



Frost periods and beginning of the ash (*Fraxinus excelsior* L.) pollen season in Basel (Switzerland)

Annie Gérard Peeters

Swiss Meteorological Institute, Zurich, Switzerland (fax: +41 12569278)

Received 20 January 2000; accepted in final form 15 May 2000

Key words: ash pollen, forecast, frost periods, meteorological factors

Abstract

In order to be able to forecast the beginning of the ash pollen season, several meteorological factors have been considered. During these research activities it appeared that the ash pollen release is closely linked to frost periods happening during the months of February and March. For 24 years over a period of 29 consecutive years, a daily concentration of 30 ash pollen grains/m³/day has been reached when the cumulated mean daily temperatures starting on the last day when the absolute minimum temperature is lower or equal to -2°C amounts on average to 214°C – admitting a variation of plus or minus 42°C . As for the five remaining years, rain is three times responsible for the delay of the pollen release.

Introduction

The ash tree (*Fraxinus*), belonging to the olive family, is widespread in Central and Northern Europe. It is also widely used as an ornamental tree within the Mediterranean area (Candau et al., 1994). Within the *Oleaceae* family, pollen of the olive tree (*Olea europaea*) is considered as the most allergenic pollen in the Mediterranean area (Bousquet et al., 1985; D'Amato et al., 1988, 1989, 1993; Gonzalez et al., 1996) as well as in the most southern part of Switzerland (the Tessin region). There, in Locarno, 54% of pollen allergic symptoms are due to this pollen (Gilardi et al., 1994). Cross-reactions between the different genera of the *Oleaceae* family have been observed in Europe (Bousquet et al., 1985; D'Amato et al., 1989; Macchia et al., 1991). *Fraxinus* pollen has so many allergens in common with *Olea* that it may happen that patients allergic to *Olea* pollen in the Mediterranean area react to the *Fraxinus* pollen when travelling to Central and Northern Europe during April and May (D'Amato et al., 1988).

In Switzerland, *Fraxinus* pollen has been considered for a long time as secondarily allergenic pollen (Helbling et al., 1985). Spring allergic symptoms

were rather attributed to birch (*Betula* spp.) pollen, which has always been considered as highly allergenic and which appears at the same period of the year as the *Fraxinus* pollen (Helbling et al., 1985; Guerin et al., 1990; Leuschner, 1991; D'Amato et al., 1993). However, since 1991 ash pollen has been included into the list of major allergenic pollen together with grass (*Poaceae*), birch and mugwort (*Artemisia*) pollen (Wüthrich et al., 1991; Peeters et al., 1994; Schmid et al., 1992; Schmid-Grendelmeier et al., 1994; Wüthrich et al., 1994; Frei et al., 1995; Wüthrich, 1995; Wüthrich et al., 1995). This also reflects the opinion of other European research workers (D'Amato et al., 1993).

One of the most essential aims of aerobiology is the prediction of the date at which pollen causing allergic reactions appears (Lejoly-Gabriel, 1978; Frenguelli et al., 1989; Candau et al., 1994; Gonzalez Minero et al., 1996). This may be a pretty difficult task since the variation of the date can be very large (see below). Therefore in Switzerland the research work is focused on the determination as precisely as possible, of the beginning of the pollen season for the most important types of pollen: hazel (*Corylus*) (Frei, 1995), ash (Peeters, 1998) and grass pollen (Clot,

1998). One of the first results of these works has been to demonstrate the great importance of local factors such as altitude, orientation and vegetation in addition to the meteorological factors that lead to pollination.

Material and methods

Meteorology

The Swiss Meteorological Institute in Zurich has provided meteorological data. Data come from the automatic network and have been published in the Annals of Swiss Meteorological Institute (Annalen der Schweizerischen Meteorologischen Anstalt, 1969–1997).

Palynology

Thanks to the initiative of Dr. R.M. Leuschner, who has performed the pollen analysis since 1969 in Basel, we dispose of a long sequence of results, which constitutes a valuable base for investigations about the influence of diverse meteorological factors on the pollen liberation.

A Hirst-type volumetric pollen and spore trap (Burkard) was placed from March 1969 to February 1977 on the roof of a building in Basel. The building was situated at an altitude of circa 279 m a.s.l. and approximately 15 m above ground level. Since February 1977 the trap has been transferred onto the roof of the County Hospital (273 m a.s.l.), 33 m above ground level and around 300 m northwards from the old location. Since the distance between the two buildings is small and altitude difference only amounts to 6 m, this relocation appears not to have any effect on the results, (Frei, personal communication).

Conventional methods, as described in Peeter (1988) have been used for trap preparation and analysis (such as slides evaluation). Pollen concentrations are expressed as pollen grains per cubic meter of air per day (hereafter: grains/m³/day). From 1969 to 1997, Dr R.M. Leuschner assumed the analysis (see the complete bibliography in Leuschner and Jenkins, 1996). Pollen data come from the Swiss work group for aerobiology for the years 1983 to 1992. Since 1993, data come from the Swiss meteorological Institute in Zurich.

Mathematical considerations

Only temperatures above or equal to zero degrees Celsius have been taken into account in the calculation of cumulative sums; negative temperatures have been considered as equal to zero degrees.

The starting point of this empirical study was the determination of an upper threshold that would be appropriate for the prediction of the beginning of ash pollen season. This threshold has been set at the date when a concentration of 30 pollen grains/m³/day is reached because from there, pollen concentration rises very quickly to the point where allergic symptoms appear – when no rain perturbs the increase of the concentration (Peeters, 1998).

In order to establish a lower threshold, several trials have been examined, working with temperatures, which are cumulated up to the date where the upper threshold is reached. As regards the lower threshold, the basic assumption was that the extremes between the lowest and highest cumulated temperatures reached at the upper threshold should be as small as possible, in order to assure some predictability to the method.

Firstly, the starting date chosen was the 1st of January. But the results were not satisfying and not particularly interesting for this study because the variation of the cumulated temperatures was too high (see Table 1, 3rd column), reaching 255 °C, the average of the cumulated temperatures over the 29 years being 359 °C.

Then the last frost periods usually happening during the months of February and March (but in January of 1990 and 1995) were taken into account. The inferior threshold (date from which temperatures are cumulated) was set on the day where the absolute minimum temperature was equal to or below –2 °C. As Figure 1 shows, the 1970 frost period has a strong impact on pollen concentration: during this period concentrations stay at a given level, without increasing.

With these considerations, two possible cases appeared: either they were one episode of frost in most cases in February or two episodes, one in March and one in February. For the first case, the frost period could last several days, even extending from February to March. The last day at which a minimal temperature of –2 °C was registered is then taken as the lower threshold. This represents more than 50% of the cases (see Table 1).

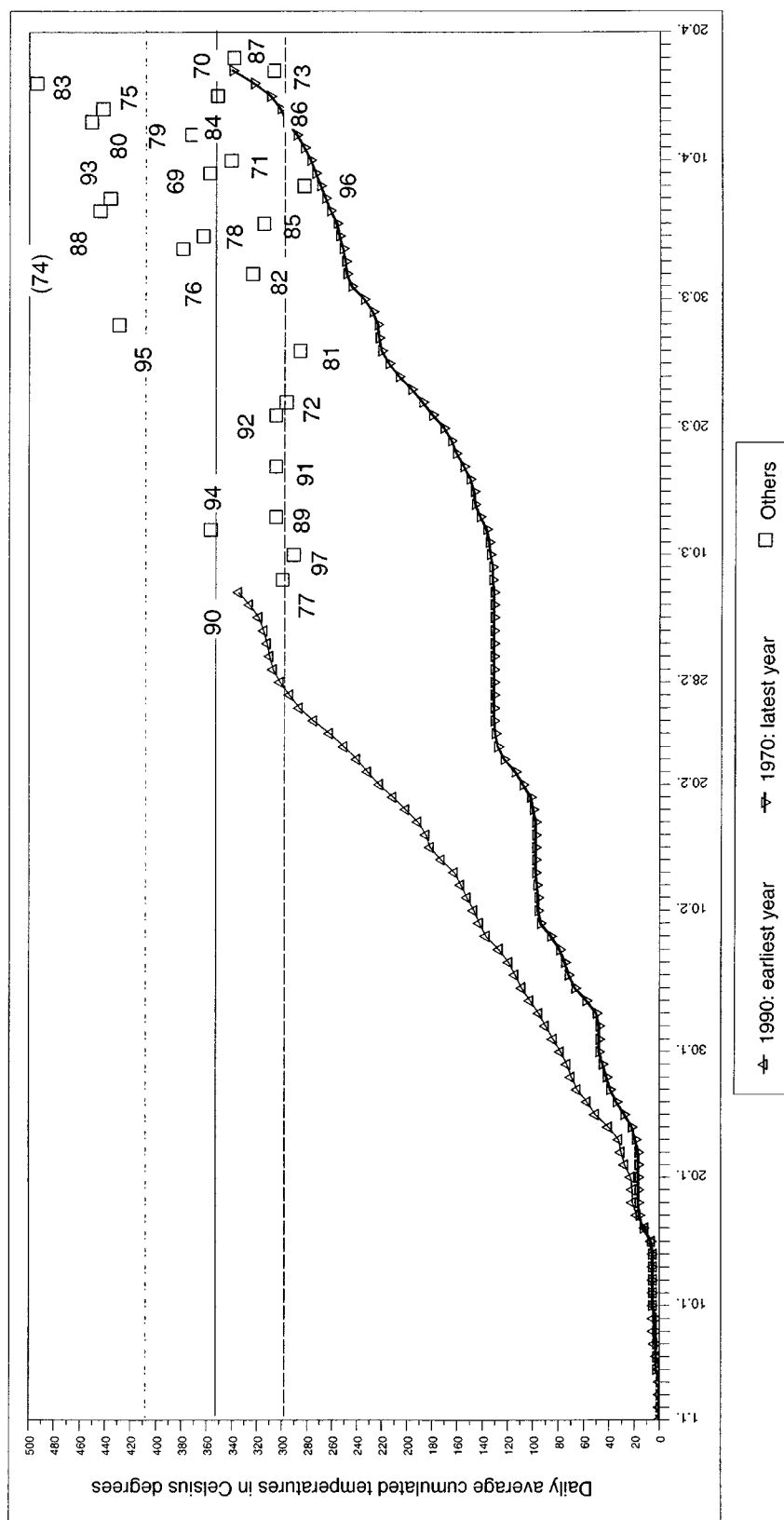


Figure 1. Diagram of the both extremes (latest and earliest years) of the cumulated daily average temperatures until the date where a concentration of at least 30 ash pollen grains/m³/day was reached. Other years are also presented at that concentration.

Table 1. Results of the different trials with cumulated mean daily temperatures ending on the day at which a concentration of 30 ash pollen grains/m³/day is reached.

Basel									
<i>Fraxinus</i>									
Years	First time 30 P	Cum. temp from 1st. 1	Date (F1) 1st. frost	Date (F2) 2d. frost	Temp. diff F2 – F1	Cum. temp beginn. at	Cum. temp.	Cum. temp.	Days
1969	09.4	358	18.2	08.3	55	09.3	209	209	31
1970	17.4	340	17.2	16.3	52	17.3	190	190	31
1971	10.4	341	12.2	09.3	54	10.3	222	222	21
1972	22.3	297	1.2	–	–	2.2	255	25	48
1973	17.4	307	17.2	17.3	54	18.3	192	192	30
1974	2.4	538	3.3	–	–	4.3	256	256	29
1975	14.4	442	27.2	30.3	146	28.2	219	219	45
1976	3.4	379	16.2	22.3	147	17.2	251	251	45
1977	8.3	300	3.2	1.3	174	4.2	243	243	32
1978	4.4	363	21.2	–	–	22.2	289		41
1979	12.4	372	28.2	–	–	1.3	281		42
1980	14.4	451	5.3	–	–	6.3	260	260	39
1981	26.3	286	27.2	–	–	28.2	216	216	26
1982	2.4	324	28.2	–	–	1.3	188	188	32
1983	16.4	494	24.2	–	–	25.2	346		50
1984	15.4	352	20.2	13.3	28	14.3	196	196	32
1985	4.4	315	23.2	20.3	95	24.2	229	229	39
1986	15.4	309	11.3	–	–	12.3	204	204	33
1987	16.4	339	25.2	21.3	60	22.3	198	198	24
1988	4.4	444	24.2	10.3	15	11.3	176	176	27
1989	13.3	305	5.2	–	–	6.2	225	225	35
1990	7.3	335	20.1	4.3	287	21.1	312		45
1991	17.3	305	18.2	–	–	19.2	202	202	26
1992	21.3	305	22.2	–	–	23.2	199	199	26
1993	5.4	436	9.3	30.3	159	10.3	204	204	26
1994	13.3	357	20.2	–	–	21.2	176	176	20
1995	28.3	429	18.1	5.3	286	19.1	417		68
1996	8.4	283	13.3	28.3	115	14.3	176	176	25
1997	10.3	291	7.2	–	–	8.2	251	251	30
Aver.		359					234	214	35
Min.		283					176	176	
Max.		538					417	260	
Diff.		255					241	84	

In the cases where they are several frost periods (representing a bit less than the other 50% of the cases), only the two last periods are considered. Moreover, the cumulated temperatures between those two periods are also taken into account. These temperatures can be distinguished into two groups. They are on one hand concentrated around 50 °C or lower (7 cases) and on the other hand they are much higher, between circa 100 °C and 290 °C (6 cases). For the first group the penultimate date is taken as the lower threshold, for the latter it is the last date that is taken.

Results

Cumulated temperatures

The average duration of the 29 years covered by this study (Table 1, 10th column) between the date of the lower threshold (Table 1, 7th column) and the upper threshold (Table 1, 2nd column) is 35 days, but it can extend from 20 to 68 days.

The average of the daily mean temperatures cumulated from the date of the penultimate or last frost day to the release of at least 30 ash pollen grains/m³/day reached 234 °C (with extremes of 176 and 417 °C) (Table 1, column 8). However, it was noticed that for five years very high cumulated temperatures were

reached (1978: 289 °C; 1979: 281 °C; 1983: 346 °C; 1990: 312 °C and 1995: 417 °C). In most of these cases (three out of five), precipitation was recorded at the moment where the concentration of 30 ash pollen grains should have been attained. Because of the rain, the pollen grains were not released whereas temperatures kept on accumulating. In 1978 for example, on the 28th of March, the average cumulated temperature (214 °C, see below) was reached, but it had been raining from the 12th to 27th of March (61.6 mm), therefore delaying the release of pollen grains. The 30 pollen grains/m³/day concentration was reached 8 days after the rain had ceased. In 1979 and 1983, the same scenario appeared. Therefore, it was decided to remove these years from the calculation. The results obtained are much more satisfying. The average cumulated temperature is then 214 °C plus or minus 42 °C, corresponding roughly to 4 days. This temperature can then be used to predict the beginning of the ash pollen season within more or less four days.

No exact reasons can be given for 1990 and 1995. In 1990, for example, the *first* frost period appeared on the 20th of January (in 1995 it was January as well). The cumulated temperature at the upper threshold reached on the 7th of March was 312 °C. It is the very earliest date for the release of at least 30 ash pollen grains/m³/day. Perhaps there is also a physiological lower threshold for the release.

Duration of ash pollen season

The ash pollen season is considered according to two criteria. Firstly on a low level, the beginning of the season is the date at which ash pollen concentration reached 30 pollen grains/m³/day. The season ends when ash pollen concentration drops under 30 pollen grains/m³/day. The second level is determined by concentrations of at least 167 pollen grains/m³/day. This concentration is considered as the critical concentration for the appearance of allergic symptoms (Horak F. et al., 1980).

On the first level (see Figure 2), the earliest season started on a 7th of March in 1990, and the latest on a 17th of April in 1970 and 1973. 41 days separate these two season beginnings. However, on average the beginning of the season is around the 1st of April. The earliest end of the ash pollen season was seen on the 8th of April in 1994 and the latest on a 21st of May in 1970. The longest ash pollen season lasted 58 days (in 1977 and 1989) when the concentration of at least 30 pollen grains/m³/day was reached during 25 days. The

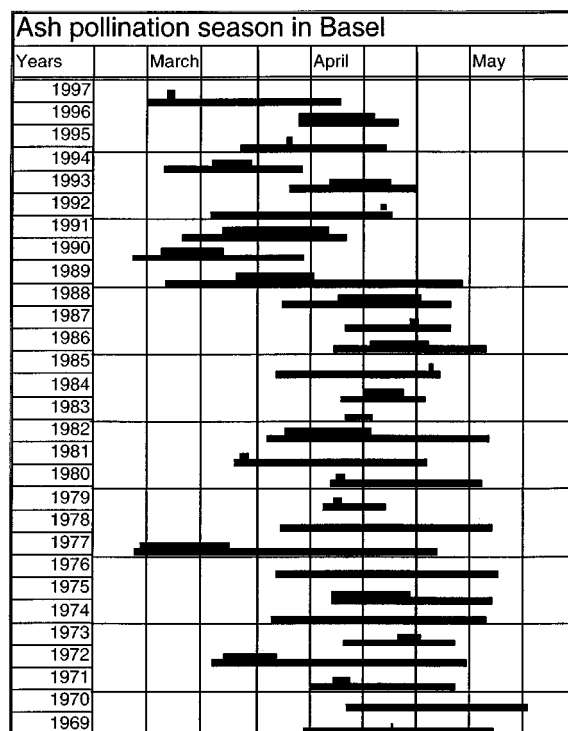


Figure 2. Duration of ash pollen season: thin line with a concentration of at least 30 ash pollen grains/m³/day, thick line with a concentration of at least 167 ash pollen grains/m³/day.

shortest period took place in 1983 with only 6 days with concentrations of 30 pollen grains/m³/day. These results show the great variability of the ash pollen season and the great difficulty in predicting its start and end as well as its length. Therefore, cumulated temperatures offer a very simple, though not absolutely precise method for predicting the beginning of the ash pollen season. On the higher level, the season with concentrations reaching at least 167 ash pollen grains/m³/day can be as short as one day or even be non-existing. The longest season with this concentration was found in 1977 with 15 days out of 18! More observations about this graph will be the subject of a later paper.

Comparison with the release of at least 30 pollen of birch

The comparison of the dates of release of at least 30 ash and birch pollen grains/m³/day (see Table 2) shows strong variations between the two trees: in 1973, for example, ash pollen grains were trapped 16 days after those of birch but on the other hand, in 1990,

Table 2. Date of appearance of at least 30 pollen grains/m³/day for ash and birch trees and difference between the two.

Years	Apperance of at least 30 pollen grains per m ³		
	<i>Fraxinus</i>	<i>Betula</i>	Difference
1969	9.4	16.4	+7
1970	17.4	18.4	+1
1971	10.4	7.4	-3
1972	22.3	26.3	+4
1973	17.4	1.4	-16
1974	2.4	25.3	-8
1975	14.4	14.4	0
1976	3.4	30.3	-4
1977	8.3	16.3	+8
1978	4.4	5.4	+1
1979	12.4	9.4	-3
1980	14.4	1.4	-13
1981	26.3	29.3	+3
1982	2.4	8.4	+6
1983	16.4	8.4	+6
1984	15.4	14.4	-1
1985	4.4	4.4	0
1986	15.4	15.4	0
1987	16.4	11.4	-5
1988	4.4	11.4	+7
1989	13.3	22.3	+9
1990	7.3	17.3	+10
1991	17.3	21.3	+4
1992	21.3	2.4	-12
1993	5.4	23.3	-14
1994	13.3	14.3	+1
1995	28.3	3.4	+7
1996	8.4	8.4	0
1997	10.3	14.3	+4

ash pollen grains were released 10 days before those of birch. Therefore, comparison between the two cannot be very useful at the moment for predicting pollen season. Obviously, other factors have to be taken into consideration.

Conclusion

In this experimental study, frost periods have been defined as days with a minimum temperature of -2 °C. These frost period strongly influence the release of pollen grains. However, this threshold was set rather empirically. Therefore, further studies are

needed to define more exactly the minimum temperature.

Although birch pollen appears roughly at the same time as the ash pollen, the two can not be compared directly. There again, further studies are needed to determine which climatological factors are responsible for the release of pollen of each tree.

References

- Annalen der Schweizerischen Meteorologischen Anstalt*: 1969–1997, Herausgegeben von der Schweizerischen Meteorologischen Anstalt, Zurich.
- Bousquet J., Guérin B., Hewitt B., Lim B. and Michel F.-B.: 1985, Allergy in the Mediterranean area. III: Cross-reactivity among *Oleaceae* pollens. *Clin. Allergy* **15**, 439–448.
- Candau P., Gonzalez Minero F. and Romero F.: 1994 Aeropalinology of *Fraxinus* (ash) in an urban area of southwestern Spain. *Aerobiologia* **10**, 47–51.
- Clot B.: 1998, Forecast of the *Poaceae* pollination in Zurich and Basel (Switzerland). *Aerobiologia* **14**, 267–268.
- D'Amato G., Mullins J., Noland N., Spieskma F.T.M. and Wachters R. (1988) City spore concentrations in the European Economic Community (EEC). VII. *Oleaceae* (*Fraxinus*, *Ligustrum*, *Olea*). *Clin. Allergy* **18**, 541–547.
- D'Amato G. and Lobefalo G.: 1989, Allergenic pollens in the southern Mediterranean area. *J. Allergy Clin. Immunol.* **83**, 116–122.
- D'Amato G. and Spieskma F.T.M.: 1993, Pollenallergie in Europa. *Allergologie* **16**, 430–433.
- Frei T.: 1995, Einfluss der mittleren Tagestemperaturen auf die Haselpollenfreisetzung in Zürich. *Präv.-Rehab.* **8**, 59–63.
- Frei T., Torricelli R., Peeters A.G. and Wüthrich B.: 1995, The relationship between airborne pollen distribution and the frequency of specific pollen sensitization at two climatically different locations in Switzerland. *Aerobiologia* **11**, 269–273.
- Frenguelli G., Bricchi E., Romano B., Mincigrucci G. and Spieskma F.T.M. (1989) A predictive study on the beginning of the pollen season for *Gramineae* and *Olea europea* L. *Aerobiologia* **5**, 64–70.
- Gilardi S., Torricelli R., Peeters A.G. and Wüthrich B.: 1994, Pollinosis im Kanton Tessin. Eine prospektive Studie in Locarno 1990–1993. *Schweiz. Med. Wschr.* **124**, 1841–1847.
- Gonzalez Minero F.J. and Candau Fernandez-Menasque P.: 1996, Prediction of the beginning of the olive full pollen season in southwest Spain. *Aerobiologia* **12**, 91–96.
- Guérin B., Wüthrich B., Peeters A.G. and Choquet P.H.: 1990, Allergie aux pollens d'arbre. *Méd. Hyg.* **48**, 1089–1096.
- Guerrier G.: 1993, Les pollinoses aux arbres chez l'enfant dans la région Lyonnaise. "Il ne faut pas que l'herbe cache la forêt". *Rev. Fr. Allergol.* **33**, 221–225.
- Helbling A., Leuschner B. and Wüthrich B.: 1985, Pollinosis. IV: Welche Pollen sollen in der Allergie-Praxis getestet werden? *Schweiz. Med. Wschr.* **115**, 1150–1159.
- Horak F., Hussarek M., Jäger S. and Skoda-Türk R.: 1980, Die Bestimmung der Aggressivität allergisierender Pollenarten. *Klin. Wschr.* **75**, 532–538.
- Lejoly-Gabriel M.: 1978, Recherches écologiques sur la pluie pollinique en Belgique. *Acta Geogr. Lovaniensia* **13**.

- Leuschner R.M.: 1991, Comparison of airborne pollen levels in Switzerland at four recording stations (Davos, Lucerne, Nyon and Basle) during 1989. *Int. J. Biometeo.* **35**, 71–75.
- Leuschner R.M. and Jenkins J.: 1996, Ruth M. Leuschner: A biographical sketch. *Aerobiologia* **12**, 141–147.
- Macchia L., Caiaffa M.F., D'Amato G.D. and Tursi A.: 1991, Allergenic significance of *Oleaceae* pollen. In: G. D'Amato, F.T.H. Spieksma and S. Bonini (eds), *Allergenic Pollen and Pollinosis in Europe*. Blackwell Scientific Publications, pp. 87–93.
- Peeters A.G. and Zoller H.: 1988, Long range transport of *Castanea sativa* pollen. *Grana* **27**, 203–207.
- Peeters A.G., Frei T. and Wüthrich B.: 1994, Vergleich des Pollenflugs und der Pollinose-Häufigkeit an zwei klimatisch verschiedenen Standorten in der Schweiz (Zürich und Locarno). *Allergologie* **17**, 501–504.
- Peeters A.G.: 1998, Cumulated temperatures for prediction of the beginning of ash (*Fraxinus excelsior* L.) pollen season. *Aerobiologia* **14**, 375–381.
- Schmid P., Peeters A.G. and Wüthrich B.: 1992, L'allergie aux pollens de frêne existe, nous l'avons rencontrée. *Rev. Fr. Allergol.* **32**, 139–140.
- Schmid-Grendelmeier P., Peeters A.G., Wahl R. and Wüthrich B.: 1994 Zur Bedeutung der Eschenpollenallergie. *Allergologie* **17**, 535–542.
- Wüthrich B. and Peeters A.G.: 1991, Allergenic pollen and pollinosis in Switzerland. In: G. D'Amato, F.T.H. Spieksma and S. Bonini (eds), *Allergenic Pollen and Pollinosis in Europe*. Blackwell Scientific Publications, pp. 197–202.
- Wüthrich B., Peeters A.G., Schindler C., Brändli O. and SAPALDIA-Team: 1994, Prevalence of atopy, hay fever and asthma in eight areas of Switzerland (SAPALDIA Study). *it Allergy and Clin. Immunol. (News Supplement 2)*.
- Wüthrich B.: 1995, Pollenallergie. Aktuelles zur Epidemiologie, Pathogenese, Diagnostik und Therapie. *Deutsches Aerzteblatt* **92**, 809–814.
- Wüthrich B., Schindler C., Leuenberger P., Ackermann-Liebrigg U. and SAPALDIA-Team: 1995 Prevalence of atopy and pollinosis in the adult population of Switzerland (SAPALDIA Study). *Int. Arch. Allergy Immunol.* **106**, 149–156.

