

Airborne pollen of Brisbane, Australia: a five-year record, 1994–1999

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The seasonal incidence of pollen in the atmosphere of Brisbane has been established from a near – continuous, volumetric trapping program over the five-year period, July 1994–June 1999. Grass pollen accounts for 71.6% of the average annual pollen load with highest densities (up to 150 grains/m³) recorded in summer and autumn. Significant contributions were also made by taxa of the Cupressaceae (8.7%) and Urticaceae (1.8%) during spring and of the Pinaceae (4.5%) during winter. Pollen seasons of the Casuarinaceae (6.5%) and Myrtaceae (3.2%) are more extended, the former peaking in late winter and the latter in late spring. The onset and duration of the Poaceae and Urticaceae seasons varied from year to year, being later when precipitation levels were low in the late spring–early summer months.

Total pollen numbers and grass pollen densities are substantially less than those recorded from southern Australia. Nevertheless, respiratory disease in Brisbane affects up to 10% of the population, and airborne pollen of Poaceae, Urticaceae, Cupressaceae, Pinaceae, and Myrtaceae have been implicated in the release of allergens.

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A pollen calendar for the subtropical city of Brisbane, Australia, has been compiled from pollen collected at a site (Rocklea) in the western suburbs of the city using a Burkard seven-day recording volumetric spore trap during the five-year period 1 July 1994–30 June 1999. This calendar extends and elaborates on the eighteen month comparative pollen survey published for Ipswich and the Rocklea sites (Rutherford et al. 1997). Previous pollen calendars published for Brisbane were during the 1960's and were based on pollen trapped by gravity and volumetric sedimentation methods (Moss 1965, Rees 1964). Since Moss and Rees's sampling periods, the environs of Brisbane have been subjected to extensive urban development and industrialization with concomitant modifications to the vegetation.

Allergy and asthma are important health issues in the region with the most recent figures indicating prevalence rates of 13.5% for asthma and 11.4% for hay-fever. These figures represent an increase of approximately 3% from the previous health survey figures (Australian Bureau of Statistics 1998). Due to the social and medical implications, the aim of the paper is to provide an updated pollen calendar for Brisbane based on five years of near continuous sampling, to document trends and fluctuations in annual pollen sums and to list starting and end dates for the key airborne pollen in the region. Moreover, relationships between shifts in seasonal timing/duration, temperature/precipitation regimes, and the seasonal incidence of grass pollen are investigated. In this context, the pollen calendar provides a guide for those that suffer allergic reactions to pollen.

During the last decade, pollen calendars have been

published for other more southerly cities and regions in Australia, including Sydney (Bass & Morgan 1997), Melbourne (Ong et al. 1995 *a, b*) and several country centres (Wagga Wagga, Tamworth, Young and the Hunter Valley) in New South Wales (McShane & Cripps 1997). However, unlike Brisbane that has a subtropical climate and a summer rainfall regime, these more southerly regions experience warm to cool temperate climates with rainfall concentrated in the winter.

Study area

Geographical position. – Brisbane, located in southeastern Queensland, has the third largest population (ca 1.6 mln) of the cities in Australia and is one of the fastest growing regions in Australia. The trapping site at Rocklea, 7 km southwest of Brisbane's Central Business District and 25 km west of the coast (Fig. 1), is on a Queensland State Government, Department of Primary Industries research farm surrounded by light commercial and residential areas. Elevation of the site is 12.5 m above sea level.

Vegetation. – The vegetation around the site is typical of that of suburban Brisbane and is composed of endemic and exotic species. The site is located in a grassy paddock surrounded by an open eucalypt woodland as well as herbaceous and riparian communities. Taxa represented at the site include *Cyperus* spp. (nut grass), *Capillipedium* spp. (scented – top grass), *Cynodon dactylon* (couch grass), *Eleusine tristachya*, *Lolium temulentum* (Darnel), *Paspalum* spp., *Sorghum* spp., *Cirsium vulgare* (Spear thistle), and scattered trees of *Eucalyptus* spp., *Acacia* spp. and *Casuarina*

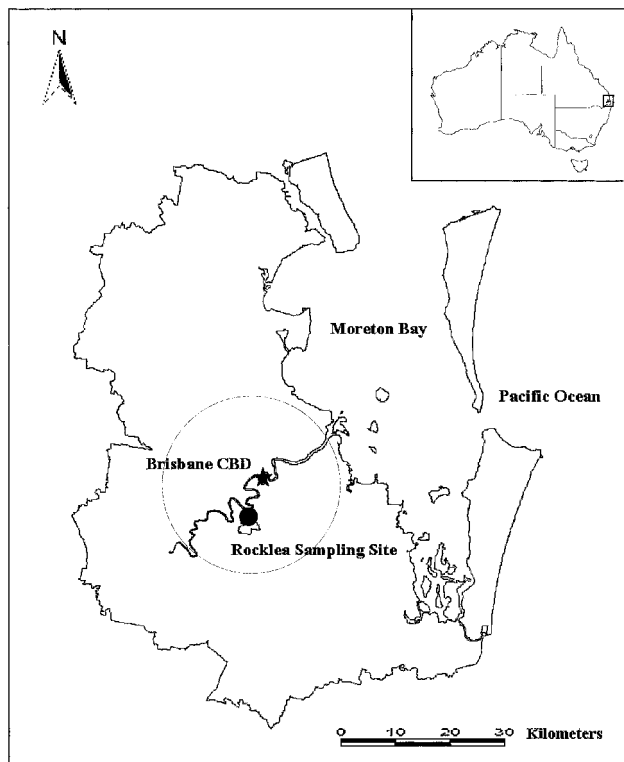


Fig. 1. Map of the greater Brisbane area, southeastern Queensland. ★ Central Business District (CBD), Brisbane; ● locality of Rocklea sampling site. Highest population densities occur within the area circumscribed by the circle.

spp. (Rutherford et al. 1997). Grasses are predominantly those that inhabit warm temperate to subtropical climates having a summer rainfall regime. Surrounding residential and commercial areas have gardens of native and exotic species as well as lawns mainly composed of *Cynodon dactylon* (couch grass).

Climate. – Brisbane has a subtropical climate with an annual mean temperature of 25.9°C and rainfall of 1114.6 mm. The mean daily temperature ranges from 30.1°C in January (warmest month) to 20.7°C in July (coolest month); precipitation is highest during the summer months (February average, 162 mm) and lowest in late winter (August average, 36.2 mm). Prevailing winds are from the southeast between November and March and from the northwest to southwest between April–October (Bureau of Meteorology 1983). Yearly averages for rainfall and minimum and maximum temperatures for the study period are shown in Table I.

MATERIALS AND METHODS

A seven-day Burkard volumetric spore trap operated near continuously at the Rocklea site between July 1994 and June 1999 with the instrument's orifice elevated two metres above ground level. Several periods of motorized trap breakdown were experienced, but these were usually brief and accounted for a total of 117 days during the entire sampling period. The trap was calibrated to sample air at ten litres per minute and the atmospheric particulate matter was deposited onto tapes coated with a thin film of Dow Corning pressure-sensitive silicone adhesive (280A). The seven-day tapes were cut into daily lengths and mounted in Carberla's solution on glass microscope slides. The entire surface area of each tape was scanned at magnifications of $\times 250$ using north–south traverses (Käpylä & Penttinen 1981) and the pollen counts then converted to correspond to grains per m³ air as a daily mean value. Pollen identification was aided by reference to photomicrographs provided by Moss (1965), Grant Smith (1990), and Hjelmroos et al. (1999). Temperature and rainfall data, measured at Brisbane airport was provided by the Bureau of Meteorology, Queensland, and was used for graphical analysis with pollen count data from the Rocklea site.

RESULTS

Pollen grains and spores deposited on the tapes from the atmosphere of Brisbane during the period July 1994–June 1999 are from 16 families of flowering plants, three of conifers and from ferns (Table II). Of the 32 332 pollen and spores counted (pollen grains m³) for the five year period, pollen of Poaceae (grasses) accounted for 71.6% of this total. Significant contributions were also made by pollen of Cupressaceae (8.7%), Casuarinaceae (6.5%), Pinaceae (4.5%), Myrtaceae (3.2%) and Urticaceae (1.8%) (Table II). Maximum pollen loads were captured during the period December–March of each year, with grasses the main contributors (Table II, Figs. 2, 3, 4 a). Pollen of Cupressaceae, Urticaceae, and Pinaceae are of considerably less abundances (Table II, Figs. 2, 4 b, d, f) and peak during the late winter and spring. Myrtaceae and Casuarinaceae pollen were captured throughout the year, with highest loads of the former in late spring and of the latter in winter (Table II, Fig. 4 c, e). Pollen and spores of other plant taxa were intermittently trapped in very low frequencies (Table II).

The pollen calendar presented here is based on averaged monthly pollen loads for the five years 1994–1999 (Figs. 3, 4 a–f). The six major contributing families to the airborne pollen of Brisbane have individualistic annual pollen signatures reflecting the duration and timing of peak emission of their pollen. However, pollen of each family

Table I. Yearly average maximum temperature, minimum temperature, rainfall and total rainfall in Brisbane (1994–1999).

	1994–95	1995–96	1996–97	1997–98	1998–99	Average 1994–99
Average Maximum Temperature (°C)	25.39	25.28	25.22	25.66	25.1	25.33
Average Minimum Temperature (°C)	14.9	15.35	15.01	15.78	15.96	15.4
Total Rainfall (mm)	695	1649.2	861.8	978.2	1387.1	1114.26
Average Rainfall (mm)	1.94	4.51	2.36	2.68	3.8	3.06

Table II. Relative percentages and annual totals (pollen grains m^{-3}) of total daily pollen concentrations averaged for the period 1994–1999.

Taxa	1994–95	1995–96	1996–97	1997–98	1998–99	Totals 1994–99	%
Poaceae	4017	7055	5200	3164	3715	23150	71.6
Cupressaceae	398	462	698	430	850	2838	8.7
Casuarinaceae	475	265	344	445	582	2111	6.5
Pinaceae	404	263	136	258	395	1456	4.5
Myrtaceae	419	124	200	125	164	1031	3.2
Urticaceae	241	134	41	63	96	575	1.8
Cyperaceae	201	63	33	40	105	442	1.4
Asteraceae	43	44	41	44	56	230	0.6
Ulmaceae	40	23	45	25	66	199	0.6
Fern Spore	22	11	9	1	10	53	0.1
Plantaginaceae	22	6	5	3	14	51	0.1
Mimosaceae	17	6	12	7	8	50	0.1
Chenopodiaceae	20	7	4	5	3	40	0.1
Fabaceae	12	3	7	2	3	27	0.0
Proteaceae; <i>Grevillea</i> spp.	3	0	15	3	3	24	0.0
Araucariaceae	9	1	2	4	4	20	0.0
Moraceae	2	0	1	0	13	17	0.0
Loranthaceae	2	0	1	1	0	3	0.0
Sapindaceae	5	0	1	3	1	10	0.0
Brassicaceae	0	1	0	0	1	3	0.0
Proteaceae; <i>Banksia</i> spp.	0	0	0	0	0	1	0.0
Totals	6356	8470	6794	4624	6089	32332	100.0

displays considerable quantitative fluctuations from one year to the next as illustrated by the sequential yearly calendars for each family (Figs. 5–10). Moreover, the starting dates and duration of the pollen seasons of Poaceae and Urticaceae varies considerably from one year to the next (Figs. 5, 10).

Average maximum temperature, minimum temperature, and rainfall are recorded together with total yearly rainfall for the study period (Table I). Although the average

maximum temperature is constant, the average minimum temperature increased by 1°C over the five-year period. Average monthly minimum temperature and average monthly rainfall are plotted against pollen concentrations of Poaceae for the five-year period (Fig. 11).

DISCUSSION

Pollen Counts. – Pollen trapped each year is mostly from herbaceous plants, with grass pollen occurring in frequencies ranging from 66–84%. In the same period arboreal pollen (the majority derived from taxa of Cupressaceae, Pinaceae, Casuarinaceae, and Myrtaceae) varied between 16% and 34% of the yearly pollen load (Table II, Fig. 2). Rutherford et al.'s (1997) values for 1994–1995 for the Rocklea site

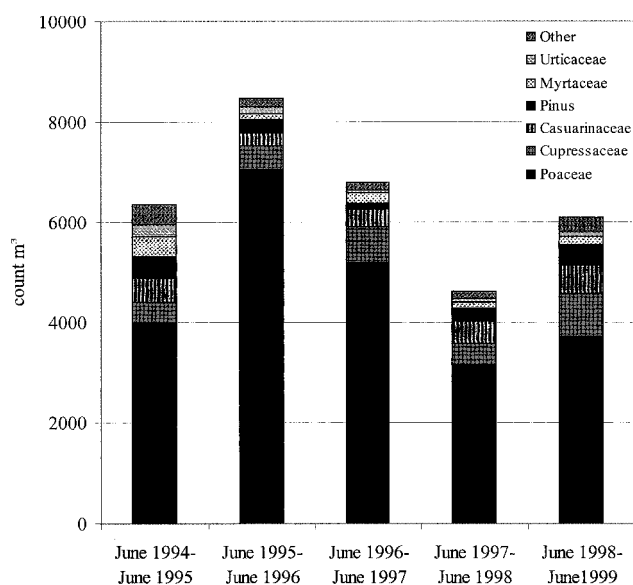


Fig. 2. The total annual sum (pollen grains/ m^3) for the years 1994–1999 in Brisbane.

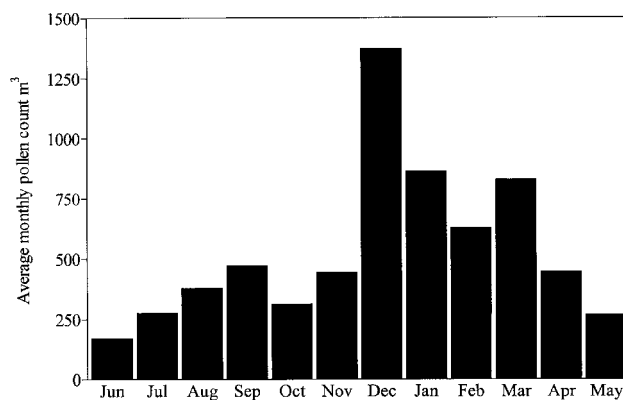


Fig. 3. Total monthly sums (pollen grains/ m^3) for the years 1994–1999 in Brisbane.

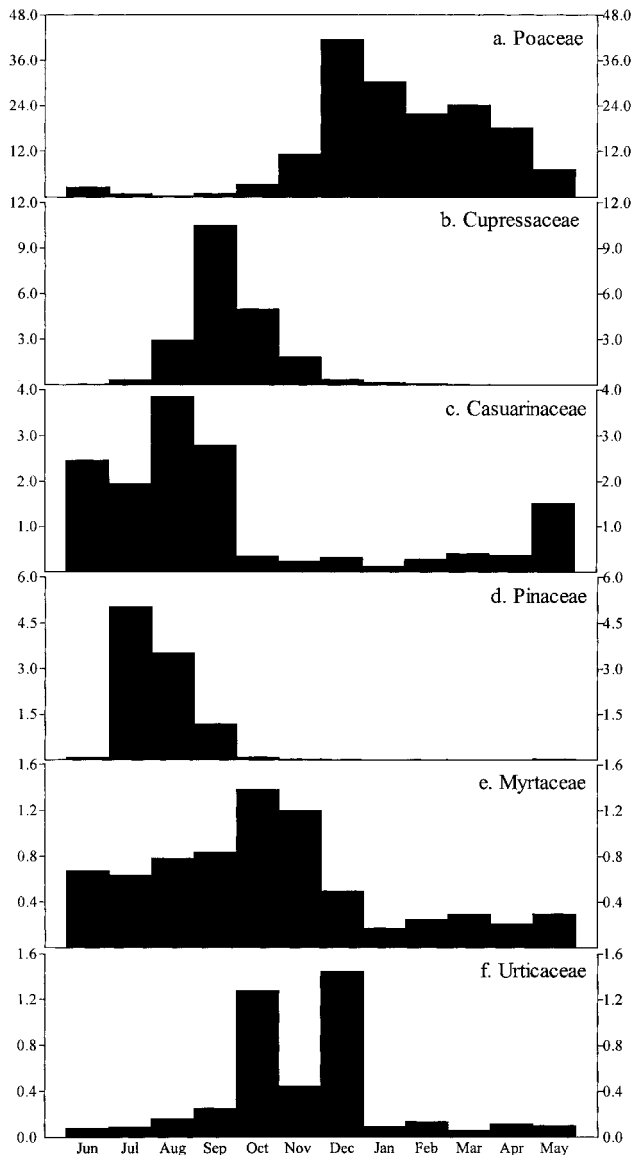


Fig. 4. a–f. Seasonal incidence (Pollen Calendar) of airborne pollen from the atmosphere of Brisbane (1994–1999). The graph shows the average for five years of daily pollen counts (per m^3 in 24 hours) from June to May the following year. Note scale differences for the individual families of airborne pollen.

fall within this range using different counting methods. Furthermore the values indicate that there has been no major shift in the quantitative and qualitative attributes of pollen loads since the studies of Rees (1964) and Moss (1965) despite differences of site location, trapping technique and counting methodologies.

Daily pollen counts averaged for the five years (1994–1999) were greatest during the months December–April (Figs. 3, 4 a–f), but on a yearly basis the timing of peak pollen emission varied from summer (December/January) in 1995–1997 to autumn (March/April) in 1994–1995 (Figs. 5–10). Furthermore, densities of pollen during the period of peak emission varied from daily counts of 50–90 grains/ m^3 during March–April 1995, up to 150 grains/ m^3

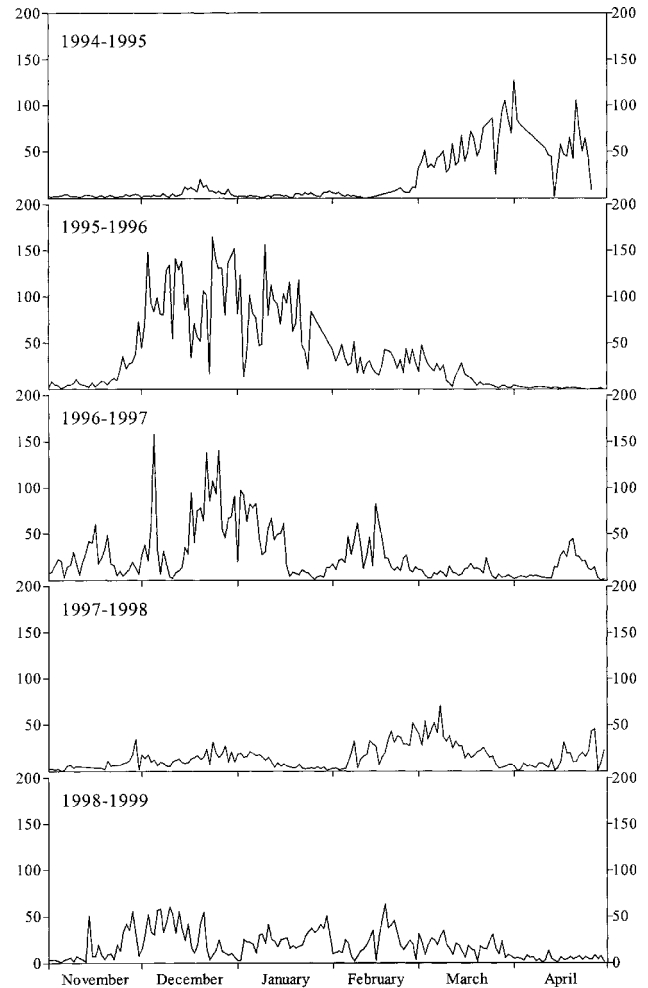


Fig. 5. Distribution of Poaceae pollen during five individual years, Brisbane, Australia. The curve graphs daily pollen counts (per m^3 in 24 hours).

during December–January in 1995–1997. For the period mid 1997–1998, highest pollen frequencies were considerably less; up to 60 grains/ m^3 (Figs. 5–10). The variation is largely accounted for by concomitant variations in densities of grass pollen (Table II). Even so, Brisbane values of grass pollen are considerably less than those reported for Melbourne (up to 549 grains/ m^3 , Ong et al. 1995b) and Sydney (up to 462 grains/ m^3 , Bass et al. 1997).

Pollen Calendar. – The pollen calendar for Brisbane (Figs. 4 a–f) documents seasons of the six most abundantly occurring airborne pollen types for the period 1994–1999. The season for Poaceae pollen spans summer and autumn months (Fig. 4 a), but the timing of peak concentration varies from year to year (Fig. 5). Maximum pollen loads of up to or more than 150 grains per m^3 occurred during December in both 1995 and 1996 following periods of prolonged rainfall when minimum temperatures were above 15°C (Fig. 11). Many of the grasses within and surrounding the site are warm temperate–subtropical species adapted to a summer rainfall regime.

Cupressaceae and Pinaceae have less variable and briefer

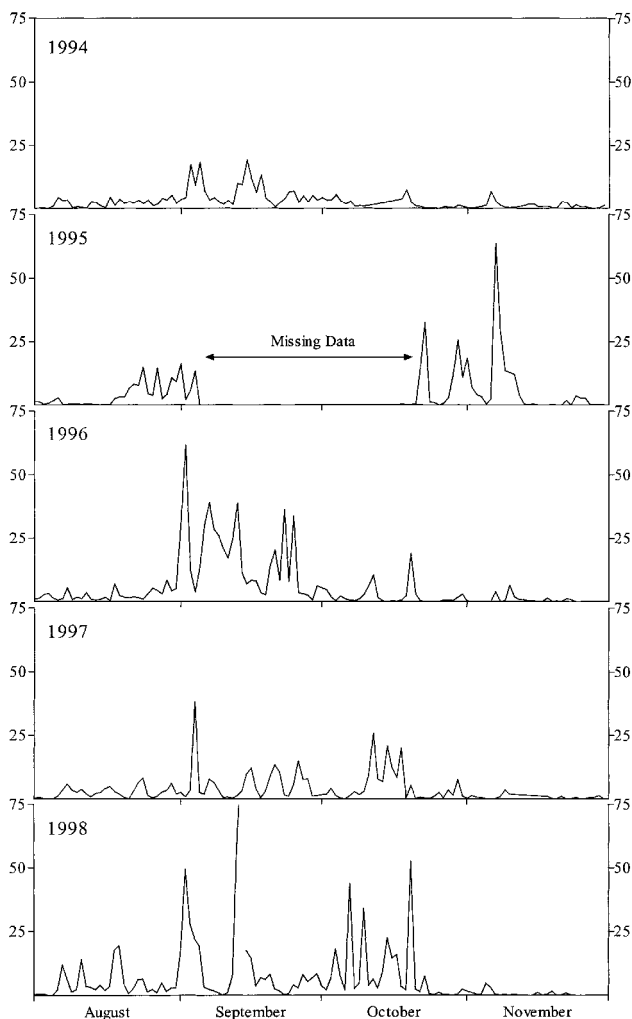


Fig. 6. Distribution of Cupressaceae pollen during five individual years, Brisbane, Australia. The curve graphs daily pollen counts (per m^3 in 24 hours).

seasons (Fig. 4 b, d) than Poaceae, the former late August–November (Fig. 6) and the latter late July–early August (Fig. 8). Source taxa of Cupressaceae pollen includes both natives (*Callitris* spp.) and exotics (*Cupressus sempervirens*), that are mainly concentrated in suburban gardens. Average pollen counts were highest (10 grains per m^3) during September, with a maximum count of 94 grains per m^3 in mid September 1998. During the brief Pinaceae season daily average counts are 11 grains per m^3 , with a maximum concentration of 159 grains per m^3 in July 1998. Pinaceae pollen is mostly derived from *Pinus radiata*, *P. caribbaea*, *P. elliotii* and *P. taeda*, which are exotic to Australia and occur individually throughout the Brisbane suburbs as well as in plantations to the north.

Pollen of Casuarinaceae and Myrtaceae occur in the atmosphere throughout the year, but in higher frequencies during their peak seasons. The main pollen season of Casuarinaceae is June to September (Fig. 4 c), but counts were highest for August with average daily values of 4 grains per m^3 and a highest daily count of 50 grains per m^3

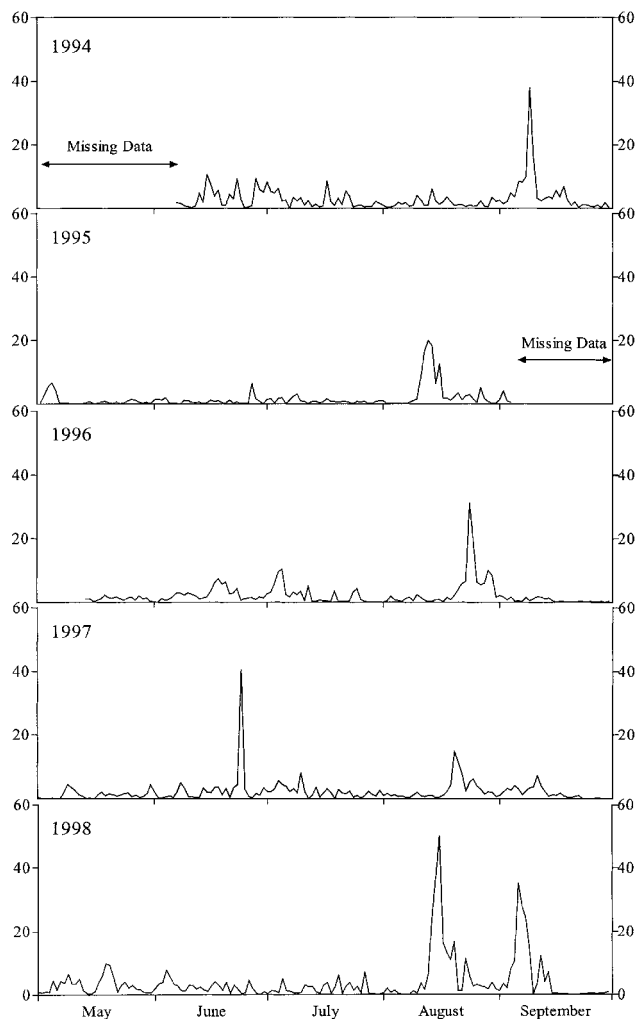


Fig. 7. Distribution of Casuarinaceae pollen during five individual years, Brisbane, Australia. The curve graphs daily pollen counts (per m^3 in 24 hours).

during mid August 1998 (Fig. 7). Sources of Casuarinaceae pollen are from *Casuarina* spp. (including *Casuarina torulosa*, *C. littoralis*, *C. glauca*, *C. cunninghamiana*), which are endemic and found throughout Brisbane's suburbs.

Members of the Myrtaceae are native and common in Brisbane and form the major vegetation in forest stands, shrublands and gardens. The family has an extended pollen season (Fig. 4 e) and is represented by taxa including *Eucalyptus* spp., *Callistemon* spp., *Melaleuca* spp. and *Leptospermum* spp. *Eucalyptus* spp. trees at the site may have accounted for the occasional high counts trapped (Fig. 9). Counts are highest in October and November (1.25 grains per m^3), with the highest count of 18 grains per m^3 occurring in October 1996.

Pollen of the Urticaceae (Fig. 3 f) is most prevalent from September to December, with average daily counts of 1.45 grains per m^3 during December. The highest frequency recorded was 64 grains per m^3 in mid December 1994. Species of this family are abundant throughout Brisbane and at the sampling site. They are found in grass paddocks

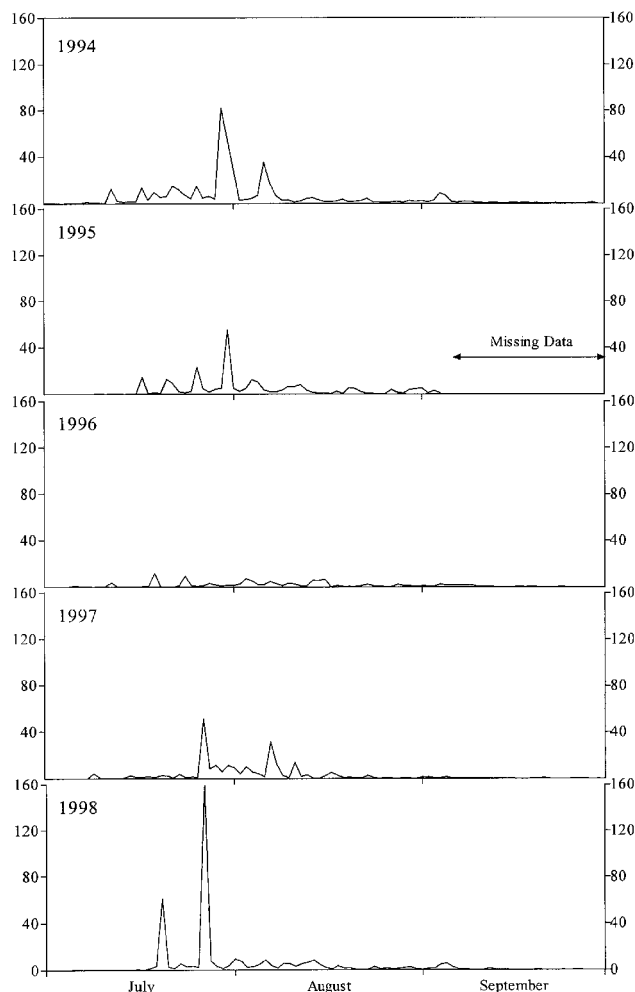


Fig. 8. Distribution of Pinaceae pollen during five individual years, Brisbane, Australia. The curve graphs daily pollen counts (per m^3 in 24 hours).

and in disturbed sites with high nitrogen content (Hjelmroos et al. 1999).

The pollen calendar based on the five-year record (July 1994–June 1999) provides a guide to the timing and duration of the seasons of the six most frequently encountered pollen types in the atmosphere of Brisbane. The calendar illustrates that pollen loads of the 1990's are essentially similar in quantitative/qualitative attributes to those trapped in the 1960's, and that grasses are the major contributors to the annual pollen load. On an annual basis there is consistency in the timing of the brief Pinaceae season (July–August) and to the more extended pollen seasons of Cupressaceae (August–November), Casuarinaceae (June–September) and Myrtaceae (June–December). However, loads of each pollen type varied considerably from year to year. For the Poaceae and to a lesser extent, the Urticaceae, there was considerable variation from year to year in the onset and duration of their respective pollen seasons and in numbers captured of each pollen type.

Seasonal Variations. – Factors that influence pollen loads

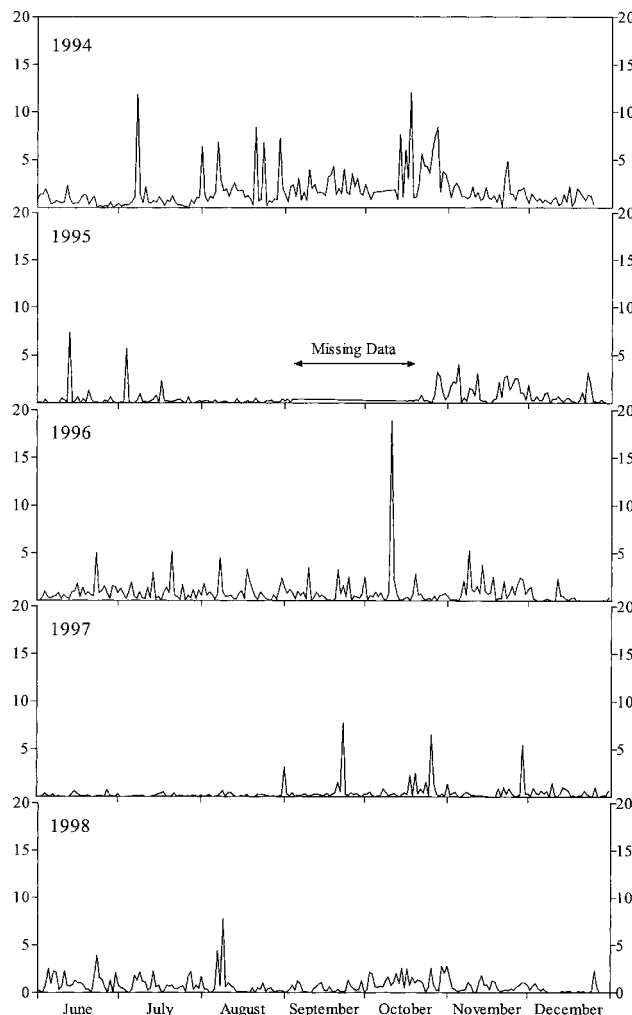


Fig. 9. Distribution of Myrtaceae pollen during five individual years, Brisbane, Australia. The curve graphs daily pollen counts (per m^3 in 24 hours).

are complex, and relate to climatological parameters that initiate flowering as well as meteorological conditions that influence anthesis, release of pollen, and dispersal of pollen in the atmosphere. Yearly and seasonal patterns in rainfall and temperature are important for flower initiation that precedes flowering by up to several months in woody taxa and several weeks in herbaceous species (Anderson 1980). For example, in *Pinus roxburghii* the delay between male strobili initiation and maturation is at least one month (Khanduri & Sharma 2000), while the delay between flower initiation and anthesis is several months in *Olea* spp. (Fernandesobar et al. 1992) and even longer in members of the Myrtaceae (Beardsell et al. 1993). Flower initiation may vary from year to year and be affected by rainfall and temperature regimes with consequent variations in the onset of anthesis. Rainfall, temperature, relative humidity and wind direction at anthesis may also affect pollen release and pollen dispersal in the atmosphere (Fornaciari et al. 1992, Frei 1998, Caramiello et al. 1994, Rutherford et al. 1997, Reddi et al. 1988).

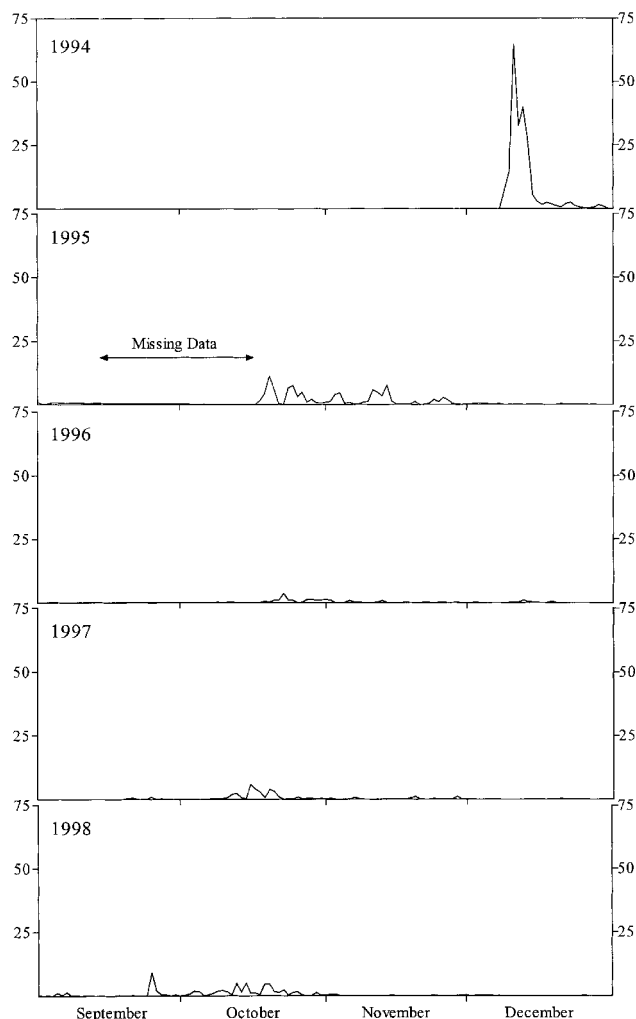


Fig. 10. Distribution of Urticaceae pollen during five individual years, Brisbane, Australia. The curve graphs daily pollen counts (per m^3 in 24 hours).

The onset and duration of the pollen seasons of the woody taxa Cupressaceae, Casuarinaceae, Pinaceae and Myrtaceae was relatively constant for each of the five years. Frequencies of each pollen type varied from year to year with lowest values recorded for Cupressaceae in 1994, Casuarinaceae in 1995, Pinaceae in 1996, and Myrtaceae in 1997 (Figs. 2, 6–9).

The onset and duration of the Poaceae and Urticaceae seasons also varied from year to year. The late start (March) of the 1994–1995 grass season may be related to unusually dry conditions in the late spring–summer months (Fig. 11). Predominant grasses in the Brisbane region flower in summer when minimum temperatures are above 14°C and precipitation levels are greatest. Dry conditions during winter–spring in Melbourne were considered to delay the grass pollen season (Ong et al. 1995 b, 1997) and in Europe the same phenomena has been documented (Frei 1998). The relatively low frequencies of grass pollen captured during the 1997–98 and 1998–99 seasons may relate to precipitation values at the time of pollen release. Increases in minimum

temperatures (Table II, Fig. 11) coupled with extended periods of rainfall during summer months of the grass pollen season may have reduced atmospheric loads of grass pollen.

The main Urticaceae pollen season occurred in October in the years 1995–1999, but was significantly later (December) in 1994, and the late start may well have been influenced by the dry conditions during the preceding months (Fig. 10).

CONCLUSIONS

Results of the study suggest that airborne pollen loads of Brisbane have not changed substantially since the 1960's studies of Rees (1964) and Moss (1965). Pollen is represented in the atmosphere throughout the year although frequencies are substantially higher during summer–autumn months, the period of the grass pollen season. Pollen trapped in the late autumn–early summer months is mainly from tree and shrubby taxa of the Cupressaceae, Pinaceae, Casuarinaceae, and Myrtaceae, and a large proportion of this pollen is from native species. Pollen loads of Sydney and Melbourne are denser than those of Brisbane and are mostly derived from arboreal exotics that flower in late winter–spring and summer. Among these are birch, maple, olive and privet whose pollen are known to be allergenic (Ong et al. 1995a, 1997, Bass et al. 1997). Grass pollen densities are generally less in Brisbane during the main grass pollen season than during the grass seasons in Sydney and Melbourne. Rye grass, a major contributor to the allergenic pollen load of Sydney and Melbourne occurs infrequently in Brisbane.

Poaceae taxa that occur in Brisbane and whose pollen have been associated with respiratory diseases include *Paspalum* spp. Allergens have also been identified in pollen of Cupressaceae, Pinaceae, Myrtaceae (Cadman 1990, Cadman & Dames 1993, Nilsson 1990) and Urticaceae (Emberlin & Norris-Hill 1991, Corden & Millington 1991, Fornaciari et al. 1992). An important characteristic of the Brisbane aerospora is the drawn out pollen periods. Collectively these span much of the year in contrast to the spring–autumn pollen seasons of Melbourne and cities in many European countries. Thus, in Brisbane there is potentially continuous exposure to pollen allergens albeit in lower densities than more southerly regions of Australia or elsewhere in cool temperate regions.

In Brisbane, pollinosis and cases of asthma are becoming more prevalent throughout the population. The pollen calendar will help this section of the community as well as people from abroad by identifying the potential allergen risk seasons. Given the long pollen seasons and number of pollen types in Brisbane, the next stage of the study is to investigate the effects and levels of exposure needed to elicit an allergic response as well as producing models to predict the future seasons.

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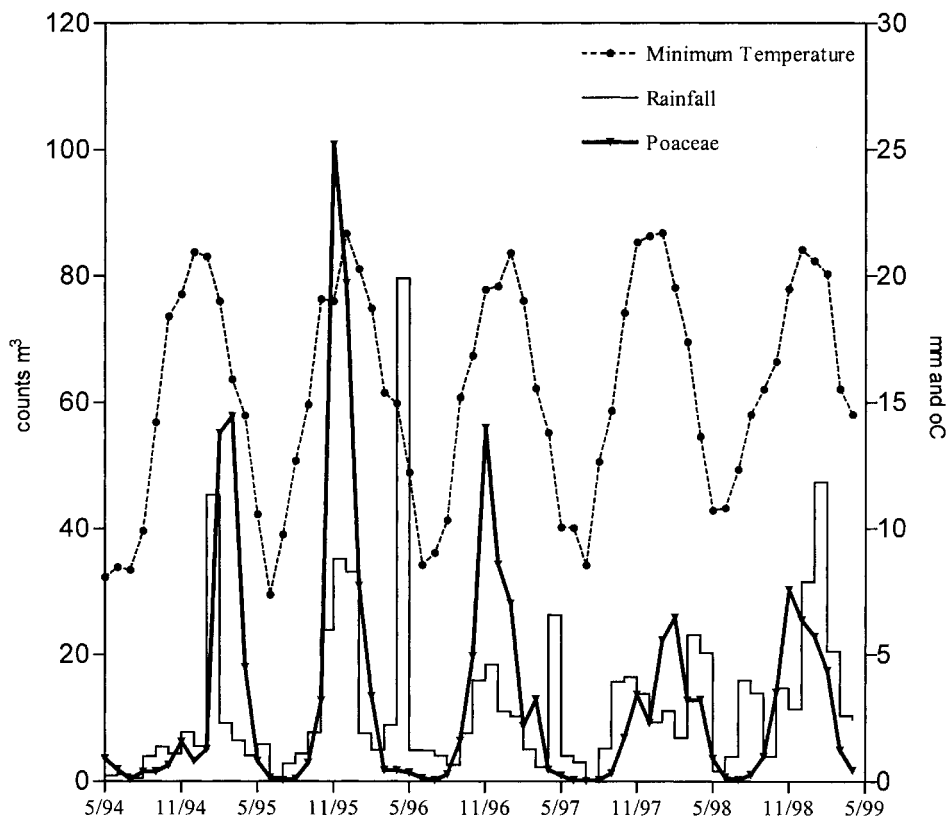


Fig. 11. Average monthly Poaceae pollen counts, minimum temperature, and rainfall for Brisbane 1994–1999.

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