

Allergy symptoms in relation to alder and birch pollen concentrations in Finland

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Abstract In order to study allergic people responding to daily changes in pollen concentrations, we compared personal diary data on allergic symptoms and the use of allergy medicines to daily pollen counts during the two unequal alder and birch pollen seasons of 2009 and 2010. Almost 90% of the 61 subjects with physician-diagnosed birch pollinosis developed conjunctival, nasal or other symptoms during the peak birch pollination. Most subjects (95%) also reported symptoms during the alder pollination. Despite a delay between the most severe symptoms and the pollen peaks and the increased risk of allergy symptoms between the alder and birch pollen peaks at much lower pollen concentrations, the number of subjects with allergy symptoms correlated with the daily pollen concentrations in both years ($r_{09} = 0.35$, $r_{10} = 0.36$, $p < 0.01$). The positive correlation was even stronger ($r_{09} = 0.69$, $r_{10} = 0.74$, $p < 0.001$) in relation to the cumulative sum of daily concentrations. The use of allergy medicines precisely followed the abundance of allergy symptoms in both years ($r_{09} = 0.96$, $r_{10} = 0.70$, $p < 0.001$). We conclude that there is a fair correlation between the daily allergy symptoms

and the particular pollen concentrations, but the risk of developing symptoms at low, moderate and high concentrations is affected by the progression of the pollen season.

Keywords Allergy symptoms · *Alnus* · *Betula* · Pollen concentration · Threshold values

1 Introduction

Pollen-monitoring networks in Europe provide information on daily pollen concentrations or symptom risk levels for advising allergic people and physicians. In northern Europe, the pollen of Betulaceae trees is the most important airborne carrier of natural allergens (Eriksson and Holmen 1996; D'Amato et al. 1998). In Finland, about 20% of the population is allergic to birch pollen in particular. Due to a common cross-reactivity, the sequential flowering of the Betulaceae genera (*Corylus*, *Alnus*, *Betula*) may cause a prolonged allergy symptom season for sensitive patients. The major allergen of birch (Bet v 1) is closely related to the major allergens of alder (Ald g 1), hazel (Cor a 1) and also to hornbeam (Car b 1) and oak (Que a 1) (Matthiessen et al. 1991; Pehkonen and Rantio-Lehtimäki 1995).

In Finland, pollen concentrations in the air are classified as low (0–10 grains/m³), moderate (>10–100 grains/m³) or high (>100 grains/m³). These levels indicate that only the most sensitive subjects, many of

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the subjects, and most of the subjects, sensitised to the particular pollen type are expected to have symptoms, respectively. Finnish threshold levels for birch (and alder) pollen are mainly based on a single study by Viander and Koivikko (1978). Based on the symptom diaries and laboratory tests, they observed the first symptoms in 10% of the patients when airborne birch pollen counts exceeded 10 grains/m³. The appearance of symptoms at pollen counts of under 30 grains/m³ in the early season was significantly associated with a high abundance of allergic rhinitis symptoms. The daily pollen count of 80 grains/m³ was high enough to provoke allergic reactions in most birch-sensitised subjects. Similar threshold studies have not been repeated since as changes in ethical practices no longer allow a control group with restricted use of any medication.

During the peak flowering period, the daily mean values for birch can be expressed also as ‘very high’, ranging from 1,000 to more than 10,000 grains/m³. The alder peaks are substantially lower, but may reach 2,000 grains/m³. The thresholds for birch and alder coincide because the size of the grains and allergen content of a grain are estimated to be close enough to each other. Sensitivity to alder, however, is not often studied in the skin prick tests, and alder-related symptoms are not well documented in birch-sensitive patients. When more than 7,600 people were tested in Skin and Allergy Hospital in Helsinki in 2010, 95% of the birch-sensitive patients (2,761; 36%) also had a positive reaction to alder (L. Petman, pers. comm.). Other taxa of Betulaceae are of minor and more local importance to allergic people.

Despite the growing number of allergic people across Europe, there are only a few studies where daily allergy symptoms have been compared to daily pollen counts (Viander and Koivikko 1978; Burr et al. 2003). One reason for this is the difficulty of evaluating the personal pollen load in the course of the season. Provocation tests and pollen chambers have been used in a controlled environment. However, the quantification of threshold values in a provocation test may be uncertain because the challenge of allergen into the nasal mucosa or the conjunctiva may prime these tissues, thereby causing a non-specific increase in the sensitivity and responsiveness (Canonica and Compalati 2009).

Real life conditions are dealt with in ambient air studies. Recently, symptom data have been collected

using the web-based diaries of voluntary hay fever patients (www.pollendiary.com). Unpublished results indicate differences between the populations. For example, a symptom score of 10 (out of 24) is reached in Finland and Austria at roughly the same pollen concentrations, i.e. around 225 grains/m³ of air (U. Berger, pers. comm.). However, a score of 15 is reached more quickly in Austria (250 grains/m³) than in Finland (600 grains/m³), indicating that the Finns are more tolerant of high birch pollen loads than the Austrians. Unfortunately, ‘patient freedom’ leads to undecipherable pollen exposures among individuals. It is also difficult to ensure the sensitivity of the individual patients to the particular pollen.

Earlier, we have compared the effects of the preseasonal use of honey enriched with bee-collected pollen in patients with allergic symptoms during the alder and birch pollen season (Saarinen et al. 2011). The physician-diagnosed subjects in the control groups did not take such preparations but they recorded their daily symptoms in a like manner. These groups allowed us to study the emergence and prevalence of allergy symptoms in real life conditions. A 2-year follow-up study was carried out as both the pollen season and the allergen content of pollen are subject to annual variation (Pehkonen and Rantio-Lehtimäki 1995; Buters et al. 2008). The main questions were (1) do allergic people respond to daily changes in pollen concentrations in the ambient air and (2) do the risk levels correspond to the number of symptomatic subjects?

2 Materials and methods

A total of 64 subjects participated in the study. All subjects were interviewed in detail to confirm their physician-diagnosed birch pollen allergy. Eighty-one percentage also reported symptoms from the alder pollen. Excluding three subjects with severe symptoms throughout the study period, the number of informative subjects in the symptom follow-up was 28 in 2009 and 33 in 2010 (Table 1). Three of the subjects (5%) participated in both years. The 61 subjects (43 women and 18 men) ranged in age from 8 to 70 years (mean 33.9). The subjects had a long history of birch pollen allergy (mean 18 years).

The study subjects recorded both the daily symptoms and the use of allergy medicines in a diary during

Table 1 Characteristics of the study participants in 2009 and 2010

Subject details	2009	2010
Number of subjects	28	33
Women	17	26
Men	11	7
Mean age (range)	34 (11–57)	34 (8–70)
Duration of allergies (range)	19 (3–35)	18 (3–40)
Allergies (%)		
Birch pollen	100	100
Alder pollen	89	67
Grass pollen	54	52
Mugwort pollen	43	61
Animals	18	67
Food	68	58
Asthma diagnose (%)	7	21

April and May. Conjunctival symptoms (itchy, swollen, watery, or sore, eyes), nasal symptoms (sneezing, runny, itchy, or blocked, nose), and other allergy symptoms, such as itchy skin, were all subjectively graded from 0 (no symptoms) to 3 (severe symptoms). In the analysis, daily allergy symptoms in general were classified according to the most severe symptom, i.e. the symptoms were severe if any of the conjunctival, nasal or other symptoms were severe. In the course of the study, all participants used their personal allergy medicines without limitations.

Daily pollen concentrations were measured by the South Karelia Allergy and Environment Institute in

Imatra, SE Finland. As part of the Finnish pollen-monitoring network, pollen was measured with a Burkard volumetric sampler with a 7-day sampling head located at the rooftop level (14 m). Most of the study subjects (88%) lived within a radius of less than 50 km from the pollen-monitoring site.

Pearson's correlation test (r) was used to determine a relationship between the daily pollen concentrations, the proportion of subjects with allergy symptoms and the use of medication. The difference between the number of symptomatic subjects and the concentration levels (low 0–10, moderate >10–100, high >100–1,000, very high >1,000 grains/m³) was statistically tested using a one-way analysis of variance. Multiple comparison procedures were used to isolate pairwise the mean differences in those cases where statistically significant results were obtained.

3 Results

3.1 Exposure to pollen

The two pollen seasons were markedly different. In 2009, the first alder pollen grains were found on March 31, but the season peaked as late as on April 22–26 (Fig. 1). The sum of the daily concentrations remained 30% lower than the average (2,950 compared to 4,270 for 2002–2008). In 2010, the alder pollen season began on March 26 and the daily counts started on March 31, with rapidly increasing concentrations

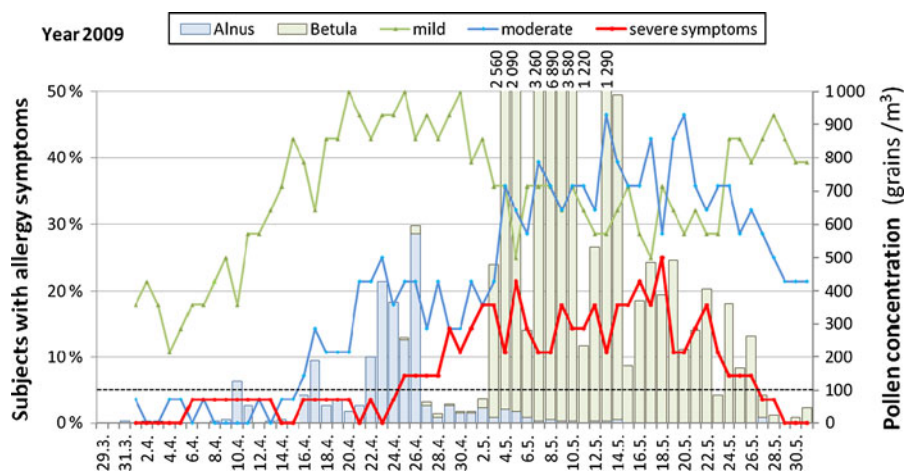
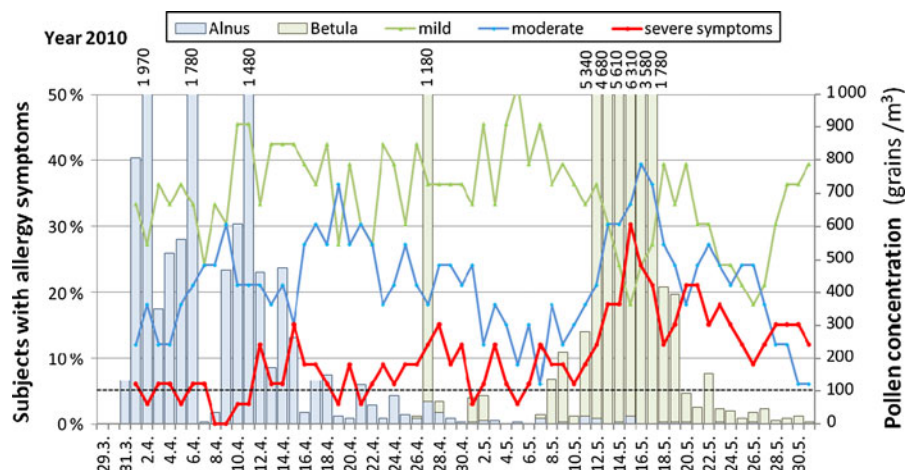


Fig. 1 Daily alder and birch pollen concentrations and the proportion of subjects with mild, moderate and severe allergy symptoms in April and May 2009. The severity of the symptoms

was classified according to the most severe symptom (conjunctival, nasal, other allergy symptom) on each day

Fig. 2 Daily alder and birch pollen concentrations and the proportion of subjects with mild, moderate and severe allergy symptoms in April and May 2010. The severity of the symptoms was classified according to the most severe symptom (conjunctival, nasal, other allergy symptom) on each day



(Fig. 2). The alder pollen season peaked as early as on April 2–11 (max 1,970 grains/m³ on 2.4.), and the total pollen sum was almost threefold (11,080) compared to the average. The number of days with high concentrations (>100 grains/m³) was 7 in 2009 and 17 in 2010 (average 10 days in 2002–2008).

The first birch pollen grains in 2009 were found on April 25 and high concentrations (>100 grains/m³) were measured on May 3–26 (max 6,890 grains/m³ on 8.5.). In 2010, the pollination period was short and intense. The first pollen grains were found on April 26, and the season peaked between May 8–19 (max 6,310 grains/m³ on 15.5.). The concentrations were high on 23 days in 2009 and on 13 days in 2010 (average 18 days in 2002–2008). The total sums of the daily concentrations were 27,460 in 2009 and 30,990 in 2010. Both seasons were about the long-term average (29,700 for 2002–2008) in terms of the total pollen count.

3.2 Allergy symptoms

During the study period, all patients suffered from nasal symptoms, 95% from conjunctival symptoms and 70% from other allergy symptoms. Severe symptoms of some kind were reported by 57% of the subjects in 2009 and 48% in 2010. During the days with only alder pollen in the air, 89% of the subjects in 2009 and 100% in 2010 reported some allergy symptoms. Antihistamine tablets were used by 87%, nasal sprays by 52% and eye drops by 36% of the subjects. Seven subjects (11%) reported no use of any allergy medicines during the study, although they

displayed symptoms (on 35 days, severe symptoms on 3 days) almost as often as on average (on 40 days, severe symptoms on 6 days). On an average day, 93% of the subjects on medication used antihistamines, 42% some kind of nasal sprays and 19% eye drops.

In early April 2009, the number of subjects with mild allergy symptoms was 10–20%, and this exceeded 20% on April 8 when the daily alder pollen counts started (Fig. 1). Over 10% of the subjects had moderate symptoms after April 17 with increasing alder pollen concentrations. Severe symptoms increased after the alder pollination on April 29 and the highest number of subjects with severe symptoms (25%) was reached a week prior to the peak birch pollination period on May 18.

Twenty-five to thirty-five percentage of the subjects already had mild allergy symptoms in early April 2010 (Fig. 2). At least 20% of the subjects had moderate symptoms as early as on April 6. Severe symptoms peaked (30%) during the birch pollination when the daily concentrations remained over 3,000 grains/m³ for five consecutive days.

Between the peak flowering periods of alder and birch, allergy symptoms did not markedly decrease. In 2009, more than half of the subjects had continuously symptoms from April 16 onwards and in 2010 from April 3 onwards till the end of May. Although the number of symptomatic subjects did not differ between the days of low, moderate and high concentration levels (Table 2), the number of subjects with allergy symptoms correlated with the daily pollen concentrations in both years (2009: $r = 0.345$, $p < 0.01$, 2010: $r = 0.362$, $p < 0.01$). The positive correlation was

Table 2 The proportion of subjects with any, and with severe, allergy symptoms (mean $\pm$ SD) during the days with different levels of alder and birch pollen concentrations in April and May 2009 and 2010

	Low (L) (0–10)	Moderate (M) (>10–100)	High (H) (>100–1,000)	Very high (V) (>1,000)
Days in 2009	12	19	23	7
Any symptoms (%)***	28.9 $\pm$ 14.5 ^{MHV}	62.4 $\pm$ 15.2 ^{LHV}	76.4 $\pm$ 15.0 ^{LM}	83.2 $\pm$ 2.7 ^{LM}
Severe symptoms (%)***	1.5 $\pm$ 1.8 ^{MHV}	5.8 $\pm$ 5.4 ^{LHV}	11.6 $\pm$ 6.8 ^{LM}	13.8 $\pm$ 4.3 ^{LM}
Days in 2010	6	26	19	10
Any symptoms (%) ^{ns}	62.1 $\pm$ 5.7 ^V	64.9 $\pm$ 7.7 ^V	65.6 $\pm$ 8.3	72.1 $\pm$ 11.9 ^{LM}
Severe symptoms (%) [*]	7.6 $\pm$ 3.7 ^V	10.7 $\pm$ 5.4	8.0 $\pm$ 4.4 ^V	14.8 $\pm$ 9.2 ^{LH}

Letters (L, M, H and V) in superscript indicate significant differences between the groups in a pairwise post hoc Duncan test ANOVA: *ns* not significant

* $p < 0.05$; *** $p < 0.001$

even stronger (2009: $r = 0.686$, $p < 0.001$, 2010: $r = 0.736$, $p < 0.001$) in relation to the cumulative sum of daily concentrations (Figs. 3, 4). The correlation was also stronger when conjunctival, nasal and other symptoms were compared separately with the pollen sum (Table 3). The use of allergy medicines followed the abundance of allergy symptoms precisely (Figs. 3, 4).

4 Discussion

Daily symptoms of the subjects suffering from both alder and birch pollinosis were compared to daily pollen counts during the two unequal seasons of 2009 and 2010. Both years had a total of 30 days with high concentrations (>100 grains/m³) during April and May, but in 2010, the first very high concentration

occurred a month earlier (2.4.) than in 2009 (4.5.). Due to a strong alder pollination in 2010, the total load of Betulaceae pollen was 25% higher compared to that in 2009. The number of subjects with any severe symptoms was, however, 10% lower in 2010 than in 2009. This contradiction between the severity of symptoms and the total pollen sums may relate to the allergen content of pollen grains, which varies a lot from year to year (Buters et al. 2008, 2010), or to the different timing and nature of the two pollen seasons. The two sets of subjects in consecutive years may also have been somewhat different with respect to sensitivity to alder and birch pollen.

Daily allergy symptoms did not precisely follow the daily pollen concentrations, especially in the latter season, 2010. This may have a result of the freedom of the patient, i.e. we do not know how long time the subjects were exposed to pollen outdoors, and thus, we

Fig. 3 Cumulative sum of alder and birch pollen (29,200 grains = 97% of the total annual sum) and the proportion of subjects with allergy symptoms and subjects using allergy medicines in April and May 2009

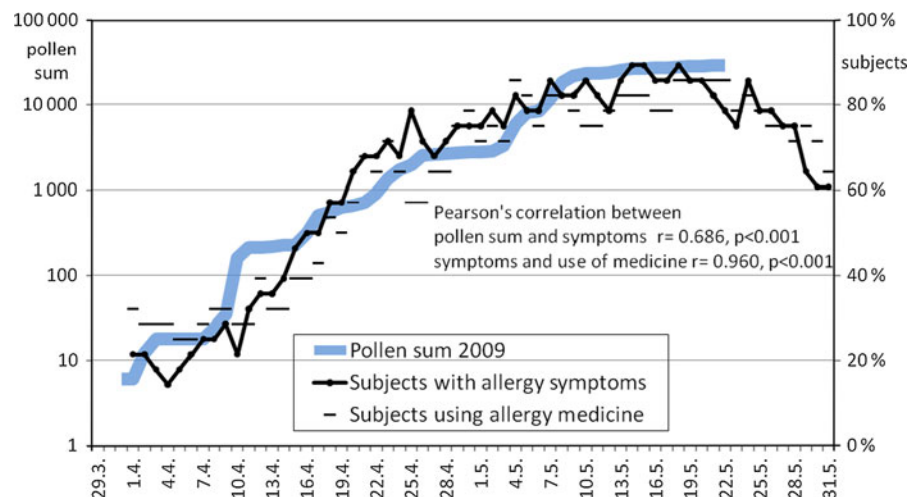


Fig. 4 Cumulative sum of alder and birch pollen (40,300 grains = 97% of the total annual sum) and the proportion of subjects with allergy symptoms and subjects using allergy medicines in April and May 2010

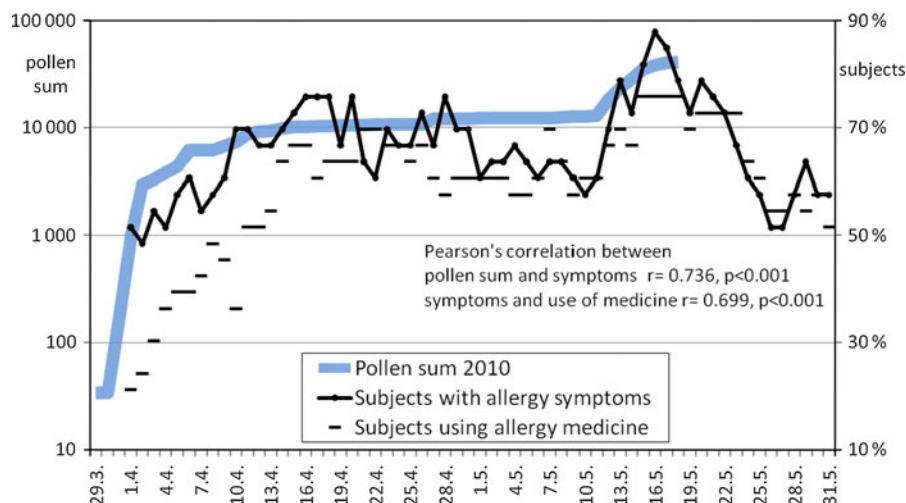


Table 3 Pearson's correlation coefficients between the subjects with allergy symptoms and alder and birch pollen concentrations in April and May 2009 and 2010

	Nasal symptoms		Conjunctival symptoms		Other symptoms	
	All	Severe	All	Severe	All	Severe
2009						
Daily pollen counts	0.326*	0.337**	0.449***	0.342**	0.396 **	0.172
Cumulative pollen sum	0.679***	0.789***	0.629***	0.458***	0.832***	0.408**
2010						
Daily pollen counts	0.516***	0.383**	0.413**	0.497***	0.227	0.293*
Cumulative pollen sum	0.856***	0.760***	0.506***	0.769***	0.654***	0.572***

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

lack their accurate pollen exposures. However, the abundance of symptoms and the daily pollen counts did show a positive correlation. Even so, there were two factors against the straightforward relationship. Firstly, severe symptoms tend to increase only after some delay. At the beginning of the peak birch pollen period, for example on 12.5.2010, 5,400 grains/m³ coincided with only 10% of the subjects having severe symptoms. Most of the severe symptoms were recorded 3 days later (30% of the subjects). After the peak pollination more than 20% of the subjects still had severe symptoms on 21.5.2010, although the pollen concentration had decreased to less than 100 grains/m³.

Secondly, the risk of allergy symptoms remained high between the alder and birch pollen peaks, although the concentrations dropped to low levels in the ambient air. For example, on May 3–6 in 2010 daily pollen counts varied between 0–11 grains/m³,

but 61–67% of the subjects reported symptoms. Once started, the allergy symptoms continued through both the alder and birch pollen season, resulting in a strong positive correlation between symptoms in the course of the season and the cumulative pollen load. Unfortunately, the early start of the pollen season in 2010 led to missing symptom scores in late March.

In both years, almost 90% of the subjects suffered allergy symptoms during the peak birch pollination. High alder pollen counts in 2010 did not have a notable effect on the number of symptomatic subjects but it may lower the proportion of the subjects with severe symptoms, thus supporting the suggestion of Burr et al. (2003) that very high exposures may confer some protection against allergy symptoms. However, tolerance to pollen did not appear to increase in line with the progress of the season. On the contrary, high alder pollen concentrations in the early season acted more like a primer, making allergic people more sensitive to

pollen later in the season (Emberlin et al. 1997). Pollen releases several substances, such as lipid mediators and larger quantities of adenosine, factors which seem to influence the sensitisation reaction of an immune system. Traidl-Hoffmann et al. (2002) have explained the reactions on a cellular level. They observed the release of bioactive lipid mediators from pollen during contact with mucous or respiratory membranes, which may act as allergen independent proinflammatory factors contributing to the initiation, manifestation or aggravation of allergic inflammation. Thus, the alder pollen may provoke stronger reactions during the low pollen concentrations before the birch pollination period. Similarly, the peak birch pollen season may provoke symptoms at the end of May, when pollen concentrations were decreased to moderate and low levels. Another explanation might be that the severity of bronchial hyperresponsiveness (BHR) in non-asthmatic patients changes with pollen-induced rhinitis during the season and evidence suggests that during the pollen season, and even after the cessation of exposure to pollen, BHR is increased for some weeks (Tilles and Bardana 1997; Kämpe et al. 2007).

In real life conditions, the exposure to pollen varies between the subjects due to differences in individual behaviour. By staying mainly indoors with lower levels of pollen, allergic people may avoid or at least reduce the risk of symptoms (Jantunen and Saarinen 2009). The irregular use of allergy medicines may also lead to the emergence of symptoms during the days of low pollen concentrations. The allergen content of the pollen is also significant. The high peak of birch pollen on 27.4.2010, for example, was a result of long-distance transport between 10 a.m. and 6 p.m. In this case, the pollen count may be misleading, since the pollen grains may have already released their allergenic material into the air and the emptied shells do not provoke allergy symptoms (Rantio-Lehtimäki et al. 1994; Holmquist et al. 2005). Subjects may also be exposed to small-sized particles possessing allergenic material that cannot be seen in the determination of pollen concentration when using a microscope (Grote et al. 2003; Taylor et al. 2004; Wang et al. 2011).

We conclude that there is a fair correlation between the daily allergy symptoms and the particular pollen concentrations, but the risk of developing symptoms during the levels of low, moderate and high concentrations is affected by the progression of the pollen season.

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