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Pollen distribution at high elevation in Switzerland: Evidence for medium range transport

THOMAS FREI

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Since Switzerland has a complex topography with high mountains it was very uncertain how much and what kind of pollen can be found at high elevations. In order to study the content of air masses at high elevation a Burkard Seven Day Recording Volumetric Spore Trap was installed at the meteorological station at Gütsch (alt. 2300 m) in the Swiss Alps. Although there are no trees at all at this elevation it is amazing how much tree pollen is found. With the exception of *Alnus viridis* most of this pollen is transported across the Alps. Special attention is given to the pollen of *Castanea* which can serve as a real tracer, since this pollen originates exclusively from the southern part of Switzerland (Tessin). Grass pollen, on the other hand, has local sources, even at this elevation, once the snowy season has ended. Grass pollen and pollen of weeds, therefore, need not have been transported. The surprisingly high amount of pollen observed may also have a relevance for people with pollen sensitization because generally it is assumed that hayfever symptoms decrease quickly with increasing elevation.

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It has been known for some time that pollen is present at different elevations in the atmosphere (Hjelmroos 1991, Leuschner 1994, Linskens & Jorde 1986, Mandrioli et al. 1984, Peeters & Zoller 1988, Tampieri et al. 1977). Since the topography of Switzerland is very complex, it was of general interest to know how much and what kind of pollen can be found in the Swiss Alps. So far the pollen data from Davos (alt. 1600 m) are the only data from a station at a higher elevation in Switzerland (Leuschner 1981). Markgraf (1980) investigated pollen dispersal in a mountain area in a different part of Switzerland. The data are, however, hardly comparable since the elevation in that study is lower, the method of pollen collecting different (Tauber traps) and the wind conditions completely different.

To study this question a Burkard Seven Day Recording Volumetric Spore Trap was installed at the meteorological station at Gütsch in the Swiss Alps next to the Gotthard pass. In general the amount of pollen decreases with increasing elevation at several pollen measuring stations in Switzerland (Clot et al. 1995). This information is important and a lot of patients use this advantage to escape from the current pollen situation at their place of residence. With the complex topography and the different meteorological conditions, it is possible that at certain locations, the quantity of transported pollen is also quite big at higher elevations and therefore medically relevant.

MATERIALS AND METHODS

The airborne pollen concentration at Gütsch, Davos and Lugano was measured using a Burkard Seven Day Recording Volumetric Spore Trap (see Fig. 1). The instrument that was especially installed at Gütsch for this study was modified in the sense, that the orifice

was supplied with a heating element in order to prevent it from freezing.

The measuring technique and pollen counting procedure are described by Peeters & Zoller (1988).

Meteorological data are all obtained from our own network (ANETZ). All three meteorological stations are next to the corresponding pollen traps.

RESULTS

Table I gives a summary of the allergologically relevant pollen that are found at Gütsch during the measuring period 1994 and 1995. Pollen data from another alpine measuring station (Davos) and corresponding data from Lugano on the southern slope of Switzerland are included for comparison. The Lugano region is also the source of most of the foreign pollen (tree pollen except *Alnus viridis*) which is found at Gütsch.

Table II gives a summary of the important meteorological parameters for the three stations used in this study with details of the corresponding wind distribution.

A typical wind situation in which pollen is transported from south to north is given in Figure 2 where the corresponding wind vectors are shown.

The maximum amount of daily *Castanea* pollen is given in Table III to enable a comparison of the amount of pollen at the source with the amount at the high elevation site.

Figures 3 and 4 show the daily variation of *Castanea* pollen percentages at Gütsch and in Lugano.

DISCUSSION

As can be seen from Table II the climate at Gütsch is rather severe with an average (1994 and 1995) annual temperature

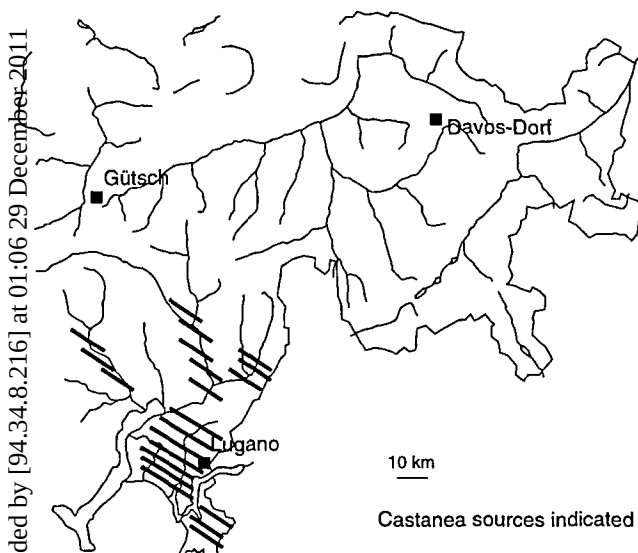
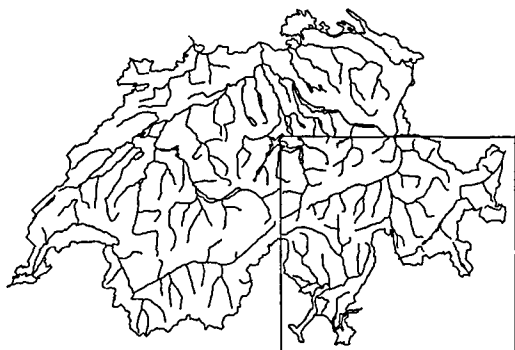


Fig. 1. Geographical locations of the three pollen traps in Switzerland and the corresponding *Castanea* sources.

of only 0.6°C and with 248 days of a snowcover annually. Accordingly the local vegetation is very limited.

It is striking that, in spite of this climate, more allergologically relevant pollen are found at Gütsch (alt. 2300 m) in the Swiss Alps, than at Davos (alt. 1600 m). As there are no trees at this elevation the question arises as to the source of this pollen.

In order to study this question, we have looked in detail at the transport of *Castanea*, since this pollen originates exclusively from the southern slope of the Alps, where the Mediterranean climate favours the growth of the tree (Frei et al. 1995). This pollen type can, therefore, serve as a tracer for following air mass movement across the Alps. *Castanea* pollen is additionally interesting, since this pollen might also be relevant for pollinosis (Sutra et al. 1987, Frei et al. 1995, Gilardi et al. 1994). *Castanea* pollen is also found in relevant quantities at Gütsch, where this pollen may have been transported across the Alps, over a distance of about 60 km (Hegg et al. 1993). The necessary southerly wind system for this pollen transport is around 40 percent of the annual winds. (Table II)

This also means that the *Castanea* pollen which is emitted at an elevation of between 300 and 800 m must rise up the mountainside in order to cross the mountains. This is quite possible in summer due to the existence of a labile layer in the atmosphere allowing the vertical exchange of particles (Lamprecht 1994).

According to Rantio-Lehtimäki (1994), pollen transport of up to 100 kilometres is classified as medium range transport, which is the case in this study. *Castanea* pollen is always found at Gütsch whenever wind from the south is blowing. The Romans already knew of this Föhn wind which produces mild temperatures on the northern slope of the Alps.

With respect to pollen transport it was interesting to know whether a daily rhythm exists in its appearance. We found (Fig. 3) that there are two peaks for the appearance of *Castanea* pollen at Gütsch: one peak in the morning (with a maximum between 10 to 12 a.m.) and a second peak which contains two minor peaks late in the evening (20 to 24 p.m.). These two peaks can very well be explained by studying the emission of this pollen at the source. The measuring station in Tessin (Lugano) also shows two peaks: a first peak (split into two minor peaks) in the late afternoon and a second peak in the early morning, around 4–6 a.m. The first peak in Tessin arrives approximately 4 hours later at Gütsch, which is to be expected because of the distance between Gütsch and Tessin. The average wind speed at Gütsch is around 15 km/h (Schüepp 1973).

The release of *Castanea* pollen in two peaks was already been identified and described by Jäger (1990). Our findings support this and show additionally, that the two peaks may be preserved during the medium range transport of pollen across the Alps, although transportation reduces the pollen concentration significantly over that distance.

CONCLUSIONS

This study shows that allergologically relevant pollen can also appear at a very high elevation of 2300 m above sea level in amounts of importance to pollen sensitised patients.

Table I. Allergologically relevant annual pollen counts for 1994 and 1995 at the three different measuring stations Gütsch (alt. 2300 m), Davos (alt. 1600 m) and Lugano (alt. 270 m).

Taxa	Gütsch (March– September)		Davos (March– September)		Lugano (January– September)	
	1994	1995	1994	1995	1994	1995
<i>Alnus</i>	208	24	24	8	7274	2608
<i>Corylus</i> sp.	8	36	0	10	3576	3524
<i>Betula</i> sp.	744	340	392	272	11,164	4300
<i>Fraxinus</i>	220	328	192	226	8406	6876
<i>Alnus viridis</i>	3328	2736	568	1424	1148	636
Poaceae	1656	816	1494	1488	5128	3088
<i>Castanea</i>	208	488	38	82	17,644	13,564
Total	6372	4768	2708	3510	54,340	34,596

Table II. Meteorological parameters for the three different measuring stations Gütisch (alt. 2300 m), Davos (alt. 1600 m) and Lugano (alt. 270 m) in 1994 and 1995. The distribution for the wind directions at Gütisch und Lugano is given in detail.

Meteorological parameters			Gütsch		Davos		Lugano			
			1994	1995	1994	1995	1994	1995		
Average annual air temperature in degrees Celsius			1.3	−0.1	4.6	3.2	13.1	12.5		
Average monthly sunshine hours			139	143	134	130	162	176		
Days with a snowcover			233	263	142	184	1	4		
Gütsch			Wind direction							
			N	NE	E	SE	S	SW	W	NW
Wind distribution in % 1994			36	12	6	14	26	4	1	2
Wind distribution in % 1995			34	17	7	5	29	6	1	1
Lugano			Wind direction							
			N	NE	E	SE	S	SW	W	NW
Wind distribution in % 1994			31	3	4	14	19	7	5	17
Wind distribution in % 1995			23	3	6	16	16	6	5	27

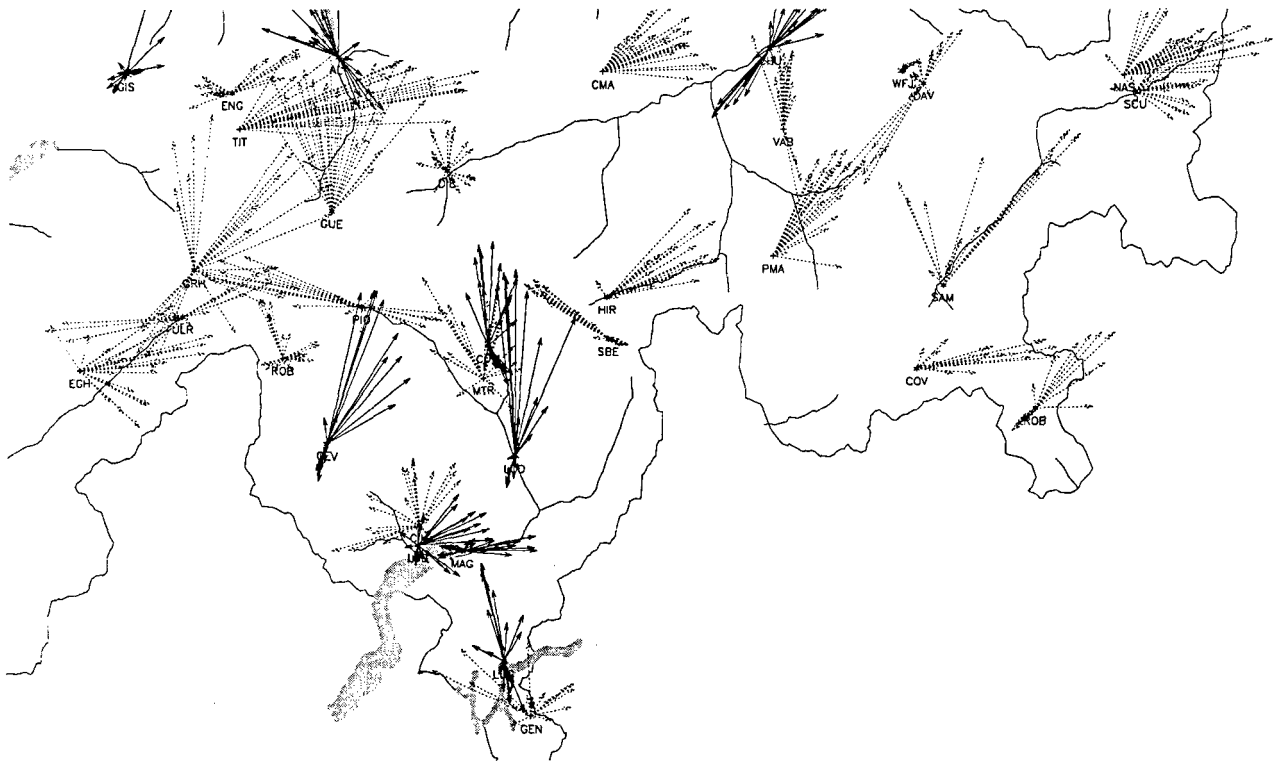


Fig. 2. Wind vectors showing the meteorological situation on 18.6.94/19.6.1994 illustrating the air transport from south to north. GUE indicates Gütisch and LUG indicates Lugano.

Table III. Comparison of peaks for Castanea pollen per m³ air per day in 1994 and 1995 at Gütisch and Lugano.

	18.6. 1994	25.6. 1994	26.6. 1994	27.6. 1995	8.7. 1995	9.7. 1995
Gütisch	28	24	32	100	96	128
Lugano	372	832	836	444	348	792

Especially interesting is the amount of transported tree pollen particularly *Betula* and *Castanea* classified as medium range transport. The observed *Alnus viridis* and *Poaceae pollen*, however, have local sources next to the pollen trap and are therefore not transported.

The statement made at the beginning of this article that pollen concentration decreases with increasing elevation, needs to be revised. Whether allergologically relevant pollen can also be found at higher elevation, depends very much on the local meteorological conditions. Therefore it could be

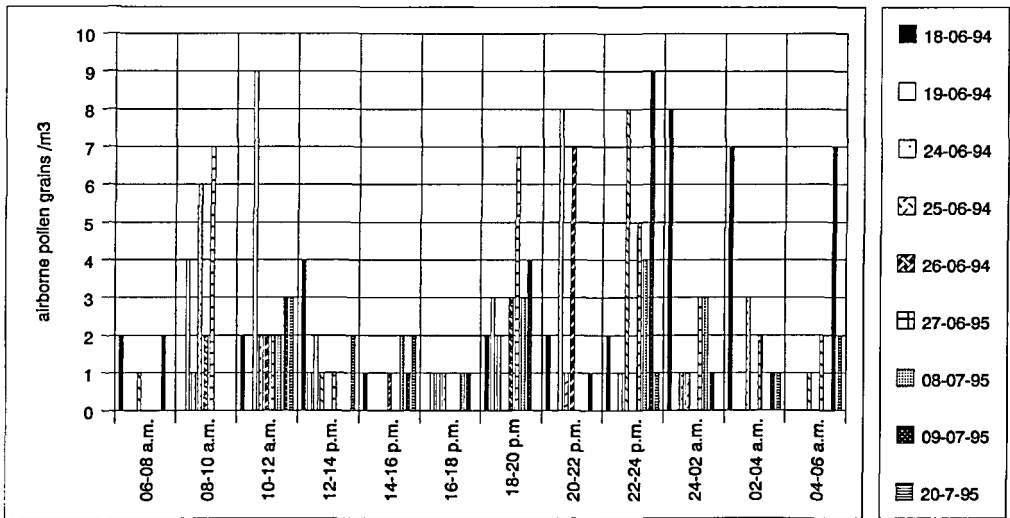


Fig. 3. The diurnal variation in *Castanea* pollen, 1994 and 1995, at Gütsch.

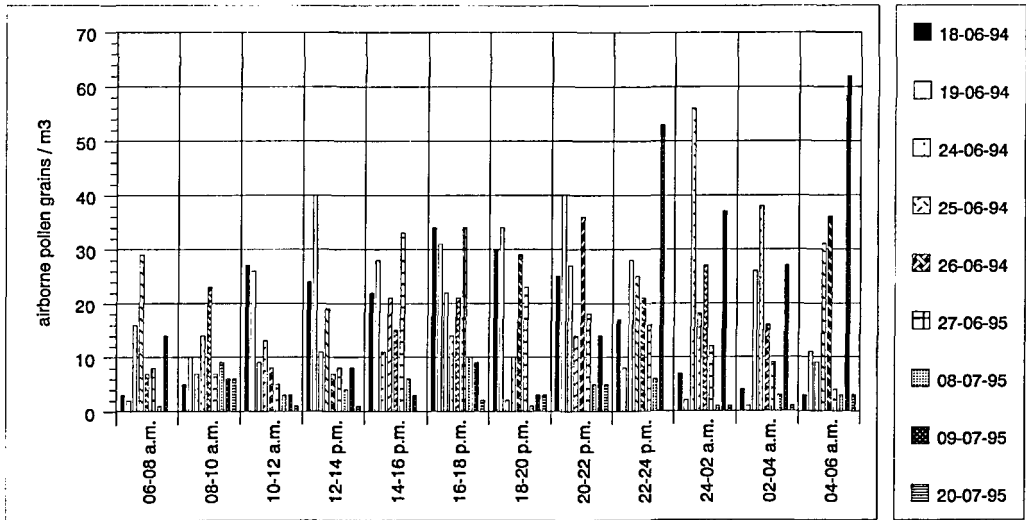


Fig. 4. The diurnal variation in *Castanea* pollen, 1994 and 1995, at Lugano.

relevant for tourist and health resorts to have a working pollen trap in order to monitor the local pollen content of the air.

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