

An analysis of the possible effects of the 2001 foot and mouth disease epidemic on grass pollen concentrations in the Midlands, UK

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Abstract

The 2001 grass pollen season in the United Kingdom was notably severe. An epidemic of foot and mouth disease (FMD) occurred in the UK during February and spread through the country during the summer. The media claimed that the control measures of culling infected animals and the restricted movement of stock, led to reduced grazing allowing pastures to flower more than in previous years. This study aimed to examine whether the severity was due only to weather factors or if the control measures also contributed. Three pollen sites from the FMD-affected Midlands region were investigated and compared with two sites from regions unaffected for differences in pollen catches, culling levels and weather. The June pollen catch in the Midlands was particularly high but this pattern also features in areas such as Cambridge in the East that were minimally affected by the epidemic. In most of the catchment areas affected by FMD the quantity of animals culled was less than 10% of the total livestock. In areas where culling was concentrated we can assume that there would have been some localized affect on the pollen levels. The results show that the main influencing variable on the 2001 grass pollen counts in the Midlands was the weather and that culling due to the foot and mouth epidemic did not exert an important influence at the regional level.

1. Introduction

The 2001 grass pollen season in the United Kingdom was severe, particularly in June, with some of the highest counts occurring since records began. At the time, it was unclear whether the severity was due only to weather factors or if culling due to foot and mouth disease (FMD) contributed to higher grass pollen counts. An epidemic of FMD, the first since 1967, broke out in the north of the UK during February and spread through the country during the Spring and Summer, affecting much of the North and the West. Reports in the national media claimed that the control measures of culling and restricted movement led to reduced grazing allowing pastures to flower more than in

previous years, leading to a severe year for hay fever and asthma sufferers. However, the weather was particularly suitable for high pollen counts in much of the country with a wet Spring, a warm May and dry, warm weather in the middle of June when most species of grass are ready to disperse their pollen.

A number of studies have detailed the factors leading to increased pollen production in grasses, including those by Holmes (1989), Emberlin et al. (1993), Emberlin (1997, 2000). In the UK, wet weather is required in the Spring to help the grasses flourish and warm, wet weather during the formation of the anthers immediately before the onset of the flowering season will lead to high pollen production. For high grass pollen concentrations

during release and dispersal, warm, dry weather with light winds must coincide with the phase in which most grasses are flowering.

The FMD (*Aphthovirus* spp.) epidemic in 2001 was caused by the very virulent Pan-Asia O strain. One characteristic of the Pan-Asia O strain is that it produces very few lesions in sheep and the disease had become widespread before it was identified in diseased pigs in an abattoir (Davies, 2002). Airborne spreading of the disease was minor for this particular strain and it is believed that movement of stock around the country was the prime mechanism for dispersal in this epidemic (Gloster et al., 2004). FMD affects many animals but economically it is the effect on domestic livestock that causes concern. The grazing animals, cattle and sheep, were particularly affected in this epidemic. The government's response, in an attempt to halt the spread of the disease, was to restrict the movement of all grazing animals and to cull infected animals and those within a 3 km radius of infected premises. As a result, three million sheep, 600,000 cattle, 142,000 pigs, 2000 goats and 1000 deer were slaughtered. This study aimed to assess the relative contributions of the effects of culling and the exceptional weather on the severity of the grass counts in order to aid forecasting of pollen seasons.

2. Materials and methods

The main approach was to compare grass pollen counts from an area affected by FMD with those from an area of similar general climate that had not been affected. For each of the two types of area, amounts of culling were determined and the main weather variables of mean maximum temperature and rainfall and grass pollen data were obtained. Grass pollen concentrations in the chosen areas were also compared over a 5-year period to assess the relative severity of the 2001 season. The corresponding weather data was analysed for variability over the 5-year span.

The Midlands was examined as an area widely affected by FMD culling. This region has some of the highest grass pollen counts in the UK. The daily pollen data (pollen grains per cubic metre of air as daily average (pg/m^3)) for the Midlands were obtained from the UK National Pollen Network which uses Burkard Seven day volumetric spore traps and standard pollen-monitoring procedures

laid down by the British Aerobiology Federation (British Aerobiology Federation, 1995). Leicester, Worcester and Derby pollen monitoring sites were used from the Midlands and these were compared for within- and between-site variation in grass pollen severity and against two sites from minimally affected regions, Cambridge in the east and Edinburgh in south-east Scotland. The latitude and longitude of the sites are given in Table 1. Grass pollen total catches cover the period April 1st to July 28th for each site, being the period over which most of the pollen is released and for which enough comparable data could be obtained. The years 1999–2001 were used for the data comparisons as they were all considered to be severe years. The peak grass pollen count was determined for each site per year, the peak being the highest daily count of the season. The quantity of high and very-high count days and daily data for 2001 were also examined. A high count is determined as 50–150 pg/m^3 , very high is a count in excess of 150 pg/m^3 .

Pre-season and in-season rainfall and temperature (mean maximum temperature) data were considered for their impact on the 2001 grass pollen season and previous years were examined for comparison. Charts were prepared showing weekly mean maximum temperature and weekly rainfall totals for the summer grass pollen season for the three Midlands sites and for Cambridge. For the purposes of comparing weather patterns in affected and minimally affected areas, Edinburgh has not been included in the weekly weather comparisons because the effect of latitude means that the weather patterns differ greatly thereby affecting the pollen production patterns and quantities. Typically, Edinburgh's total pollen catch is much lower than the sites in the Midlands and at Cambridge.

Statistics and information on the foot and mouth epidemic were obtained from the website of

Table 1. The latitude and longitude of the pollen monitoring sites used in the analysis

Pollen monitoring site	Latitude	Longitude
Cambridge	52° 12' N	00° 07' W
Derby	52° 55' N	01° 29' W
Edinburgh	55° 56' N	03° 12' W
Leicester	52° 37' N	01° 07' W
Worcester	52° 11' N	02° 14' W

DEFRA and the DEFRA e-mail helpline. The number of sheep and cattle slaughtered were calculated as percentages, for each county, based on figures from the June 2000 agricultural census. The area of farmland used for grassland and grazing for each county were also obtained from the June 2000 census.

3. Results

3.1. Culling levels

The percentage of cattle and sheep that were culled for each of the counties during the epidemic show considerable differences (Table 2). The majority of the counties of the West Midlands, including Herefordshire, Worcestershire, Cheshire, North Gloucestershire, Staffordshire and Shropshire, were the worst affected (Figure 1). North Gloucestershire had the highest culling levels with 29% sheep culled and 21% cattle. However, most counties had culling levels below 10% of the June 2000 census stock figures. The counties of the East Midlands, Nottinghamshire, Leicestershire, Derbyshire and Northamptonshire had very low numbers of animals culled. Similarly, Cambridgeshire was a minimally affected area with only 0.4% of sheep and 1.3% of cattle culled. In the Midlands as a whole, culling occurred in April and early May and 136 farm and small-holding premises were infected, compared to 2026 nationwide.

The area of farmland used for grass and grazing differs between counties. Derbyshire has 75.2% of farmland used for grass and grazing, whereas in Cambridgeshire it is only 9.0%. Although counties are not directly comparable because they differ in size, it is clear that a small county with a high percentage of farmland devoted to grass and grazing would have received a relatively greater impact from the culling.

3.2. Meteorological factors

The histograms for weekly mean maximum temperature and for rainfall totals in 2001 at the Midlands sites and Cambridge (Figures 2 and 3) show a similar pattern for the four sites, with a cool and showery start to June and then a warm, dry period in the third and fourth weeks. Derby is located in a more northern latitude than the other sites with correspondingly lower weekly mean maximum temperatures. July was cooler and more showery for the first 3 weeks and then warm and dry in the last week but most of the pollen would have been dispersed by that time.

Taking Worcester and Cambridge as examples of meteorological variation over the last 3 years (Figures 4–7), it is apparent that the 2001 weather was drier and warmer than the previous 2 years at Worcester, during the peak pollen production weeks of June. At Cambridge, the middle of June 2000 was actually 1.5 °C warmer on average than 2001. However, the last week of June 2001 was

Table 2. Culling levels and land-use information for the Midlands and Cambridgeshire

County	Sheep culled (%)	Cattle culled (%)	Total area farmland (ha)*	% farmland used for grass and grazing
Cambridgeshire	0.4	1.3	279,342	9.0
Cheshire	8.3	2.5	155,956	69.5
Derbyshire	1.2	1.3	176,883	75.2
Herefordshire	8.0	5.2	175,545	50.6
Leicestershire	2.0	0.8	187,341	36.3
North Gloucestershire	29.0	21.0	N/A	N/A
Northamptonshire	2.3	0	186,696	30.8
Nottinghamshire	0.4	0	150,446	19
Shropshire	11.4	4.5	273,948	53.2
Staffordshire	18.0	5.6	184,486	61.9
Warwickshire	1.2	2	151,399	35.7
West Midlands County	4.7	0.2	13,794	50.6
Worcestershire	8.6	4.9	121,245	46.6

N/A : Not Applicable.

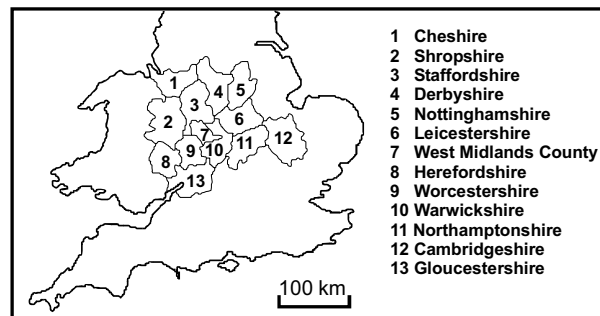


Figure 1. The counties of the UK used in the analysis.

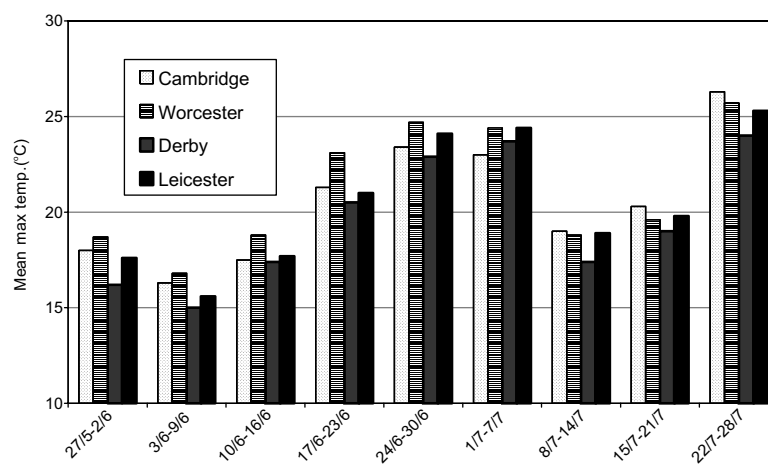


Figure 2. Weekly mean maximum temperature (°C) at Cambridge, Worcester, Leicester and Derby in the main grass pollen season of 2001.

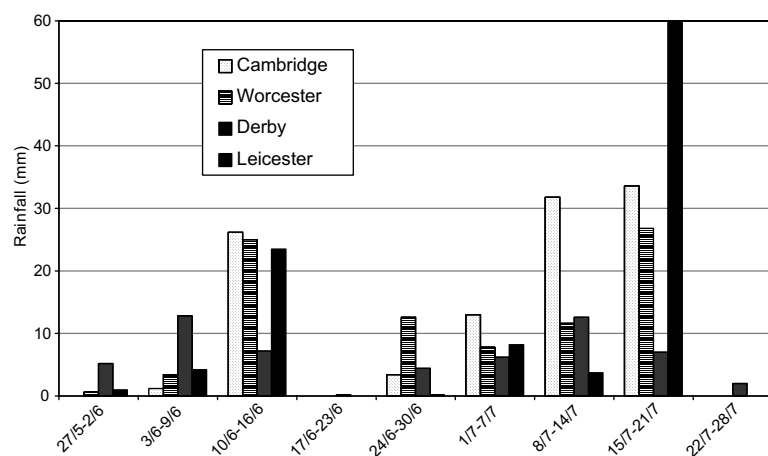


Figure 3. Total weekly rainfall (mm) at Cambridge, Worcester, Leicester and Derby in the main grass pollen season of 2001.

5.5 °C warmer than the same period in 2000. The first half of June was generally cooler at both locations in 2001 than the previous 2 years and July was wetter.

3.3. The pollen concentrations

The 3-year period up to and including 2001 saw an upward trend in total grass pollen catch (Figure 8)

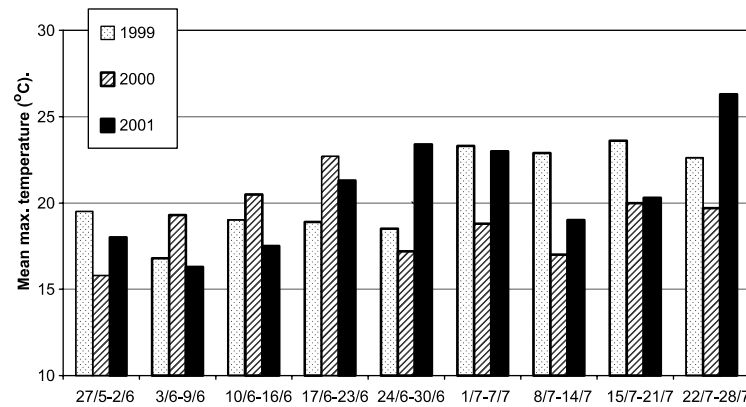


Figure 4. Weekly mean maximum temperature (°C) at Cambridge (Andrewsfield MET site) 1999–2001.

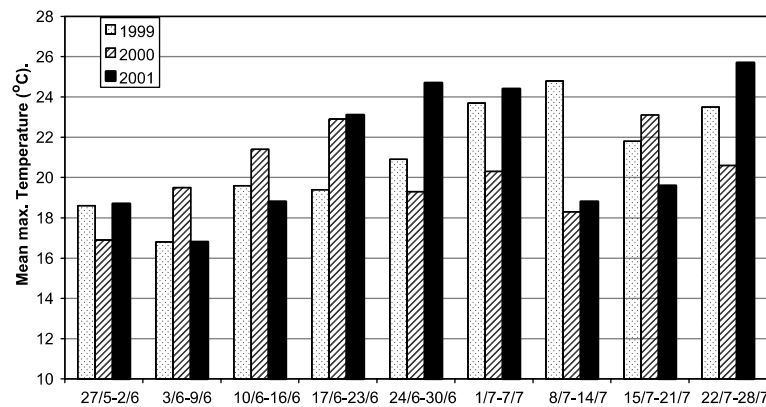


Figure 5. Weekly mean maximum temperature (°C) at Worcester during the main grass pollen season, 1999–2001.

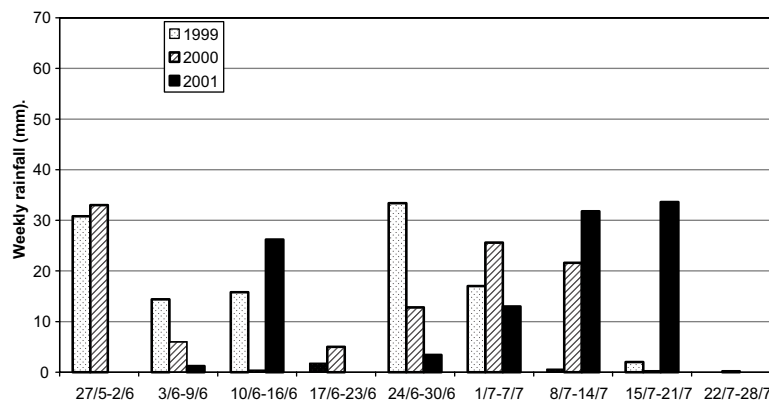


Figure 6. Weekly rainfall totals (mm) for Cambridge (Andrewsfield Met. Site) during the main grass pollen season, 1999–2001.

at all sites except Leicester. The year 2001 was severe at all sites in terms of total pollen catch, including those that were minimally affected by FMD. The overall magnitude of the grass pollen catch differed greatly between regions with Edin-

burgh having a grass pollen catch of 2119 grains and Derby attaining almost 8017 grains. Peak pollen counts (Figure 9) show a similar trend to that of the total pollen catches over the 3-year period except that Leicester follows the trend in

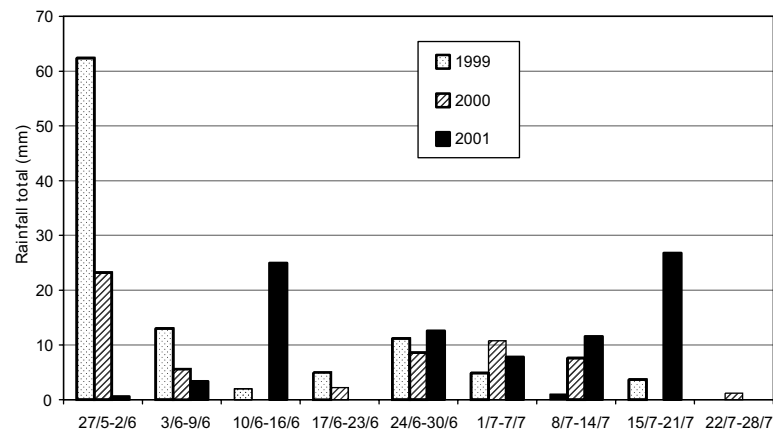


Figure 7. Weekly rainfall totals (mm) for Worcester during the main grass pollen season, 1999–2001.

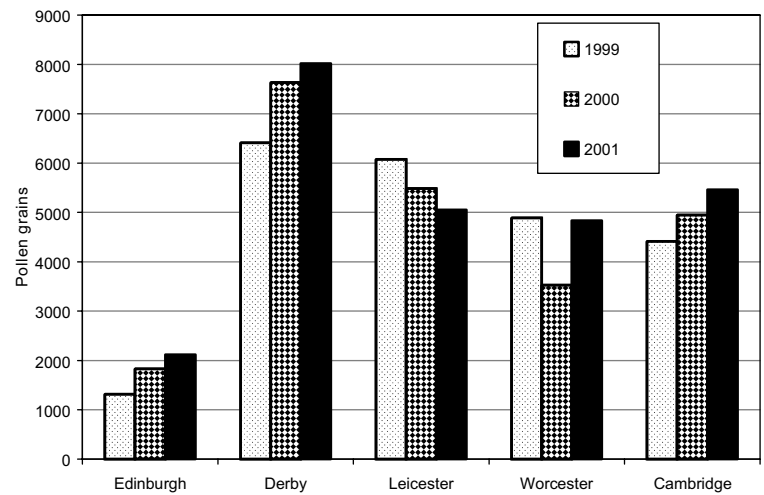


Figure 8. Total grass pollen catch (grains) at pollen sites in the Midlands and minimally affected regions, 1999–2001.

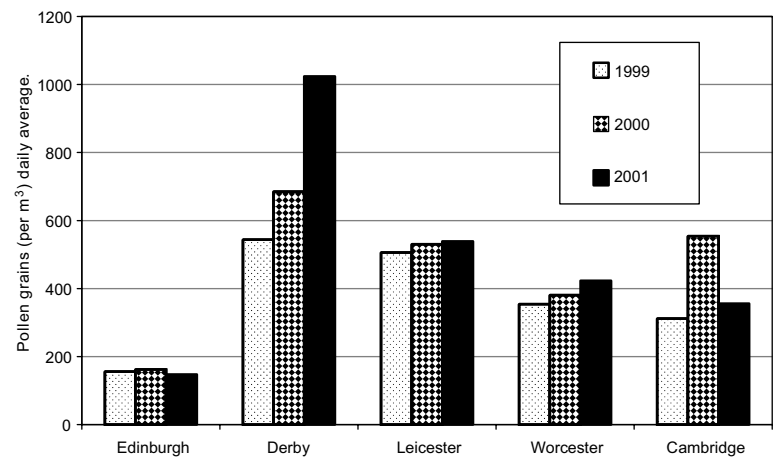


Figure 9. Peak daily count (pg/m^3) at pollen sites in the Midlands and minimally affected regions, 1999–2001.

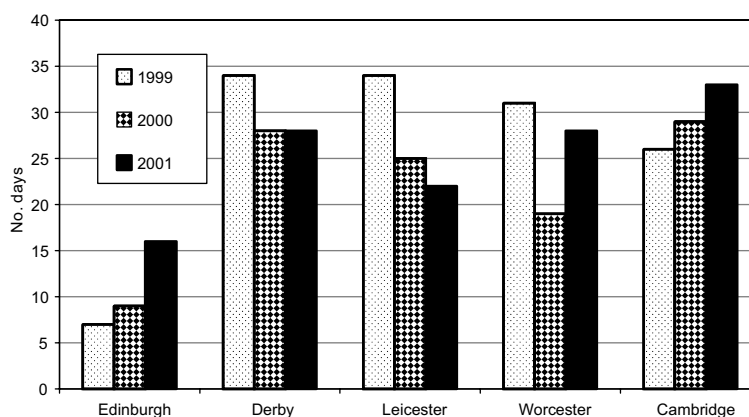


Figure 10. Number of high and very high count days at pollen sites in the Midlands and minimally affected regions, 1999–2001.

this case and Cambridge had a lower peak than in 2000. Derby attained an unusually high peak daily count in 2001 of 1024 grains.

The two sites in the minimally affected areas show a marked increase in the number of high-count days in 2001 over the previous years, whereas those in the Midlands indicate that 1999 was a more severe year in these terms (Figure 10). The number of high-count days in Cambridge was 33 in 2001, whereas Derby and Worcester had 28 and Leicester had 22. Although Cambridge had more high-count days the peak counts were lower (Figure 9) than the Midlands sites. The first high-count day in 2001 occurred at Cambridge on 28th May while there were none in the Midlands until 5th June, by which time Cambridge had experienced four high-count days.

4. Discussion

The weather patterns in the Midlands and Cambridge regions were generally similar in 2001 allowing reasonable comparisons of pollen catches to be made. Edinburgh's pollen catches followed a similar pattern to those of Cambridge albeit at a lower magnitude.

In 2001 the total pollen catches were more severe than those of the two previous years at most sites but there was little difference between the years in the number of high-count days at the Midlands sites. In fact, all 3 years would be considered severe. In contrast, the minimally affected areas had a severe season in 2001 in terms of both total catch and number of high count days. The

pollen records indicate, particularly in the Midlands, that the grasses released their pollen in response to the warm, dry June weather that occurred just at the time when most of the different species were ready to flower. The winter and early spring had been colder than in the previous years and so some of the early grasses would have been retarded while later-flowering species would have brought forward their flowering time in response to the warm May in 2001. Fitter et al. (1995) discuss this ability of plants, including some grasses, to adapt according to the prevailing temperatures at certain stages of their development in a study of first flowering dates of 243 species of angiosperms in central England.

Given that the natural limit of aerial pollen dispersal, in usual summer meteorological circumstances, is 50–100 km (Faegri and Iversen, 1992), it can be assumed that any additional pollen produced from fields left to flower would have been unlikely to reach the Cambridge or Edinburgh areas, which lie at a greater distance from the affected areas.

It would require a further study to determine how much land related to the number of grazing animals culled and to find out the actions of individual farmers in terms of restocking and cutting their fields. It is known, as an example, that the sheep on the Malvern Hills, which is a large area to the west of Worcester, were returned to graze in July, although some other areas of common land did lose their stock and flowered freely. Farmers were allowed to cut their fields for hay and silage throughout the epidemic (pers.com. DEFRA e-mail helpline). There was no change to

verge-cutting policy by the councils. It is interesting to note that grass pollen levels were also well above average in many parts of France in 2001 (Thibaudon and Laaidi, 2002) where there were only two recorded cases of FMD.

The results produced by this study will help to clarify the relationships between weather and the pattern of grass pollen catches for 2001 by indicating possible effects of changes in land use as opposed to differences in the weather. This will aid in pollen forecasting. The results may also be helpful in assessing the future impacts of changes in grassland use.

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