The effect of temperature, relative humidity and rainfall on airborne ragweed pollen concentrations

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Abstract
Major weather parameters have long been known to alter airborne pollen and spore concentrations. The following study was conducted to study the effect of three of these parameters on airborne ragweed pollen concentrations. During the ragweed (RW) season for the years 1997 and 1998, 10 minute pollen collections were taken at least every 4 hours using an Allergenco MK-3 spore trap. Slides were fixed, and counted microscopically at 400X. During this same period, weather parameters were monitored by an Automated Weather Systems recording station located within a few meters of the collector. The ragweed season for this region begins in mid August and ends by mid October. Temperature patterns for the period demonstrated usual daily fluctuations with highs 13 to 35 °C and lows 8 to 24 °C. Relative humidity readings for the period varied between 25 and 100%. Highest RW values were seen after seasonal cooling in September. Daily rainfall for the period varied between 0 and 100 mm. Airborne RW always declined sharply after strong rainfall events (> 10 mm/day). Peak airborne RW concentrations were often associated with the passing of frontal boundaries and the change in wind direction and velocity that accompanies that passing. Factors influencing airborne RW concentrations are multiple and complex, but atmospheric forces have great influence. The passing of major weather fronts and the associated temperature drops, wind disturbances and rainfall are the major factors.

Introduction
Ragweed pollen levels in the atmosphere are a function of three processes: production, release and dispersal. Production is dependent on the suitability of the growing season and the availability of land for ragweed growth. Pollen release occurs when pollen grains or clumps of them are expelled from anthers on inflorescent vegetation. This release is likely governed by the time of day, daily low temperatures and relative humidity. The released pollen must dry out from its exposure to morning dew and be transferred from surrounding surfaces into the atmosphere for dispersal. This process is supposed to be related to temperature, humidity, wind speed and relative turbulence.

Weather related factors as precipitation, wind speed, temperature and relative humidity have often been noted to influence airborne pollen concentrations (Emberlin and Norris-Hill, 1996). These parameters, therefore, have influence on release and dispersal of ragweed pollen grains. In the ideal situation the relationship between production and release of ragweed pollen, and measured atmospheric concentrations would be predictable (Comtois and Boucher, 1996). However, differing climatic conditions impact different factors in the equation that predicts measurable airborne ragweed pollen levels and the associated discomfort of persons sensitive to the proteins contained in these grains (Comtois and Sherknies, 1992; Raynor and Hayes, 1970). Several authors have addressed the relationship of ragweed pollen and meteorological parameters. For example, peak pollen production has been described to occur shortly after sunrise (Bianchi et al., 1959; Ogden et al., 1969)
and may be related to photocycle or cooler morning temperatures and lower humidity. Additionally, in northern latitudes total pollen production in a given year has been related to the cumulative heating degree-days (Comtois and Boucher, 1996). Also, atmospheric conditions as inversion layers and rainfall events are expected to strongly influence ambient ragweed pollen concentrations (Ogden et al., 1969). Using data collected in Kansas City, Missouri during the ragweed seasons of 1997 and 1998 we tested three hypotheses. First, the occurrence of heavy rainfall reduces airborne ragweed pollen concentrations. Second, the presence of exceptionally high temperatures tends to result in lowered airborne ragweed concentrations. Third, the coincidence of periods of high relative humidity result in increased airborne ragweed concentrations.

Materials and methods

Air for visual identification and enumeration of pollen grains and fungal spores was collected on top of a 5-story building in the center of the Kansas City Metropolitan area using a Hirst type pollen and spore trap (MK-3, Allergenco/Blewstone Press, San Antonio TX, USA). The device was calibrated to collect 15 liters of air per minute using a Vitilograph Spyrometer (Vitilograph, Lenexa, KS, USA). Materials for collection including microscope slides, cover slips and storage boxes were obtained from Curtin Matheson, Scientific (Houston TX, USA). Chemicals and ingredients for mounting media and stains were obtained from Sigma Chemical Company (St. Louis, MO, USA).

The Allergenco device was not wind oriented and was protected from direct rainfall by a 1-meter square roof suspended 2 feet over the device. For this study the Allergenco sampler was programmed to collect for 10 minutes at the beginning of every 2-hour period in 1997 and every 4-hour period in 1998. The unit produced at least 6 individual discrete collections during a 24-hour period at 0:00, 4:00, 8:00, 12:00, 16:00 and 20:00 hours. The data described represent the months of August, September and October and encompass the entire ragweed pollination season for Kansas City, Missouri, USA.

All samples from the collector were examined microscopically using methods described previously (Cage et al., 1996). Briefly, slides were stained with glycerin jelly containing 1.0% Calberla’s solution, fitted with a coverslip, and examined at 400× magnification using a Zeis Axioscope microscope. No factors reflecting a presumed collection efficiency of the sampler units were applied. All of the pollen grains in the 10-minute collection were counted and divided by 0.15 cubic meters of air to arrive at particles per cubic meters of air. In order to test the potential variation introduced by different persons counting the slides, each counter evaluated a set of identical slides. The numbers of pollen grains counted was averaged to produce a mean for all counters. The counts of individuals were compared to that mean.

Meteorological data was monitored within 20 meters of the collection site using a station obtained from Automated Weather Source (Gaithersburg, MD, USA). The station provided data on temperature, humidity, rainfall, wind velocity and direction. The weather station includes a datalogger, which collects up to 4 months of data and provides for downloading and archiving data on a personal computer.

Results

We initially conducted an examination of possible variations in the counts that might be introduced by different individuals. Quality control evaluations of variations in results generated by an individual counter and variations in counts generated by all counters are shown in Figure 1. Variations in counts generated by a single counter and those generated by all counters were within 10% of the mean. The normalized counts for all counters center on 1.0 (Figure 1) and there is no increase in variation as particle numbers decrease.

The object of this work is to examine the ragweed pollen counts during the 1997 and 1998 pollen season.