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A comparison of 1978 and 2006 peak pollen seasons and sampling methods in Missoula, Montana

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Abstract

A study was conducted in Missoula, Montana to compare local pollen counts from 1978 with those measured nearly 30 years later in 2006 using two different measurement techniques (Durham gravimetric sampler and a Burkard volumetric sampler). Trends in peak pollen times measured during the spring, summer and autumn, respectively, were compared between the two years by Pearson's correlation and frequency of occurrence of plant genus. Meteorological conditions were also examined during each of the two study periods.

In comparing the two years, there was a statistically significant linear association between the different counts for the months of April through August, with similar levels of pollen types for any given month. The five predominant pollen types (based on counts) identified in each study were *Pinus*, Poaceae, *Populus*, *Alnus*, and *Betula* for 2006 and *Pinus*, Poaceae, *Populus*, *Acer* and *Artemisia* for 1978. In summary most of the genera displayed similar peak pollination timing between the two years, suggesting that results from the Durham (gravimetric) and Burkard (volumetric) sampling methods are comparable when reporting relative frequency of occurrence.

Keywords

pollen; aeroallergens; peak pollination; seasonal rhinitis; climate change

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Aeroallergen research and information contributes to the understanding of the relationship between pollen and seasonal allergies (Waisel et al., 2004), and is crucial to diagnosis of patient symptoms and recommendation of an effective therapy (Puc, 2003). Seasonal rhinitis is especially relevant to the study of aeroallergens and peak pollination events, as seasonal allergies increase during periods of peak plant pollination (Tobías et al., 2003). Pollen collection / counting is the most accurate way to determine which pollen are most abundant in the ambient air at certain times during the year, enables the allergist to correlate the patient's symptoms with periods of peak pollination, and aids in prescribing treatment strategies.

Ambient pollen concentrations can be influenced by many factors, including seasonal variations and meteorological conditions (including wind speed, temperature, and precipitation (O'Rourke, 1990; Hall, 1992; Feher & Jarai-Komlodi, 1997; McCartney, 1994)). The methodologies and equipment used during sampling can also influence

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measured results (Pedersen & Moselholm, 1993). Gravimetric methods such as the Durham trap (Durham, 1946) are cheaper than volumetric methods, but have been shown to have limitations (D'Amato et al., 1991). Volumetric samplers such as the Burkard draw a constant air volume, and are often used to allow for the determination of daily variations in pollen concentrations.

Familiarity with regional aerobiology is also very important for understanding and diagnosing seasonal allergies. Pollen types and pollination times vary widely among geographic regions, plant types, and communities. Until recently, there were no certified reporting stations in the Northern Rocky Mountain region of western Montana. The closest pollen count station to Missoula (west-central Montana) was located in Twin Falls, Idaho, 475 miles to the south. The types of pollen that the Twin Falls station measures are very different from that of the Missoula station. The predominant pollen types in Missoula include Alder (*Alnus*), Maple (*Acer*), Elm (*Ulmus*), Juniper (*Juniperus*), Poplar (*Populus*), Pine (*Pinus*), Birch (*Betula*),Willow (*Salix*), Larch (*Larix*), Ash (*Fraxinus*), Sedge (*Carex*), Cattail (*Typha*), Grasses (Poaceae), Ragweed (*Ambrosia*), Pigweed (*Amaranthus*), Goose-foot (*Amaranthus/Chenopodium*), and Wormwood/Mugwort (*Artemisia*).

In the summer of 2006, The University of Montana's Center for Environmental Health Sciences (CEHS) established the first NAB certified pollen count station in the Northern Rocky Mountains. Located between the Sapphire and Bitterroot mountains in western Montana, Missoula (elevation of 3,200 feet above sea level) has a population of over 70,000 (see Figure 1). It is the largest municipality in the US completely surrounded by the Rocky Mountains.

This manuscript presents a comparison of seasonal pollen counts and meteorological conditions in the Missoula valley from a 1978 study (Gillespie & Hedstrom, 1979) with results from a study performed in Missoula during 2006. These two datasets also afforded the opportunity to compare the results from two different types of sampling methods: a Durham gravimetric sampler (as used in the 1978 study) with a Burkard volumetric sampler (2006 study). Finally, the results presented here are from an under-studied airshed located in the northern Rocky Mountain region of the United States.

Material and methods

For the 2006 sampling program, a Burkard 7-day pollen and spore sampler was utilized to collect airborne pollen. It was equipped with a 7-day sampling head, which rotates one full revolution in 7 days within the sampler at 2 mm / hour. Samples were collected continuously from April 1 until October 31 (2006) on the roof of a three story building at The University of Montana. Flow rates were checked every 7 days prior to sampling and were maintained at 10 liters / minute. Samples were collected using Melinex® tape coated with silicon grease and wrapped around the sample head. At the end of the seven day sampling period the tape was removed from the drum and cut with a thin pair of scissors into 48 mm pieces (corresponding to each 24 h period) on a cutting board. The strips were then mounted on microscope slides with 10% gelvatol adhesive. Slides were stained with Calberla's solution (a basic stain), sealed with a cover slip, and coated around the edges with clear nail polish for preservation. The slides were analyzed for pollen type and abundance by an NAB certified pollen counter using a Zeiss Axioskop 2 plus, phase contract microscope with 40X magnification.

The pollen study conducted by Gillespie and Hedstrom (1979) began in 1975 and continued through 1978. In this study, pollen was collected at two sites in Missoula located approximately one mile apart. One sampler was located at the county fair grounds at ground level, and another was placed on top of a four story county health building (~45 ft v. 13.7 m above ground) in downtown Missoula. Both of these locations are located in semi-urban areas, with similar vegetation surrounding the monitoring sites. These sites were within two miles of the site used in the 2006 sample collection (also located in a semi-urban location, with similar vegetation as the 1978 sites). Using a Durham gravity sampler over a 24 hour period, slides were collected from the months of March through September, with counts performed in a two square cm area. For comparison with the 2006 study, the data from the 1978 study represent the averaged monthly total from both sites in grains / cm^2 / month (Gillespie & Hedstrom, 1979).

The 2006 and 1978 data sets were then compared, with trends in peak pollen times and species composition analyzed for similarities and differences. The data from 1978 was chosen as the most representative year to compare with the data from 2006 because the 1978 data was available in counts per month [as presented in the Gillespie & Hedstrom (1979) manuscript], whereas the 1975-1977 data was represented only as periods of peak pollination within the month and gave no corresponding counts per genus. Because of the two different types of sampling methods between the two studies, total pollen counts from each year cannot be directly compared. However, a comparison between 2006 and 1978 counts is appropriate using relative frequency of occurrence for each genus. This was calculated by dividing the total pollen genus count for a certain month by the total pollen count for that month, providing the total percentage of a specific pollen genus relative to the total percent of pollen counted in one month. Pollen counts from both years were compared for each month by Pearson's correlation to determine if there was a statistically significant difference in the timing of peak pollination events between the two years.

Meteorological conditions during the years prior to and during each pollen count year were compared to examine the effects of temperature, precipitation, and snow accumulation on pollen counts. These parameters were examined as a result of Missoula being located in an ecosystem that relies on snowpack and snow melt as a source of water for plants in the spring. Groundwater and river levels are highly affected by the amount of spring snow run-off, which supplies most of the water for riparian and terrestrial vegetation throughout the summer and early autumn, and can highly impact the number of plants that bloom and pollinate (Kenda et al., 1995). Meteorological data were collected by the National Oceanic and Atmospheric Administration (NOAA) in Asheville, North Carolina and was obtained from the NOAA website (http://cdo.ncdc.noaa.gov/CDO/cdo).

Meteorological data were summarized for monthly average temperature, monthly total precipitation, and monthly total snowfall for January 1977 through September 1978 and for January 2005 through September 2006. The meteorological parameters were compared by t-test, paired by month.

Results

When comparing the two study periods, identified pollen types were similar between the 1978 and 2006 studies. The exceptions were *Typha*, and *Carex*, which were seen in small amounts in the 1978 study, but were not noted in the 2006 study. This could be the result of different sampling locations between the two years (one of the 1978 sites was located at ground level near a pond), or misidentification. Anthesis times between the two years were the same for the following: *Alnus*, *Juniperus*, *Populus*, *Pinus*, *Betula*, *Larix*, *Fraxinus*, Poaceae, *Amaranthus*/*Chenopodium*, and *Artemisia*. *Acer*, *Ulmus* and *Salix* peaked later in 2006, while *Ambrosia* peaked earlier in 2006.

Comparing peak pollen season events between the two years using relative frequency of occurrence (Table I) showed that *Alnus, Juniperus, Populus, Betula*, Poaceae, and *Larix* peak times were the same. *Acer, Ulmus, Salix, Fraxinus and Artemisia* peaked later in 2006, while *Pinus*, *Ambrosia*, and *Amaranthus/Chenopodium* pollen peaked earlier. There were no new pollen types identified in the 2006 study.

Pollen counts from both years were compared for each month, and tested by Pearson's correlation as well as frequency of occurrence. There was a statistically significant linear association between the different pollen counts for the months of June through August. The correlation coefficients and levels of significance were as follows: April, $r = 0.7763$, $P < 0.0002$; May, $r = 0.8774$, $P < 0.0001$; June, $r = 0.9977$, $P < 0.0001$; July, $r = 0.9798$, $P < 0.0001$; and August, $r = 0.8721$, $P < 0.0001$. The data comparison for September was not statistically significant. The data comparison from both years suggests similar levels of pollen types for any given month, with June and July being the most similar between 1978 and 2006.

Monthly temperature, precipitation and snowfall for January 1977 through September 1978 and January 2005 through September 2006 were compared using data from NOAA. The graphed results of the meteorological data analysis are presented in Figures 2, 3 and 4, respectively. When comparing only the years prior to the pollen collection (1977 and 2005), there were no significant differences in temperature ($p = 0.51$), precipitation ($p = 0.51$), or snowfall ($p = 0.99$). When comparing January 1977 through September 1978 with January 2005 through September 2006, some differences in temperature and snowfall were noted. Average temperature was slightly higher in 2005/2006 compared to the earlier years. Overall average temperature (and the range of average monthly temperatures) was 7.9 °C (−6.4 to 19.0) in 1977/1978 and 8.9 °C (−5.7 to 22.4) in 2005/2006 ($p = 0.053$). Snowfall was lower in 2005/2006 when compared to 1977/1978. Total monthly snowfall (and the range) averaged 0.3 inches (0.0 – 2.0) in 1977/1978 and 0.1 inches (0.0 to 0.5) in 2005/2006 ($p = 0.037$). No significant differences were observed in precipitation between the years. Total monthly precipitation (and the range) averaged 1.4 inches (0.2 – 3.3) in 1977/1978 and 1.6 inches (0.1 – 4.3) in 2005/2006 ($p = 0.41$).

Discussion

There are some differences in the study design between the two years that may have influenced results. Pollen sampling in the 1978 study was conducted using a Durham gravity sampler, while the 2006 study used a Burkard 7-day pollen and spore volumetric sampler. The Durham gravity sampler is used to count pollen grains / cm^2 on a single slide, while the Burkard is a volumetric sampler (flow rate of 10 liters / minute) with counts reported as pollen grains / m^3 air. To address this difference, the count comparisons were conducted by comparing the frequency of occurrence for a pollen genus count per month for both years. The Pearson's correlation was used to give a qualitative representation of peak pollination events.

The results of this study showed that data generated by both the gravimetric and volumetric methods nearly 30 years apart (and reported as relative frequency of occurrence) are similar, and consistent with the findings in other studies that report that the methods are comparable (Bhat & Rajasab, 1989; Charpin et al., 1991; Kasprzyk, 1996; Belmonte et al., 2000; Bricchi et al., 2000; Piotrowska & Weryszko-Chmielewska, 2003; and Teranishi et al., 2006). Latorre et al. (2008) compared the Burkard, Rotorod, and Tauber samplers, and found that the Burkard trap provided more sensitive detection of pollen present at low concentrations when compared to the other two samplers. O'Rourke (1990) found that some seasonal taxa patterns between Burkard and Durham samplers varied, particularly for Gramineae and Compositae.

It should also be noted that the October 2006 data were not used for comparison because there was no data for this month in 1978. The sampling locations used in the 1978 and 2006 studies were different. However, all three sites were within two miles of one another, and overall this influence is expected to be negligible. The peak pollination in 2006 of *Acer, Ulmus, Salix* and *Fraxinus* may be correlated to less snowfall in 2006, relating to less soil moisture and spring runoff, as all of these plants peaked in April of 1978 during the time of snowmelt. Early peak pollination of *Pinus, Ambrosia, and Amaranthus/Chenopodium* in 2006 could be the result of warmer temperatures in 2006.

Conclusions

This manuscript presents the results of a study comparing 2006 pollen counts measured from a NAB reporting station in Missoula, Montana with pollen counts measured in a 1978 program. Peak pollen types and times were similar in both studies. These findings also suggest that there were minimal differences in the results generated by the Durham gravimetric sampler used during the 1977/1978 program, and the volumetric (Burkard) sampler used in the 2005/2006 program when reporting results as relative frequency of occurrences. Exceptions (early or late peak pollination) may be due to seasonal variation and/or a change in meteorological parameters between the two periods. Three of the five most abundant pollen types in the Missoula valley stayed the same between both study years (*Pinus*, Poaceae and *Populus*) and there were no new pollen types recorded. *Typha* and *Carex* were noted in small amounts in the 1978 study, but were not seen in the 2006 study.

The results of this manuscript are significant in that western Montana is currently an under-studied region of the country. Continuation of the NAB pollen count station will yield an accurate qualitative and quantitative picture of the seasonal changes in peak pollination events throughout the years, and will continue to help area allergists diagnose seasonal rhinitis and recommend treatments.

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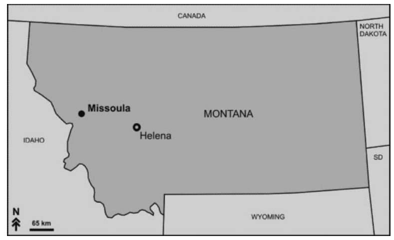

Figure 1.
Map of Montana, with the city of Missoula (square) including.

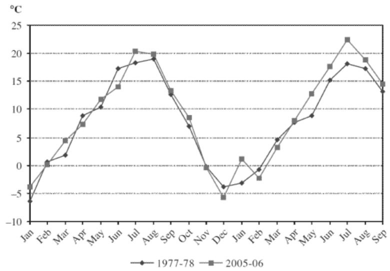

Figure 2.

A comparison of 1978 and 2006 peak pollen seasons and sampling methods in Missoula, Montana. Monthly Mean Temperature (°C) for years prior to and during collection of pollen data.

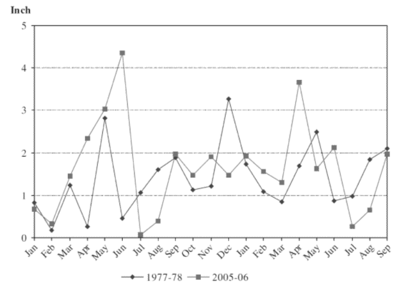

Figure 3.
A comparison of 1978 and 2006 peak pollen seasons and sampling methods in Missoula, Montana. Monthly Total Precipitation (inches) for years prior to and during collection of pollen data.

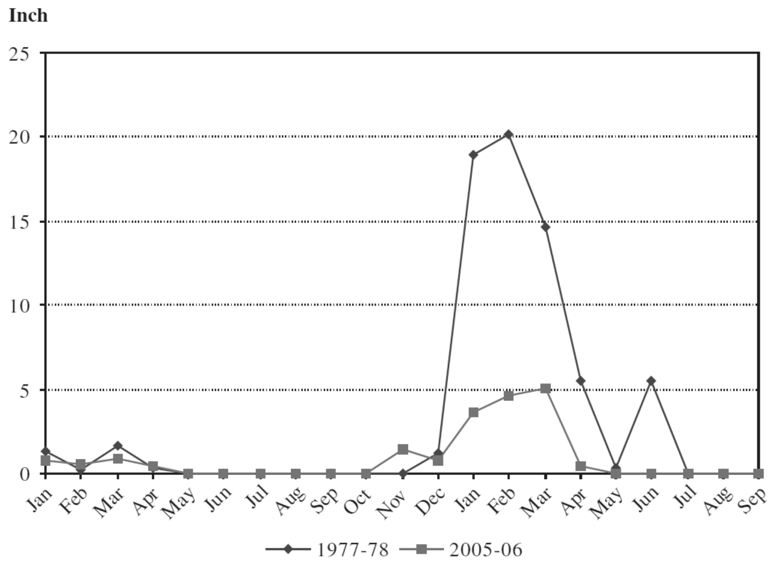

Figure 4.
A comparison of 1978 and 2006 peak pollen seasons and sampling methods in Missoula, Montana. Monthly Total Snowfall (inches) for years prior to and during collection of pollen data.

Table I

Relative frequency (%) of the pollen types for given months of the years 1978 and 2006.

Month / Year / Species	Apr		May		Jun		Jul		Aug		Sep	
	1978	**2006**	**1978**	**2006**	**1978**	**2006**	**1978**	**2006**	**1978**	**2006**	**1978**	**2006**
Alnus	1,23	0,87	1,45	4,09	2,29	6,01	0,09	1,08	0,00	0,00	0,00	0,00
Acer	26,44	0,00	10,63	0,00	0,11	0,36	0,00	0,54	0,00	0,00	0,00	0,00
Ulmus	0,93	0,00	0,00	0,00	0,00	1,04	0,00	0,00	0,00	0,00	0,00	0,00
Juniperus	8,03	14,86	2,81	0,00	0,07	1,32	0,00	1,08	0,00	0,80	0,00	0,00
Populus	35,70	59,80	3,06	4,09	0,00	0,08	0,00	0,00	0,00	0,00	0,00	0,00
Pinus	0,85	0,00	44,56	73,15	79,54	74,27	78,96	61,11	23,51	23,29	7,23	8,74
Betula	9,49	16,35	10,54	3,84	0,02	0,28	0,00	0,00	0,00	0,00	0,00	0,00
Salix	4,38	2,87	2,04	9,72	0,25	1,44	0,00	0,27	0,00	0,00	0,00	0,00
Larix	10,80	4,62	18,79	0,51	0,18	0,16	0,00	0,00	0,00	0,00	0,00	0,00
Fraxinus	1,90	0,62	0,34	0,77	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Carex	0,26	0,00	0,43	0,00	0,07	0,00	0,04	0,00	0,00	0,00	0,00	0,00
Typha	0,00	0,00	0,09	0,00	0,03	0,00	0,22	0,00	0,00	0,00	0,00	0,00
Poaceae	0,00	0,00	3,91	0,00	17,24	13,47	18,89	26,69	7,13	16,87	1,70	15,53
Ambrosia	0,00	0,00	0,68	0,00	0,08	0,00	0,18	1,63	2,12	6,02	3,19	4,85
Amaranthus/ Chenopodium	0,00	0,00	0,68	1,28	0,12	0,48	1,53	5,96	56,65	37,35	7,66	16,50
Artemisia	0,00	0,00	0,00	2,56	0,00	1,08	0,09	1,63	10,60	15,66	80,21	54,37

Note that the 2006 study used the Durham gravimetric sampler, while the 2006 study used the Burkard volumetric sampler.