

Fluctuations in Grass-Pollen Counts in Relation to Nightly Inversion and Air Pollution Potential of the Atmosphere

by

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ABSTRACT. – The idea has been generally accepted that accumulative properties of the lower atmosphere during stable non-turbulent air conditions by night (inversion) would lead to relatively high concentrations of airborne particles including those of biological origin like pollen grains originating from wind pollinating plants. Using temperature gradient, air pollution potential, and urban grass-pollen counts as criteria in a meteorologically homogenous region in the western part of the Netherlands, this relation between inversion and airborne grass-pollen concentration appears to be very weak and of no significance for the causation of nightly peaks in the grass-pollen counts.

INTRODUCTION

Outdoor airborne grass-pollen concentrations are not constant during a 24-hour period. It has been suggested by several authors (Assem, 1973; Fuckerieder, 1976; Hyde, 1973; Käpylä, 1981; Mullins, 1981; Raynor, Hayes and Ogden, 1976; Singh and Babu, 1980) that there is a basic diurnal variation, with a lower pollen concentration in the early morning, and a higher one in the afternoon. But very often, and particularly in regions with rapidly changing weather conditions like in North-Western Europe, the courses of the daily pollen concentrations are primarily affected by actual meteorological factors like rain, sunshine, and temperature (Fuckerieder, 1976; Raynor et al., 1976; Spieksma, 1980).

However, when looking at the diurnal fluctuations of the grass-pollen counts in Leiden, one sometimes observes extremely high pollen concentrations around midnight (Fig. 1).

These high grass-pollen counts by night cannot be explained by a diurnal rhythm or by a sunny type of weather. A number of authors (Fuckerieder, 1976; Leuschner and Boehm, 1981 and Spieksma, 1980) have repeatedly suggested that such night peaks might be the result of atmospheric temperature inversion and thus stable air, preventing vertical air transport and raising airborne particle concentrations in the lower layers of the atmosphere.

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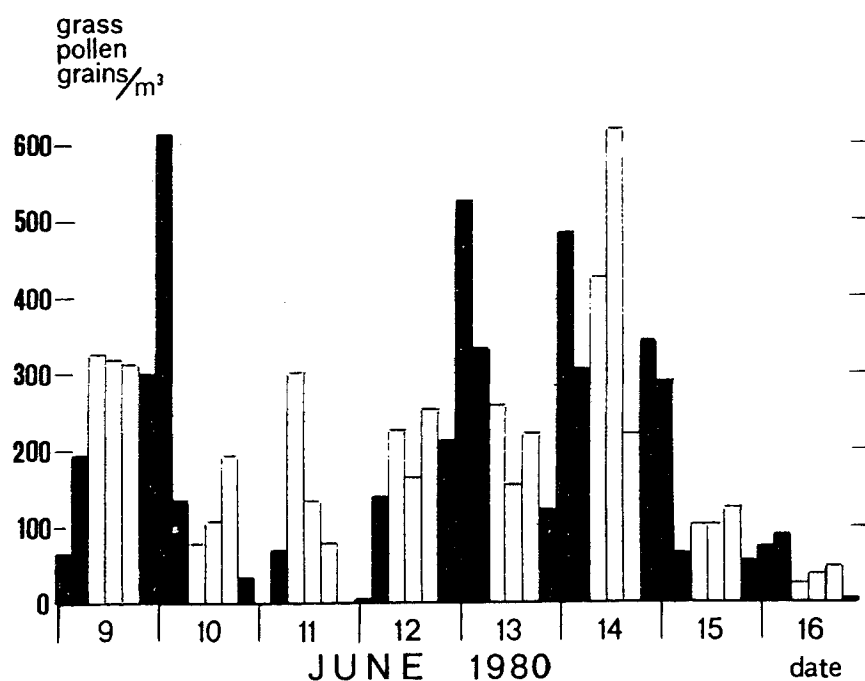


Fig. 1. Counts of grass-pollen grains in 4-hour periods; white columns: by day, between 7 a.m. and 7 p.m.; black columns: by night, between 7 p.m. and 7 a.m.

MATERIAL AND METHOD

For the present study, data from the Royal Dutch Meteorological Institute (KNMI) were used in which inversion is rated based on the reversed temperature gradient by night in the lower 500 metres of the atmosphere (Dop, Ulden and Raaff, 1975).

STRENGTH OF INVERSION: – This is defined by

$$\Delta^{\ominus} = t_{500\text{ m}}^{(0,h)} - t_{2\text{ m}}^{(0-6\text{ h})} + 5^{\circ}\text{C}$$

e.g. $\Delta^{\ominus} = 12^{\circ}\text{C} - 9^{\circ}\text{C} + 5^{\circ}\text{C} = 8^{\circ}\text{C}$

AIR POLLUTION POTENTIAL: – This, ($I^{(\text{APP})}$) is defined by

$$I^{(APP)} = c_1 \Delta^\ominus + c_2 (Lu)^{-1}$$

where $\Delta^\ominus$ = strength of inversion ($^\circ\text{C}$)
 L = maximal height of homogenously mixed air (metres)
 u = average wind-speed (metres/sec.)

$c_1 = 2.5^\circ \text{C}^{-1}$ and $c_2 = 64,000 \text{ m}^2/\text{s}$

KNMI data were used to compute $I^{(APP)}$ for the lower atmosphere over 24 hrs from observations on inversion, level of air mixing and wind-speed (Dop et al., 1975)
 Eg. $\Delta^\ominus = 8^\circ\text{C}$, $L = 3,200 \text{ m}$, $u = 10 \text{ m/s}^{-1}$

$$I^{(APP)} = 2.5 \times 8 + \frac{64,000}{3,200 \times 10} = 20 + 2 = 22$$

These observations were made approximately 50 km from Leiden, but, because the meteorological conditions are very homogenous over our flat country, they are considered representative for the mid-western part of The Netherlands.

The data on the airborne pollen concentrations are collected with a widely used volumetric pollen trap, the Hirst impaction trap, and expressed as number per cubic metre of air.

Data presented are from the months of June and the first half of July in the years 1979, 1980, and 1981.

RESULTS

As a more or less direct presentation of the results, in the following three figures (Figs. 2, 3, and 4) the grass-pollen concentrations and the nightly inversion rates are shown. Nights with relatively high grass-pollen concentrations in 1979 (Fig. 2) are on June 13 and 24, while high rates of inversion occur on June 1, 4, 10, 21, and 28, and in July on the 6, 13, and 14, clearly not on the same dates.

In 1980 (Fig. 3) high nightly pollen counts were found on June 10, 13, 14, 15, 19, 22, and 28, and July 12; but high rates of inversion are found on June 5, 6, and 7 only.

Also in 1981 (Fig. 4) nights with inversion and high pollen concentrations rarely coincide: a large amount of pollen on June 7, 9, 15, 16, 30, and July 1, 8, and 9; inversion in June on 2, 13, 15, 24, and in July on 8 and 9.

If there was a simple relation between inversion and pollen count by night, this should have become visible in these figures. Also comparing the pollen concentration with the air pollution potential (as a rate of accumulation in the lower atmosphere) reveals no pronounced or clear relation.

CORRELATION COEFFICIENTS

Another way of evaluating these data is to calculate the coefficients of correlation for various combinations, examples of which from 1980 are shown in the next three figures.

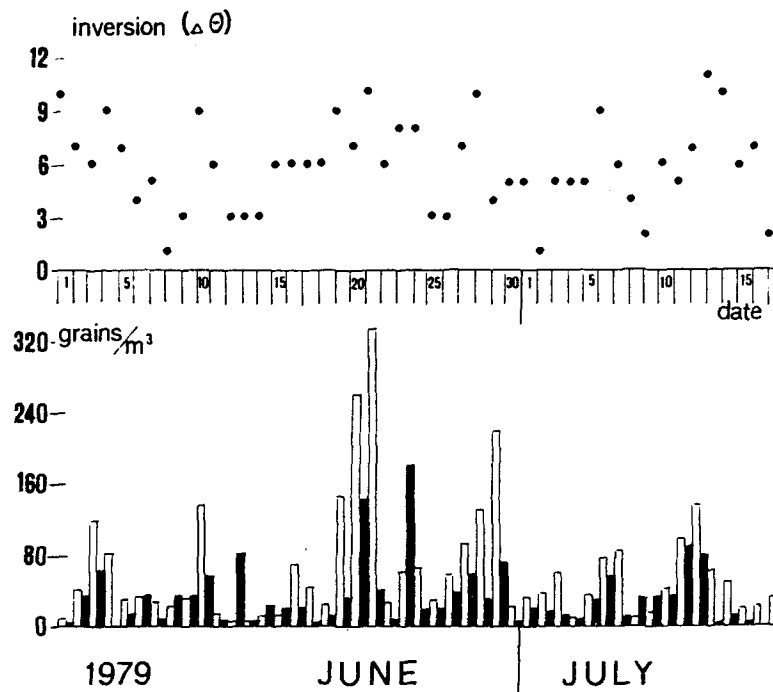


Fig. 2. Top: nightly rates of inversion ($\Delta\Theta$); bottom: grass-pollen counts, by day (white columns) and by night (black columns).

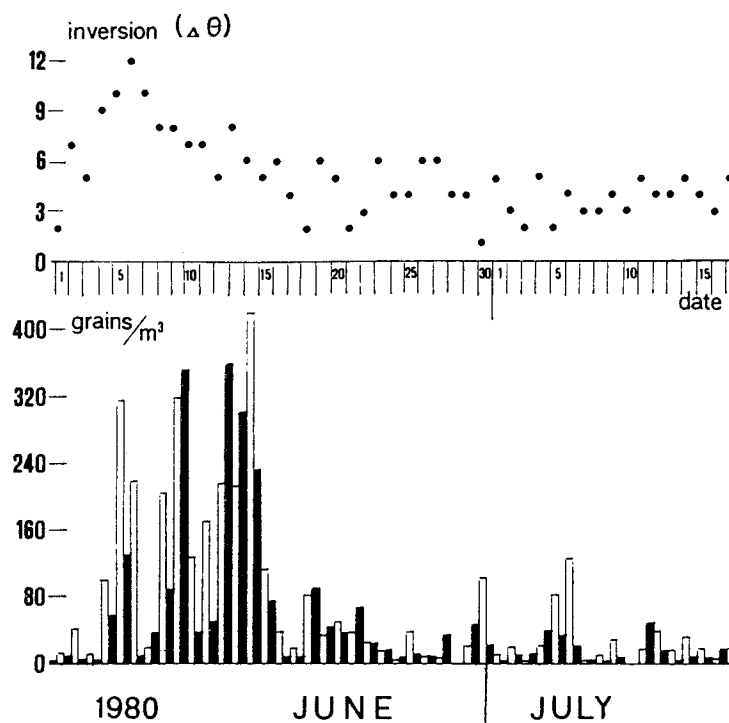


Fig. 3. (Legend: see Fig. 2.)

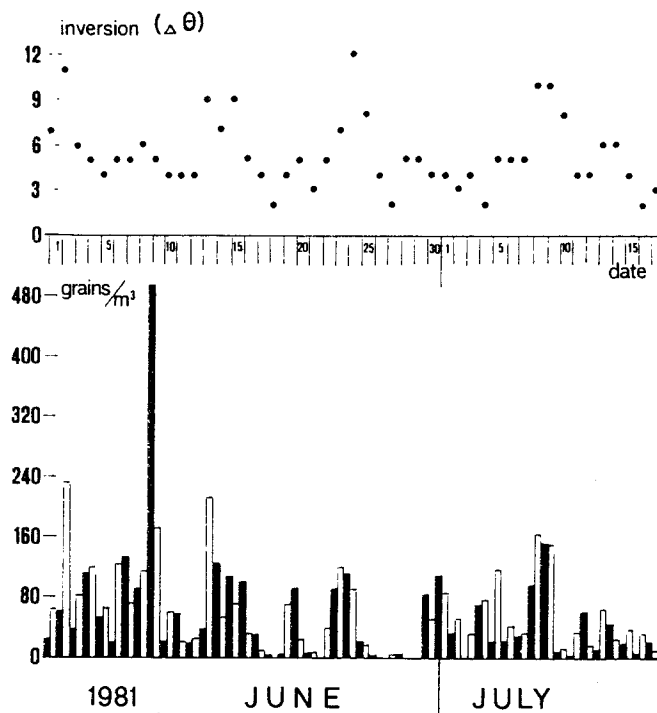


Fig. 4. (Legend: see Fig. 2.)

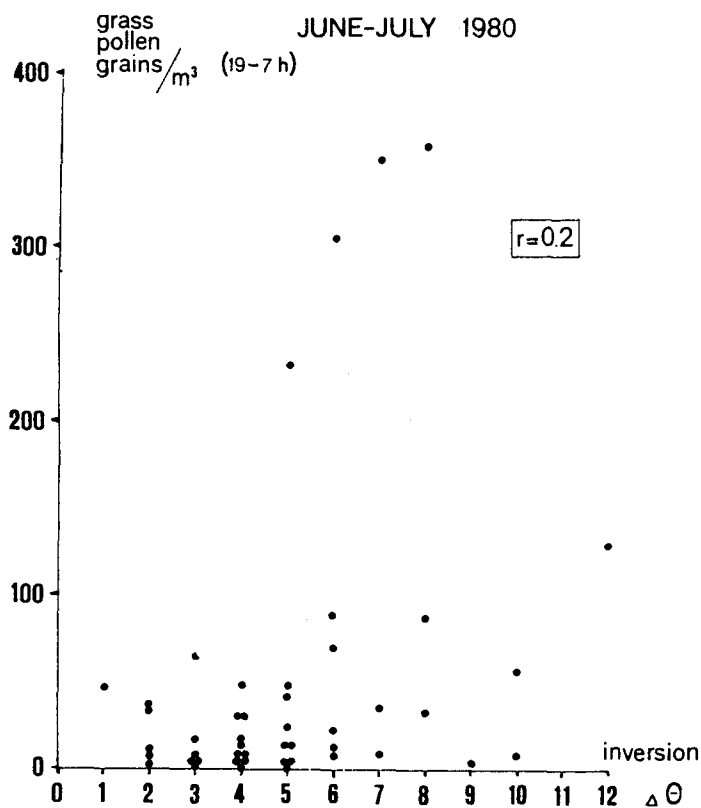


Fig. 5. Correlation between rate of inversion ($\Delta\Theta$) and grass-pollen count by night.

Fig. 5 is a visualization of the correlation between the grass-pollen concentration and the rate of inversion both by night, each dot representing the observed condition on an individual day. The dots in this figure are scattered, and the correlation coefficient is correspondingly low ($r = 0.2$).

Fig. 6, showing the correlation between grass-pollen concentrations and air pollution potential both over 24 hours, the cloud of dots has a slightly better grouped form, with a coefficient of $r = 0.4$.

To illustrate that the data do contain suitable and reliable information, in Fig. 7 the correlation is shown to be expected between maximum temperature and pollen count, both by day, $r = 0.7$.

Table 1 summarizes the correlation coefficients for the most relevant combinations.

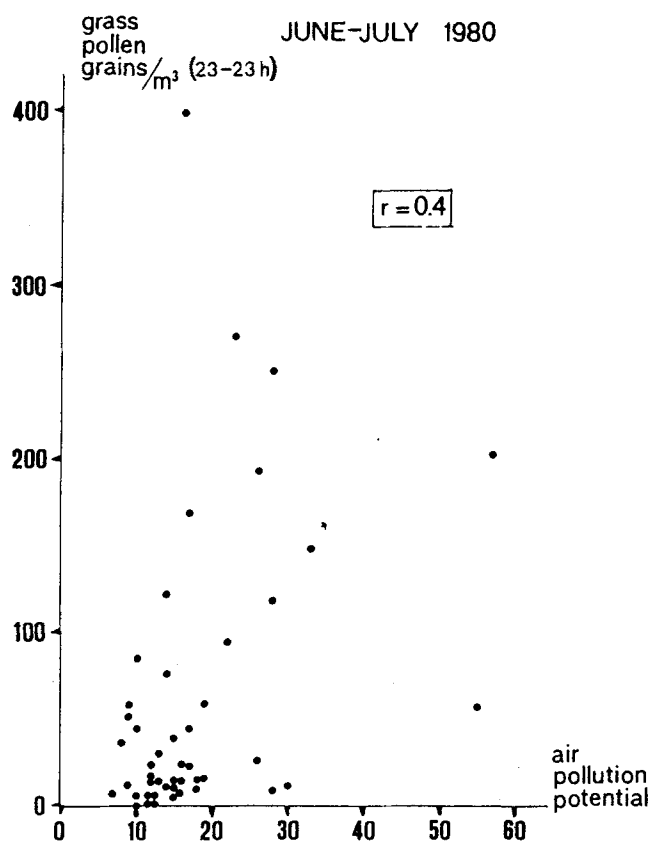


Fig. 6. Correlation between air pollution potential and 24-hr grass-pollen count.

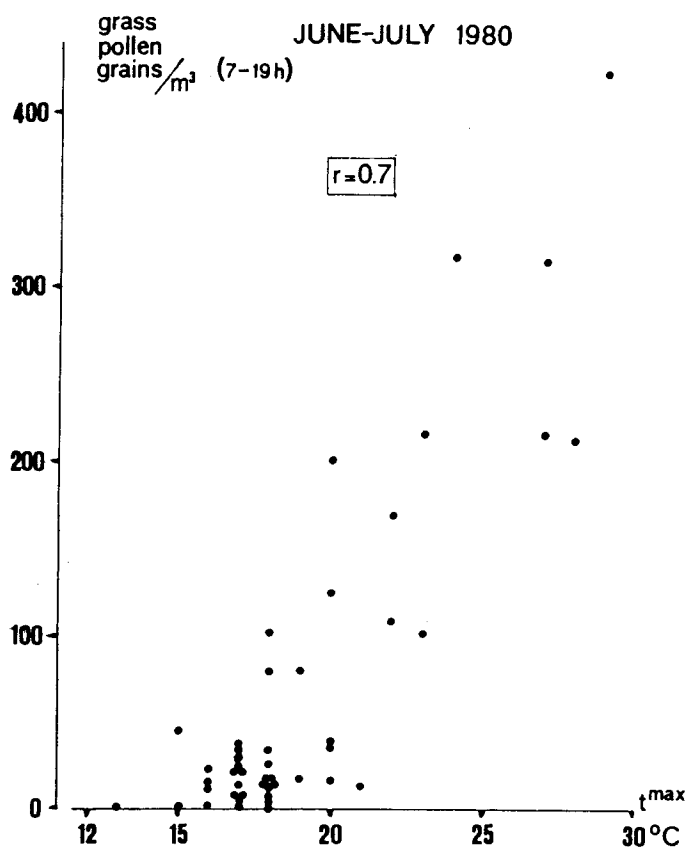


Fig. 7. Correlation between maximal temperature and grass-pollen count, both by day.

Table 1. Correlation coefficients between various meteorological parameters and grass-pollen counts, Leiden, 1980.

CORRELATION COEFFICIENTS			
strength of inversion	—	grass-pollen concentration by night	
1979 :	$r = 0.3$		
1980 :	$r = 0.2$	$r = 0.2$	
1981 :	$r = 0.2$		
air pollution potential	—	grass-pollen concentration by night	
1979 :	$r = 0.1$		
1980 :	$r = 0.2$	$r = 0.0$	
1981 :	$r = 0.0$		
air pollution potential	—	grass-pollen concentration (24 hrs)	
1979 :	$r = 0.3$		
1980 :	$r = 0.4$	$r = 0.3$	
1981 :	$r = 0.3$		
maximum temperature	—	grass-pollen concentration by day	
1979 :	$r = 0.6$		
1980 :	$r = 0.7$	$r = 0.6$	
1981 :	$r = 0.6$		

CONCLUSION AND SUMMARY

The preliminary conclusions of this study can be summarized as follows:

1. High grass-pollen concentrations by night do not, as a rule, occur when there is a high rate of nightly inversion; and, *vice versa*, at nights with a high rate of inversion the pollen count is not always high.
2. There is a very weak general relationship between rate of inversion and grass-pollen concentration by night; and between air pollution potential and grass-pollen concentration over 24 hours.

Future observations and the taking into account other factors will probably be necessary to elucidate the causes of high grass-pollen concentration by night.

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