid (1991) argued for coevolution of mistletoes and mistletoe birds, although in arid zones mistletoe birds may be dependent on very few species of mistletoes for survival, just as frugivores are on a coral cay. Comparative studies of the eating habits of the mainland and cay varieties of silvereyes and of the seasonality of flowering in *Tournefortia argentea* may be profitable in this context.

Acknowledgements

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REFERENCES

Barker, R.J. & Vestjens, W.J.M. 1989. 'The Food of Australian Birds. 2. Passerines'. CSIRO, Canberra.

Chaloupka,M.Y., and Domm, S.B. 1986. Role of anthropochory in the invasion of coral cays by alien flora *Ecology* **67,** 1536-1547.

Fosberg, F.R. 1961. Description of Heron Island. *Attol Research Bulletin* **82,** 1-4.

Herrera, C.M. 1986. Vertebrate dispersed plants: why they don't behave the way they should. In 'Frugivores and Seed Dispersal' (eds A Estrada & T.H.Fleming) pp 5-18. Junk, Dordrecht.

Odgers, B.M. and Rogers, R.W. 1993. Contrasting diaspore and vegetation attributes from natural and disturbed habitats in an urban eucalypt forest reserve. *Australian Journal of Botany* **41,** 637-648.

Reid, N. 1991. Coevolution of mistletoes and frugiverous birds. *Journal of Ecology* **16,** 457-69.

Rogers, R.W. 1993. Plant colonization of a rubble bank on Heron Island, Great Barrier Reef, Australia. *Atoll Research Bulletin* 384, 1-8.

Specht, R.L., Rogers, R.W. & Hopkins, A.J.M. 1981. Seasonal growth and flowering rhythms: Australian Heathlands. In 'Ecosystems of the World 9B: Heathlands and Related Shrublands' (ed R.L. Specht) pp 5-13. Elsevier, Amsterdam.

Walker, T.A. 1991a. Pisonia Islands of the Great Barrier Reef. Part 1. The distribution, abundance and dispersal by seabirds of *Pisonia grandis*. *Atoll Research Bulletin* **350,** 31-39.

Walker, T.A. 1991b. Pisonia Islands of the Great Barrier Reef. Part 3. Changes in the vascular flora of Lady Musgrave Island. *Atoll Research Bulletin* 350, 31-39.

Woolhouse, H.W. & Kwolek, A.V.A. 1981. Seasonal growth and flowering rhythms in European heathlands. In 'Ecosystems of the World 9B: Heathlands and Related Shrublands' (ed R.L.Specht) pp 29-38. Elsevier, Amsterdam.

Wilkinson, L. 1990. SYSTAT: 'The System for Statistics'. Evanston, Systat Inc.

Appendix 1: Flowering calendar for Heron Island.

1 = plant seen in flower; 0 = no plant seen in flower.

Year	**90**	**90**	**91**	**91**	**91**	**91**	**92**	**92**	**92**	**92**	**93**	**93**	**93**	**93**
Month	**S**	**D**	**M**	**J**	**S**	**D**	**M**	**J**	**S**	**D**	**M**	**J**	**S**	**D**
Species														
Abutilon indicum	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Achyranthes aspera	0	0	0	1	0	0	0	0	1	0	0	1	1	0
Amaranthus viridis	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Apium leptophyllum	1	1	0	0	1	1	0	0	1	1	0	0	1	1
Bidens pilosa	1	0	1	1	1	1	0	1	1	1	1	1	1	1
Boerhavia tetrandra	1	1	1	1	1	1	0	1	1	1	1	1	1	1
Brachiaria subquadripara	0	0	1	1	0	0	0	1	1	1	0	1	1	1
Bromus catharticus	1	0	0	0	1	0	0	0	1	0	0	0	1	1
Cakile edentula	1	0	1	1	0	0	0	1	1	0	0	1	1	1
Calyptocarpus vialis	0	0	1	1	0	0	0	0	0	1	0	1	1	1
Capsella bursa-pastoralis	1	1	0	1	1	0	0	1	1	0	0	1	1	0
Cassytha filiformis	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Casuarina equisetifolia	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Celtis paniculata	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cenchrus echinatus	0	0	1	1	1	1	1	0	0	1	1	1	1	1
Commicarpus insularum	1	0	1	1	1	0	0	0	1	1	0	0	0	1
Conyza bonariensis	0	0	1	1	1	1	1	1	1	1	1	1	0	1
Cordia subcordata	0	0	1	0	0	1	1	0	0	1	1	0	0	1
Coronopus didymus	1	0	1	1	1	1	0	1	1	0	1	1	1	1
Cynodon dactylon	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Digitaria ciliaris	0	0	1	0	0	1	1	1	1	1	1	1	1	1
Eleusine indica	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Euphorbia atoto	1	1	1	0	0	0	0	0	0	0	0	1	1	1
Euphorbia cyathophora	0	0	1	1	1	1	1	1	1	1	1	1	1	1
Euphorbia prostrata	0	0	1	0	0	1	1	0	0	1	1	1	1	1
Euphorbia tannensis	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ficus opposita	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gnaphalium luteo-album	1	0	0	1	1	1	0	1	1	1	0	1	1	1
Ipomoea pes-caprae	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Lepidium virginicum	1	1	0	0	1	1	0	1	1	1	0	1	1	1
Malvastrum coromandelianum	0	1	1	0	0	1	0	1	1	1	1	1	1	1
Pandanus tectorius	0	0	1	0	0	0	0	0	0	0	1	0	0	0
Pipturus argenteus	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pisonia grandis	0	1	0	1	1	1	0	0	0	0	0	0	1	1
Poa annua	1	0	1	1	1	1	0	1	1	0	0	1	1	0
Portulaca oleracea	0	0	0	1	1	1	1	1	1	1	1	0	1	1
Salsola kali	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Scaevola taccada	1	1	1	1	1	1	1	1	1	1	1	0	1	1
Sisymbrium orientale	1	0	1	0	1	1	0	1	1	0	0	1	1	1
Solanum americanum	1	1	0	1	1	1	0	1	1	1	1	1	1	1
Sonchus oleraceus	1	0	1	1	1	1	0	0	1	1	1	1	1	1
Sporobolus virginicus	0	0	1	0	0	0	1	0	0	0	0	0	0	1
Stenotaphrum micranthum	1	1	0	1	1	1	0	1	1	1	0	1	1	1
Suriana maritima	1	1	0	1	1	1	0	1	1	1	0	1	1	1
Thuarea involuta	0	1	1	1	0	0	1	1	1	1	1	1	1	1
Tournefortia argentea	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Tribulus cistoides	1	1	1	1	0	1	1	1	1	1	1	1	1	1
Wollastonia biflora	0	1	0	1	1	1	0	0	1	1	0	0	1	1

Appendix 2: Fruiting calendar for Heron Island.

1 = plant seen bearing fruit; 0 = no plant seen bearing fruit.

Year	**90**	**90**	**91**	**91**	**91**	**91**	**92**	**92**	**92**	**92**	**93**	**93**	**93**	**93**
Month	**S**	**D**	**M**	**J**	**S**	**D**	**M**	**J**	**S**	**D**	**M**	**J**	**S**	**D**
Species														
Abutilon indicum	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Achyranthes aspera	0	0	1	1	0	0	0	1	0	1	1	1	1	0
Amaranthus viridis	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Apium leptophyllum	1	0	0	0	1	1	0	0	1	1	0	0	1	1
Bidens pilosa	1	0	1	1	1	1	0	1	1	1	1	1	1	1
Boerhavia tetrandra	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Brachiaria subquadripara	1	0	1	1	0	0	0	1	1	1	0	1	1	1
Bromus catharticus	1	0	0	0	1	1	0	0	1	0	0	0	1	1
Cakile edentula	1	1	1	1	1	1	0	1	1	0	0	1	1	1
Calyptocarpus vialis	0	0	1	1	0	0	0	0	0	1	0	1	1	1
Capsella bursa-pastoralis	1	1	1	1	1	1	0	1	1	0	0	1	1	0
Cassytha filiformis	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Casuarina equisetifolia	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Celtis paniculata	0	0	1	1	1	1	1	0	0	0	1	1	1	1
Cenchrus echinatus	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Commicarpus insularum	1	0	1	0	1	0	0	0	1	1	0	0	0	1
Conyza bonariensis	0	1	1	1	1	1	1	1	1	1	1	1	0	1
Cordia subcordata	0	0	1	1	1	0	0	1	1	0	1	1	1	0
Coronopus didymus	1	0	1	1	1	1	0	1	1	0	0	1	1	1
Cynodon dactylon	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Digitaria ciliaris	0	0	1	1	0	1	1	1	1	1	1	1	1	1
Eleusine indica	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Euphorbia atoto	1	1	1	0	0	0	0	0	0	0	0	1	1	1
Euphorbia cyathophora	0	0	1	1	1	1	1	1	1	1	1	1	1	1
Euphorbia prostrata	0	0	1	0	0	1	1	0	0	1	1	1	1	1
Euphorbia tannensis	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ficus opposita	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gnaphalium luteo-album	1	1	0	1	1	1	0	0	1	1	0	1	1	1
Ipomoea pes-caprae	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidium virginicum	1	1	0	1	0	1	0	1	1	1	0	1	1	1
Malvastrum coromandelianum	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Pandanus tectorius	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pipturus argenteus	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pisonia grandis	0	0	0	0	0	1	0	0	0	1	1	0	0	1
Poa annua	1	0	1	1	1	1	0	0	1	0	0	1	1	0
Portulaca oleracea	0	0	0	0	1	1	0	0	0	1	1	0	0	0
Salsola kali	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scaevola taccada	0	0	1	1	1	1	0	1	0	1	1	0	0	1
Sisymbrium orientale	1	1	1	0	1	1	0	1	1	0	0	1	1	1
Solanum americanum	1	1	0	0	1	1	0	1	1	1	1	0	1	1
Sonchus oleraceus	1	0	1	1	1	1	0	0	1	1	1	1	1	1
Sporobolus virginicus	0	0	1	0	0	0	1	0	0	0	0	0	0	1
Stenotaphrum micranthum	0	1	0	1	1	1	0	1	1	1	0	1	1	1
Suriana maritima	0	1	0	1	1	1	0	0	1	1	0	1	1	1
Thuarea involuta	0	0	1	1	0	0	1	1	1	1	1	1	1	1
Tournefortia argentea	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Tribulus cistoides	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Wollastonia biflora	0	1	0	0	1	1	0	0	1	1	0	0	1	1