



Pollen distribution at elevations above 1000 m in Switzerland

Regula Gehrig & Annie G. Peeters

Swiss Meteorological Institute, Zurich, Switzerland

(e-mail: reg@sma.ch, agp@sma.ch)

(Received 17 January 2000; accepted in final form 15 May 2000)

Key words: Swiss Alps, birch pollen, grass pollen, mesoscale pollen transport, pollen allergy

Abstract

In Switzerland the concentration of allergenic pollen decreases with increasing elevation of the sampling site of the Swiss pollen measuring network. The aim of this study was, to compare the pollen concentrations of five different localities in the Swiss Alps and in the Jura mountains, to get an idea of the differences in the pollen abundance in altitudes above 1000 m. The investigated localities are: La Chaux-de-Fonds (1040 m), Wiesen (1420 m), Davos (1600 m), Samedan (1705 m) and Gütsch (2287 m). These pollen sums were compared to the Swiss plateau (Basel 273 m). Basel, La Chaux-de-Fonds and Wiesen show clearly higher pollen values than Davos, Samedan and Gütsch. Pollen concentrations of *Corylus*, *Alnus glutinosa*-type and *Fraxinus* are reduced with increasing altitude and are only a small problem for allergies above 1000 m. *Betula* pollen are also reduced in the higher localities, but there still occur many days with high pollen concentrations. Especially *Betula* pollen from medium range transport can play an important role for allergies in higher localities. The total grass pollen sum does not decrease up to an altitude of 1500 m. The grass pollen concentration depends more on factors like composition of the local grassland, land use and wind situation.

Pollen concentrations at higher elevations is influenced by the local vegetation, a reduced pollen production, land use, topography, exposition, wind velocity and wind direction. These factors modify the pollen concentration considerably. Due to the complex topography of the Prealps and Alps, it is therefore not possible to propose a general rule of pollen reduction with increasing altitude.

1. Introduction

In the Swiss Alps and in the Jura mountains many people live in villages or small towns in altitudes above 1000 m. Many of these places are also important for tourism. Several studies show, that those regions have generally a lower aerial pollen concentration than the localities on the Swiss plateau with an altitude of 250–600 m (Markgraf, 1980; Leuschner and Boehm, 1989; Frei, 1997; Frei et al., 1997). In the Swiss Alps and Prealps many climate health resorts are situated, where pollinosis and asthma patients benefit from this situation and get a reduction from their symptoms (Leuschner, 1994). With increasing altitude the local vegetation changes from a deciduous forest to a mixed forest and to a conifer forest. But the local vegeta-

tion is not the only factor that influences the aerial pollen content. The pollen production of the plants normally decrease with increasing altitude, because of a shorter growing season and therefore worse growing conditions (Markgraf, 1980; Landolt, 1984; Moe, 1998). Additionally important are climate, relief, wind exposition and meteorological conditions. In higher localities pollen concentration is enhanced by medium range and long distance transport of pollen (Markgraf, 1980; Jochimsen, 1986; Peeters and Zoller, 1988; Frei, 1997).

The aim of this study is to contrast the pollen counts of five different localities in the Swiss Alps and in the Jura mountains, to investigate the differences in the pollen distribution in altitudes above 1000 m (Figure 1). These pollen sums were contrasted with pollen

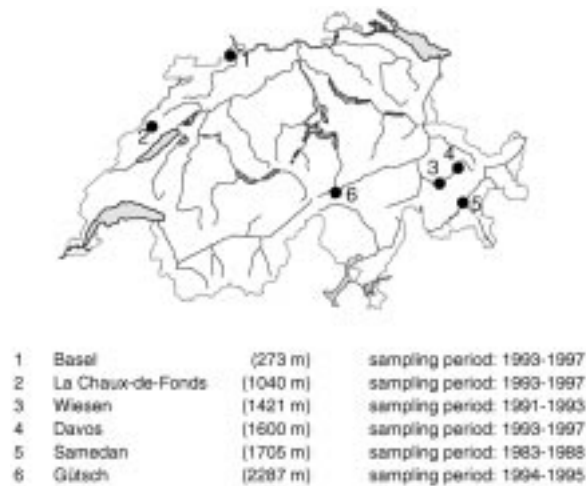


Figure 1. Location of the investigated pollen sampling sites.

values of the Swiss plateau (Basel 273 m). The results can be used to advice pollinosis patients to escape from the pollen situation at their place of residence.

La Chaux-de-Fonds (1040 m), Wiesen (1420 m), Davos (1600 m) and Samedan (1705 m) are villages or small towns in a rural environment surrounded mainly by conifer forests. The most allergenic species in Switzerland, *Betula* and *Poaceae*, are present at each sampling site, except at Gütsch. Gütsch (2287 m) is situated above the actual timberline. The local vegetation consists of alpine meadows. Up to an altitude of 2000 m grow *Alnus viridis*, *Larix* and *Pinus mugo*. This wind exposed station shows the effect of medium range transport (Frei, 1997). The comparison of Davos (1600 m) and Wiesen (1420 m) is interesting, because these two localities are only about 20 km apart from each other in the valley of the Landwasser.

2. Materials and methods

The pollen were collected with Burkard seven-day recording volumetric spore traps. From Basel, Davos and La Chaux-de-Fonds pollen counts from 1993–1997 are chosen for this study (carried out by the Swiss Meteorological Institute). These stations belong to the Swiss pollen measuring network. Apart from these, pollen counts in Samedan date from 1983–1988 (Peeters 1986 and Peeters unpubl. data), in Gütsch from 1994–1995 (by the Swiss Meteorological Institute) and in Wiesen 1991–1993 (Leuschner unpubl. data). The pollen traps in Samedan, Gütsch and Wiesen are no longer in function.

The volume or mass flow of the Burkard pollen trap is dependent on the air density, that is on pressure, temperature and relative humidity of the atmosphere. When we measure in higher locations, this effect has to be studied. At an altitude of about 2300 m at Gütsch a mean air pressure of 770 hPa and a mean temperature of -0.5°C is measured. Compared to Basel (979 hPa, 9.5°C) the differences are 209 hPa and 10°C , respectively. Because of the reduced air density at Gütsch, the sampling efficiency of the Burkard pollen trap is decreased by approximately 10%. This means that the counting error (Comtois et al., 1999) is bigger than the influence of altitude. Therefore the pollen concentrations of higher altitudes are not corrected in this study.

The limits for the number of days with high pollen values were chosen as following: *Corylus*, *Alnus*, *Betula* 70 pollen/ m^{-3} day $^{-1}$, *Fraxinus* 100 pollen/ m^{-3} day $^{-1}$, *Poaceae* 50 pollen/ m^{-3} day $^{-1}$, *Rumex* 25 pollen/ m^{-3} day $^{-1}$. They correspond with the thresholds used in Switzerland for high concentrations which can cause hayfever symptoms.

3. Results and discussion

In general, the six localities can be divided in two groups. Basel (273 m), La Chaux-de-Fonds (1040 m) and Wiesen (1420 m) show clearly higher pollen values than Davos (1600 m), Samedan (1705 m) and Gütsch (2287 m). As expected, the pollen concentrations on the Swiss plateau are the highest, except for the *Poaceae* pollen. But there are differences within the different allergenic species (Figure 2).

Corylus, *Alnus glutinosa*-type, *Fraxinus*

The pollen concentration of *Corylus*, *Alnus glutinosa*-type and *Fraxinus* decrease with increasing altitude. For allergies, they do not play a significant role above 1000 m. Only *Fraxinus* pollen occurs at an altitude of 1000 m in quantities which can cause hayfever. These results coincide with the distribution of these trees and shrubs in altitude. *Corylus* and *Alnus incana* grow up to an altitude of 1700 m, but above 1000 m, especially *Corylus* becomes less abundant. The upper limit of *Fraxinus* and *Alnus glutinosa* is about 1200 m asl.

Betula

Betula pollen are important also in higher altitudes. In the Swiss Alps birch can grow up to an altitude of

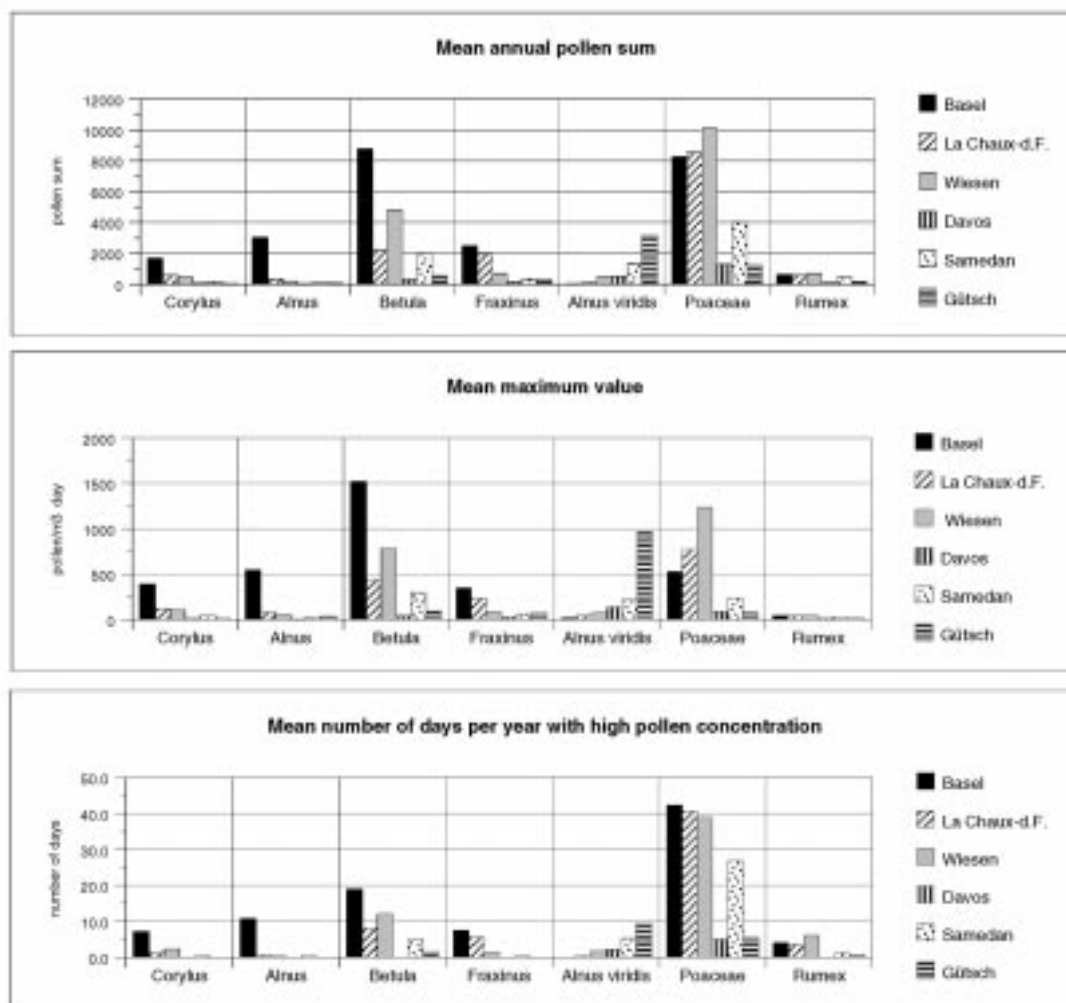


Figure 2. Comparison of the pollen concentrations for localities in the Swiss Alps, Jura mountains and the Swiss plateau (Basel 273 m, La Chaux-de-Fonds 1040 m, Wiesen 1420 m, Davos 1600 m, Samedan 1705 m, Gütsch 2387 m).

2000 m. So birch trees are present near each of the sampling localities with the exception of Gütsch.

With increasing altitude the pollen production of trees decrease remarkably (Markgraf, 1980). Moe (1998) showed this effect for *Alnus incana* in south Norway, where the main reasons for this are climate factors like local summer temperatures, frost injury and length of the growing season. The reduction of the pollen production is also important for birch. As expected the Swiss plateau has the highest birch pollen concentrations. But even in Samedan (1705 m) there are 5 days with high pollen concentrations. In Wiesen (1420 m) there are 12 days with high concentrations, while La Chaux-de-Fonds (1040 m) has only 8 and in Davos (1600 m) there is no day at all with high

pollen values. Even Gütsch (2287 m) has higher birch pollen concentrations than Davos although all pollen at Gütsch originate from medium range transport. The same pattern is visible in the annual pollen sum and in the maximal values. This shows that not only altitude and local vegetation is responsible for the birch pollen distribution in Switzerland.

To explain the difference in birch pollen concentrations, the pollen counts of Wiesen and Davos are compared (Figure 3). In the measuring period from 1991 to 1993 each year shows a different pattern of birch pollen transport. In all three years it is clearly visible, that in Wiesen high birch pollen concentrations are registered during the main flowering season of birch on the Swiss plateau. The peaks correspond

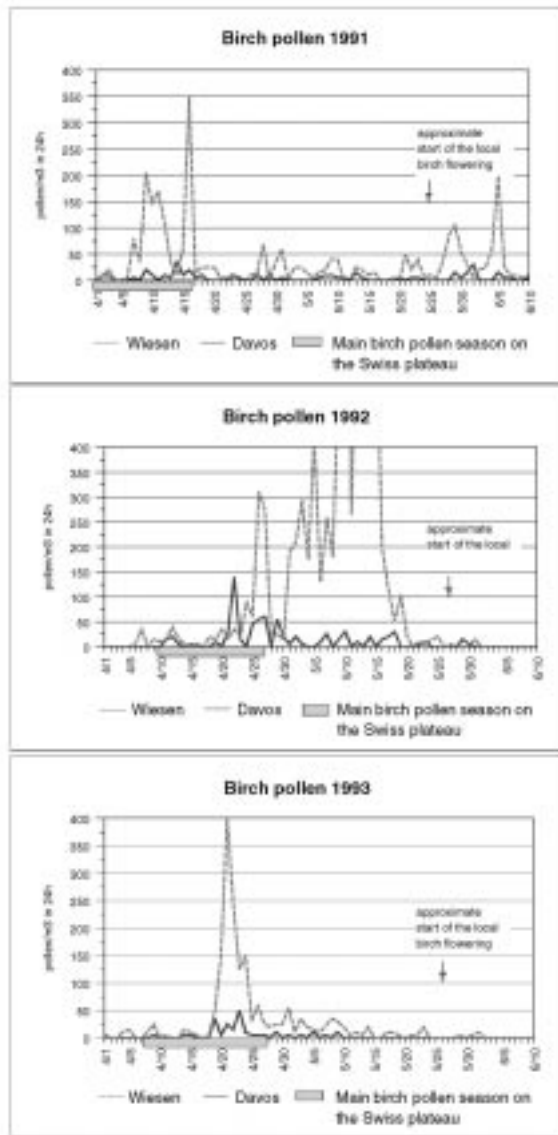


Figure 3. Birch pollen seasons 1991–1993 in Wiesen (1420 m) and Davos (1600 m).

well with those from the eastern Swiss plateau. Wiesen is well protected from the general wind circulation, but especially on sunny days a mountain valley wind system is well developed (Nater et al., 1998). It brings pollen from lower altitudes to Wiesen. 1991 and 1993 most of the birch pollen in Wiesen originate from this transported pollen. Only in 1991 birch pollen from local origin are registered (period May 21–June 10). The local birches normally start flowering towards the end of May. In 1992 and 1993 the local birches produced only very few pollen. The high pollen con-

centration in 1992 from May 1 to May 19 originate also from medium range transport. During this period, birches of an altitude of approximately 900–1200 m were flowering. Davos has exceptional low birch pollen concentrations. Birch is sparsely distributed in the forests of the nearer surroundings of Davos. Additionally there exist some birch trees in the garden of the hospital near the Burkard pollen trap. So the local pollen production is low. It seems that Davos is also very well protected by the mountains from the wind circulation, so pollen from lower altitudes are hardly brought to Davos.

Samedan shows a similar pattern as Wiesen. Also in Samedan most of the *Betula* pollen come from medium range transport. Local pollen occurs only about every three year in important concentrations.

Despite a mostly low pollen production of the local birches, pollen from medium range transport can cause allergies at higher elevations. The difference of the birch pollen counts from year to year and the varying importance of transported pollen makes it very difficult to forecast the birch pollen concentrations at these localities.

The advantage of higher altitudes is, that the pollen season starts later and that the local pollen production is mostly low. This is especially the case for Davos, Samedan and Gütsch. Thanks to the special geographical situation, Davos has no day with high *Betula* pollen concentration.

Alnus viridis

Alnus viridis is a shrub which flowers in June and which grows from 1000 to 2300 m in the Alps and Prealps. Therefore pollen concentrations increase with increasing altitude of the sampling site. Basel and La Chaux-de-Fonds show only *Alnus viridis* pollen from medium range transport. Wiesen has on the average 1.7, Davos 2.2, Samedan 4.8 and Gütsch 9.5 days with high pollen concentrations. The same pattern is visible in the annual pollen sum where Gütsch shows the maximum with 3122 pollen per year. The pollen trap at Gütsch is situated about 1 km away and 300 m above of some individual species of *Alnus viridis*, but on the opposite slope of the valley exists an extensive *Alnus viridis* belt which is most likely the source of these pollen. So in the Swiss Alps and Prealps people with alder pollen allergies must be aware of high alder pollen values in June which can cause hayfever symptoms.

Table 1. Mean starting date and mean maximum value of grass pollen at different elevation in Switzerland (Basel 273 m, La Chaux-de-Fonds 1040 m, Wiesen 1420 m, Davos 1600 m, Samedan 1705 m, Gütsch 2387 m)

	Mean starting date of high grass pollen values	Mean date of the maximum of grass pollen
Basel	May 9	June 4
La Chaux-de-Fonds	May 24	June 16
Wiesen	May 29	June 28
Davos	June 5	June 21
Samedan	June 3	July 16
Gütsch	June 15	June 24

Poaceae

The Swiss plateau (Basel), La Chaux-de-Fonds and Wiesen show increased Poaceae pollen sums. There is no decrease in the total grass pollen sum up to an elevation of 1500 m. To the contrary, the total grass pollen sum and the annual maximum value are the highest in Wiesen (1420 m). The only difference is, that in Wiesen the grass pollen season starts about three weeks later than on the Swiss plateau (Table 1). Davos, Samedan and Gütsch have rather low grass pollen values. Davos shows the lowest grass pollen sums. At Gütsch the comparable early date of the maximum grass pollen value shows that the main amount of grass pollen comes from lower altitudes.

The sum of grass pollen depends mainly on the local and regional vegetation, the composition of the species in the grassland, which change with increasing altitude and the agricultural use. In the surroundings of La Chaux-de-Fonds meadows and pastures dominate, so the grass pollen sum is greater than in Basel. Wiesen is a small village where most of the grassland is used as hay meadows. In Davos over 80% of the alpine grassland is used as pasture for cattle (Günter, 1986). The hay meadows in the valley bottom occupy only a relatively small area (Landolt et al., 1986). It is possible that land use is responsible for the difference in grass pollen concentrations between Wiesen and Davos. The local wind circulation and the relief are additional factors influencing the grass pollen concentrations. This seems to be the case in Samedan where the valley is very large and open to winds, so pollen can be transported better. In Samedan the grass pollen concentration is high during 27 days, but the yearly

grass pollen sum is much lower than in Wiesen but greater than in Davos.

Herbaceous plants: Rumex

Pollen of herbaceous plants play a role for allergies only in localities below 1500 m. As an example of the herbaceous plants *Rumex* is chosen for a comparison between these stations. Only Basel, La Chaux-de-Fonds and Wiesen show days each year with high pollen concentrations. In Samedan and at Gütsch high pollen concentrations occur periodically. During this survey, Davos never had any day with high *Rumex* pollen values. The reason for this differences may also be the different agricultural use of the meadows and pastures, the occurrence of different *Rumex* species and different pollen production of these species.

4. Conclusion

At high elevation tree pollen values are distinctly lower than on the low elevation of the Swiss plateau, so people with allergy to tree pollen benefit from this reduction. Although *Betula* pollen is not as much reduced as pollen of *Corylus*, *Alnus glutinosa*-type and *Fraxinus*, the concentrations are decreased at higher altitudes. Additionally, the pollen season starts later at high elevation. From phenological studies it is known that in Switzerland the delay is about 4–7 days/100 m in spring (Defila, 1991). So many patients use this advantage to escape from the current pollen situation on the Swiss plateau. The example of Wiesen shows that – depending on the local and regional vegetation and even more on the local wind situation – pollen from medium range transport can occur in such numbers that allergies are possible. Several papers describe that pollen from medium or long distance transport are still allergenic and can produce allergic symptoms (Wallin et al., 1991; Hjelmroos, 1992). In a study at the polar timberline in Lapland, Hicks (1993) showed that the more open the local vegetation is, the greater the proportion of pollen which comes from outside. In the mountains *Alnus viridis* could be a problem for people with allergies to Betulaceae. Its pollen increases with increasing altitude and can cause allergies in June.

Poaceae pollen show a different behavior. In this study there is no reduction of grass pollen up to an altitude of 1500 m. Above 1500 m the grass pollen sum and the maximal daily counts decrease clearly.

But there are still days with high grass pollen concentrations depending on the local circumstances of a locality.

Apart from the local vegetation, factors like altitude, topography, wind situation and mesoscale pollen transport are very important and modify the pollen concentration. It is not possible to make a proposal for a general rule of a pollen reduction with increasing altitude in the Alps.

It is necessary to determine the pollen content of the air and the pollen season by measurement for each locality itself. If these are known, the Alps and Prealps can be very suitable for allergic people so they can spend the time with highest pollen concentrations on the Swiss plateau in higher locations.

Acknowledgments

We like to thank Mrs. Dr. R. M. Leuschner and the Kurverein Wiesen for the unpublished pollen data of Wiesen, which we could use for this research.

References

- Comtois P., Alcazar P. and Néron D.: 1999, Pollen counts statistics and its relevance to precision, *Aerobiologia* **15**, 19–28.
- Defila C.: 1991, Pflanzenphänologie der Schweiz, PhD thesis Universität Zürich, *Veröff. der Schweiz. Meteorol. Anstalt* Nr. **50**, 1–233.
- Frei Th.: 1997, Pollen distribution at high elevation in Switzerland: Evidence for medium range transport, *Grana* **36**, 34–38.
- Frei Th., Petri E., Schmitz M., Vocks E. and Borelli S.: 1997, Messung des Pollenflugs an zwei verschiedenen Standorten im Hochgebirgstal von Davos, *Allergologie* **20/6**, 296–300.
- Günter Th.: 1986, Nutzungsgeschichte. In: O. Wildi and K. Ewald (eds), *Der Naturraum und dessen Nutzung im alpinen Tourismusgebiet von Davos, Ergebnisse des MAB-Projektes Davos, Eidg. Anstalt für d. forstl. Versuchswesen Bericht* **289**, 215–238.
- Hicks S.: 1993, The use of recent pollen rain records in investigating natural and anthropogenic changes in the polar tree limit in Northern Fennoscandia. In: B. Frenzel (ed), *Oscillations of the Alpine and Polar Tree Limits in the Holocene, Paläoklimaforschung Band* **9**, 5–18.
- Hjelmroos M.: 1992, Long-distance transport of *Betula* pollen grains and allergic symptoms. *Aerobiologia* **8**, 231–236.
- Jochimsen M.: 1986, Zum Problem des Pollenflugs in den Hochalpen. *Diss. Bot.* **90**, 1–249.
- Landolt E.: 1984, *Unsere Alpenflora*, Verlag Schweizer Alpen-Club: Zürich.
- Landolt E., Zumbühl G. and Krüsi B.: 1986, Vegetation und landwirtschaftliche Nutzungsmöglichkeiten. In: O. Wildi and K. Ewald (eds), *Der Naturraum und dessen Nutzung im alpinen Tourismusgebiet von Davos, Ergebnisse des MAB-Projektes Davos, Eidg. Anstalt für d. forstl. Versuchswesen Bericht* **289**, 139–174.
- Leuschner R.M.: 1994, Vergleich der Luftpollen an drei Messstellen: Davos-Wolfgang, Wiesen GR und Basel. *Allergologie* **17/11**, 505–508.
- Leuschner R.M. and Boehm G.: 1989, Schadstoffe in der Luft in verschiedenen Höhenlagen. *Präv.-Rehab.* **1/2**, 67–74.
- Markgraf V.: 1980, Pollen dispersal in a mountain area. *Grana* **19**, 127–146.
- Moe D.: 1998, Pollen production of *Alnus incana* at its south Norwegian altitudinal ecotone. *Grana* **37**, 35–39.
- Nater W, Matthys H and Virchow C: 1998, Luftqualität und Klima von Wiesen (GR), Schlussbericht der Wiesener Klimauntersuchungen: Touristikverein Wiesen.
- Peeters A.G.: 1986, Recherches aéropalynologiques à Samedan, Haute-Engadine (Suisse) de 1983 à 1985, PhD thesis, Universität Basel, Switzerland.
- Peeters A.G. and Zoller H.: 1988, Long range transport of *Castanea sativa* pollen. *Grana* **27**, 203–207.
- Wallin J.-E., Segerström U., Rosenhall L. and Hjelmroos M.: 1991, Allergy symptoms caused by long-distance transported birch pollen. *Grana* **30**, 381–394.