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***Alternaria* spores in the atmosphere of Sydney, Australia, and relationships with meteorological factors**

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Abstract *Alternaria* spores are found in the atmosphere in many locations around the world. They are significant from a human health perspective because they have been known to trigger allergic respiratory disease such as asthma and hay-fever. The presence of *Alternaria* spores in the atmosphere has been related to meteorological factors in past studies, but this has not been done previously in Sydney, Australia. This paper reports the results of such a study in Sydney. *Alternaria* spore concentration data for the period 19 August 1992 to 31 December 1995 were examined with meteorological data for the same period. The daily *Alternaria* spore concentration was compared to the meteorological data for the same day and for up to 3 days previously. The analysis methods were Spearman's rank correlation and multiple regression. *Alternaria* spores appear in the atmosphere of Sydney year-round, although they peak over spring, summer, and autumn. A number of meteorological factors, including mean, minimum, and maximum, temperature, dew point temperature, and air pressure, are significantly correlated with the atmospheric concentration of *Alternaria* spores. Some of these meteorological variables (temperature and dew point temperature) show significant correlations with a 1, 2, and 3 day lag, as well as for the same day. Regression models indicate that up to 31.1% of the variation in *Alternaria* spore concentration can be explained by meteorological factors. There is potential for the results of this study to be used by public health authorities in the prediction of *Alternaria* spore concentrations in Sydney.

Keywords *Alternaria* · Aerobiology · Sydney · Atmosphere · Asthma

Introduction

This study demonstrates a relationship between meteorological factors and the concentration of *Alternaria* mould spores in the atmosphere of Sydney, Australia. Sydney is the largest city in Australia, both in population and physical size. It is located on the east coast at approximately 151° east and 34° south (Fig. 1). To the west of the Sydney region are the Blue Mountains, a part of the Great Dividing Range.

Much of Sydney's population resides in areas that are near the coast. Development has largely followed the transport routes and the rivers. The population density is

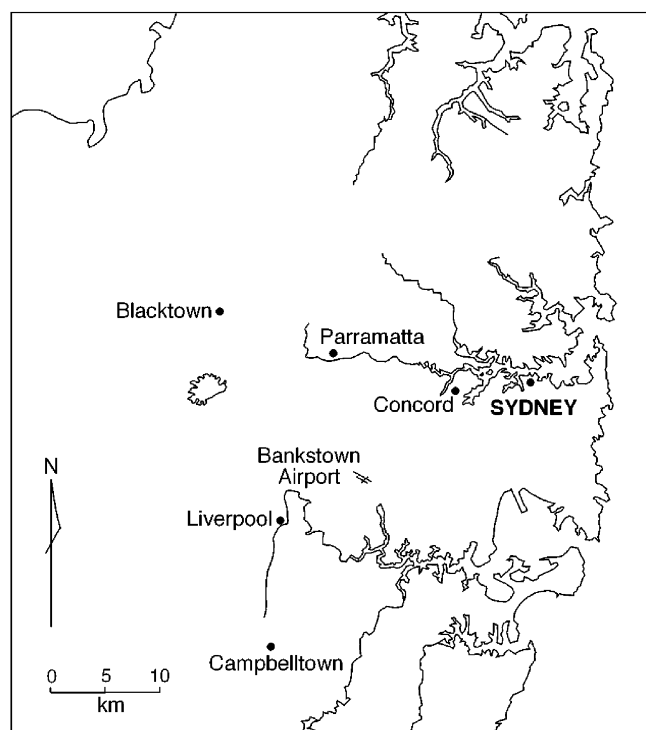


Fig. 1 The study area and meteorological and spore sampling sites

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Table 1 A summary of climate data at Bankstown Airport for the study period and long term (28–33 years). (T temperature, $T_{\min}$ minimum temperature, $T_{\max}$ maximum temperature, p_r rainfall, $RH_{3\text{ p.m.}}$ relative humidity at 3 p.m., T_d dew point temperature, u wind speed, P air pressure)

Variable	Mean (1992–1995)	SD (1992–1995)	Long-term mean
T (°C)	16.5	3.5	17.5
Average annual mean $T_{\min}$ (°C)	12.8	5.1	12.0
Average annual mean $T_{\max}$ (°C)	21.7	5.1	23.0
Average daily p_r (mm)	2.0	6.0	2.5
Average annual mean $RH_{3\text{ p.m.}}$ (%)	52.1	19.3	51.4
Average annual mean T_d (°C)	10.7	5.3	10.6 (3 p.m.)
u (m/s)	3.03	1.47	Not available
Average annual mean P (hPa)	1,017.8	0.9	1,015.7 (3 p.m.)

highest around the Sydney Harbour and along the Parramatta River and Georges River valleys and extends west to include the cities of Bankstown, Liverpool, Parramatta, and Blacktown. The north, south, and more distant western areas are less developed. The greater Sydney area contains many sparsely populated areas that are semi-rural, and other large areas that are set aside as parks and reserves.

Sydney has a temperate climate. Bankstown Airport is one of Sydney's major and most central climate stations. The station at this site has been in operation since it was opened in January 1968, and a summary of some data for this period is presented for comparison with that of the study period in Table 1. The eastern Australian climate, especially rainfall, is influenced by the El Niño-Southern Oscillation which is a cause of drought and flood.

Alternaria mould spores have been named as an environmental hazard associated with asthma in NSW (Public Health Division 2000). *Alternaria* species are known to be highly allergenic based on skin tests (Salvaggio and Aukrust 1981). Peat and Woolcock (1991), in a study of 1,217 school children at Villawood (5 km north of Bankstown Airport), found the prevalence of atopy to *Alternaria tenuis* was 4.4% (3.3%, 5.6% confidence interval). Studies have also demonstrated significant associations between *Alternaria* and asthma emergency department visits (Stieb et al. 2000).

The NSW Health Department reports the prevalence of current asthma in the South West Sydney Health Area (the area in which monitoring was conducted for this study) is 8.6% (Public Health Division 2000). Peat et al. (1980) studied Sydney school children over a 6-year period and found the cumulative prevalence of one or more attacks of asthma was 11.5% for boys and 6.1% for girls aged 13.9 years. They also found that by the age of 17 years, 3.7% of boys and 2.2% of girls had current asthma requiring treatment in the previous 12 months, and they speculated that this may be typical of the adult population too. In addition to the high prevalence of asthma, there were 246 deaths from asthma in New South Wales during 1998 (a death rate of 3.4 per 100,000) (Public Health Division 2000).

Because of its importance to human health, many studies have examined *Alternaria*, both on its own (e.g. Angulo-Romero et al. 1999; Mitakakis et al. 2001; Munuera Giner et al. 2001) and in conjunction with other fungal spores or with pollen (e.g. Rutherford et al. 1997; Sabariego et al. 2000) (Table 2).

Alternaria species are parasites or saprophytes on plants and are widely distributed (Angulo-Romero et al. 1999). *Alternaria* is largely a soil-borne fungus that lives on rotting organic matter including wood, leaf debris, and grasses (Mitakakis et al. 1997). The amount of this fungus is related to the amount of dead vegetation available for it to consume, so its seasonal pattern reflects that of the local vegetation (Mitakakis et al. 1997).

The literature has few references to the number of spores that are needed to provoke an allergic reaction in susceptible individuals. There is considerable variation between those numbers that have been presented. One estimated threshold concentration of *Alternaria* spores needed to provoke an allergic response is 100 spores/m³ of air (Gravesen 1979). Licorish et al. (1985), however, suggest that of the order of 10⁴–10⁷ spores need to be inhaled over a 24-h period. Hasnain et al. (1998) suggest that a mean daily concentration of 50 *Alternaria* spores/m³ are needed to cause sensitisation, after which smaller concentrations can cause symptoms.

Fungi have a short asexual reproduction cycle taking a few days and they produce vast numbers of spores. Previous studies done elsewhere (Table 2) have found relationships between *Alternaria* mould spore concentration and meteorological variables including temperature, rainfall, relative humidity, dew point temperature, wind speed and direction, sunshine hours, air pressure, and evaporation. The length of record and sampling interval examined in such studies have varied considerably, with studies ranging in length from 4 days to 20 years, and sampling intervals varying from hourly to monthly, with daily being most common.

While many studies have been conducted outside Australia, and studies within Australia have been done in Melbourne, Brisbane, and rural NSW, no studies have yet been published for Sydney. This study aims to examine the existing *Alternaria* data for Sydney, and explore relationships with meteorological factors.

Materials and methods

The daily average concentration of *Alternaria* mould spores has been determined at three locations in the Sydney area: (i) Concord Repatriation General Hospital, on the roof, July 1992 to March 1993 and December 1993 to January 1994; (ii) Blacktown, adjacent to the local swimming pool, February 1994 to January 1995; and (iii) Campbelltown, on the campus of the University of Western Sydney, 19 August 1992 to 31 December 1995. Air at these loca-

Table 2 Summary of studies of relationships between *Alternaria* (and other) mould spores midity, T_d dew point temperature, u wind speed, d wind direction, h sunshine hours, P air and meteorological factors. (T temperature, p precipitation, p_r rainfall, RH relative humidity, T_d dew point temperature, u wind speed, d wind direction, h sunshine hours, P air pressure, E evaporation)

Reference	Location	Other spores/pollen grains studied	Length of record (interval)	Meteorological factors studied
Hirst (1953)	Harpden, UK	<i>Cladosporium</i> , <i>Erysiphe</i> , smuts and rusts, <i>Phytophthora</i> , <i>Polythrincium</i> , <i>Lycopodium</i> , <i>Ustilago</i> , pollen	8 months in a 16 month period (2-hourly)	T , p_r , RH, u , sunshine
Sneller et al. (1981)	Tucson, USA	Pollen	20 years (daily)	T , p , RH, incident radiation
Hjelmroos (1993)	Stockholm, Sweden	<i>Cladosporium</i>	10 years (2-h, 6-h, daily)	T , p , u , d , P , cloud cover
Li and Kendrick (1995)	Waterloo, Canada	<i>Cladosporium</i> , <i>Epicoecum</i> , <i>Polythrincium</i> , <i>Aspergillus</i>	58 days over 1 year (5–7 days)	T , p , RH, u
Calderón et al. (1997)	Mexico City, Mexico	<i>Penicillium</i> , <i>Leptosphaeria</i> , <i>Coprinus</i> , <i>Ganoderma</i>	359 days (hourly, daily, weekly)	T , RH, u
Herrero and Zaldivar (1997)	Palencia, Spain	Deuteromycete, Basidiomycete, Ascomycete	3 years (daily, weekly)	T , p , RH, u , d
Katál et al. (1997)	Denver, USA	<i>Cladosporium</i> , total spores	9 months/year for 8 years (daily)	T , p , RH, u , P
Mitakakis et al. (1997)	Melbourne, Australia	<i>Cladosporium</i> , total fungal spores	3 years (daily)	T , p_r
Rutherford et al. (1997)	Brisbane, Australia	<i>Cladosporium</i> , <i>Ustilago</i> , <i>Epicoecum</i> , other spores, pollen	18 months (daily)	T , p_r , RH, u
Takahashi (1997)	Yokohama, Japan	<i>Cladosporium</i> , <i>Penicillium</i> , <i>Pestalotia</i> , <i>Fusarium</i> , <i>Aspergillus</i> , and others	3 times per day on 2 days per month for 2 years	T , p , RH, u
Angulo-Romero et al. (1999)	Cordoba, Spain	none	1 year (daily)	T , p_r , RH, h
Sabariego et al. (2000)	Granada, Spain	<i>Cladosporium</i> , <i>Ustilago</i>	1 year (daily)	T , p_r , RH, u , h
Marchisio and Airaudi (2001)	Turin, Italy	<i>Cladosporium</i> , <i>Penicillium</i> , <i>Epicoecum</i> , <i>Aspergillus</i> , and many others	48 samples in 2 years (fortnightly)	T , p_r , RH, u , P
Mitakakis et al. (2001)	Wagga Wagga and Moree, Australia	none	2 years (daily)	T , p_r , RH, u , d , cloud cover
Munuera Giner et al. (2001)	Murcia, Spain	none	6 years (hourly, daily, seasonal, annual)	T , p_r , RH, u , d , E
Troutt and Levetin (2001)	Tulsa, USA	<i>Cladosporium</i> , <i>Epicoecum</i> , <i>Curvularia</i> , <i>Pithomyces</i> , <i>Drechslera</i> , smut spores, ascospores, basidiospores, other spores	2 months (hourly and daily)	T , p , T_d , u , d , P
Asan et al. (2002)	Edirne, Turkey	<i>Cladosporium</i> , <i>Aspergillus</i> , <i>Penicillium</i> , <i>Curvularia</i> , <i>Drechslera</i> , <i>Scytalidium</i> , <i>Fusarium</i>	For 2 h, 12 times over 12 months (once per month)	T , p_r , RH, u , h
Burch and Levetin (2002)	Tulsa, USA	<i>Cladosporium</i> , <i>Epicoecum</i> , <i>Curvularia</i> , <i>Pithomyces</i> , <i>Drechslera</i> , smut spores, ascospores, basidiospores	4 days (hourly and daily)	T , p_r , RH, T_d , u , d , P

Fig. 2 Temporal extent and seasonality of Sydney *Alternaria* spore data

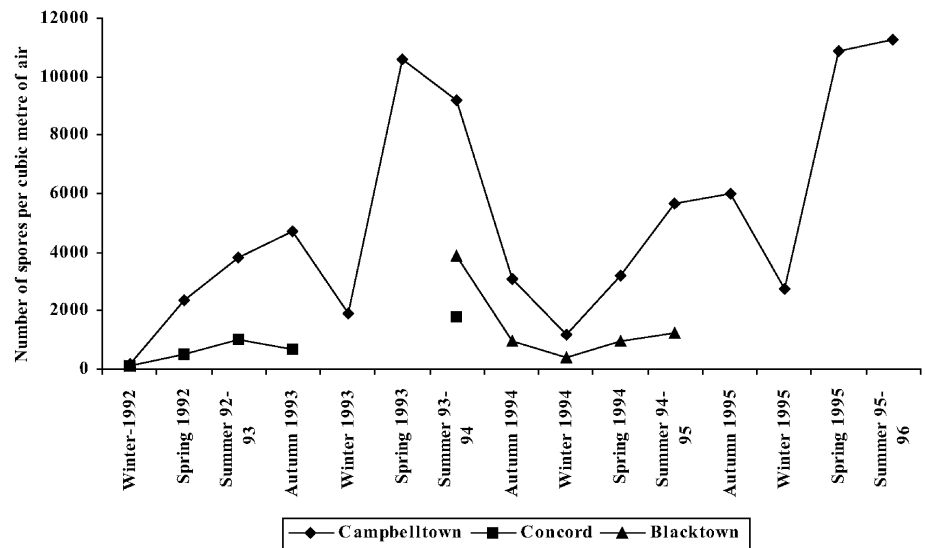
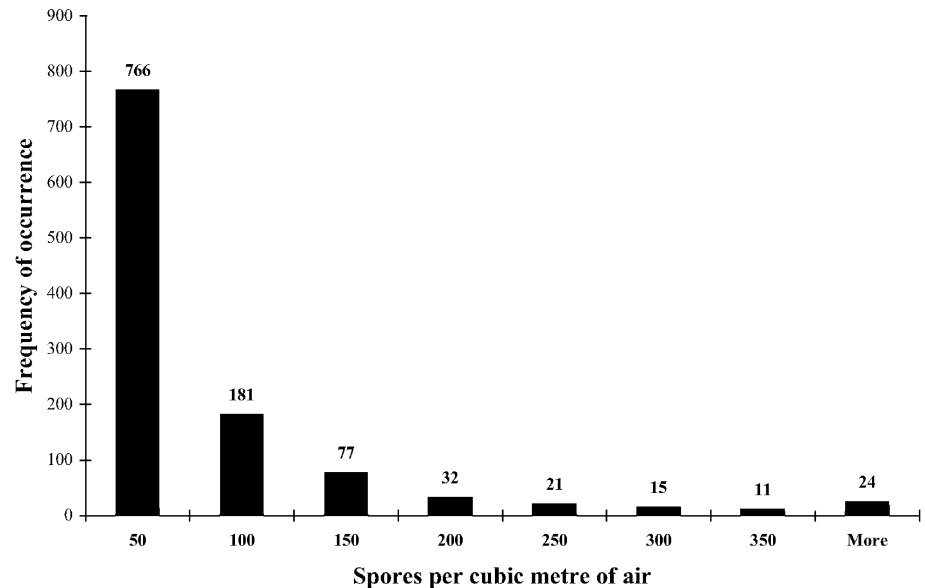


Fig. 3 *Alternaria* spore data frequency distribution, Campbelltown 1992–1995



tions was continuously sampled using Seven-day Recording Volumetric Spore Traps (Burkard Manufacturing). The adhesive-coated Melinex tape on which airborne particles had been impacted was sectioned, using the supplied perspex cutting block, into lengths representing the 7-day cycle. These were stained and mounted on microscope slides to be examined under the microscope. The number of *Alternaria* spores was recorded. Figure 2 shows the seasonal daily average concentration of *Alternaria* spores at the three Sydney locations. Only the longest and most complete data set (Campbelltown) was used in this study. Campbelltown is a satellite city on the south-western fringe of Sydney. It is located in an area of transition between the coastal plain and the foothills of the Blue Mountains (Fig. 1). The vegetation around Campbelltown is dry grassland with small trees on the ridges. There is ample evidence that the area is subject to bushfires and drought.

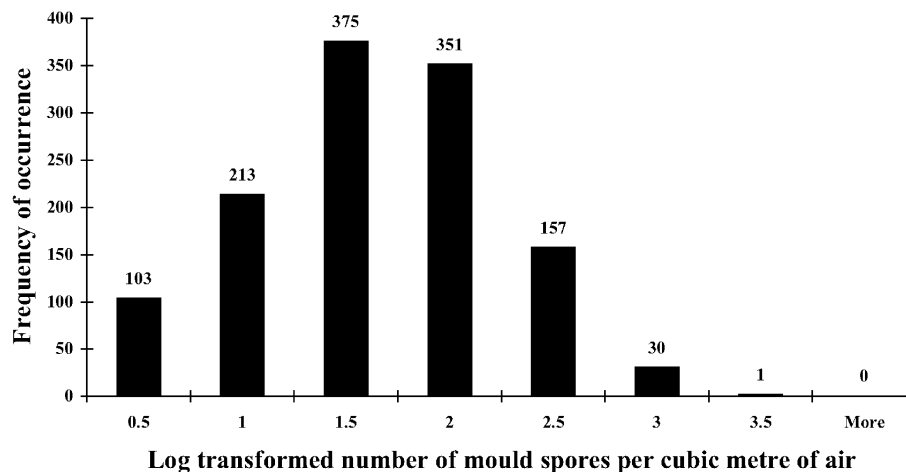
Meteorological data were obtained from the Australian Bureau of Meteorology. The data used in this study are from Bankstown Airport (elevation 6.5 m, Site Number 66137) which is the closest station to the study area that has data that is both comprehensive and relatively complete for the entire study period. The airport is located at a similar elevation and distance from the coast as Campbelltown, but about 10 km to the north. These data are from

3-hourly readings (midnight, 0300 hours, 0600 hours, etc.) except for rainfall which is reported as a daily total from 0900 hours on the previous day to 0900 hours on the day of the report. They include temperature, relative humidity, dew point temperature, atmospheric pressure, wind speed and direction, and rainfall. Daily maximum and minimum temperature were estimated from the data using all of the temperature data available for the day. On days where it was recorded that a reading represented several days rainfall, each day's rainfall was estimated by dividing the accumulated rainfall by the number of days of accumulation. The climate data are summarised in Table 1.

Analysis

Analysis was performed using the Minitab Statistical Package (Minitab 1998 v.12). A frequency plot of the data was produced to determine the statistical distribution that might best describe them. As has been found by other authors (Angulo-Romero et al. 1999; Burch and Levetin 2002; Strachan et al. 1990), the *Alternaria* spore data approximated an exponential distribution (Fig. 3). The association between the daily average spore concentrations and mete-

Fig. 4 *Alternaria* spore data frequency distribution after log transformation, Campbelltown 1992–1995



orological variables was explored by Spearman's rank correlation, as has been done by a number of authors (e.g. Calderón et al. 1997; Mitakakis et al. 1997; Munuera Giner et al. 2001; Rutherford et al. 1997; Sabariego et al. 2000). Lags between meteorological variables and *Alternaria* concentration of 1, 2, and 3 days were examined. Calderón et al. (1997) similarly examined lagged relationships, although only extending to a 1 day lag.

Following the example of Burch and Levetin (2002), stepwise regression was performed using the *Alternaria* spore data as the dependent variable with all the meteorological data as independent variables, in order to determine which of these variables, if any, explain the variation in the concentration of *Alternaria* spores in the atmosphere. Like Troutt and Levetin (2001) the daily averages in this study were logarithmically transformed to normalise the data. In order to eliminate zeros, 0.9 was added to each datum, as suggested by Strachan et al. (1990) (Fig. 4). Meteorological variables are not normally distributed so they were logarithmically transformed. Some data were no better when transformed and were used raw. These variables were further scrutinised to determine if any could be removed without significantly reducing accuracy. This would simplify the model.

Results

Table 3 presents a numerical description of the *Alternaria* spore concentration data for each season and over the

study period. Over the study period the mean, daily average concentration of spores per cubic metre was 61.5. The minimum was zero and the maximum was 1,125. The data covers 1,230 days, of which *Alternaria* spores were detected on 1,127 days amounting to 92% of days. The few days where *Alternaria* spores were not detected occur most frequently in winter. Figures 2 and 5 and Table 3 show clear seasonality, with peaks tending to occur spring through to autumn and lower concentrations during winter.

Table 4 summarises the result of the Spearman's rank correlation. Temperature and dew point temperature are most strongly and consistently associated with the concentration of *Alternaria* spores in the atmosphere of Sydney. The daily mean, minimum, and maximum of these variables (both on the same day and 1, 2, and 3 days previously) are significantly positively correlated with *Alternaria* concentration. A highly significant negative correlation was found between mean, minimum and maximum air pressure and *Alternaria* spore concentration, although this only occurred on the same day and with a 1 day lag.

Table 3 Numerical description of the *Alternaria* spore concentration for each season and over the study period

	Spring (SON)	Summer (DJF)	Autumn (MAM)	Winter (JJA)	Full study period
Number of days	364	301	276	289	1,230
Number of mould days	341	292	264	230	1,127
Number of zero days	23	9	12	59	103
Mean conc. (spores/m ³)	74.33	75.04	50.03	20.26	56.35
Median conc. (spores/m ³)	26.25	45.00	27.50	12.50	25.00
Mode conc. (spores/m ³)	7.50	27.50	25.00	0	0
Trimmed mean conc. (spores/m ³)	53.19	63.87	38.32	14.93	46.10
Standard deviation conc. (spores/m ³)	131.57	85.14	83.29	38.39	96.32
Standard error of the mean conc. (spores/m ³)	6.90	4.91	5.01	2.26	NA
Minimum conc. (spores/m ³)	0	0	0	0	0
Maximum conc. (spores/m ³)	1,125	575	957	457	1,125
Q1 ^a conc. (spores/m ³)	7.50	21.25	12.50	2.50	7.50
Q3 conc. (spores/m ³)	75.00	102.50	57.50	25.00	62.50
Total spores	27,057.5	22,587.5	13,807.5	5,855	69,308
Proportion	0.39	0.33	0.20	0.08	1

^a Q1 lower quartile, Q3 upper quartile

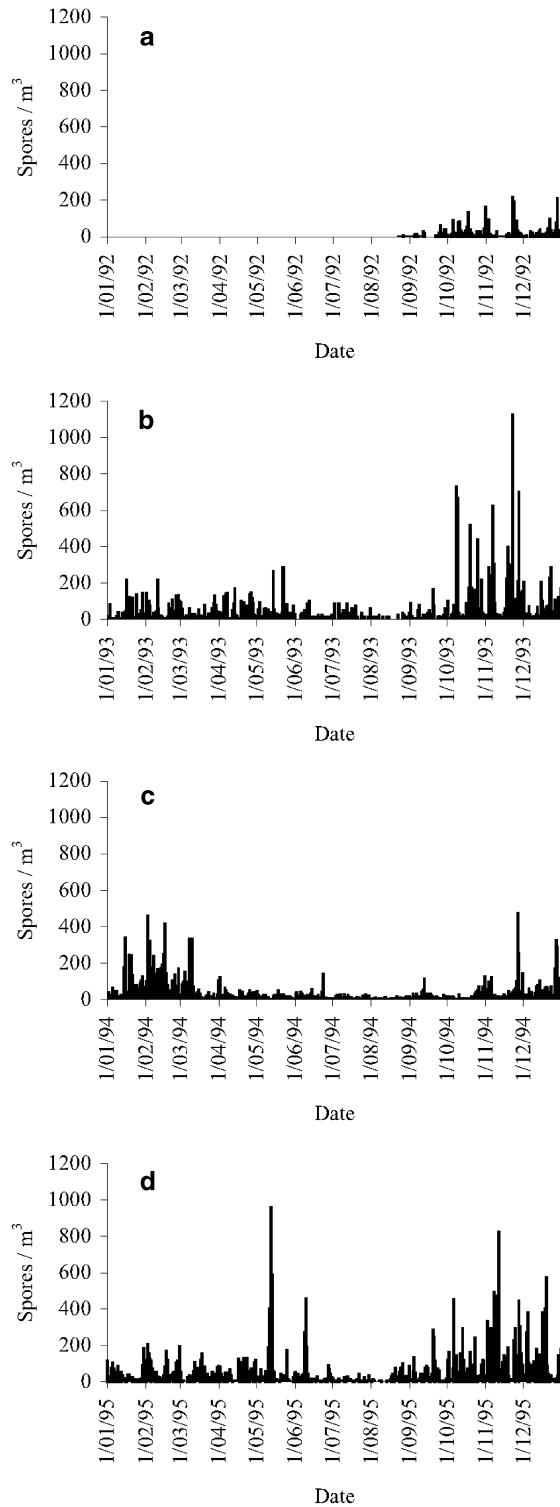


Fig. 5 Daily average *Alternaria* spore concentration, Campbelltown **a** 1992, **b** 1993, **c** 1994, **d** 1995. Date format is day/month/year

Associations with other variables appeared to be weaker and less consistent. Rainfall 2 and 3 days previously was positively correlated to *Alternaria* spore concentration. Similarly, relative humidity in the previous 1,

Table 4 Spearman's rank correlation matrix for *Alternaria* spore and meteorological variables. (T temperature, minimum, maximum, p_r rainfall, RH relative humidity, T_d dew point temperature, u wind speed, P air pressure, P -value * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$)

Variable	Same day	Lag 1	Lag 2	Lag 3
T	0.505 ***	0.431 ***	0.390 ***	0.375 ***
$T_{\min}$	0.327 ***	0.320 ***	0.318 ***	0.320 ***
$T_{\max}$	0.554 ***	0.429 ***	0.339 ***	0.312 ***
p_r	-0.020	0.055	0.075 **	0.093 **
RH	-0.040	0.125 ***	0.133 ***	0.122 ***
RH _{min}	-0.065 *	0.096 **	0.131 ***	0.128 ***
RH _{max}	0.105 ***	0.138 ***	0.088 **	0.080 **
T_d	0.377 ***	0.421 ***	0.412 ***	0.395 ***
$T_{d\min}$	0.318 ***	0.387 ***	0.388 ***	0.369 ***
$T_{d\max}$	0.411 ***	0.423 ***	0.407 ***	0.388 ***
u	0.003	-0.085 **	-0.019	0.043
$u_{\max}$	0.066 *	-0.042	-0.015	0.067 *
P	-0.287 ***	-0.141 ***	-0.044	-0.028
$P_{\min}$	-0.304 ***	-0.143 ***	-0.040	-0.028
$P_{\max}$	-0.281 ***	-0.158 ***	-0.066 *	-0.038

Table 5 Results of regression for *Alternaria* spore and meteorological variables. (T temperature, minimum, maximum, p_r rainfall, RH relative humidity, T_d dew point temperature, u wind speed, P air pressure, P -value * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$)

Variable	Same day	Lag 1	Lag 2	Lag 3
Coefficients				
T	0.03312*	0.04007*	0.03651*	0.02774
$T_{\min}$	0.011855	-0.005337	0.004735	0.013123
$T_{\max}$	0.01645	-0.00268	-0.01867	-0.01956
p_r	-0.005940*	0.002746	-0.000412	-0.001706
RH	-0.005329	-0.006270	-0.005821	-0.007511*
RH _{min}	-0.003861*	0.001809	-0.001272	-0.002062
RH _{max}	0.006707*	-0.002242	0.000272	0.003690
T_d	0.00955	0.05749*	0.02359	0.05583*
$T_{d\min}$	0.00598	-0.01571	-0.00490	-0.01463
$T_{d\max}$	-0.00558	-0.00992	0.02254	-0.00016
u	-0.012444	-0.025789*	-0.009335	-0.010001
$u_{\max}$	-0.002240	-0.001030	-0.002491	0.005581
P	0.04890	0.05104	0.05503	-0.00989
$P_{\min}$	-0.04051	-0.02075	-0.01250	0.01814
$P_{\max}$	-0.01849	-0.03635	-0.03870	0.00083
Analysis of variance				
F	36.81	23.71	18.60	17.24
R^2	31.3%***	22.7%***	18.7%***	17.6%***

2, and 3 days appeared to be positively correlated with *Alternaria* spore concentration. Maximum wind speed was positively correlated for the same day and for a lag of 3 days, while wind speed with a 1 day lag showed a significant negative correlation.

The regression results shown in Table 5 suggest a considerable amount of the variation in *Alternaria* spore concentration can be accounted for by meteorological variables. The R^2 value decreases going from the same day (31.3%) to a 3 day lag between the meteorological variables and *Alternaria* spore concentration. On the same day, four meteorological variables are significant, including mean temperature, rainfall, and minimum and maximum relative humidity. Temperature continues to be significant up to 2 days prior to *Alternaria* spore concentration. The only other variable reaching significance

more than once in the regression models is dew point temperature, which appears in both the 1 day and 3 day lag models.

Discussion

The existence of *Alternaria* spores in the atmosphere throughout the year is consistent with previous findings (e.g. Angulo-Romero et al. 1999; Munuera Giner et al. 2001). The seasonality displayed in Sydney also appears consistent with that found in other locations. Mitakakis et al. (2001) identified the peak period from early spring to late autumn, and late spring to summer, for two rural NSW locations. Mitakakis and Guest (2001) reported a peak in spring and summer, Asan et al. (2002) reported the peak during summer or early autumn, and Munuera Giner et al. (2001) reported a main *Alternaria* spore season extending from spring to mid autumn.

A strong positive relationship was found between *Alternaria* spore concentration and temperature. A similar finding has been reported in previous studies by, for example, Burch and Levetin (2002), Marchisio and Airaudi (2001), Angulo-Romero et al. (1999) and Sabariego et al. (2000) (for mean, minimum and maximum temperature), Corden and Millington (2001) and Mitakakis et al. (2001) (for maximum temperature), Troutt and Levetin (2001), and Munuera Giner et al. (2001) (particularly mean temperature). Similarly, the association between dew point temperature and *Alternaria* is consistent with the results of a number of previous studies (e.g. Burch and Levetin 2002), but is inconsistent with others that have found a negative relationship (e.g. Troutt and Levetin 2001).

Although the relationship between air pressure and *Alternaria* has not been examined as often as the relationship between a number of other meteorological factors and *Alternaria*, the relatively strong result for the same day and a 1 day lag in this study seems at odds with previously published results. For example, Burch and Levetin (2002) only found air pressure to be a significant parameter in their regression analysis of hourly spore concentrations on one of the four days examined. Further, the beta value was positive rather than negative. Troutt and Levetin (2001) did not find atmospheric pressure to be a significant parameter in their regression analyses.

Although rainfall 2 days and 3 days previously was positively correlated with *Alternaria*, the negative association for the same day in the regression results of this study is consistent with *Alternaria* being a dry-air spore, and some other studies (e.g. Angulo-Romero et al. 1999; Sabariego et al. 2000). Although Troutt and Levetin (2001) did not find a significant relationship between *Alternaria* and precipitation in their multiple regression analyses, they did find a 58% reduction in the number of *Alternaria* spores in a month with above average precipitation compared to a month with below average precipitation. Burch and Levetin (2002) only found a significant association with precipitation in their multiple

regression analyses of hourly spore concentrations on one of the four days and at one of the three locations studied, in both cases the association was positive. Similarly, Hjelmroos (1993) found *Alternaria* spore concentrations tended to increase with daily precipitation.

The wind speed results in this study appear contradictory. However, the negative correlation with a 1 day lag is consistent with the study by Munuera Giner et al. (2001) which found low wind velocities favoured high spore counts. Other studies have found no relationship with wind speed (e.g. Burch and Levetin 2002; Herrero and Zaldivar 1997; Sabariego et al. 2000) which is similar to other wind correlations in this study.

Weather does affect the concentration of *Alternaria* spores in the atmosphere of Sydney. It appears to account for about 31% of the variation encountered in this study. The R^2 value of the regression models was similar to that found by other studies. Burch and Levetin (2002), for example, found 36.6% of the variation in *Alternaria* was explained in a regression model with three independent variables (temperature, dew point temperature, and air pressure). Some of the unexplained variation in the prevalence of mould spores may be due to the presence of spores that have originated at locations remote from the sampling site, perhaps days or weeks earlier (Hirst 1953). It may be necessary to consider large-scale weather patterns to detect possible remote sources of mould spores so the model can be refined. Nevertheless, there is potential for the results of this study to be used by public health authorities in the prediction of *Alternaria* spore levels in Sydney.

There is scope for further research on aeroallergens in the atmosphere of Sydney. If the data became available, it would be useful to consider other types of spores or to look at the concentration of *Alternaria* spores in the atmosphere over a much longer time period. It is also important for relationships between pollen concentrations and meteorological factors in Sydney to be examined.

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