



Trends in airborne pollen: An overview of 21 years of data in Neuchâtel (Switzerland)

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Abstract

Airborne pollen analysis has been carried out in Neuchâtel (Switzerland) since 1979. In the context of increasing prevalence of pollen allergies and global climate warming, this study attempts to confirm whether airborne pollen may be responsible for the former or indicative of the latter, and presents some general features of pollen flight in western Switzerland.

The most common pollen types are *Taxus/Cupressaceae*, *Quercus*, *Poaceae*, *Pinus*, *Betula*, *Urticaceae* and *Fraxinus*. During the 21 years studied, there was no major change in the abundance of pollen. Among the twenty-five taxa studied only five presented a significant trend: an increase of pollen quantities was observed for *Alnus*, *Ambrosia*, *Artemisia* and *Taxus/Cupressaceae* and a decrease for *Ulmus*. The plant species flowering in winter and in spring were influenced by the mild winters of the 1990s: 71% of the dates of the onset or the end of the pollen seasons nowadays occur significantly earlier in the year. The observed advance reaches 0.84 days/year. Trees appear to react stronger to the climate change than grass and weeds. No pollen type present a prolonged season, so the trend appears to be towards a shift in the timing of pollen presence in the air.

These observations show that the main cause of the spectacular increase of pollinosis prevalence in industrialised countries is probably not to be found in the weak tendency towards a rise of pollen abundance, except for some particular pollen types which can broaden the spectra and/or intensify the abundance of major allergens present in an area. However, airborne pollen is confirmed to be a sensitive indicator of climate change. The observed shifts in the pollen seasons make necessary the adequate information for people concerned with pollen allergies, in particular for prevention and therapy purposes.

1. Introduction

Long term airborne pollen records have in recent years found a special audience in the discussion of two important challenges for modern societies: the increasing prevalence of allergies, and the global climate warming.

Among many possible causes for an increasing prevalence of pollinosis in the second part of the twentieth century (Wüthrich, 1989; Schapowal, 1997; Jackson, 2001), the increase in the amounts of allergenic pollen grains is a trivial one to consider. Even if this count does not always represent the perfect

measurements of allergenic agents present in the air (Schäppi et al., 1996; Beggs, 1998), it is the only one that has been monitored continuously for a long enough time to perform trend analysis.

Climate warming is nowadays no more doubtful (IPCC, 2001) and the question arose of what may be the impact of this changes on living organisms (Walther et al., 2001): Airborne pollen is considered as a sensitive indicator of the reaction of plants to climate change (Newnham 1999, Schneiter et al., 2002).

The present study aims to present the observed situation in western Switzerland during the last two decades of the twentieth century and to provide some

arguments useful in the discussion of these two topics. The pollen data accumulated in Neuchâtel since 1979 at the same place with the same standard method represent a good basis to perform such analysis (Clot, 2000).

2. Materials and methods

Daily average pollen concentrations were measured with a Hirst-type pollen trap (Hirst, 1952) located on the roof of the Institute of Chemistry of the University of Neuchâtel, at an altitude of 490 m and around 18 m over the ground level, using standard methods (Peeters et al., 2002). 21 years of data (1979–1999) were used. The data set is not complete because of temporary technical problems with the trap. The following years have therefore been excluded for the analysis of *Alnus*, *Corylus*, *Taxus/Cupressaceae*: 1979, 1981, 1982; *Fraxinus*, *Populus*: 1979, 1981; *Betula*, *Carpinus*, *Fagus*, *Picea*, *Pinus*, *Platanus*, *Poaceae*, *Quercus*, *Salix*, *Urticaceae*: 1981; *Artemisia*: 1979, 1989; *Castanea*: 1982, 1988, 1992.

Seasonal Pollen Index (SPI) is the annual sum of daily average pollen concentrations (Mandrioli et al. 1998; Comtois 1998). The start of the season was chosen as the day when the cumulated daily counts reached 5% – and the end as the day when the 95% – of the SPI (90% period). After comparison of birch with several other methods (first of five consecutive days, day with concentration over 30, sum 50, 1%, 5%) to define the start of the season, we found no important influence on the results of the trend analysis (Clot, 2000. For more comments concerning the start of the season see for example, Spieksma and Nikkels, 1998).

The seasonal average concentration (SAC) was also calculated for the 90% period. The number of days when the pollen concentration exceeds a certain threshold (NDOT) has been calculated for the 20 (NDOT 20) and 50 (NDOT 50) pollen grains/cubic meter air thresholds (10 for *Artemisia* and *Ambrosia*). The lack of data in January until 1992 has been taken into account in the analysis for the taxa flowering in winter (*Alnus* and *Corylus*). *Alnus viridis* pollen has not been included in the study. Unfortunately, *Taxus* and *Cupressaceae* pollens are grouped in one pollen type.

A linear regression model was used for the trend analysis. A significance cut off of $P = 0.05$ was used (F-test).

3. Results

Considering the whole data set, 17 taxa have an average SPI over 250, representing the 92% of the pollen present in the air in Neuchâtel, and have been considered for trend analysis: *Alnus* (alder), *Betula* (birch), *Carpinus* (hornbeam), *Castanea* (chestnut), *Corylus* (hazelnut), *Fagus* (beech), *Fraxinus* (ash), *Picea* (spruce), *Pinus* (pine), *Plantago* (plantain), *Platanus* (plane tree), *Poaceae* (grass), *Populus* (poplar), *Quercus* (oak), *Salix* (willow), *Taxus/Cupressaceae* (yew and cypress family), *Urticaceae* (nettle family). *Artemisia* (mugwort) and *Ambrosia* (ragweed), with an average SPI respectively of 110 and 46, were added to this list because of their high allergenic significance. 5% of the pollen present in the air in Neuchâtel represent several other pollen taxa that occur in lower quantities or occasionally, and the remaining 3% some pollen of which determination was impossible or doubtful because of deformation or presence of dust, and some unrecognised pollen grains. Figure 1 shows the 7 most abundant airborne pollen taxa in Neuchâtel and the amplitude of variation of their SPI. They represent together 75% of the pollen present in the air at this site. Four of these pollens are in the list of the most important aeroallergens in Europe (*Poaceae*, *Betula*, *Fraxinus*, *Cupressaceae*), one is an allergen of medium importance (*Quercus*) and the remaining two are of less allergenic significance (*Pinus* and *Urtica*) (Corsico, 1993). The grouping of *Taxus* and *Cupressaceae* in one type in the records has artificially augmented the importance of this group. *Quercus* pollen is very abundant in Neuchâtel because of the large natural oak forests present at the foot of the Jura Range. *Urticaceae* group comprise mostly *Urtica* pollen (*Parietaria* plants are scarce north of the Alps) and includes few *Cannabis* and *Humulus* (*Cannabaceae*) pollen grains. *Alnus* (*A. glutinosa*, *A. incana*) pollen is collected from January to the beginning of April. *Alnus viridis* pollen is collected at the end of May and beginning of June and represent an interesting case of medium range transport: the plants of this species grow in the Alps and under certain wind conditions their pollen is brought through the Swiss plateau to the Jura Mountains. Because of these particularities, it was excluded from the trend analysis.

Table 1 shows an overview of the results of the trend analysis concerning 19 pollen types.

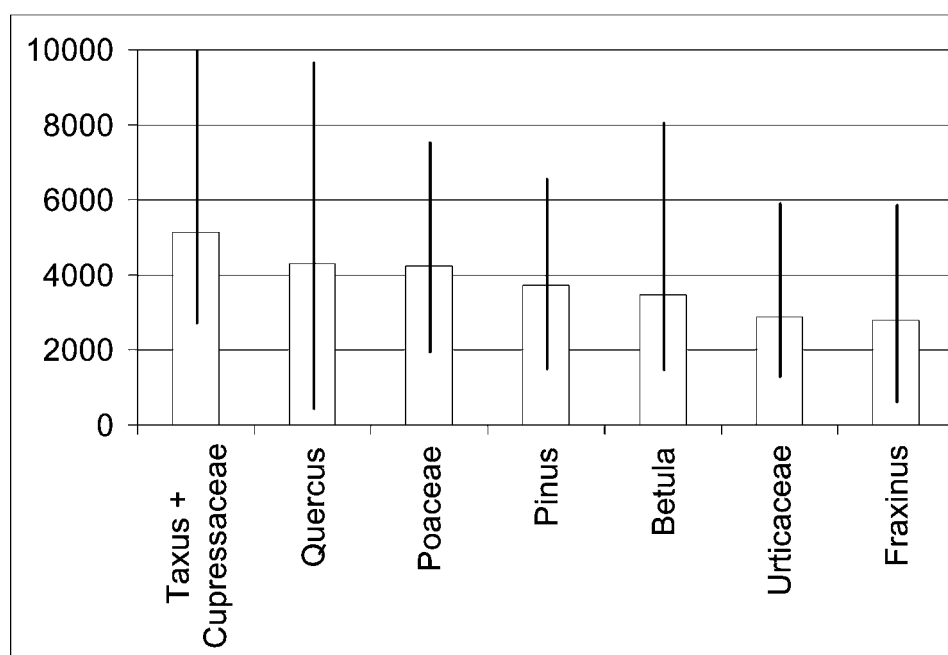


Figure 1. Minimum, average and maximum values of seasonal pollen index of the 7 most abundant pollen types in the air of Neuchâtel.

Table 1. Results of the trend analysis 1979–1999 on 19 pollen types (n.s. non significant, other abbreviations: see text).

	SPI	SAC	NDOT 20 (* 10)	NDOT 50	Starting date in 1979 (regression value)	Shift in 21 years (Δ days)	Ending date in 1979 (regression value)	Shift in 21 years (Δ days)	Duration of the season
<i>Corylus</i>	n.s.	n.s.	n.s.	n.s.		n.s.	6-Apr	–28	n.s.
<i>Alnus</i>	+	n.s.	+	+		n.s.	14-Apr	–39	n.s.
<i>Taxus/Cupressaceae</i>	+	n.s.	+	n.s.	20-Mar	–27		n.s.	n.s.
<i>Populus</i>	n.s.	n.s.	n.s.	n.s.		n.s.	29-Apr	–22	n.s.
<i>Salix</i>	n.s.	n.s.	n.s.	n.s.	9-Apr	–34	25-May	–26	n.s.
<i>Fraxinus</i>	n.s.	n.s.	n.s.	n.s.	21-Apr	–30	6-Jun	–45	n.s.
<i>Carpinus</i>	n.s.	n.s.	n.s.	n.s.	21-Apr	–22	24-May	–34	n.s.
<i>Betula</i>	n.s.	n.s.	n.s.	n.s.	21-Apr	–20	13-May	–17	n.s.
<i>Fagus</i>	n.s.	n.s.	n.s.	n.s.	4-May	–15	2-Jun	–22	n.s.
<i>Platanus</i>	n.s.	n.s.	n.s.	n.s.	8-May	–25	30-May	–29	n.s.
<i>Picea</i>	n.s.	n.s.	n.s.	n.s.	14-May	–17		n.s.	n.s.
<i>Quercus</i>	n.s.	n.s.	n.s.	n.s.	15-May	–21	1-Jun	–19	n.s.
<i>Pinus</i>	n.s.	n.s.	n.s.	n.s.	19-May	–12		n.s.	n.s.
<i>Plantago</i>	n.s.	n.s.	n.s.	n.s.		n.s.		n.s.	n.s.
<i>Poaceae</i>	n.s.	n.s.	n.s.	n.s.	29-May	–14		n.s.	n.s.
<i>Urticaceae</i>	n.s.	n.s.	+	n.s.	25-Jun	–16	1-Sep	–8	n.s.
<i>Castanea</i>	n.s.	n.s.	n.s.	n.s.	12-Jul	–25	1-Aug	–14	n.s.
<i>Artemisia</i> (*)	+	n.s.	+	no data	2-Aug	–17		n.s.	n.s.
<i>Ambrosia</i> (*)	+	n.s.	+	no data	31-Aug	–20		n.s.	n.s.

3.1 Trend in abundance: Seasonal pollen index (SPI)

The SPI of the total pollen show a weak, but not significant, positive tendency (this tendency is significant when considering the raw data, but the fact that the trap was not active in January before 1993 introduces an artefact in this calculation; it is then not demonstrated that the air was free of pollen grains in January before that year; data series from neighbouring stations present the same problem; however, the observed shifts in seasonal distribution – see below – and phenological observations in Switzerland let think that there were rarely airborne pollen in January before the mild winters recorded since 1988). Even if all the taxa – but *Pinus* and *Picea* – show a light tendency towards an increase of SPI, only four of the nineteen taxa studied present a significant trend. SPI of *Alnus*, *Taxus/Cupressaceae* and *Artemisia* pollen were more or less four times higher in 1999 than twenty years before. It is unfortunately not possible to know from these data if both yew tree and cypress family pollens are increasing or only one of them. *Ambrosia* pollen was rarely observed during the first years of the survey and has been regularly collected these last years. Figure 2 shows an example of increasing SPI (*Alnus*). *Corylus* SPI showed only a nearly significant positive trend when January data were included. *Alnus* SPI showed a significant positive trend both when January data were included and excluded: this confirms the increase of alder pollen abundance during the considered period.

Six additional taxa were also analysed for trends in SPI: *Acer*, *Chenopodiaceae*, *Cyperaceae*, *Tilia*, *Rumex*, *Ulmus*, and only the last one presented a significant trend. Because of Dutch Elm Disease, many elm trees died or were cut at the end of the 1980s and their pollen consecutively became less abundant in a few years (Figure 3).

3.2 Trend in abundance: Seasonal average concentration (SAC)

The seasonal average pollen concentration for total pollen and for each of the 19 taxa studied reveal no significant trend.

3.3 Trend in abundance: Number of days when concentration is over a threshold (NDOT)

These results are similar with those of the SPI. In addition, *Urticaceae* show a significant trend to the

increase of the NDOT 20. Only *Alnus* shows a significant trend for the NDOT 50.

3.4 Trend in seasonal distribution: Dates of the onset and of the end of the season

Trends in the onset and end dates of the pollen season in Neuchâtel have been analysed for the above 19 mentioned pollen types. From the 38 time series examined, 27 (71%) show a significant negative trend. Not any one revealed a positive trend. 15 series present an early starting date and 12 series an early end date of the pollen season. The average advance reaches 23 days in 21 years (or 1.1 days/year). In Figure 4 the example of the begin and end of airborne birch pollen season is shown.

It is interesting to note that among the time series concerning trees (and occurring in majority in late winter or spring) 79% show a significant trend (with an average early occurrence of 25 days), and that among those concerning weeds and grass (and occurring in summer or autumn) only 50% are significant (with an average early occurrence of 15 days).

3.5 Trend in seasonal distribution: Duration of the season

The duration of the pollen season does not show a significant trend for any of the taxa studied (illustrated in Figure 4).

4. Discussion

4.1 Trend in abundance

In the present study, there is no significant trend in abundance for the majority of pollen types, or for the two major allergens in Switzerland: grass and birch pollen. Only the quantities of four from twenty-five pollen types studied (16%) have increased. A tendency towards an increase of pollen abundance can be observed in some other taxa. Even if studies covering the whole pollen spectra in an area were lacking since the publication from Jäger in 1990, published papers concerning Europe fail to demonstrate a uniform tendency: some tree pollen were found increasing at some places and not at others (Spieksma et al., 1995; Jäger et al., 1996; Corden and Millington, 1999; Detandt et Nolard, 2000; Frei et Leuschner, 2000). Weeds show the same locally varying results (Detandt et Nolard,

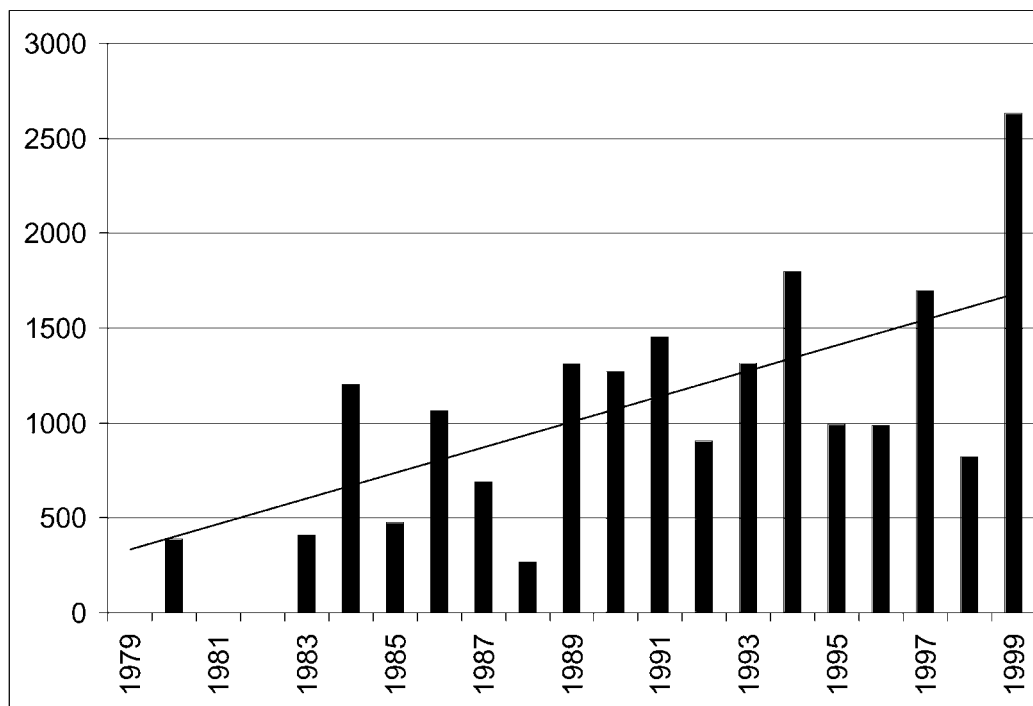


Figure 2. Seasonal pollen index of alder show positive trend, including January data (1979, 1981, 1982: no data).

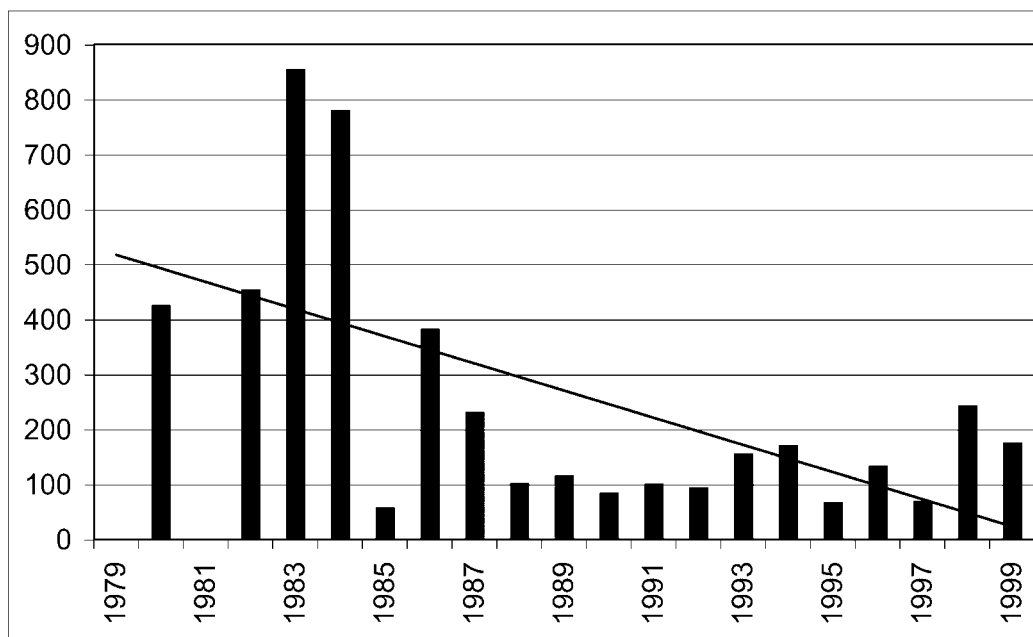


Figure 3. Seasonal pollen index of elm show negative trend (1979, 1981: no data).

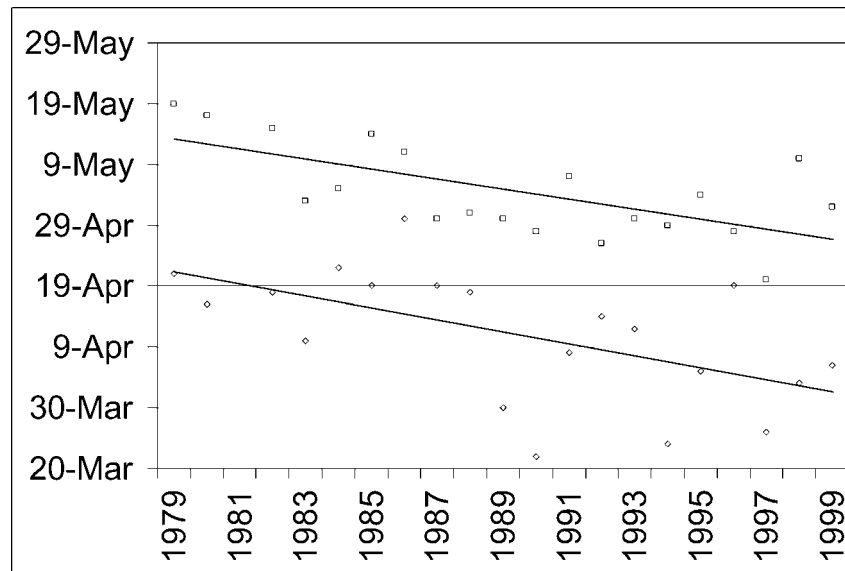


Figure 4. Dates of the onset and of the end of the birch pollen seasons 1979–1999 and trend lines; the average duration of the seasons remains the same (1981: no data).

2000; Frei et Leuschner, 2000; Voltolini et al., 2000) but were less studied from this point of view, ragweed being of course an exception (Rybníček and Jäger, 2001). Significant change was never registered concerning grass pollen (Spieksma et Nikkels, 1998; Leuschner et al., 2000; Voltolini et al., 2000).

The comment from Spieksma et al. (1995) “This demonstrates the great value of long-term monitoring of these kind of biological phenomena which may stay obscure on short-term periods of observation” will probably be proved correct for many pollen types and future observations will demonstrate trends where they are still hidden because of the too short duration of measurements. But it also demonstrates that if such slow changes occur they are without direct relationship with the quick and spectacular increase in allergy prevalence in the past decades (Jäger, 1998; Voltolini et al., 2000). Seasonal average concentration and NDOT give probably a better estimation of the impact of a pollen season on people with allergies than the SPI. The corresponding results confirm for the majority of the pollen types, including birch and grass, that there is no significant increase of the pollen load and therefore probably no other impact on allergies than the year to year variation. However, shorter term changes in abundance of some particular pollen can be of importance. In Neuchâtel, the increase in alder pollen abundance certainly reinforces and extends the season of allergies to pollen related to birch family,

and the possible greater abundance of cypress family pollen increases the risk for some people to get allergic symptoms in an area until now free of it. The increase in mugwort pollen is also very important for summer and late summer allergies.

The relationship between slow and long-term increase in pollen quantities and climate change, even probable, requires further detailed investigations. In the short term, the reasons for the increase in alder and yew tree/cypress family pollens are also not evident. A longer duration of the pollen season could have been a simple explanation, but is not observed here. These plants are not more abundant than before in the surroundings of the pollen trap nor in a larger area. The mild winters that occurred during the 1990’s have probably been favourable for the pollen production and dispersal of these taxa. Hazelnut pollen, which is usually collected simultaneously with alder pollen, also shows a nearly significant positive trend.

The increase in weeds (mugwort, ragweed and nettle) pollen is related to the more widespread presence of these plants in Western Switzerland, which is among other factors favoured by a warmer climate. This could be the first sign of the future consequences of the climate change on the composition of the vegetation, an expected shift of the Mediterranean climate and vegetation to the North. The increase in quantities of ragweed pollen registered is provoked by the expansion in France of this invasive plant from the Lyon area

and long range transport of pollen, as isolated individual plants were up to now only occasionally found in Neuchâtel (Clot et al., 2002). The continuous extension of ragweed in Europe during the last fifty years is however obviously not related to climate change, but to the own invasive dynamic of this species.

4.2 *Trend in seasonal distribution*

Our results show a strong trend towards an earlier season for tree pollen and a less remarkable shift for grass and weeds, which also flower later in the year. The absence of significant trend for the beginning of the season of hazelnut, alder and poplar is due to the great variability of the start date of the season in winter, consecutive to the variability of weather conditions in this period of the year. Indeed, we observed since 1989 several years with an early flowering of these trees which an advance of more than one month and there is no doubt that they also in Switzerland strongly react to the climate change (Frenguelli et al., 1991; Frei, 1998). The trend to an earlier start of ragweed season is probably biased, because, as already mentioned, ragweed pollen arrives in Neuchâtel with long range air transport: during the first years of the study, the pollen was only occasionally recorded and did then not represented a real "season".

Our results are in accordance with those from Jäger et al. (1996), who showed the same type of reaction of tree pollen in the Nordic countries, Emberlin et al. (1997), who revealed a strong trend towards an earlier appearance date of birch pollen in England, Corden and Millington (1999) who found an earlier pollen season for oak in the UK and Frei and Leuschner (2000) who demonstrated a tendency for some trees to flower earlier in Basel (Switzerland). Spieksma and Nikkels (1998) and Leuschner et al. (2000) did not found any trend for grass and Emberlin et al. (2000) an early start of grass pollen season only at some places in Europe. These results are also well congruent with those from Defila and Clot (2001) who demonstrated in Switzerland a strong trend towards earlier appearance of plant phenophases in late winter and spring; these authors found an even stronger trend in summer, but only trees were concerned.

As the phenology of plants and pollen flight is dependant of air temperature, in particular in spring (Defila, 1991; Frenguelli et al., 1991; Spieksma et al., 1995), the observed shift in pollen season has then clearly for origin the climate warming, which was also measured stronger in winter and early spring than in

late spring and summer (Rebetez, 2000). D'Odorico et al. (2002) arrived also to the same conclusion. It is however not possible to conclude from these results if the stronger reaction of the trees compared to the weeds depends only of the stronger changes of temperature in winter and early spring or if the factors that influence the phenology of weeds are different.

5. Conclusion

The observations made in this study confirm that the main cause of the spectacular increase of pollinosis prevalence in industrialized countries is probably not to be found in the rise of pollen abundance, which is for the majority of the taxa very slow and not limited to these countries. The increase in abundance of some particular pollen types can however be of medical importance, because these pollens can broaden the spectra and/or intensify the abundance of allergens present in an area. They can also be responsible for a longer period of allergic risk. In this respect, a share of the increase in the allergies can be related to climate change.

Airborne pollen, which was already known very sensitive to meteorological factors, is confirmed as a sensitive indicator of climate change. The observed shifts in the pollen season have important consequences: they make the adequate information of people concerned by pollen allergies necessary, in particular for prevention, pre-seasonal therapy purposes and management of the medicine's stocks. They could also make changes in the parameters used until now for pollen forecasts necessary.

The relationships between climate change and the local or global increase in pollen abundance are not evident and will be the subject of further investigations including climatic parameters. In this analysis of twenty-one years, the results have been influenced by the particularly mild winters of the 1990s. At long term, with the expected continuation of the climate warming, the following-up of the observations will show if the changes affecting pollen seasons and abundance will continue or if a plateau will be reached at a certain moment, what is mostly probable. Actually, if temperature increases greatly, this could affect the local vegetation and eventually lead to lower pollen counts of some species, in particular trees like birch or spruce, which are better acquainted to colder climates, when weeds pollen could be greatly favoured.

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