Aerobiologia **18:** 253–265, 2002.
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The effects of climate change on the birch pollen season in Denmark

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Received 10 October 2001; accepted 16 September 2002

Key words: birch pollen, Growing Degree Hour (GDH), long-term trends, modelling, start and size of season

Abstract

During the last two decades the climate in Denmark has become warmer and in climate scenarios (IPCC, 2001) it is foreseen that the temperature will increase in the coming decades. This predicted future increase in temperature will probably affect both the flowering of plants and the dispersion of pollen in the air. In this study the already observed effects on the birch pollen season are studied. Trend analyses of the birch pollen season for two stations in Denmark more than 200 km apart give similar results. In Copenhagen there is a marked shift to an earlier season – it starts about 14 days earlier in year 2000 than in 1977, the peak-date is 17 days earlier and the season-end is 9 days earlier. For Viborg the trend to an earlier season is in general the same, but slightly smaller. During the same period there has also been a distinct rise in the annual-total amount of birch pollen, peak-values and days with concentrations above zero. Rising mean temperatures during winter and spring can explain the calculated trends toward earlier pollen season. Models for estimation of the starting date based on Growing Degree Hours (GDH's) give very fine results with a correlation coefficient around 0.90 and rms error around 4.2 days. For annual-total there is a significant positive correlation with the mean temperature in the growing season the previous year.

1. Introduction

In 1977 continuous monitoring of airborne pollen was started in Denmark. Today routine monitoring of pollen is performed at two locations in Denmark; Copenhagen in Zealand and Viborg in Jutland. The results of the daily pollen monitoring have been reported to the public from 1979 for alder (*Alnus*), hazel (*Corylus*), elm (*Ulmus*), birch (*Betula*), grass (Poaceae) and mugwort (*Artemisia*). These pollen types are considered to be of the greatest allergological importance in Denmark (Dirksen and Østerballe, 1980). Since 1981 forecasts of the predicted concentrations of pollen in the air the following day have been performed for birch, grass and mugwort.

During the last two decades the climate in Denmark has become warmer, and in climate scenarios (IPCC, 2001) it is foreseen that the temperature will increase further in the coming decades. This predicted future increase in temperature will probably affect both the flowering of plants and the dispersion of pollen in the air. In this study the already observed effects on the birch pollen season are studied, especially with focus on the start of season and the size of season, as an accurate prediction of these is most important for the medication of allergic patients. Birch pollen is known to be a major cause of pollen allergy in Denmark and pre-dominates the pollen registrations in the spring.

The prevalence of pollen allergy in Denmark seems to be an increasing problem. Thus one study showed an increase from 6.5% in 1987 to 10.3% in 1997 (Keiding, 1997), while another study showed an 50% increase in prevalence from 1989 to 1997 (Linneberg et al., 1999). A definite explanation of the observed increase was not given, but increasing awareness of symptoms may partly explain the increase. The increase in prevalence has also been observed in other

European countries, and several hypothesis have been discussed such as the role of air pollution and the so-called unhealthy 'western lifestyle' (D'Amato et al., 1991; Novak et al., 1998; Von Mutius et al., 1998).

Another obvious reason for the increase in the prevalence could be an increasing amount of pollen. Increasing trends in annual sums of birch pollen have been reported for other countries (eg. Emberlin et al., 1993; Spieksma et al., 1995; Jäger et al., 1996; Frei, 1998; Frei and Leuschner, 2000). But in general the observed trends were relatively small and insignificant except for Switzerland (Frei, 1998), where the observations showed a yearly increase of nearly 4% of birch pollen and also increases for other pollen types. He concluded that this increase probably together with the 'western style of life' was critical for the increasing prevalence of pollen allergy.

Concerning the starting date there are several studies on this issue (Hocevar and Segula-Ilic, 1990; Andersen, 1991; Frenguelli et al., 1992; Spieksma et al., 1995; Jäger et al., 1996; Emberlin et al., 1997; Hallsdóttir, 1998). In general the analyses show a clear correlation with the temperature in the pre-season and the starting date of the season. Thus Spieksma et al. (1995) for several stations found a high correlation between the starting date and the mean temperature of the forty days preceding the mean starting date (e.g. $r = -0.84$ for Vienna, $r = -0.72$ for Stockholm). Hallsdóttir (1998) found an even better correlation using an accumulated thermal sum up to 15 May, just prior to the earliest start of the birch pollen season in Reykjavík. Hocevar and Segula-Ilic (1990) also found that global radiation could improve the result for some stations, while precipitation and wind velocity did not significantly improve the results.

Unfortunately the definition of the starting date of the pollen season is not obvious, and it has been defined in several different ways e.g.: 'the sum-75 method' stating that the season starts when the accumulated daily sum reaches 75, 'the date when the accumulated sum reaches 2.5% of the annual total' (Emberlin, 1997); 'the first day with a pollen amount exceeding 1% of annual total, providing this was not followed by more than six consecutive days with zero values' (Jäger et al., 1996), 'the first day when the sum reaches 1% of the logarithmic mean of annual total' (Spieksma et al., 1995). The different definitions have different advantages and drawbacks, e.g. the '2.5% of annual total' means that the determination of starting date only is possible after the season, while using a fixed threshold value may imply that the season does not start at all in small seasons.

Frei (1998) instead used the peak-date in his study of the relation between temperature and the flowering. He found a high significant correlation ($r = -0.85$, $p < 0.05$) between mean temperature of February-March and peak-date of birch pollen.

2. Material and methods

Pollen sampling is performed with Burkard Traps in Copenhagen, Zealand, at the Danish Meteorological Institute (55°43′ N, 12°34′ E) and in Viborg, Jutland, at Viborg-Kjellerup Hospital (56°27′ N, 9°24′ E). The traps are placed 15 and 21 meters above ground level, respectively. The distance between the two stations is about 220 km.

Meteorological data used for Copenhagen are taken from the synoptic stations at Værløse (55°46′ N, 12°19′ E), Kastrup Airport (55°39′ N, 12°40′ E) and Tune (55°35′ N, 12°08′ E). Data have been quality controlled and in this study mean data for the three stations have been used. The distances from the synoptic stations to the pollen station in Copenhagen are 15 km, 12 km and 28 km respectively.

Standard methods are used for the counting of pollen (Käpylä and Pentinnen, 1981). Pollen grains are counted in 12 transverse stripes at a magnification of ×640 and pollen are identified to generic genus.

The birch pollen data used in this study cover 24 years (1977–2000) for Copenhagen and 21 years (1980–2000) for Viborg. The start-date of the season is here defined as the date of which the accumulated sum reaches 2.5% of the total yearly number. The peak-date is defined as the date with highest daily concentration (peak-value) and the duration of season is here defined as number of days with accumulated counts between 2.5% and 97.5%.

The daily pollen data are averaged over five days, and for the main trend analysis an overlapping mean of five years has been used. Trends are examined at significance levels of $p < 0.001$ (***), $p < 0.01$ (**) and $p < 0.1$ (*). For the statistical analysis the Numerical Algorithm Group (NAG) library is used.