



Long-term trends and regional variation in the aeroallergen *Alternaria* in Cardiff and Derby UK – are differences in climate and cereal production having an effect?

Julie M. Corden^{1,*}, Wendy M. Millington¹ & John Mullins²

¹Midlands Asthma and Allergy Research Association, Derby, UK; ²Sully Hospital, Penarth, Cardiff, UK

(*author for correspondence: 12 Vernon Street, Derby, UK DE1 1FT; Phone: +44 (0) 1332362461; Fax: +44 (0) 1332362462; E-mail: jmcmaara@maara.org)

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Abstract

Alternaria is a known aeroallergen, being a risk factor in childhood and adult asthma. This study compared 1970–1996 daily records of *Alternaria* spores in Cardiff and Derby, two very different regions of the UK. There has been a dramatic upward trend in the seasonal total for Derby *Alternaria* spores whereas in Cardiff the trend is downwards. On certain days in recent years Derby *Alternaria* spore counts have exceeded 1000 spores per cubic metre of air, but in Cardiff such very high counts have not occurred since 1970. Derby *Alternaria* spore levels were most positively correlated with wind from the SE (over large stretches of arable land), whereas in Cardiff the most positive correlation was with wind from the north (over grassland). In Derby the increase in cereal production, together with higher midsummer temperatures, could account for the rising *Alternaria* counts. This upward trend in Derby is expected to continue whereas in Cardiff the coastal position together with the small amounts of arable production ensure *Alternaria* spore levels will remain low. The comparison between these two sites highlights regional differences in the numbers of airborne *Alternaria* spores and confirms the importance of maintaining long established sites. In Derby these results have implications for *Alternaria* sensitive patients as very high counts could trigger an asthma attack.

1. Introduction

Alternaria is an extremely common and widespread saprophyte, often found on cereal crops. In Cardiff, Hyde and Williams (1946) found *Alternaria* spores were especially prevalent in the air at harvest time and in Derby very large numbers are found during August and September (Corden and Millington 2001), the main harvesting period. *Alternaria* spores have been known to trigger asthma for over 70 years (Hopkins et al. 1930) and are a known risk factor in childhood and young adult asthma (O'Hollaren et al. 1991; Tariq et al. 1996). Targonski et al. (1995) found the risk of asthma-related deaths is more than doubled when there is a high incidence of mould spores and a recent study by Newson et al. (2000) indicated asthma epi-

demics in the Trent region of the UK were about ten times more likely on a day with a high mould count with significant associations (at the 5% level) with *Alternaria* when analysed with a 1 day lag. Also a cross sectional study from a European Community respiratory health survey found sensitisation to *Alternaria alternata* is a powerful risk factor for severe asthma in adults (Zureik et al. 2002).

This comparative study of a coastal (Cardiff) and landlocked (Derby) area of the UK is especially interesting as previous studies in New South Wales, Australia (Peat et al. 1995) have identified higher *Alternaria* sensitisation inland rather than in coastal areas. Only *Alternaria* in the outdoor air was considered, as Mitakakis et al. (1998) and Stern et al. (1999) showed only very small numbers of *Alternaria* penetrated

houses from outside, especially when the houses were double-glazed. The increasing upward trend found in Derby *Alternaria* levels was possibly associated with changes in climate and cereal production (Corden and Millington 2001) and this study was instigated to see if this upward trend was happening in another part of the UK.

2. Materials and methods

Cardiff is the largest city in Wales (population 309,400) being only 2.4 km from the sea whereas Derby is the third largest industrial city in the East Midlands (population 230,000) situated more than 100 km from any coast (Figure 1) and surrounded on three sides by large areas of arable farming. Volumetric spore traps (Hirst 1952) have been used to monitor spores at Cardiff (1954–1996) and Derby from (1970 onwards). The Derby volumetric spore trap in a suburb, is sited 10m above ground level, 106 km from the sea at an altitude of 110 metres, with a meteorological station 0.5 km from the trap site. Whereas, the Cardiff trap is at an urban site 2.4 km from the sea, 13 metres above ground level at an altitude of 26.7 metres with a meteorological station 3 km from the trap site.

Daily average June to October *Alternaria* spore concentrations were used and seasonal totals were calculated for each year and plotted to assess any long-term trend. As Derby data is still being routinely monitored, Derby data was considered up to and including 2001. Cardiff ceased monitoring in 1997 so data was only available until 1996. Monthly *Alternaria* totals and spore level frequencies were also studied for all years and from the seasonal totals, the start, end and duration of season were calculated. The method used was that defined as the date by which 2.5% of the total June–October spore census for the year was trapped. This method has previously been used with Derby *Alternaria* (Corden and Millington 2001). The duration of the season is the difference between the start and the end of the season. Trends for seasonal total, start, end, and duration of season were calculated and plotted. All *Alternaria* spore counts of 100 spores or more per cubic metre of air were recorded as well as the peak days each year. Seasonal, monthly and daily mean concentrations of *Alternaria* spores were compared with meteorological data and selected statistical analyses were carried out.

Information about the agricultural use of the areas in the vicinities of the sites (within an area of 50–

100 miles) was obtained from the yearly volumes of the Digest of Agricultural Statistics for England and Wales (1963–1996). Special emphasis was placed on the amount of arable land within the catchment area of the sites and in the case of the Cardiff site agricultural use was included across the Bristol Channel as the prevailing wind is from the south west so the *Alternaria* spores from the area across the estuary could contribute to the total catch under certain meteorological conditions.

3. Results

The seasonal (June–October) *Alternaria* spore concentration in Derby from 1970–1996 showed a distinct upward trend whereas in Cardiff the trend was downward (Figure 2). The Derby trend became more dramatic when data from 1990–2001 was considered (Figure 3). Yearly peak values were nearly always higher in Derby than Cardiff for the period under study (Figure 4), the highest daily Derby *Alternaria* spore count occurred in 1996 whereas the yearly peak value was at its highest in Cardiff in 1970. The *Alternaria* start date using the 2.5% method is getting earlier in Derby whereas there was no start date change in Cardiff (Figure 5). Cardiff showed a decreasing number of days with counts of 100 or more spores per cubic metre (Figure 6) and no counts of 1000 or more after 1971 but in Derby the number of days when the *Alternaria* count was above 100 spores or more increased (Figure 6) and latterly there were more days over 1000. There was much greater monthly variation in Derby than Cardiff (Figure 7) in fact there was very little monthly variation in Cardiff. In 1976, a drought year, the majority of Derby *Alternaria* spores were found in June, whereas in 1996 the “bumper” month was September, however the bulk of Derby *Alternaria* spores were usually trapped in August. There were no *Alternaria* spores in the Derby October 1976 air (a drought year) but 1200 in October 1996.

In Cardiff *Alternaria* spore counts were most positively correlated with wind from the north (mostly over grassland), the proximity to the sea reducing spore numbers, whereas Derby *Alternaria* spore levels were most positively correlated with wind from the south east, when the wind was coming over large stretches of arable land (Table 1). Cardiff August rainfall was much higher than at Derby, for instance the mean 1993–1997 August rainfall was almost three times greater in Cardiff than in Derby (Table 2).



Figure 1. A map of the UK showing the position of Cardiff and Derby.

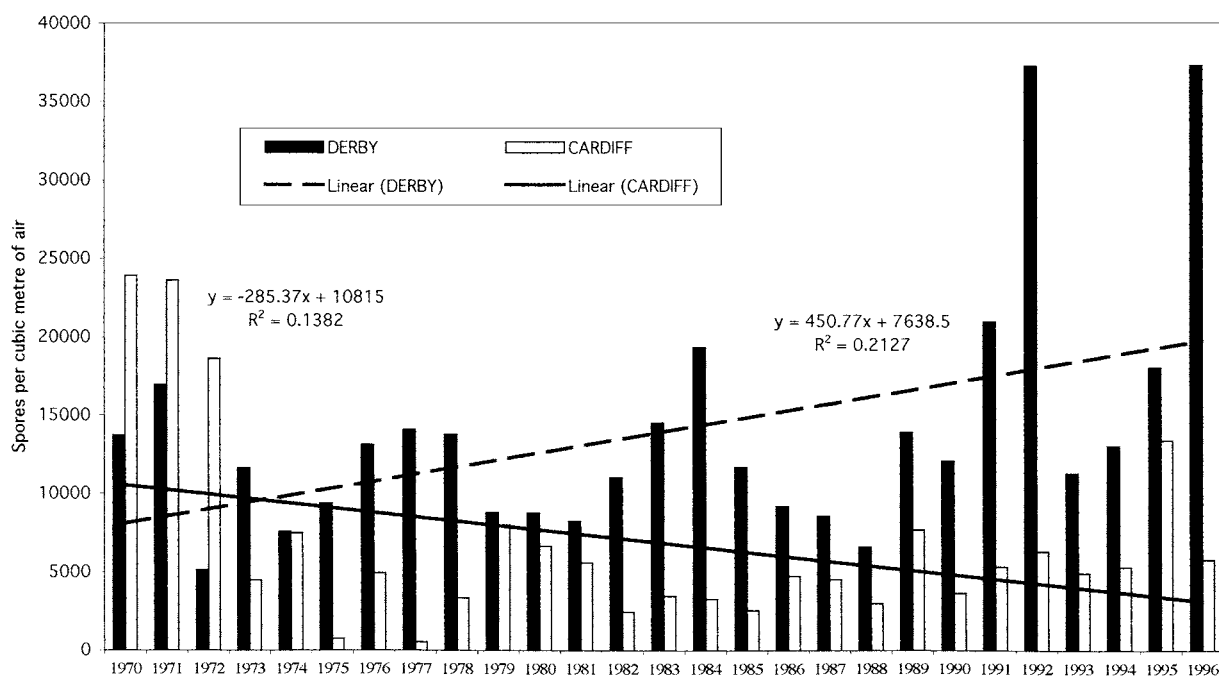


Figure 2. Seasonal (June–October) Derby and Cardiff *Alternaria* spore totals with trend lines 1970–1996.

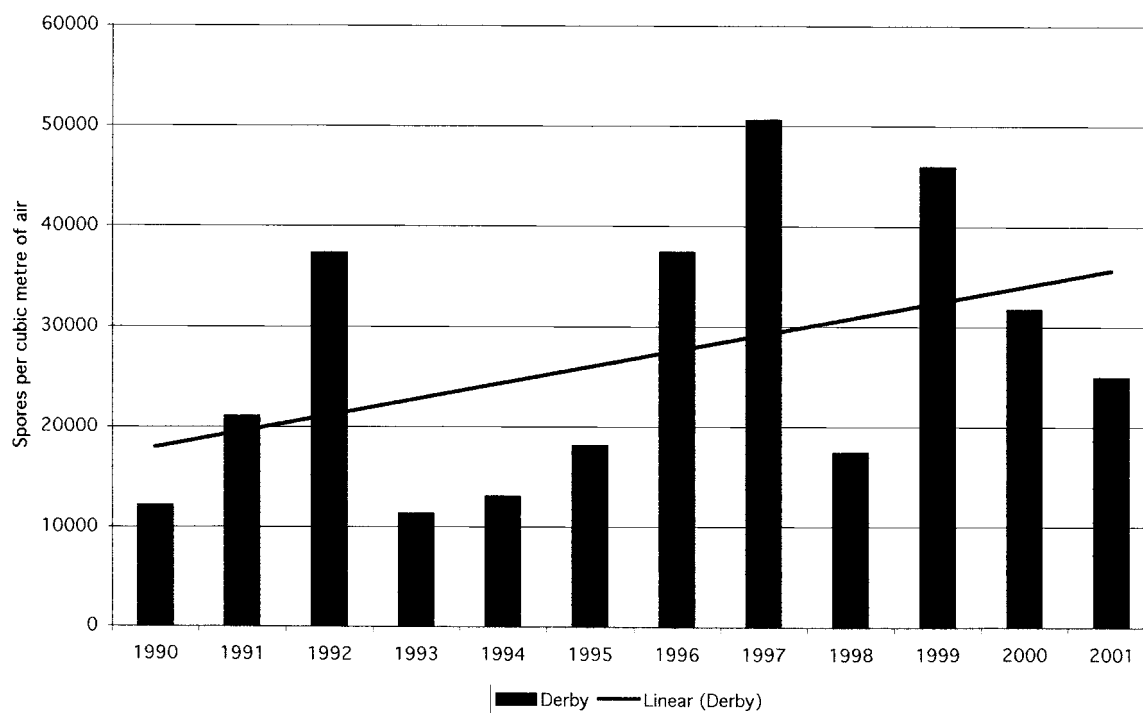


Figure 3. Seasonal (June–October) Derby *Alternaria* spore totals with trend line 1990–2001.

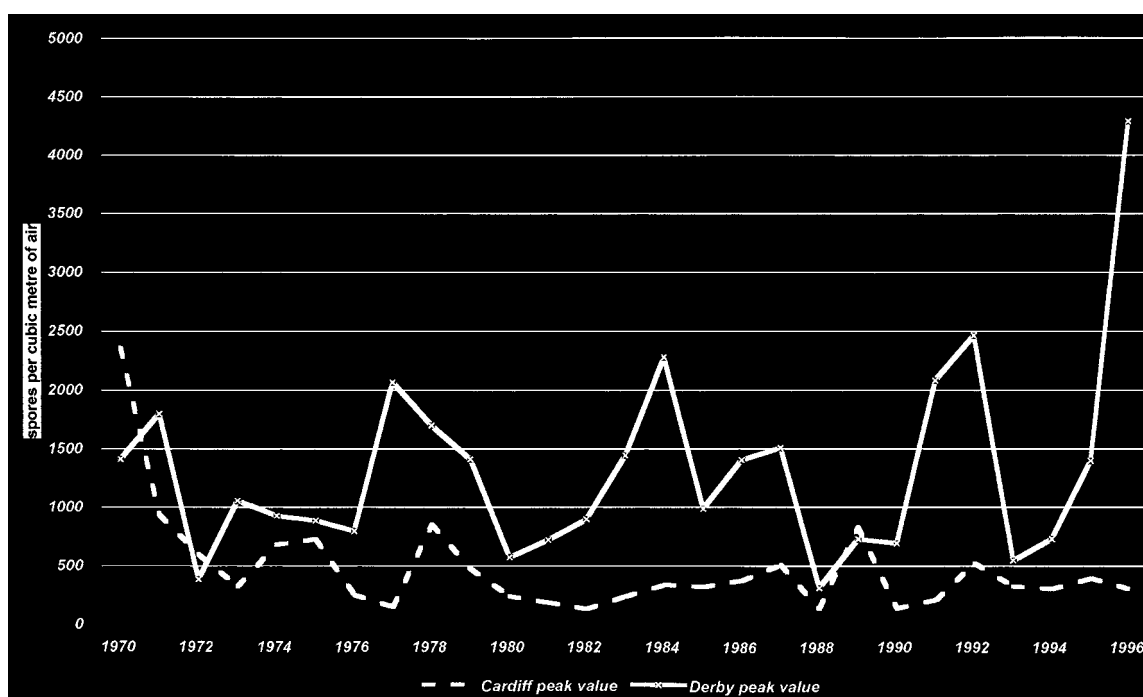


Figure 4. The Cardiff and Derby yearly peak values for *Alternaria* spores 1970–1996.

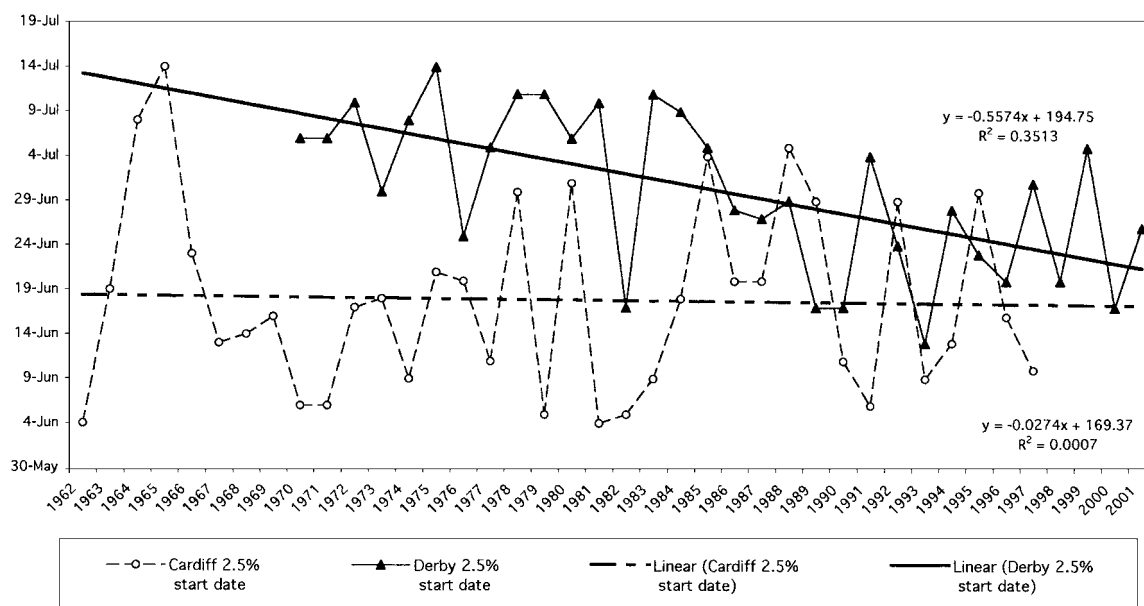


Figure 5. The Cardiff and Derby 2.5% start dates for *Alternaria* spores 1970–1996.

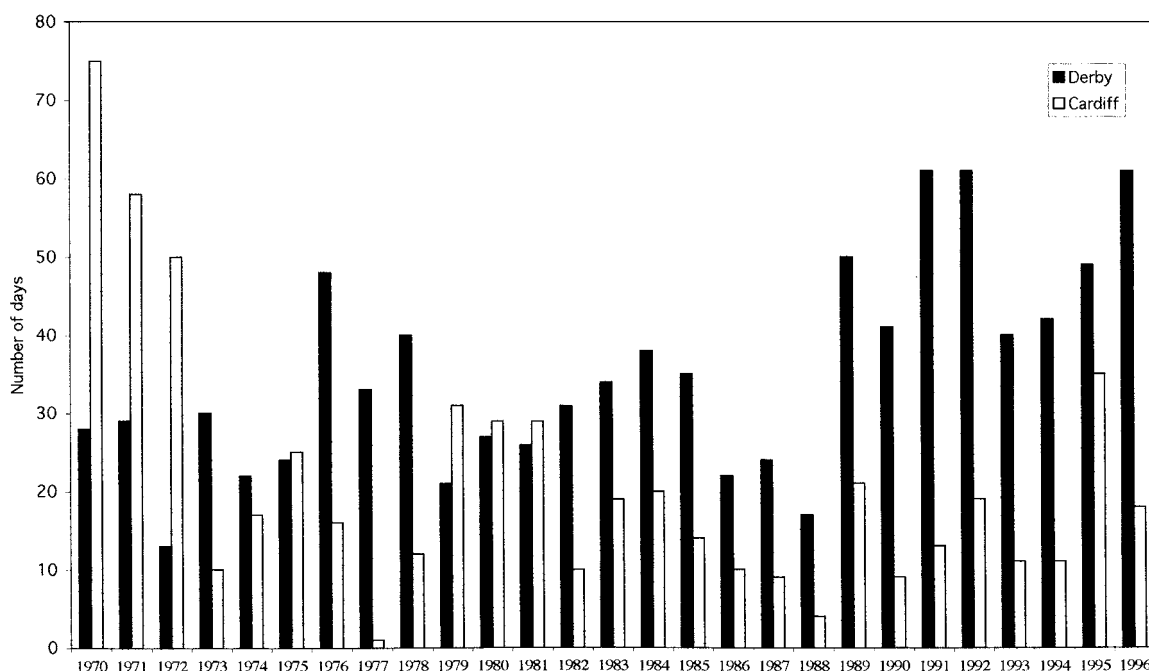


Figure 6. Number of days in Cardiff and Derby with 100 or more *Alternaria* spores per cubic metre of air from 1970–1996.

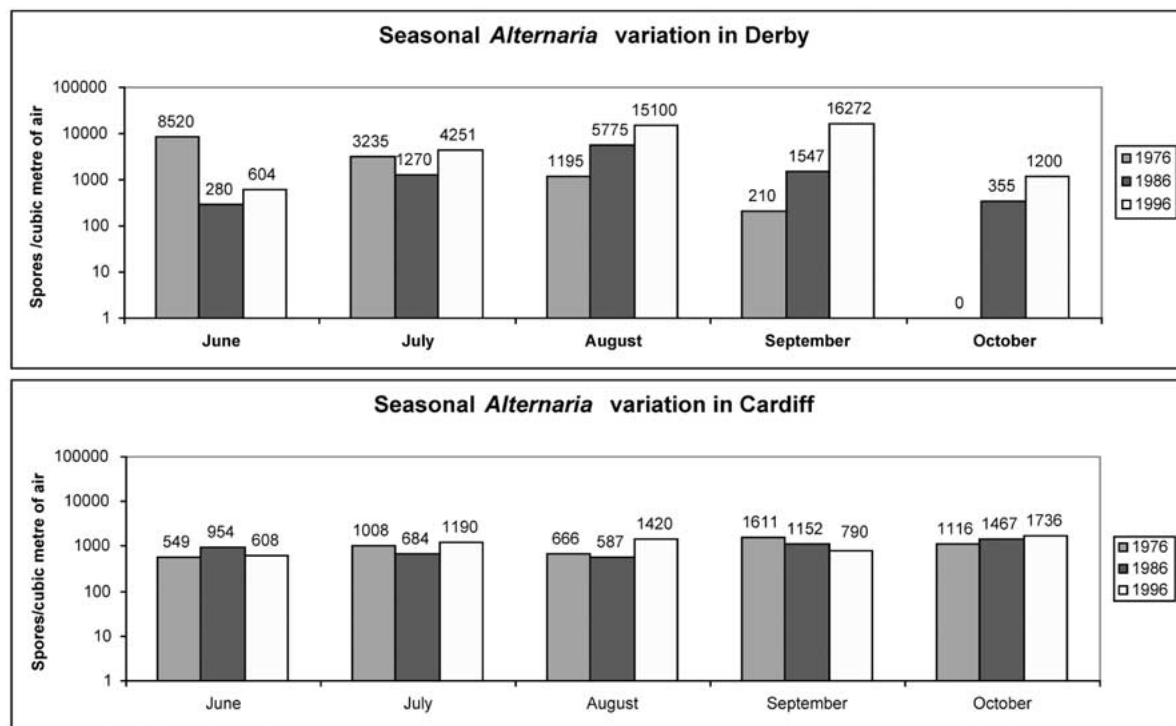


Figure 7. Monthly *Alternaria* spore variation in Cardiff and Derby.

Table 1. Cardiff and Derby wind direction correlations with *Alternaria* spores in August

Wind direction	Derby	Cardiff
N	-0.59	0.85
NE	0.05	-0.82
E	0.04	-0.74
SE	0.85	-0.46
S	0.80	0.67
SW	-0.41	-0.17
W	-0.37	0.36
NW	-0.30	0.23

Table 2. A comparison of August rainfall in Cardiff and Derby 1993–1997

Year	Cardiff	Derby
1993	53.3	42.1
1994	85.1	30.6
1995	85.1	9.4
1996	126.4	43.5
1997	249.1	99.1
Total 1993–1997	602.6	224.7
Mean 1993–1997	120.52	44.94

Agricultural statistics for 1976–1995 show a decrease in crops and grassland in England and Wales (Table 3). When comparing the year 1980 with 1995, there was a slight increase in grassland in both England and Wales. However, in the East Midlands region (which includes Derby), the arable percentage of crop and grassland in 1995 was 71%, the difference in the arable percentage between Wales and the East Midlands being 54% (Digest of Agricultural Statistics). Also there has been a decrease in agricultural area

in the East Midlands for the period 1963–1996 but there has been a 9% increase in cereals (Shackley et al. 2001).

4. Discussion

Hyde and Williams (1946) investigating *Alternaria* levels in Cardiff, said *Alternaria* spores were present in large numbers throughout the late summer especially during harvest time and they postulated that

Table 3. Crop and grass agricultural statistics for England and Wales

Agricultural statistics			
Crops and grass for England and Wales (hectares)			
1976–1977	9,552,217		
1995	8,675,156		
1980	Arable	Grassland	Crops and grass
England	5,349,628	3,064,331	8,413,959
Wales	264,682	854,086	1,118,768
1995	Arable	Grassland	Crops and grass
England	4,596,678	3,679,547	8,276,225
Wales	205,773	1,037,116	1,242,889
East Midlands	788,852	324,963	1,113,815
Arable percentage of crop and grassland in 1995			
Wales	17%		
England	56%		
East Midlands	71%		

asthma attacks were more likely in the late summer especially near wheat fields or wheat threshing whilst Buisseret (1976) said *Alternaria* was the commonest fungal spore to cause seasonal allergy in the late summer and early autumn. In Cardiff and Derby the three main months for *Alternaria* spore release are July, August and September, which are the main months for combine harvesting. The East Midlands region of the UK is an area of high arable production (Digest of Agricultural Statistics), so it is to be expected that Derby *Alternaria* spore concentrations will be greatly increased during harvesting. Friesen et al. (2001) estimated that wheat harvesting liberated immense numbers of fungal spores into the air many of which are carried long distances in wind currents. As *Alternaria* is a saprophyte living on most vegetation, the volumes of dust generated by combine harvesters will include enormous numbers of *Alternaria* spores, which will be dispersed over a wide area. In Derby wheat is harvested in August followed by spring rape in September and linseed in October/November. Corden and Millington (2001) postulated that the present increase in harvesting duration and the milder weather in the autumn and winter might result in higher levels of *Alternaria* spores in the air and associated increases in asthma and allergic rhinitis. For over 70 years it has been known that spores of the genus *Alternaria*

cause asthma (Hopkins et al. 1930; Frankland and Davies 1965; Licorish et al. 1985; O'Hollaren et al. 1991; Tariq et al. 1996). Last (1955) found high concentrations of *Alternaria* spores within the crop of a wheat field and Sreeramulu (1958) described a four fold increase in the concentration of *Alternaria* spores associated with mowing grass. Also McCartney and Lacey (1992) found *Alternaria* spores were released from an oilseed rape crop in the daytime and Corden and Millington (2001) observed that bursts of *Alternaria* occur during periods of grass mowing, and at harvest time, especially when the weather has been warm and dry. In the USA the greatest number of *Alternaria* spores are found in grain growing areas such as the Midwest (O'Hollaren et al. 1991) and children in Australia had greater *Alternaria* sensitisation when they lived in the drier inland regions (Peat et al. 1995), whilst in rural Australian towns *Alternaria* spore levels were directly influenced by spore concentration in the wheat crop outside the towns (Mitakakis et al. 1998).

The annual mean temperature over Central England showed a warming trend of +0.6% between 1901 and 1998. The 6 warmest years of the 20th century in Central England have occurred in 1989, 1990, 1995, 1997, 1998 and 1999. Relative to 1961–1990 these years were 0.9–1.2°C warmer than average, the warming was greatest from midsummer to late autumn. This temperature increase, (+0.8°C in July, +1.2°C in August and +0.9°C in September) coincided with the dramatic increase in Derby *Alternaria* spores and since the 1930s annual precipitation in Central and Eastern England has increased slightly by +3% (Shackley et al. 2001). Corden and Millington (2001) thought that an increase in cereal production along with a temperature increase could account for the rising *Alternaria* counts in Derby, and they had evidence that during dry weather occasional rainfall results in higher monthly *Alternaria* spore concentrations. However, in Cardiff the small amount of arable production together with its coastal position has ensured *Alternaria* spore levels are low and are often below the allergenic threshold. Frankland and Davies (1965) suggested a threshold level of 50 *Alternaria* spores per cubic metre of air but other researchers have taken the threshold level as 100 or more spores per cubic metre of air (Graveson 1979). There are many days in Derby with over 100 *Alternaria* spores per cubic metre and an increasing number of days over 1000 spores per cubic metre since 1990. Targonski et al. (1995) suggested that the risk of asthma

related deaths was increased 2.16 times when the total mould count was 1000 spores per cubic metre or above as *Alternaria* is known to be a high risk factor for severe asthma with resulting hospitalisation (O'Hollaren et al. 1991). The climate changes and associated increases in East Midland arable production indicate that *Alternaria* could cause severe asthma especially during harvest time in arable areas of the UK. It is highly likely that people working at ground level especially close to crops or combine harvesters are exposed to far higher counts than are recorded at roof top height as Hjelmroos (1993) said *Alternaria* was under represented at roof level. Zureik et al. (2002) suggested fungal spores may be inhaled as fragments and other amorphous bio aerosols, and the fragmentation of *Alternaria* observed by Corden and Millington (2001) is likely to be increased during combining or mowing, making entry into the lung relatively easy, although Licorish et al. (1985) suggested that with vertical presentation the spore had a diameter small enough to allow it to easily enter the lungs. Fewer people are allergic to fungal spores than to pollen, but as mould spores have been implicated as a major risk factor for fatal asthma attacks in Chicago USA (Targonski et al. 1995) the effect of climate change and associated arable production should not be ignored.

5. Conclusion

In Derby the increase in cereal production along with climate changes could account for the rising *Alternaria* counts. This trend is expected to continue. However in Cardiff the coastal position together with small amounts of arable production ensures *Alternaria* levels in Cardiff remain low.

This study indicates regional differences in *Alternaria* spore concentrations in the UK. *Alternaria* sensitive patients must be made aware that levels of *Alternaria* are likely to be much higher at harvest time in arable areas of the UK and may cause exacerbation of their asthma.

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