ORIGINAL ARTICLE

Patterns and Seasonal Changes of Airborne Pollens in Phitsanulok, Lower Northern Thailand: A 16-Year Aeroallergen Survey

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Objective: Airborne pollens are significant triggers of allergic rhinitis, atopic conjunctivitis, and asthma. The present study aimed to examine the patterns, quantities, and dynamic changes of airborne pollens in Phitsanulok, lower northern Thailand, during three periods, November 2006 to October 2007, August 2013 to July 2014, and August 2022 to July 2023.

Materials and Methods: In 2006 to 2007, airborne pollens were collected using a Rotorod sampler positioned 1.5 to 2 meters above ground. In 2013 to 2014 and 2022 to 2023, pollens were collected using a Burkard seven-day volumetric spore trap positioned 15 meters above ground. The exposed rods and slides were stained for microscopic analysis. Meteorological data were also obtained.

Results: Monthly airborne pollen counts ranged from 48 to 304 grains/m^3 in 2006 to 2007, 28.1 to 110.8 grains/m^3 in 2013 to 2014, and 60.7 to 151.7 grains/m^3 in 2022 to 2023. Peaks occurred in February, May, and August in 2006 to 2007, December in 2013 to 2014, and February and December in 2022 to 2023. Wild grass and cultivated grass were the most and second most common pollen, respectively, across all three periods, with variations in the pollen types ranked third to tenth. Total annual rainfall from 2013 to 2014 was the lowest among the three periods. The highest temperatures and lowest humidity levels, recorded in April 2013 to 2014 and 2022 to 2023, corresponded to low pollen levels.

Conclusion: The average monthly pollen count during 2022 to 2023 was lower than that recorded in 2006 to 2007 but slightly higher than in 2013 to 2014. Wild grass was the predominant pollen type over the 16-year period, with levels considered a high allergic risk.

Keywords: Airborne pollens; Grass pollens; Pollen counts; Allergic symptoms; Asthma; Thailand

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Outdoor aeroallergens, such as airborne pollens and mold spores, are significant triggers of allergic diseases, including allergic rhinitis, atopic conjunctivitis, and asthma. Sensitization to pollens, particularly grasses and ragweed, is higher in some temperate regions compared to indoor allergens such as house dust mites and animal dander[1,2]. Conversely, in tropical regions like Thailand and Singapore, while pollen sensitization is notable, house dust mite sensitization predominates[3-8].

Airborne pollen and mold spores vary across different geographical areas and climatic zones. In temperate countries, pollen release often follows seasonal patterns, with trees, weeds, and grasses being common sources of allergenic pollen[4,9]. Grass pollens, particularly from the Poaceae family, are among the most dominant allergens worldwide[4]. Previous studies conducted in temperate and subtropical regions have demonstrated that exposure to airborne grass pollen increases the risk of asthma-related emergency department visits[10,11].

In Thailand, most outdoor aeroallergen surveys have been focused primarily in major regions, including Bangkok, Chiang Mai in the north, and Songkhla in the south[9,12-16]. Many surveys conducted in Bangkok, spanning between 1972 and 2022, consistently indicated that grass pollen was either the most common or the second most common airborne allergen[9,12,14-16]. One study found that the most common and second most common pollens in Chiang Mai, were from Mimosa and wild grass, respectively, while in Songkhla, they were from Casuarinaceae and Mimosa[13]. To date, no outdoor aeroallergen survey

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including airborne pollen study has been conducted in Phitsanulok, the second-largest city in the northern region. This is significant given the high prevalence of pollen allergies among both adults at 34.5% to 41.4% and children with asthma at 25.1% to 31.4%[7,8].

The present study aimed to examine the patterns and quantities of airborne pollens over three distinct time periods, spaced 8 to 10 years apart, in Phitsanulok. Additionally, the authors investigated the dynamic changes in pollen types and counts from 2007 to 2023, a period marked by climate change and increased industrialization. Understanding the types and amounts of common pollen in this region will aid in selecting relevant allergens for skin testing and specific immunotherapy in the future.

Materials and Methods

Aeroallergen sampling

Outdoor aeroallergens were collected during three distinct periods, 2006 to 2007, 2013 to 2014, and 2022 to 2023, in Phitsanulok, Thailand, which has a latitude 16°44'55.1" north and longitude 100°11'20.5" east.

During the first period, from November 2006 to October 2007, sampling was conducted using a Rotorod sampler positioned 1.5 to 2 meters above ground in both the city areas of Phitsanulok and at Naresuan University Hospital, located 13 kilometers from the city center. Two silicone-greased rods were attached to the collector rods of the device. Following the standard operating procedure[17], the sampling device was operated three times per week for one hour each day, from 9:00 to 10:00 a.m., at a motor speed of 2,400 RPM over 12 months. The exposed rods were mounted onto holder slides for further staining and microscopic analysis.

In the second period, from August 2013 to July 2014, outdoor aeroallergens were collected using a Burkard seven-day volumetric spore trap. The instrument was placed on the terrace area outside the fourth floor of Naresuan University Hospital in Phitsanulok, which was 15 meters above ground level. According to the British Aerobiology Federation's trapping guide[18], adhesive tape was mounted on a rotating drum, which moved at a rate of 2 mm per hour, completing a full rotation every seven days. Air was drawn through a 14×2 mm orifice at a flow rate of 10 liters per minute, and airborne particles with sufficient inertia were deposited onto the greased tape. At the end of each seven-day cycle, the tape was removed, divided into daily segments, and affixed to microscopic glass slides. This process ran throughout the 12 months.

During the third period, from August 2022 to July 2023, outdoor aeroallergen sampling was again conducted using a Burkard seven-day volumetric spore trap. The instrument was placed on the terrace area outside the fourth floor of Naresuan University Hospital, similar to the setup during the second period.

Pollen identification and counting

The holder slides on which exposed rods were placed during the first survey period and the microscopic glass slides collected during the second and third survey periods were stained with Calberla's solution, which consists of glycerol, ethyl alcohol, water, and basic fuchsin. Pollen grains were stained pink, and their types were identified based on their morphological features using a compound light microscope at 400x magnification[9,15]. The readers were well-trained to identify various pollen types and fungal spores observed on the rods and slides, with their readings verified and standardized.

Pollen counts from the Rotorod sampler were calculated and reported as the number of grains per cubic meter of air as grains/m³, following the Rotorod sampler operating instructions[9,17]. Likewise, pollen counts from the Burkard seven-day volumetric spore trap were calculated and reported as the number of grains per cubic meter of air as grains/m³, according to standard protocols[18,19].

To facilitate comparisons across the three survey periods, all data from each survey period were reorganized to cover January through December, resulting in the surveyed months being presented out of chronological order.

The current data from the aeroallergen survey were reviewed and approved for research and publication by the Faculty of Medicine, Naresuan University (No. 0603.10.02/313).

Meteorological data

The meteorological data for Phitsanulok were obtained from the Thai Northern Meteorological Center. The data included daily temperature, rainfall, and relative humidity, covering the periods of November 2006 to October 2007, August 2013 to July 2014, and August 2022 to July 2023. Monthly averages for temperature and relative humidity were calculated, while rainfall was reported as the total monthly precipitation. The comparison of meteorological data across the three study years is shown in Figure 1.

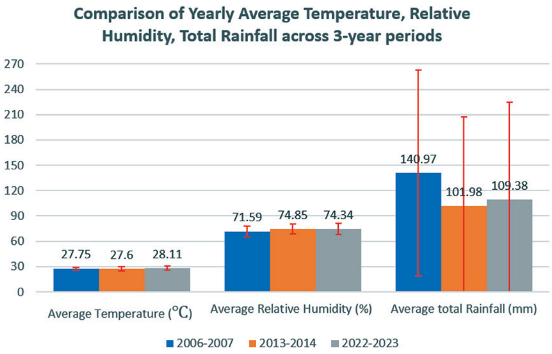

Figure 1. Comparison of meteorological data - including average monthly temperature (°C), average total monthly rainfall (mm), and average monthly relative humidity (%) - in Phitsanulok during the periods of November 2006 to October 2007, August 2013 to July 2014, and August 2022 to July 2023.

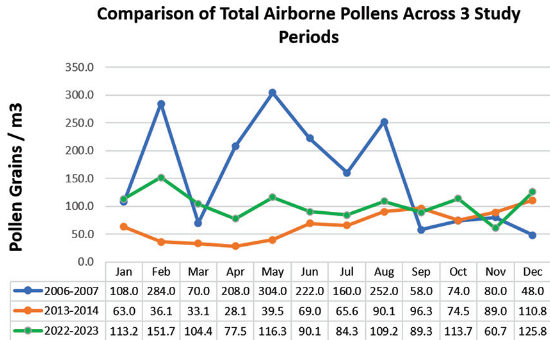

Figure 2. Comparison of total airborne pollens across three study periods: November 2006 to October 2007, using a Rotorod sampler. August 2013 to July 2014, and August 2022 to July 2023, using a Burkard seven-day volumetric spore trap.

Statistical analysis

The present study employed both descriptive and inferential statistics using the Stata, version 17 (StataCorp LP, College Station, TX, USA), to analyze all data parameters. These parameters were reported as means, frequencies, and percentages. To evaluate the effect of monthly variation within each study period on total and individual pollen types, we applied the Kruskal-Wallis test. To assess the correlation between total airborne pollen counts and meteorological data as temperature, relative humidity, and total rainfall, we used the Pearson correlation coefficient for normally distributed variables and Spearman's rank-order correlation coefficient for non-normally distributed variables. A two-sided p-value of less than 0.05 was considered statistically significant.

Results

Airborne pollen grains

Between November 2006 and October 2007, the average monthly total airborne pollen counts were calculated from daily records of exposed rods collected using the Rotorod sampler. Airborne pollen was detected year-round, with monthly pollen counts ranging from 48 to 304 grains/m³. The average annual pollen count was 155.7 grains/m³. Three peaks in pollen counts were observed in February, May, and August, with values of 284, 304, and 252 grains/m³, respectively, as shown in Figure 2. The three lowest concentrations were recorded in March, September, and December, with values of 70, 58, and 48 grains/m³, respectively (Figure 2).

During the second period, from August 2013 to July 2014, the average monthly total airborne pollen counts were calculated from daily records of tape-attached slides collected using the Burkard instrument. The monthly airborne pollen counts ranged from 28.1 to 110.8 grains/m³, with an average annual pollen count of 66.3 grains/m³. The peak pollen concentration (110.8 grains/m³) occurred in December, while the two lowest concentrations were recorded in March and April at 33.1 and 28.1 grains/m³, respectively (Figure 2). Overall, the average pollen concentration during this period was lower than that recorded in 2006 to 2007.

During the third period, from August 2022 to July 2023, the monthly total airborne pollen counts ranged from 60.7 to 151.7 grains/m³ (Figure 2). The year-round mean pollen count was 103.0 grains/m³. Two peak pollen concentrations were observed in February and December with 151.7 and 125.8 grains/m³, respectively, while the two lowest concentrations were recorded in April and November with 77.5 and 60.7 grains/m³, respectively.

In general, the average monthly pollen count during this period was lower than that recorded in 2006 to 2007, but slightly higher than that of the 2013 to 2014 period, as shown in Figure 2. The Kruskal-Wallis test showed no statistically significant effect of monthly variation on total airborne pollen counts in 2006 to 2007 (p=0.44), 2013 to 2014 (p=0.44), or 2022 to 2023 (p=0.44).

Airborne pollen types and changes in pollen components over 16 years

In the present survey, pollen types were categorized into 12 groups based on physical characteristics observed at 400x magnification under light microscopy. Grass pollens from the Poaceae family were classified by size with grass pollens

Table 1. Percentage of pollen types per year during November 2006 to October 2007, August 2013 to July 2014, and August 2022 to July 2023, listed in decreasing order of prevalence

	2006-2007*		2013-2014**		2022-2023**	
1	Wild grass	45.07%	Wild grass	77.74%	Wild grass	90.71%
2	Cultivated grass	21.52%	Cultivated grass	9.05%	Cultivated grass	5.77%
3	Fern	11.24%	Careless weed	8.56%	Mimosa	1.41%
4	Palm	5.25%	Acacia	1.50%	Acacia	1.35%
5	Eucalyptus	5.25%	Mimosa	1.06%	Careless weed	0.69%
6	Sedge	4.93&	Sedge	0.74%	Fern	0.04%
7	Careless weed	3.10%	Palm	0.73%	Asteraceae	0.04%
8	Mimosa	1.28%	Asteraceae	0.29%	Sedge	0.00%
9	Pine	0.43%	Lythraceae	0.29%	Palm	0.00%
10	Acacia	0.11%	Fern	0.04%	Lythraceae	0.00%

* Rotorod sampler was utilized, ** Burkard seven-day volumetric spore trap was utilized

smaller than 40 µm were categorized as the wild grass group, while those larger than 40 µm were categorized as the cultivated grass group. As all grass pollens are monoporate, characterized by a single circular to oval pore, further differentiation into subfamily, genus or species levels, was not feasible under light microscopy(4). Across all three study periods spanning 16 years, wild grass and cultivated grass pollens consistently ranked as the most and second most abundant pollen types, respectively. The other 8 to 10 pollen groups varied in rank order among the surveys conducted 8 to 10 years apart (Table 1, lists in decreasing order of frequency percentage).

In 2006 to 2007, the pollens ranked third to tenth were Fern, Palm, Eucalyptus, Cyperaceae (sedge), Careless weed, Mimosa, Pine, and Acacia, with frequencies of 11.2%, 5.3%, 5.3%, 4.9%, 3.1%, 1.3%, 0.4%, and 0.1%, respectively. There were significant changes in the airborne pollen types ranked third to tenth between 2006, 2014, and 2023, as shown in Table 1. For example, Fern, Palm, Eucalyptus, and Sedge pollen gradually decreased in prevalence from 11.2%, 5.3%, 5.3%, and 4.9% in 2006 to 0.04%, 0%, 0%, and 0% in 2023.

Wild grass pollen was the predominant airborne pollen in lower northern Thailand throughout all three study periods spanning 16 years. This dominance was evidenced by the highest average wild grass pollen counts recorded in 2006 to 2007, 2013 to 2014, and 2022 to 2023 at 70.2, 51.5, and 93.4 grains/m³, respectively, with annual ranges of 28.0 to 166.0, 23.5 to 77.9, and 47.3 to 137.1 grains/m³, respectively (Figure 3). While the monthly wild grass pollen concentrations in 2006 to 2007 were comparable to those in 2022 to 2023, the concentrations during 2013 to 2014 were notably lower than in the other two study periods, particularly from April to May.

The concentration of cultivated grass pollens in 2013 to 2014 and 2022 to 2023 was significantly lower than in 2006 to 2007, with annual pollen counts ranging from 1.6 to 16.2, 1.9 to 12.1, and 6.0 to 74.0 grains/m³, respectively (Figure 3). Meanwhile, airborne pollens from Mimosa, Careless weed, and Acacia were consistently observed at low concentrations, with average levels ranging from 0.7 to 2.0, 0.7 to 5.7, and 0.2 to 1.4 grains/m³, respectively, across all three survey periods from 2006 to 2023 (Figure 3).

Monthly variation did not have a statistically significant influence on the counts of each pollen type during the 2006 to 2007, 2013 to 2014, and 2022 to 2023 periods with wild grass (p=0.44, 0.44, 0.44), cultivated grass (p=0.44, 0.44, 0.44), Mimosa (p=0.58, 0.46, 0.46), Careless weed (p=0.49, 0.44, 0.48), and Acacia (p=1.00, 0.45, 0.46), respectively.

Seasonal variation and effect of climate on airborne pollens

The seasonal variations in airborne pollens, along with meteorological data such as temperature, relative humidity, and rainfall, were analyzed over 12 months and compared across the three study periods, as shown in Figure 4.

In 2006 to 2007, both wild grass and cultivated grass pollens peaked in February and May, with levels of 166 and 154 grains/m³ for wild grass, and 64 and 74 grains/m³ for cultivated grass, respectively. Additionally, cultivated grass exhibited high levels in June with 70 grains/m³ during this period.

In 2022 to 2023, wild grass pollens reached their highest levels during the same months, which were February and May, with pollen counts of 131.1 and

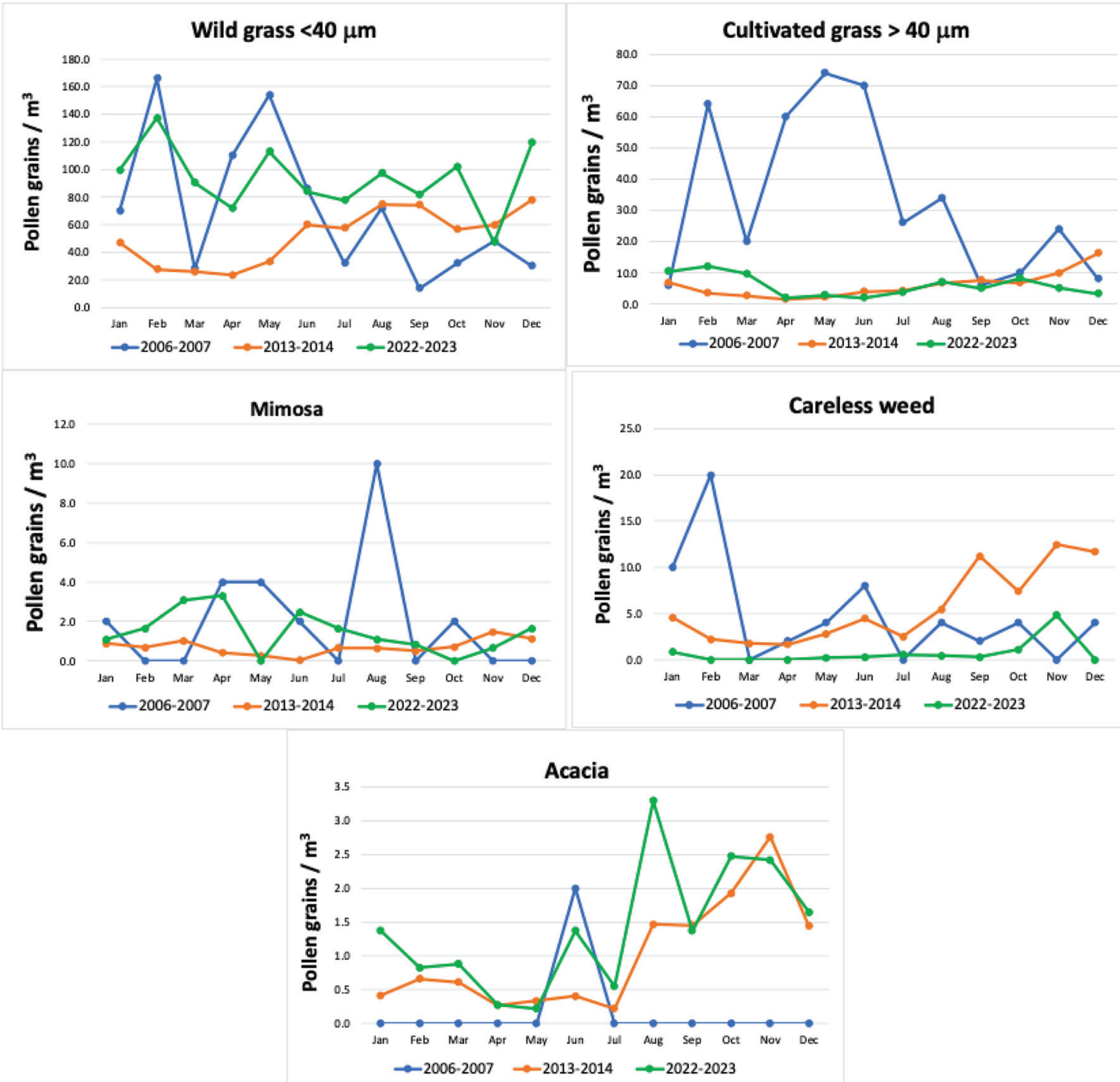

Figure 3. Seasonal variation of 5 common airborne pollens recorded during November 2006 to October 2007 using a Rotorod sampler, and during August 2013 to July 2014 and August 2022 to July 2023 using a Burkard seven-day volumetric spore trap.

113 grains/m³, respectively. In addition, a significant peak in wild grass pollens was observed in December 2022 with 119.2 grains/m³. Similarly, the highest concentration of wild grass pollens in 2013 to 2014 was recorded in December, at 77.9 grains/m³.

Cultivated grass pollens reached their highest levels in December 2013 to 2014 and February 2022 to 2023, with concentrations of 16.2 and 12.1 grains/m³, respectively. However, these levels were lower compared to those recorded throughout the 12 months of 2006 to 2007. Mimosa pollens peaked at 10.0 grains/m³ in August of 2006 to 2007 survey period but remained at low levels of less than 3.5 grains/m³ during the other two study periods. Careless weed pollens showed high concentrations in February of 2006 to 2007 and November to December of 2013 to 2014 study periods with 20.2, 12.5, and 11.7 grains/m³, respectively. Conversely, these pollens remained below 5 grains/m³ across all 12 months of 2022 to 2023. Acacia pollens were consistently low or undetectable throughout the year, although slightly higher levels were observed in August, October, and November of 2013 to 2014 and 2022 to 2023 compared to other months.

The authors investigated how weather conditions could influence airborne pollen in Phitsanulok, as shown in Figure 4. Temperatures and relative humidity did not vary significantly across the months

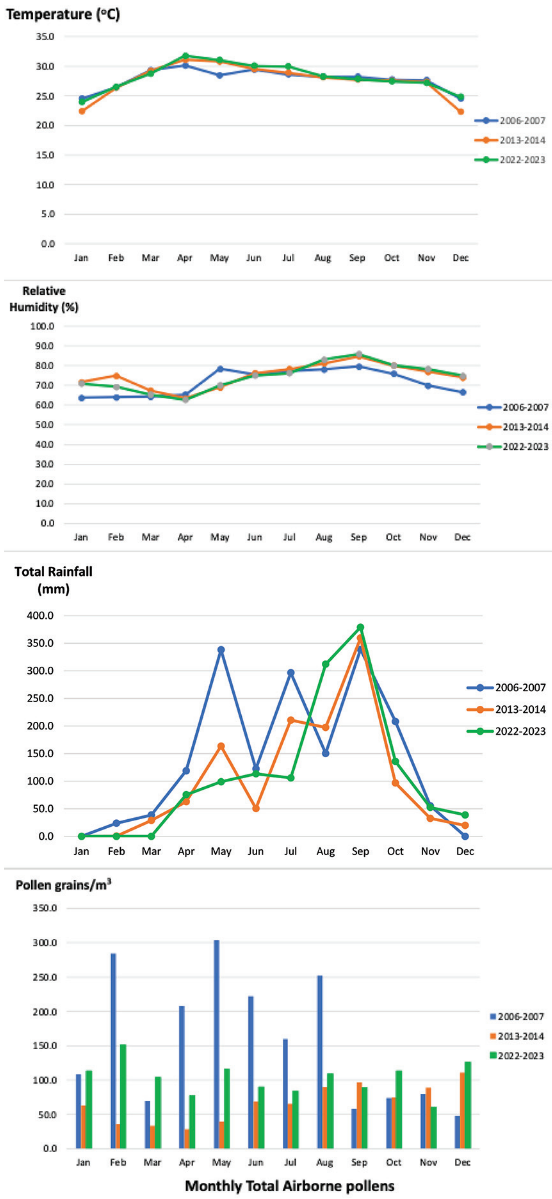

Figure 4. Comparison between meteorological data and total airborne pollen counts during November 2006 to October 2007 (using Rotorod sampler), and during August 2013 to July 2014, and August 2022 to July 2023 using Burkard seven-day volumetric spore trap.

of the three study periods. However, the total annual rainfall from 2006 to 2007 was substantially higher than in 2013 to 2014 and 2022 to 2023, particularly in May and July. Remarkably, the total annual rainfall from 2013 to 2014 was the lowest among all three study periods.

Across all three study periods, the highest rainfall was consistently recorded in September, while minimal rainfall was observed from November to April. The highest temperatures and lowest humidity levels were recorded in April of 2013 to 2014 and 2022 to 2023 survey periods, which corresponded to low levels of airborne pollens during these periods. Monthly rainfall did not appear to significantly influence monthly airborne pollen counts during the survey periods. Interestingly, high pollen levels were observed in November of 2013 to 2014 and 2022 to 2023, as well as in February of 2006 to 2007 and 2022 to 2023, despite minimal rainfall during these months (Figure 4). The statistical analysis of the correlation between total airborne pollen counts and meteorological data showed that temperature and total rainfall were normally distributed, while relative humidity was not. Total airborne pollen counts tended to decrease with higher temperatures in 2013 to 2014 and 2022 to 2023, and showed a positive correlation in 2006 to 2007, however, none of these correlations reached statistical significance ($r=-0.52$, $p=0.08$; $r=-0.43$, $p=0.16$; $r=0.30$, $p=0.34$; respectively). Regarding total rainfall, a positive correlation with total airborne pollen counts was observed in 2006 to 2007 and 2013 to 2014, and a negative correlation in 2022 to 2023, but none were statistically significant ($r=0.19$, $p=0.55$; $r=0.31$, $p=0.33$; $r=-0.22$, $p=0.48$; respectively). Interestingly for relative humidity, there was a statistically significant positive correlation with total airborne pollen counts in 2013 to 2014 ($r=0.73$, $p<0.05$). In contrast, weak positive and negative correlations were observed in 2006 to 2007 and 2022 to 2023, respectively, without statistical significance ($r=0.08$, $p=0.81$; $r=-0.20$, $p=0.54$; respectively).

Discussion

The present study is the first survey of airborne pollens conducted in Phitsanulok, lower northern Thailand, located in Southeast Asia. The study is also the first in Thailand to use the Burkard seven-day recording volumetric spore trap to collect aeroallergens and compare its performance with the Rotorod sampler. Most aeroallergen studies in Thailand have been conducted in Bangkok using the Rotorod sampler[9,12,14-16].

In the present surveys spanning 2006 to 2023, wild grass pollens of particle size smaller than 40 µm were the most predominant airborne pollens in lower northern Thailand, consistent with findings from the most recent survey in Bangkok[9]. Grass pollens were also identified as one of the principal airborne pollens in Bangkok in earlier studies, including surveys from 1972 to 1981[16], 1973 to 1987[14], and 2012[15].

Cultivated grass pollens of size greater than 40 μm were observed to be the second most common type of pollen in the Phitsanulok atmosphere, differing from the findings of most surveys conducted in Bangkok[12,15,20]. This discrepancy could be attributed to the higher prevalence of agricultural plants in the lower northern region of Thailand, such as rice, sugarcane, bamboo, and corn. The pollen morphology of these plants falls within the cultivated grass group and cannot be easily distinguished from one another[4]. Corn, sugarcane, and Johnson grass belong to the Panicoideae subfamily. Corn pollen grains are relatively large, measuring approximately 90 to 100 μm. The pollen sizes of Johnson grass and rice are 26 to 50 μm and 31.3 to 46.4 μm[4], respectively, with most exceeding the 40 μm threshold for classification as cultivated grass pollens.

Beyond grass pollens (Poaceae), there was noticeable diversity in other pollen types when compared to those observed in the north, as Chiang Mai is 399 km from Phitsanuolok, in the south as Songkhla is 1,331 km from Phitsanulok, and in the central region as Bangkok is 375 km from Phitsanulok Thailand[9,12-16,20]. For example, four commonly found pollen types in northern Thailand in 1987 were Mimosa, wild grass, Urticaceae, and Cyperaceae[13]. In southern Thailand in 1987, the five most common pollen types were Casuarinaceae, Mimosa, Urticaceae, Cyperaceae, and wild grass in descending order[13]. In Bangkok, the 2022 survey identified Poaceae, Arecaceae, Typhaceae, and Casuarinaceae, in descending order, as the most common airborne pollens[9], while the 2012 survey reported unidentified pollens, wild grass, Typhaceae, Fern, and Sedge[15]. The diversity of pollens across different areas of Thailand is likely influenced by variations in geography, climate, and agricultural practices.

The decrease in total airborne pollen counts from 2006 to 2013 and the unchanged counts from 2013 to 2022 can be attributed to differences in the height above ground of the sampling instruments as Rotorod sampler is 1.5 meters and the Burkard seven-day recording volumetric spore trap is 15 meters, and the use of different types of aeroallergen collection instruments. The Rotorod sampler was used during the first study period in 2006, while the Burkard spore trap was used during the latter two periods in 2013 to 2023. Studies suggest that the height of the instruments significantly affects pollen collection, with lower concentrations observed at higher elevations, particularly for grass pollens[21,22]. Grass and weed pollens are generally more abundant at ground level than at 15 meters above ground[23]. Regarding the use of different types of aeroallergen collection instruments, research comparing these two devices has yielded mixed results. Studies have reported that the Rotorod sampler has a capture efficiency of approximately 85% to 90% for particles larger than 20 μm, but its efficiency drops significantly for particles smaller than 5 μm due to turbulence and particle bounce[4]. The Burkard instrument, on the other hand, demonstrates better capture efficiency for particles smaller than 5 to 10 μm[4,24], while the Rotorod sampler is comparable to, or slightly more efficient than, the Burkard instrument for particles larger than 10 μm[24]. Both instruments have shown minor differences in collecting pollen-sized particles[24], with pollen grains of common Poaceae taxa, or grass family, typically measuring 20 to 40 μm[25]. Another study found that the Burkard seven-day sampler and the Rotorod sampler reported similar concentrations for Poaceae pollens but significantly different results for smaller pollen types, such as Urticaceae, which are 12 to 17 μm[25]. Despite these differences, a strong correlation in concentration data for both types of pollen was observed between the two instruments[25]. Therefore, comparing the results from these two devices is considered valid for grass pollen, which was the most abundant in the present study. However, for certain pollen types with sizes between 10 and 20 μm such as Careless weed and Cyperaceae, and those smaller than 10 μm such as Mimosa, comparisons between the two devices should be interpreted with caution.

Additionally, wind velocity may have influenced pollen capture in the present study surveys. The Burkard instrument performs best when its aperture faces into the wind and the wind velocity aligns with its intake flow, whereas the Rotorod sampler is not affected by wind direction[4]. Unfortunately, wind speed was not recorded during the surveys, which limits the study ability to assess its impact. Furthermore, the changes in the total amount of pollen and pollen types from 2006 to 2023 can be attributed to the expansion of buildings and housing into agricultural areas, farmlands, and wasteland. The cultivated plants surrounding Naresuan University Hospital have also diminished due to urban expansion, which may explain the reduction in cultivated grass and sedge pollens during the last two study periods.

Weather changes, including temperature, relative humidity, and total rainfall, did not appear to significantly influence the monthly peak pollen counts during the three study periods over 16 years, with two notable exceptions. First, lower pollen counts were consistently observed during the summer months, particularly in March 2006 to 2007 and 2013 to 2014 and April 2013 to 2014, and 2022 to 2023, when temperatures were higher, and relative humidity levels were lower. This pattern was supported by a significant positive correlation between total airborne pollen counts and relative humidity in the year 2013 to 2014. Similar results were reported in Bangkok surveys[9,15]. Second, in terms of yearly total rainfall, the elevated levels recorded in 2006 to 2007 was 1,691.6 mm, 2013 to 2014 was 1,223.7 mm, and 2022 to 2023 was 1,312.5 mm, which may have contributed to the corresponding increases in total yearly pollen counts measured at 1,868.0 grains/m³, 795.0 grains/m³, and 1,236.3 grains/m³, respectively.

The pattern and distribution of total pollen, predominantly grass pollens, in lower northern Thailand were observed year-round, with high pollen counts in February, May, August, and December during certain years. These patterns differed from those reported in Bangkok studies[9,15]. Monthly variation during each study period did not significantly influence the counts of total or individual types of pollen. This may be attributed to the tropical climate in Thailand, where airborne pollen levels do not exhibit the distinct seasonal changes seen in subtropical regions.

Regarding the clinical importance of airborne pollens in allergic sensitization and allergy, our research among asthmatic children and adults revealed that airborne pollen sensitization was comparable to cat dander, ranking third after house dust mites and cockroaches[7,8]. Skin sensitization to allergen extracts of Bermuda grass, Johnson grass, Careless weed, and Acacia among asthmatic children and adults was 31.4% and 38.6%, 30.7% and 41.4%, 27.4% and 34.5%, and 25.1% and 34.5%, respectively. The pollen levels of Bermuda grass, classified under the wild grass group with a particle size of 28 to 30 µm, consistently exhibited high counts at 20 to 199 grains/m³[26] across all three study periods. These levels are considered a high allergic risk, with many individuals with pollen allergies likely to experience allergic symptoms[26]. For Johnson grass, classified under the cultivated grass group, pollen levels were 6 to 24, 1.6 to 16.2, and 1.9 to 12.1 grains/m³ in 2006, 2013, and 2023, respectively. These counts fell within the moderate allergic risk range, which is 5 to 19 grains/m³, during certain months of all three study periods, indicating that some individuals, particularly those with sensitivities, may experience symptoms[26]. As for Careless weed and Acacia pollens, the present surveys across all three study periods primarily revealed low pollen counts at 1 to 9 grains/m³ for weed pollens and 1 to 14 grains/m³ for tree pollens, which are considered minimal allergic risk levels for most individuals[26].

Based on these findings, monitoring both airborne pollen levels and distribution of pollen types could play a crucial role in the management and prevention of allergies especially for individuals sensitive to airborne pollens. Further studies on clinical allergic exacerbations associated with high airborne pollen counts would be beneficial for long-term management and avoidance planning for pollen-allergic patients.

The limitations of the present study include the use of different instruments to monitor aeroallergens and the variation in the height of these instruments above ground, making it challenging to directly compare pollen counts and types across the three study periods. Moreover, the pollen collection sites were limited to only one or two locations, which may not be representative of the entire Phitsanulok province. Nonetheless, the patterns and trends of aeroallergens remained discernible, which is a strength of the present study. Additionally, this survey represents the first conducted in Phitsanulok and marks the first use of the Burkard seven-day volumetric recording spore trap in Thailand.

Conclusion

From 2006 to 2023, the most and second predominant airborne pollens in Phitsanulok, lower northern Thailand, were wild grass at a size smaller than 40 µm and cultivated grass at a size greater than 40 µm, respectively. Total airborne pollen was detected year-round, with the lowest counts consistently observed in summer, April, over the 16-year period. During this time, wild grass pollen counts ranged from moderate to high allergic risk levels throughout the year, with peak levels in February, May, and December. Cultivated grass pollen counts ranged from low to moderate allergic risk levels in most months, except for the high levels recorded during 2006 to 2007. Other pollen, such as Careless weed, Mimosa, Acacia, and Asteraceae, were consistently observed at low allergic risk levels year-round. A decreasing trend was noted in total pollen counts, cultivated grass, and other pollen types from 2006 to 2023, with the exception of wild grass. The yearly decrease in total rainfall may have contributed to the reduction in total pollen counts.

What is already known about this topic?

In Thailand, pollen allergy affects approximately 15% to 41% of the population. Most outdoor aeroallergen surveys have been conducted in Bangkok. These Bangkok surveys, spanning from 1972 to 2022, identified various types of pollen, with nearly all indicating that grass pollens were either the most common or second most common airborne pollens. A study in Chiang Mai, northern Thailand, found that Mimosa was the most prevalent pollen, followed by wild grass, while a study in Songkhla, southern Thailand, reported that Casuarinaceae ranked first, followed by Mimosa.

What does this study add?

This study represents the first survey of airborne pollens conducted in Phitsanulok, lower northern Thailand. It is also the first in Thailand to utilize the Burkard seven-day recording volumetric spore trap and compare its performance with the Rotorod sampler. Between 2006 and 2023, wild grass of size smaller than 40 µm and cultivated grass of size greater than 40 µm, were the most and second most predominant airborne pollens, respectively, in Phitsanulok. Airborne pollen was detected year-round, with the lowest counts consistently recorded in summer, April, throughout the 16-year period. Wild grass pollen counts ranged from moderate to high allergic risk levels year-round, peaking in February, May, and December. Cultivated grass pollen counts remained low to moderate allergic risk levels for most months. Other pollen types, including Careless weed, Mimosa, Acacia, and Asteraceae, were consistently observed at low allergic risk levels throughout the year. A decreasing trend in total pollen counts, cultivated grass, and other pollen types was noted from 2006 to 2023, with the exception of wild grass, which remained relatively stable.

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Data availability

The datasets used in this study are available from the corresponding author upon reasonable request.

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Conflicts of interest

The authors have no conflict of interest to disclose.

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