

## Pollen concentration of invasive tree of heaven (*Ailanthus altissima*) on the Northern Great Plain, Hungary

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### SUMMARY

In areas where the tree of heaven (*Ailanthus altissima*) appears and multiplies, the original vegetation degrades and transforms. The invasive tree of heaven is also of great importance in urban environments, where it causes building damage, static problems and endangers utilities. *Ailanthus* pollen concentration was measured during the 3-year period (2016-2018) at three county capitals (Szolnok, Debrecen, Nyíregyháza) of the Northern Great Plain, Hungary (Jász-Nagykun-Szolnok county, Hajdú-Bihar county and Szabolcs-Szatmár-Bereg county), with a 7-day Hirst-type (Burkard) pollen trap. The highest total pollen count of *A. altissima* was measured in all three years in Nyíregyháza (1114 pollen m<sup>-3</sup> in 2016; 788 pollen m<sup>-3</sup> in 2017; 635 pollen m<sup>-3</sup> in 2018), while the lowest values were measured in Szolnok in all three years (99 pollen m<sup>-3</sup> in 2016; 78 pollen m<sup>-3</sup> in 2017; 93 pollen m<sup>-3</sup> in 2018). In Debrecen, the annual total pollen concentration varied between 109-127 pollen grains m<sup>-3</sup> in the studied period. The extent of the prevalence of *A. altissima* can be deduced from its pollen concentrations. For this purpose, multi-year pollen data is displayed on a map in which areas characterized by different pollen concentrations are represented by colour codes. Pollen monitoring provides information on the size of *A. altissima* stands and provides a basis for proposals and plans for measures to control this invasive tree species and mitigate the damage caused by it.

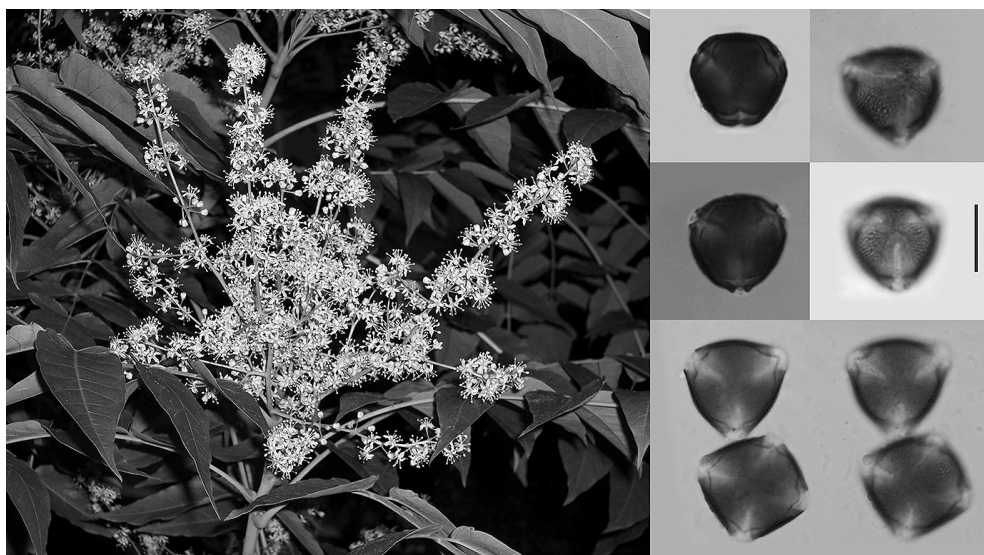
**Keywords:** *Ailanthus altissima* (tree of heaven), invasive plant, Northern Great Plain region in Hungary, pollen concentration.

## INTRODUCTION

The tree of heaven (*Ailanthus altissima* (Mill.) Swingle) belongs to the family *Simaroubaceae*. The genus, numbering about 10 species, has a focal point of distribution in the front and back of India, as well as in the Far East. The basic variant of the species, *A. altissima* var. *altissima*, is native to China. The bark of *A. altissima* var. *tanakai*, which is widespread in Taiwan, is yellower than the base species and has shorter leaves. It is recognized by the reddish branches of *A. altissima* var. *sutchuenensis*. In addition to the tree of heaven, the downy tree of heaven (*A. giraldii* Dode) and the thorny tree of heaven (*A. vilmoriniana* Dode) are also among the temperate species of the genus (Hegi, 1924; Hu, 1979; Udvardy, 2004).

Tree of heaven is dioecious, with male and female flowers being borne on different individuals. The flowers open in loose endless buds, greenish-yellow, woolly on the inside, consisting of 5 or 6 cups, petals and fruit leaves. The number of stamens per flower is 5+5 or 6+6. The flowers produce a lot of nectar (Barkman, 1988; Bartha, 1994). Its flowering time is in June and July (Simon, 1992). Pollen grains are medium-sized (26-50  $\mu\text{m}$ ), tricolporate, striato-reticulate (Figure 1). The flowers are ambophilous (both wind and insect pollinated) (Thompson, 2008). The main factors that enable the invasiveness of *Ailanthus altissima* are the following: 1) rapid propagation from seed; 2) strong root formation; 3) rapid growth (Mihály and Botta-Dukát, 2004; Csiszár, 2012).

The tree of heaven is native in areas along the lower reaches of the Yangtze River to north-eastern, central China (Hubei, Honan, Anhui, Jiangsu; Hunan, Jiangxi, and Zhejiang provinces) and Korea. The distribution of this species is currently between 22°N and 43°N,



**Figure 1.** *Ailanthus altissima* inflorescence and pollen grains. Scale bar = 20  $\mu\text{m}$ . (Photo: Dóra Kajtor-Apatini)  
**Slika 1.** Cvast i polenova zrna vrste *Ailanthus altissima*. Jedinica mere = 20  $\mu\text{m}$ . (Fotografija: Dóra Kajtor-Apatini)

up to 1,500-1,800 m above sea level. Its worldwide spread began in the 1740s, when its seeds were transported to Paris on a land journey through Siberia (Russia). It was planted in London in 1751 as an ornamental tree. It was brought to North America in the 18<sup>th</sup> century, where it was first planted as an ornamental tree in northern cities. In 1856, it was reported (Ascherson and Graebner, 1914) that the stock was already in a natural forest at the territory of South Tyrol (Austria). It was planted in Paris to replace the hybrid plane or the London plane tree (*Platanus*) in 1875. *Ailanthus altissima* is widespread in most of the western hemisphere today. It is often planted in the subtropical and northern temperate zones, including throughout East Asia and Europe, as well as North America. Due to its favourable properties, it has spread to all inhabited continents (Good, 1974; Böcker and Kowarik, 1982; Kowarik, 1983; Kowarik and Böcker, 1984).

First data on the occurrence of *A. altissima* in Hungary is available from a documentation of planting experiments of this species in Villány in 1841-1843 (Bartosságh, 1841; Bartosságh, 1843). It has been established in the Great Plain since the middle of the 20<sup>th</sup> century, due to its stock-like, conscious settlements and spontaneous outbursts. Today, it occurs almost everywhere in the hilly, lowland areas of the country with a warmer climate. It is relatively rare in Western Transdanubia and in the higher regions of the central mountains (Soó and Jávorka, 1951; Kovács and Priszter, 1974).

The tree of heaven is considered to be an invasive species (Landenberger et al., 2007). Nowadays, the problem of invasive species is gaining more and more attention. In areas where the *A. altissima* appears and multiplies, the original vegetation degrades and transforms. The tree of heaven is also of great importance in urban environments, where it causes building damage, static problems and endangers utilities. In addition, it is worth mentioning that *A. altissima* pollen is an allergen (Mousavi et al., 2017).

The aim of our study is to investigate the pollen concentration of *Ailanthus altissima* (tree of heaven) in the Northern Great Plain region of Hungary.

## MATERIAL AND METHODS

The pollen concentration of *Ailanthus altissima* was measured in three county capitals (Szolnok, Debrecen, Nyíregyháza) of the Northern Great Plain region (Jász-Nagykun-Szolnok county, Hajdú-Bihar county, Szabolcs-Szatmár-Bereg county) (Figure 2), with the 7-day Hirst-type (Burkard) pollen trap (Figure 3), for the 3-year period (2016-2018).

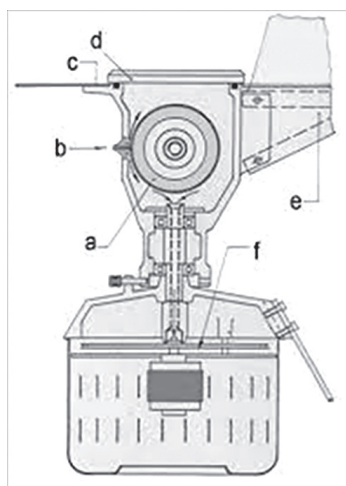
The device collides the pollen content of the intake air onto a tape with a sticky surface (Melinex tape). The tape is divided into two-hour bands, and the pollen grains stained with basic fuchsin are counted in two 0.5 mm bands 6-6 mm from the edges at 400× magnification. The results are given as a 24-hour average, expressed in pollen grains / m<sup>-3</sup> of air.

The pollen season was defined as the day on which the sum of the daily average pollen concentration reaches 1% of the final amount and the end of the season when it reaches 99% (Ziska et al., 2019).



**Figure 2.** The Northern Great Plain region (Jász-Nagykun-Szolnok county, Hajdú-Bihar county, Szabolcs-Szatmár-Bereg county) in Hungary

**Slika 2.** Region Velike severne ravnice (Jász-Nagykun-Szolnok county, Hajdú-Bihar county, Szabolcs-Szatmár-Bereg county) u Mađarskoj



**Figure 3.** Hirst-type (Burkard) pollen trap

**Slika 3.** Hirst tip (Burkard) hvatača polena

## RESULTS

**Pollen data for Jász-Nagykun-Szolnok county.** In Szolnok, the pollen trap caught a total of 99 *A. altissima* pollen grains in 2016. The highest amount of pollen grains were counted on the 3<sup>rd</sup> and 6<sup>th</sup> of June (15 pollen m<sup>-3</sup>). One year later, the annual pollen count of the tree of heaven was 78, when the highest daily amount (14 pollen m<sup>-3</sup>) was detected on June 6<sup>th</sup>. In 2018, 93 pollen grains were counted as an annual sum. The highest daily pollen count of 15 pollen m<sup>-3</sup> was recorded in the city of Szolnok on May 24<sup>th</sup>, 2018.

**Pollen data for Hajdú-Bihar county.** In Debrecen, the total annual number of *A. altissima* pollen was 127 in 2016. The highest daily concentration was detected on June 5<sup>th</sup> (19 pollen m<sup>-3</sup>). In the following year, a total of 110 *Ailanthus altissima* pollen grains were counted. In 2018, the annual total pollen count of the tree of heaven was 109, while the highest daily amount (19 pollen grains m<sup>-3</sup>) of *A. altissima* pollen was measured on May 26<sup>th</sup>.

**Pollen data for Szabolcs-Szatmár-Bereg county.** In Nyíregyháza, the total number of *Ailanthus* pollen was 1114 in 2016. The highest daily concentration of pollen grains (405 pollen m<sup>-3</sup>) was measured on June 6<sup>th</sup>. One year later, the total *A. altissima* pollen count was 788, while the highest daily concentration (229 pollen m<sup>-3</sup>) was detected on June 5<sup>th</sup>. In 2018, we counted 635 *Ailanthus* pollen grains. The highest daily value (peak value) was recorded on May 19<sup>th</sup> (82 pollen m<sup>-3</sup>) in Nyíregyháza.

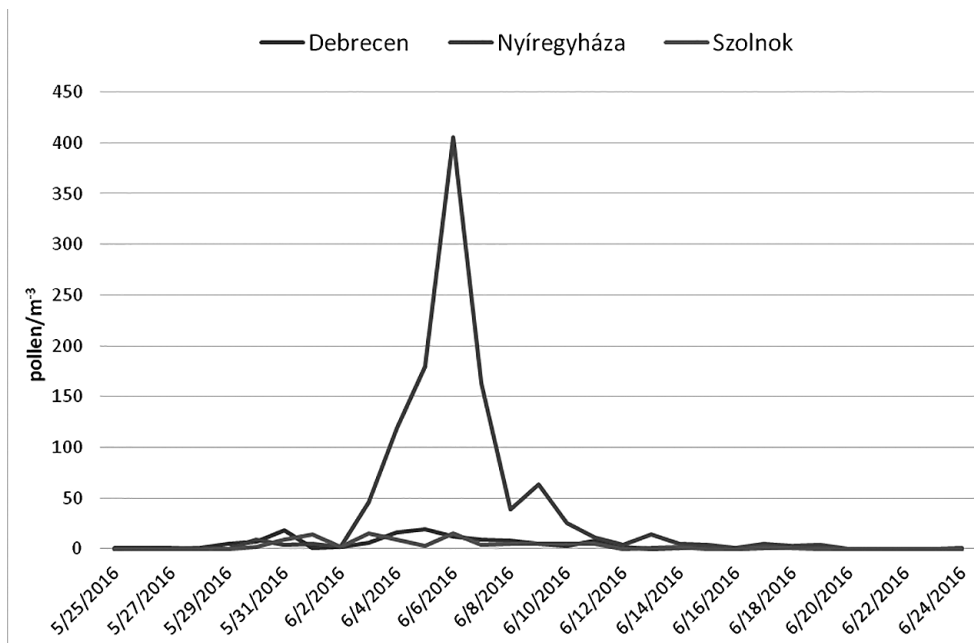


Figure 4. Daily pollen concentrations of *Ailanthus altissima* in 2016

Slika 4. Dnevna koncentracija polena vrste *Ailanthus altissima* u 2016. godini

The data on the daily pollen counts of tree of heaven in 2016, 2017 and 2018 are shown in Figures 4-6, respectively.

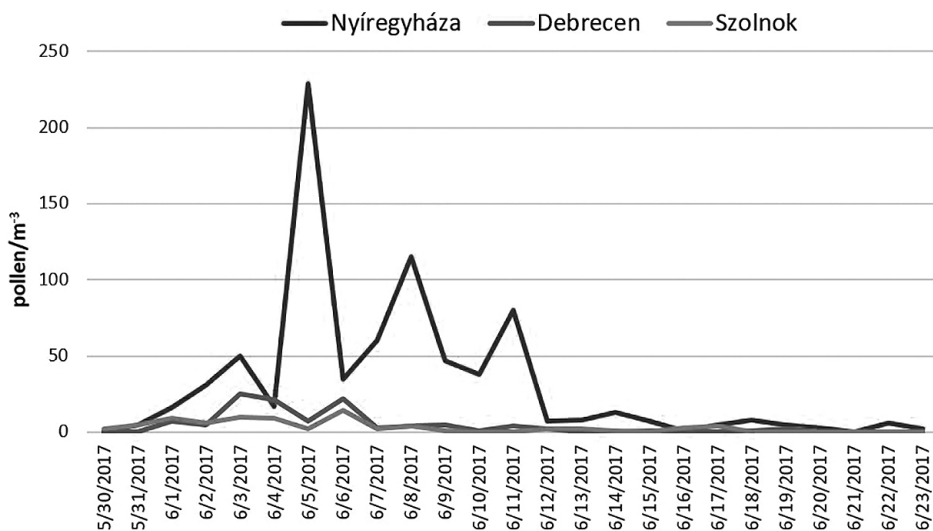


Figure 5. Daily pollen concentrations of *Ailanthus altissima* in 2017

Slika 5. Dnevna koncentracija polena vrste *Ailanthus altissima* u 2017. godini

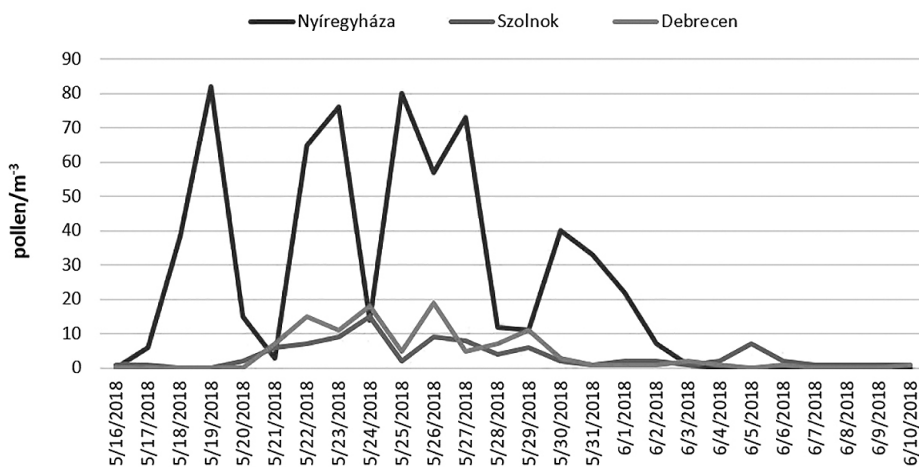


Figure 6. Daily pollen concentrations of *Ailanthus altissima* in 2018

Slika 6. Dnevna koncentracija polena vrste *Ailanthus altissima* u 2018. godini

## DISCUSSION

The highest total pollen count of *A. altissima* was measured in all three years in the Szabolcs-Szatmár-Bereg county (1114 pollen in 2016; 788 pollen in 2017; 635 pollen in 2018), while the lowest value in all three years was measured in the Jász-Nagykun-Szolnok county (99 pollen in 2016; 78 pollen in 2017; 93 pollen in 2018). In Hajdú-Bihar county, the total annual pollen concentration varied between 109-127 pollen grains in the studied period.

Data on the extent of plant populations can be obtained in two ways: by a direct survey of vegetation (e.g., National Weed Survey in Hungary), or indirectly by summarizing and mapping other data related to the potential distribution of plants. The latter group may include environmental variables (suitable soil type and pH, precipitation, etc.) that determine the plant's needs on the site, as well as anthropogenic factors (crop structure, urbanization level, etc.). Additionally, data from atmospheric pollen concentration measurements also provide important information for anemophilous plants (Thibaudon et al., 2014; McInnes et al., 2017). For this purpose, the multi-year pollen data may be displayed on a result map in which the areas characterized by different pollen concentrations are represented by colour codes. Based on our studies, pollen monitoring data could also be used to study the distribution of *A. altissima*. Our work draws the attention to the differences in the distribution of the tree of heaven in the Northern Great Plain, based on which it can be seen that there can be more than a tenfold difference between the monitoring areas in terms of the total annual pollen count. Further research is needed to examine data from more monitoring stations and years that would allow for greater accuracy. In addition, we plan to include pollen data from other Hungarian cities, which can be explored on a national map to reveal the spatial differences in plant distribution.

The total annual pollen count (Table 1) of other pollen-producing woody plants (*Acer*, *Betula*, *Fraxinus*, *Moraceae*, *Platanus* species) common in urban environments is generally higher than that of the tree of heaven (Udvardy et al., 2018; Udvardy et al., 2019). This is probably because these plants are mostly planted as urban ornamental trees and therefore have higher numbers of individuals and higher pollen emissions than *A. altissima*. As the tree of heaven is an invasive species, there is no so-called *A. altissima* containing species proposed for planting in urban green spaces in the List of Public Row Wood (Szabó, 2019).

The size of the trees (height, radius of the crown projection) is proportional to the amount of pollen release according to some model calculations (Cariñanos et al., 2014; Magyar et al., 2020). The tree of heaven, like other noxious plants/weeds, is often removed before it reaches a larger size. This also results in lower pollen counts compared to other urban tree species, whose large specimens emit significant amounts of pollen (e.g. old sycamore trees; Cariñanos et al., 2014).

The situation of *A. altissima* is somewhat similar to that of *Broussonetia papyrifera*, which is also an invasive, anemophilous tree species in urban environments (Peng and Chen, 1996). However, their pollen production is not comparable because the pollen grains of *B. papyrifera* are pooled with other tree species having similar pollen grains (*Morus alba*, *Morus nigra*) as “*Moraceae* pollen” during aerobiological monitoring.

**Table 1.** Total pollen number of plant species planted as urban ornamental trees in the Northern Great Plain region (2017-2018)**Tabela 1.** Ukupan broj polenovih zrna gajenog i urbanog dekorativnog drveća u regionu Velike severne ravnice (2017-2018)

Allergen Species Alergene vrste	City Grad	Szolnok Solnok		Debrecen Debrecin		Nyíregyháza Níredhaza	
	Year Godina	2017	2018	2017	2018	2017	2018
<i>Acer</i> spp.		447	484	251	119	1381	366
<i>Betula</i> spp.		1815	3560	2183	4906	5412	7946
<i>Fraxinus</i> spp.		1353	3775	705	1606	629	1690
<i>Moraceae</i>		2164	3167	2333	1830	3109	3024
<i>Platanus</i> spp.		10228	8891	2139	2029	5485	4969

## CONCLUSION

The mass appearance of *A. altissima* is a serious problem in almost all areas (national parks, forests, inner city zones and towns), where its control/eradication would cost millions of euros. Pollen data provide information on the size of *A. altissima* stands endangering the static problems, endangers utilities and buildings of cities. Pollen monitoring provides a basis for proposals and plans for measures to control the invasive tree species and mitigate the damage caused by them.

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## Koncentracija polena invazivnog pajasena (*Ailanthus altissima*) na području Velike severne ravnice Mađarske

### REZIME

Na području gde se javlja i umnožava pajasen (*Ailanthus altissima*), dolazi do izmene i degradacije prvobitne dekorativne vegetacije. Biljke invazivnog pajasena su takođe i problem u urbanim područjima, gde stvara probleme na zgradama, duž puteva i otežava komunalne usluge. Koncentracija polena *A. altissima* merena je tokom tri godine (2016-2018) u tri glavna grada (Solnok, Debrecin, Niređhaza) na području Velike severne ravnice u Mađarskoj (Jász-Nagykun-Szolnok, Hajdú-Bihar i Szabolcs-Szatmár-Bereg), sa hvatačem polena tipa Hirst (Burkard) u kontinuitetu od sedam dana. Najveći ukupan broj polenovih zrna *A. altissima* u sve tri godine izmeren je u gradu Niređhazi (1114 polenovih zrna  $\text{m}^{-3}$  u 2016; 788 polenovih zrna  $\text{m}^{-3}$  u 2017; 635 polenovih zrna  $\text{m}^{-3}$  u 2018), dok su najmanje vrednosti u sve tri godine izmerene u gradu Solnoku (99 polenovih zrna  $\text{m}^{-3}$  u 2016; 78 polenovih zrna  $\text{m}^{-3}$  u 2017; 93 polenova zrna  $\text{m}^{-3}$  u 2018). U Debrecinu, ukupna koncentracija polenovih zrna, na godišnjem nivou, u proseku za sve tri godine se kretala od 109-127  $\text{m}^{-3}$ . Stepen zastupljenosti i brojnosti *A. altissima* se može zaključiti iz utvrđene koncentracije njegovog polena. U tu svrhu, višegodišnji podaci o koncentraciji polena pajasena su predstavljeni različitim bojama na graficima za ova tri grada. Monitoring polena daje realne informacije o veličini sastojina *A. altissima* i predstavlja osnovu za predlaganje i planiranje mera za suzbijanje ove invazivne biljne vrste, a samim tim i ublažavanjem šteta od nje. **Ključne reči:** *Ailanthus altissima* (pajasen), invazivna biljka, region Velike severne ravnice u Mađarskoj, koncentracija polena.