



Ragweed plants and airborne pollen in the Baltic states

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Abstract

Presence of pollen in the atmosphere was determined in Tartu in 1989–1997, in Kuressaare in 1996–1997 and in Šiauliai in 1997. Ragweed airpollen was found in late summer in three years. The distribution, abundance and flowering of local ragweed plants were estimated. It appeared that the number of local sources did not exceed twenty per country per year. Majority of these sources consisted of a small number of pollinating *A. artemisiifolia* individuals. The largest local sources, consisting of several hundreds of individuals, were exclusively rare. Transport of ragweed pollen by air masses from distant sources was studied. It was found that incursions of ragweed pollen were determined by air fluxes originating from the Ukraine as well as from the southeastern and southern regions of the European part of Russia. These incursions occurred in extensive high-pressure areas whose centre was located in the central region of the European part of Russia with a periphery extending to the Baltic countries.

Abbreviations: HPA – high-pressure area; LDT – long distance transport of pollen; PCF – pollen-containing air flux; PFF – pollen-free air flux; C Russia – central region of the European part of Russia; N Russia – northern region of the European part of Russia; S Russia – southern region of the European part of Russia; SE Russia – southeastern region of the European part of Russia

1. Introduction

Ragweed, an alien in the European flora, is represented by three species – *Ambrosia artemisiifolia* L., *A. coronopifolia* Torr. et Gray and *A. trifida* L. – on the northwestern edge of the East European plateau. There, on the eastern coast of the Baltic Sea, *A. artemisiifolia* was first found as follows: in Lithuania in 1884, in Latvia in 1936 and in Estonia in 1954 (Gudzhinskas, 1993; Tabaka et al., 1988; Eesti NSV flora, 1978). *A. coronopifolia* has been found in Latvia but not in Lithuania (Tabaka et al., 1988; Gudzhinskas, 1993). In Estonia it was first found in 1933, but there have been no new records for the last

forty years (Eesti NSV flora, 1978; Kuk, 1991). *A. trifida* was first found as follows: in Latvia in 1900, in Lithuania in 1947 and in Estonia in the 1960s, the first written record dating from 1990 (Tabaka et al., 1988; Gudzhinskas, 1993; Kuk, 1997). Ragweed is colonizing progressively larger areas in Europe and, due to its aero-allergenic pollen, the environment is becoming more harmful for the man. Very little relevant information is available for the Baltic states. Also, the opinions expressed on this topic (Spieksma et al., 1993) need revision. The aims of this study are: to consider present aero-allergenic situation; to estimate possible sources of airpollen; to prognosticate future aero-allergenic situation. For this purpose,

we will summarize and analyse the existing aerobiological, floristic, phenological and meteorological data concerning the topic.

Materials and methods

2.1 Airborne pollen

The territory of the Baltic states expands about 650 km in the N-S direction and 450 km in the E-W direction. Two monitoring sites were situated in its northern part, Tartu (58° 21' 23" N and 26° 40' 50" E, 65 m a.s.l.) on its eastern edge and Kuressaare (58° 15' 02" N and 22° 28' 14" E, 1 m a.s.l.) on its western edge. Both sites lie about 150 km south of the northernmost fringe of the territory. The third monitoring site, Šiauliai (55° 55' 30" N and 23° 16' 44" E, 130 m a.s.l.), was located near the central N-S axis of the territory, about 200 km north of the southernmost fringe of the territory.

The daily mean concentration of pollen grains per cubic metre of the air was determined in Tartu and Kuressaare, while for Šiauliai counts from slides indicated only generally the presence of pollen in the atmosphere and its abundance. Samplers were placed on the roof of a building, at the height of 14 m, 14 m and 18 m above ground, respectively. Continuous volumetric 7-day samplers (Burkard) were used in Tartu and Kuressaare. In Tartu, monitoring was performed continuously from 1989 to 1997. In Kuressaare, it was carried out during the pollen seasons of 1996 and 1997. By screening slides, random fields method was used in Tartu, while a method with three longitudinal bands was employed in Kuressaare. The studied area made up 1.2% and 7.0% of daily slide surface, respectively. In Šiauliai, a gravitational settling sampler of local production was used during the pollen season of 1997. By screening the slides, 11–13 longitudinal bands were examined. The studied area made up about 10% of the daily slide surface. All grains belonging to the "*Ambrosia-Iva* type" group were identified as ragweed pollen.

2.2 Local plants

Estimation of the distribution and phenology of plants is based on the studies of the last ten years, published or available in a manuscript form, and on observations made by local botanists. In Lithuania, regular field investigations of alien plants have been carried out on the whole territory since 1987. Data on ragweed from 1987–1992 are published (Gudzhinskas,

1993), recent data are based on observations made by Z. Gudžinskas and V. Motiekaitytė. For Estonia, the occurrence frequency of ragweed plants is given according to Kukk (1997), while the rest of the data are based on observations made by T. Ploompuu on the ruderal flora over the whole territory in 1989–1992 and more sporadically later on. For Latvia, the occurrence frequency of ragweed plants is presented according to Tabaka et al. (1988), considering the situation up to 1986.

2.3 Weather and trajectories

To analyse meteorological conditions, data on the location and movement of low- and high-pressure areas in the lower part of the atmosphere in Europe were taken into account.

Air fluxes were determined by synoptic back-trajectories method, while synoptic maps for 850 hPa (approximately at the height of 1.2–1.5 km a.s.l.) were used. The distance covered by air particles as well the general direction of their movement were calculated using mean wind velocity and direction. The interval between estimations was 12 hours. The trajectories were calculated for the 96-hour period preceding the arrival of air particles at the site of aerobiological monitoring. They were established for 1996 and 1997 but, due to lack of synoptic maps, not for 1992. A total of 67 trajectories were calculated: 35 for PCF and 32 for PFF. The trajectories of air fluxes indicate LDT if two conditions are fulfilled. First, in case of PCF, they originate from areas rich in pollinating ragweed plants, or cross them. Second, in case of PFF, they originate from areas where pollinating ragweed plants do not occur, or where they occur in negligible numbers and, moreover, do not cross areas abounding in pollinating ragweed plants.

The areas closest to the Baltic countries, which could be regarded as sources of LDT, are Hungary, the Ukraine, and SE and S Russia. *A. artemisiifolia* is established in Hungary (Járai-Komlódi and Juhász, 1993) while *A. artemisiifolia* and *A. trifida* are established in the Ukraine and in SE and S Russia (Nikitin, 1983; Maryushkina, 1986; Kovalev, 1989). Ragweed grows very rarely as a casual alien in the neighbourhood of the Baltic states: in Leningrad, Novgorod, Pskov and Kaliningrad regions of Russia, in Byelorussia, and in Poland (except for South Poland) (Minyaev, 1970; Guide to higher plants, 1981; Yanayev and Tretyakov, 1979; Tacik, 1971; Gudzhinskas, 1993).

3. Results

3.1 Airborne pollen

Ragweed pollen was found in 1992 in Tartu, in 1996 in Tartu and in Kuressaare, and in 1997 at all three sites. Data on pollen concentration in Tartu and in Kuressaare are given in Table 1. In Šiauliai, data on ragweed are available only four days: August 20, 21, 27 and 29. Ragweed pollen was found on August 29.

3.2 Local plants

Plants of all three species occur in synanthropic habitats which represent, in the absolute majority of cases, ruderal habitats connected closely with the transport and processing of imported grains. Their present distribution has formed as a result of repeated introduction of ragweed seeds together with grain and other agricultural products imported from regions where *Ambrosia* is a widely distributed weed (North America, southern regions of the European and Asian parts of Russia, and the Ukraine).

A. artemisiifolia occurs in all three countries. In Estonia, about 30 records were reported in 1989–1992. In most cases small numbers of individuals were found. One of the largest groups covered about 100 m² (in Taebala in 1995). In Latvia, plants have been found very rarely. In Lithuania, in the course of investigations performed in 1987–1992, 85 records were reported from 49 towns. In most localities, small numbers, usually from several up to 20–30 sporadically growing individuals have been encountered. Only in a few cases the numbers were larger (about one hundred to several hundreds), and plants covered an area more or less entirely. Such plant groups were observed in Vievis (in 1987), in Radviliškis (in 1989), in Kaunas (in 1989 and 1990), in Šeduva (in 1991) and in Mickūnai (in 1988 and 1989). The situation of the latest period, 1993–1997, is similar to that of the studied period. A numerous group was observed in Vilnius in 1996, where plants covered about 100 m².

Like *A. artemisiifolia*, *A. trifida* occurred, though less frequently, in all three countries. In Estonia, as a result of investigations performed in 1989–1992, about 10 records of this species were established. In all cases a small number of individuals were found. In Latvia, plants occurred very rarely. In Lithuania, 26 records were reported from 20 towns during 1987–1992. In most cases a few individuals (1–5) were recorded. Rarely, the number was larger (about 10

individuals). More than 50 individuals were found only once.

A. coronopifolia plants occurred very rarely in a comparatively limited area in Latvia, mostly in Riga.

A. artemisiifolia plants did not flower every year in Estonia, but they did flower every year in Lithuania. In Estonia, even in hot and sunny summer and autumn, plants rarely reached the pollination stage. Such a situation occurred in Taebala in 1995: at the end of the vegetative period, in mid-October, most plants had only unopened florets; in flowering plants, merely part of florets were pollinated. In Lithuania, flowering began in July–August or September and was in progress until the end of the vegetative period. *A. trifida* plants flowered neither in Estonia nor in Lithuania; they were in vegetative or early generative condition even in late autumn. Flowering individuals were observed only twice (in 1947 and 1992) in Lithuania.

The above data can be summarized as followed: sites with flowering ragweed were scattered randomly over the territory and their number did not exceed twenty per country per year, while the number of plants per site did not exceed some hundreds.

A. artemisiifolia plants did not produce seeds in Estonia; even in years with favourable weather conditions for the development of ragweed, only seed embryos were observed. In Lithuania, seeds ripened in some years, but continuous reproduction by seeds did not take place; plants with ripe seeds were found at the end of September. It is supposed that in some localities (e.g. Kaunas, 1989, 1990; Mickūnai, 1988, 1989), *A. artemisiifolia* reproduced by seeds in several years. However, due to succession of vegetation, the species was not found later in these localities.

3.3 Weather and trajectories

During all three ragweed pollen seasons, weather was sunny, dry and very warm, with daily mean air temperatures higher than normal for August. At the time when pollen occurred, a HPA occupied most of East Europe (as in 1996), or extended its western periphery even to Central Europe (as in 1997). The centre of this HPA was standing above C Russia (as on 15.8.96, 28.8.–3.9.96, 28.–30.8.97), or was shifting either towards it (coming from N Russia on 26.–27.8.96 and from the N Ukraine on 26.–27.8.97) or away from it (approaching N Russia on 31.8.–1.9.97), while its western or northwestern periphery was extending to the Baltic countries. When another pressure area near the Baltic countries or above them was act-

Table 1. Daily mean concentration (pg/ m³/ 24h) of ragweed pollen in Tartu (T) and Kuressaare (K).

Year	Site	August																			September					
		13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6
1992	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	8	25	42	0	0	0	0
1996	T	0	0	9	9	9	26	0	0	0	0	0	0	0	9	18	26	<9	26	18	<9	9	9	0	0	0
	K	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	3	7	26	13	0	13	1	0	1	0
1997	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	18	18	9	0	0	0	0	0
	K	0	0	0	0	0	0	0	0	0	1	0	0	1	10	16	16	13	0	1	0	0	0	0	0	0

ively influencing this HPA from the west or from the north or from both directions simultaneously, then the pollen was often (on 16.–17.8.96, 23.–24.8.96, 5.9.96 and 23.8.97) found only at one monitoring site.

Pollen did not occur in the following situations: a pressure area was above the Baltic countries or near them, influencing actively the East European HPA whose centre was located above C Russia (on 4.9.96 and 25.8.97); the Baltic countries were occupied by the southwestern periphery of the East European HPA with its centre located above N Russia (on 25.8.96 and 2.9.97); the Baltic countries were occupied by HPA whose centre was moving eastward from N Germany (on 19.–22.8.96); the Baltic countries were occupied by the northwestern periphery of the East European HPA whose centre was shifting from the N Ukraine to C Russia (on 24.8.97).

The trajectories of 27 PFF originated from areas and crossed areas where ragweed did not grow, or grew in negligible quantities (see groups 1–4 in Table 2). The trajectories of 5 PFF originated from areas regarded as sources of ragweed pollen (groups 5 and 6).

The trajectories of 31 PCF originated from territories rich in ragweed plants, or crossed such a territory later (groups 7–10). The trajectories of 2 PCF originated from a territory where ragweed plants grew in negligible quantities, but these fluxes could have moved over a territory, rich in ragweed plants, earlier (group 11). The trajectories of 2 PCF originated from territories where ragweed plants did not grow at all, or occurred in very small numbers, and did not pass such territories later (group 12).

4. Discussion

4.1 Origin of airborne ragweed pollen

Due to negligible quantities, local flowering plants could not been responsible for the observed airpollen. Moreover, if pollen had originated from them, then it must have been present on all days favourable for pollination. However, in spite of such conditions, pollen was found on some days but was not observed on other days. In this respect, the situation in Tartu in 1996 was the most expressive: pollen occurred only on the first four days and on the last nine days of the season, and was absent in the 7-day interval between them (Table 1).

The conditions indicating LDT were satisfied in case of 87% of trajectories (groups 1–4 and 7–10 in Table 2) but not in case of 13% of trajectories (groups 5, 6, 11 and 12). It was common for all the latter cases that difficult synoptic conditions occurred on the Baltic Sea or on the mainland near Lithuania and Byelorussia: another pressure area, more often a low-pressure area, influenced the periphery of the East European HPA. In such conditions pollen-containing and pollen-free air particles could have previously reached the sites crossed by the trajectories. That is why these minority cases do not support the hypothesis of the local origin of pollen. 94% of PCF with known pollen sources originated mainly from the Ukraine or from SE and S Russia, while peak pollen concentrations could be attributed only to such circumstances.

4.2 Present aero-allergenic situation with respect to ragweed

Distances between the monitoring sites were equal to or lesser than the diameter of air fluxes in HPA

Table 2. Details of the trajectories for Kuressaare (K), Tartu (T) and Šiauliai (S).

Group	Sites of origin	Areas crossed	Arrival sites and dates
1–	North Sea, Norwegian Sea, Baltic Sea, W Germany, Sweden, Karelia	N Germany, Denmark, Norway, Sweden, Finland, Baltic Sea, Leningrad-Pskov regions (NW Russia), Latvia	K: 20.8, 25.8, 4.9.96; 24.–25.8.97 T: 24.–25.8, 4.–5.9.96 S: 20.–21.8.97
2–	middle course of the Volga (C Russia)	Pskov-Novgorod-Leningrad regions (NW Russia), Latvia	K: 26.8.96, 2.9.97 T: 13.–14.8.96, 2.9.97
3–	Lithuania, Byelorussia	Lithuania, Latvia, Pskov region (NW Russia)	K: 21.–22.8.96 T: 20.–23.8.96
4–	N Ukraine, N Bulgaria, C Roumania	W Ukraine, Byelorussia, Lithuania, Latvia	K: 15.–17.8., 19.8.96, T: 19.8.96
5–	S Ukraine	Byelorussia, Lithuania, Latvia	K: 1.9.96, 31.8.97 S: 27.8.97
6–	Penza-Saratov-Voronezh regions (S Russia)	Smolensk-Novgorod-Pskov regions, Byelorussia, Lithuania, Latvia	K: 27.8.96 T: 29.8.97
7+	Ukraine (excl. N Ukraine)	Byelorussia, Lithuania, Latvia, Voronezh-Kursk-Smolensk- Pskov- Novgorod regions (SW, W and WN Russia)	K: 18.8., 29.–30.8., 2.–3.9.96; 27.–28.8., 1.9.97 T: 16.–18.8., 2.–3.9.96; 31.8., 1.9.97
8+	Volgograd-Rostov-Voronezh-Saratov-Pensa regions (SW, S Russia)	Ukraine, Byelorussia, Lithuania, Latvia; Voronezh- Kursk-Smolensk- Pskov- Novgorod regions, Moskva- Saratov regions (SW,W,WN and C Russia)	K: 28.8.96; 29.–30.8.97 T: 15.8., 26.8.–1.9.96; 28.8., 30.8.97 S: 29.8.97
9+	W Roumania	C Ukraine, Byelorussia, Lithuania, Latvia	K: 31.8.96
10+	N Italy-Austria-S Germany	Germany, Baltic Sea	K: 23.8.97
11+	Byelorussia	Lithuania, Latvia	K: 23.–24.8.96
12+	NW Germany, Baltic Sea	Baltic Sea, Finland	K: 5.9.96, 26.8.97

Trajectories of pollen-free air fluxes are marked with “–” and trajectories of pollen-containing air fluxes, with “+”.

responsible for carrying pollen to the Baltic countries. Therefore, since the trajectories of simultaneous PCF were parallel and originated from a common distribution area of ragweed, then pollen must have occurred on the whole territory bordering on these trajectories. Pollen-containing air masses covered all the territory of the Baltic countries at least on 7 days in 1996: N-NNW directed PCF arrived in Tartu and Kuressaare across Lithuania and Latvia. The trajectories of simultaneous PCF and PFF indicated that pollen must have been present only in some parts of the territory. Such a situation (pollen was present in E Estonia but absent in W Estonia, or *vice versa*) occurred on at least 10 days in Estonia in 1996 and 1997. Thus in some synoptic conditions, pollen occurred on the whole territory of the Baltic states, whereas in different conditions, it was present only in some parts of it.

For ragweed, the symptomatic threshold value, used by many investigators, is 20 pg/m³/24h. In this study, the data on pollen concentration (see Table 1) indicate that aero-allergenic situation was very changeable but never severe.

4.3 Future aero-allergenic situation with respect to ragweed

In northern regions, flowering and seed reproduction of *Ambrosia* is suppressed due to climatic conditions. General aero-allergenic situation there would change in case of massive colonization of neighbouring southern countries by ragweed, or in case the occurrence frequency of some large HPA, located in East Europe in late summer, were higher.

According to Safra (1962), *A. artemisiifolia* is able to become naturalized up to 55° N. It could establish in ruderal habitats in the southern part of Lithuania, while an early ecotype would be the most likely candidate (Gudzhinskas, 1993). Such plants are lower, and their flowering and fruiting begin about 1½ months earlier compared with the other forms (Maryushkina, 1986). As ruderal habitats, favourable for ragweed, are not numerous, and their area is not large, massive colonization in South Lithuania is not likely. In localities with established ragweed, pollen will occur every year, and seasons will be longer than in case of long

distance pollen. In such localities, aero-allergenic situation may turn out moderate or severe, because local pollen retains its allergenic nature, which need not be the case with foreign pollen.

5. Conclusions

Aero-allergenic situation in the Baltic states in 1989–1997 was sporadic in the temporal and spatial aspects, and mild and highly changeable in the allergenic aspect. Emission of pollen from local sources was not responsible for the airpollen observed here. Incursions of pollen from the Ukraine and from SE and S Russia were determined by LDT; they occurred in about one third of the years in a situation where a large HPA was located above East Europe in the second half of August and at the beginning of September.

Drastic changes in aero-allergenic situation can be expected on the whole territory of the Baltic states when the occurrence frequency of a large HPA above East Europe in late summer would increase, or when there would occur massive colonization of neighbouring southern countries by ragweed.

It is possible that aero-allergenic situation will change in the southern part of Lithuania as a result of the establishment of *A. artemisiifolia* in this region. This change would have a local effect in a restricted area. Considering the above facts and prognostications, it would be useful to try to eradicate the harmful plant in the Baltic countries, as long as it occurs only at a few sites. Such attempt would be consistent with the Common Position of the Members of the European Community (No 46/96 of 27 June 1996) according to which the activities to be carried out in developing countries should focus on improvement of the environment (Article 2, paragraph 1).

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References

- Eesti NSV flora*: 1978, **6**, Valgus: Tallinn. (In Estonian)
- Gudzhinskas Z.: 1993, Genus *Ambrosia* L. (Asteraceae) in Lithuania. *Thaiszia, Kosice* **3**, 89–96.
- Guide to higher plants of the North East European part of Russian SFSR*: 1981, Leningrad University Press, Leningrad. (In Russian)
- Járai-Komlódi M. and Juhász M.: 1993, *Ambrosia elatior* (L.) in Hungary (1989–1990). *Aerobiologia* **9**, 75–78.
- Kovalev O.V.: 1989, Spread of adventive plants of the Ambrosieae tribe and methods of biological control of *Ambrosia* L. (Asteraceae). *Theoretical Principles of Biological Control of Common Ragweed*. Leningrad, pp. 7–23.
- Kukk T.: 1991, Tallinna flora nimestik. *Scripta botanica* **7**, Tartu. (In Estonian)
- Kukk T.: 1997, Eesti soontaimede nimestik, <http://www.zbi.ee/~tomkukk/nimestik/algus.htm>, 666kB, 202 pp. (In Estonian)
- Maryushkina V.: 1986, *Common Ragweed (Ambrosia artemisiifolia) and Principles of its Biological Control*. Kiev. (In Russian)
- Minyaev N.A. (ed): 1970, *Conspectus of Vegetation of the Pskov District*. Leningrad University Press, Leningrad. (In Russian)
- Nikitin V.V.: 1983, *Weed Plants of the Flora of the USSR*. Leningrad. (In Russian)
- Safra R.A.: 1962, Natural and prospective areas of weeds subjected to quarantine. *Sb. Rabot Vopr. Karantina Rast.* **12**, 159–173. (In Russian)
- Spieksma F.Th.M., Nolard N., Frenguelli G. and Van Moerbeke D.: 1993, *Pollens de l'air en Europe*. UCB-Secteur Pharmaceutique, Bruxelles.
- Tabaka L., Gavrilova G. and Fatare I.: 1988, *Flora of Vascular Plants of the Latvian SSR*, Zinatne: Riga. (In Russian)
- Tacik T.: 1971, *Ambrosia* L., *Ambrozja*. *Flora Polska* **12**, Kraków, 222–225.
- Vynayev G.V. and Tretyakov D.I.: 1979, Classification of introduced anthropophytic species new for the Byelorussian flora. *Botanika, Issledovaniya* **21**, 62–74. (In Russian)