



Allergenic Pollens in Turkey

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ABSTRACT

In this study, atmospheric pollen data of previous studies belonging to 54 different stations in Turkey, conducted by using the gravimetric and/or volumetric method, were evaluated in terms of flora, biogeography and aeropalynology. In line with these data, Turkey is divided into 5 aeropalyno-geographical regions, which are represented with their characteristics (North, West, South, Central, and East), and the skin prick tests were evaluated on the basis of pollen allergy data regionally and concurrently.

In general, the dominant pollen seen in Turkey's atmosphere has been found to be represented by 29 different types. The pollen sum of these 29 taxa was found to represent more than 85% of the total pollen concentration detected in the atmosphere when evaluated according to different regions. Of these pollen types, 20 belong to woody and nine belong to herbaceous plants. It has generally been reported that there are higher pollen concentrations of woody plants in the atmosphere in Turkey.

Overall, Cupressaceae/Taxaceae, *Pinus*, and Gramineae pollens were found as the common types to all of Turkey's five aeropalyno-geographic regions, in which they were recorded within the first three dominant pollen types. It has also been observed that *Quercus*, *Platanus* and *Populus* pollens from woody plants, and Amaranthaceae and Urticaceae pollens from the herbaceous plants were commonly recorded in high amounts for all regions. However, when the revised data are examined in detail, it has been determined that tree pollens like *Fagus*, *Carpinus*, *Alnus*, *Corylus* and *Betula* in the atmosphere were characteristic for the Northern Turkey region; the highest amounts of *Olea europaea* pollen for the Western Turkey region; higher quantities of the Cupressaceae/Taxaceae pollen for the Southern Turkey region; and very high amounts of Gramineae, *Morus*, *Fraxinus* and *Artemisia* pollens for the Eastern Turkey region have been recorded as characteristic in the atmosphere.

Compared to Europe; *Morus*, *Salix*, *Populus*, *Mercurialis* and *Plantago* pollens in the atmosphere of Turkey differ in their presence and quantity. On the other hand, invasive plants such as *Ambrosia* and *Ailanthus* or exotic plants such as *Casuarina* and *Eucalyptus*, which have allergenic pollens, must be remembered among the dominant taxa in the air in different regions on a seasonal basis. It has been shown that the ideal allergen panels have to be updated according to the area and especially by including the dominant taxa. However, these updates should be made by taking into account cross-reactions, and at least one of the reacting taxa should be included in the panel.

Key words: Palynology, pollen concentration, aeropalyno-geographical regions, pollen allergy

INTRODUCTION

Pollens are one of the critical atmospheric bio-particles and mainly consist of important aeroallergens. Pollens have therefore particularly attracted the attention of aeropalynologists, and the vast majority of atmospheric studies have focused on allergenic pollens. In this sense, aeropalynological studies have begun in the world for the first time with Charles Blackley in 1870s who conducted skin tests and determined that the hay fever he suffered from was due to the pollen of *Lolium italicum* (1). Later on, related studies continued, increased and became

the focus of attention for the last 3-4 decades (2-12). In Turkey, aeropalynological investigations were started synchronously by Aytug et al. (13) and Karamanoğlu & Özkaragöz (14) and continued to increase in number after 1990s.

Pollen grains of wind-pollinated plants may cause respiratory diseases such as allergic rhinitis, conjunctivitis and even asthma in sensitive individuals. Population problems such as excessive urbanization, industrialization related increase of air pollution, frequent use of allergenic pollen producing plants for planting in new settlements,

and uneven distribution of the human population can also be listed as primary factors that increase respiratory tract diseases and respiratory allergies. In this context, pollen allergies began to enter the literature frequently, especially for industrial centers where the population density is intensifying. Investigations over many years have shown the effects of the factors mentioned above and the increase in the prevalence of allergies. Therefore, the evaluation of the pollen allergy prevalence in urban centers in parallel with the recent aeropalynological studies revealed the situation. Although different allergy prevalences have been reported from different regions, the pollinosis frequency has reached 40% in Europe (15). In Turkey, there is no comprehensive study on this issue and only local studies have been conducted.

Pollen sampling from the atmosphere is necessary to obtain atmospheric pollen data, i.e., belonging to plants, distribution times and densities. For sampling, there are two generally accepted methods; gravimetric and volumetric. In the gravimetric method, which is more primitive but practical and cheap, distribution and seasonal variations in pollen rain can be determined gravitationally. In the more advanced volumetric method, detailed data such as daily and hourly variations can be obtained in m³ air. Atmospheric pollen data may vary from year to year in the same region and in different areas depending on circumstances. Because, the concentrations of pollen in the atmosphere may vary depending on the meteorological factors, the flora of the region, and the geographical features of the area. For this purpose, it has become inevitable to try to obtain short- or long-term atmospheric pollen data specific to the region at different locations in the world (16-24).

This evaluation study was conducted in order to assess the status of aeropalynology and pollen allergy in Turkey; with determination of the allergenic pollen profile based on the data of 54 different stations (25-77), consideration of the newly revealed and modified aeropalynologically different regions, and evaluation of pollen allergy data based on the skin prick test results (78-121).

BIOGEOGRAPHY AND REGIONAL FLORA IN TURKEY

Turkey, because of its position in the transition zone between the Europe and Asia continents, has great importance in terms of geography, biodiversity and flora. This importance is due to possessing the intersections of

different phytogeographical regions, which are shaped by unique topography and climate. The Anatolian Peninsula is a geographical area where three sides are surrounded by sea with plateaus rising to the east and plenty of rough and microclimatic areas.

In this geography, the part representing the Northern Anatolian and the Black Sea coasts belongs to the Europe-Siberian phytogeographical region, the Western and Southern Anatolian geographic regions to the Mediterranean phytogeographical region, and the Central and Eastern Anatolian regions to the Irano-Turanian phytogeographical region in bold line (122). From the floristic point of view, the slopes facing the Black Sea of North Anatolian mountain range and the northern part of Thrace are predominantly covered by moist and broad-leaved forests such as *Alnus*, Pinaceae, *Betula*, *Corylus* and *Fagus*, mostly similar to the inner and northern Europe. The Western and Southern Anatolian regions are under the influence of the Mediterranean climate and have mainly maquis vegetation in parallel with the southern European-Mediterranean countries and are mostly composed of members of the Cupressaceae and Pinaceae families, *Fraxinus*, *Pistacia*, *Olea europaea* L., *Quercus*, *Morus* and herbs like *Mercurialis*, Urticaceae and *Plantago* intensively. The inner and eastern Anatolian regions are floristically similar and compatible with the Near East, and the vegetation cover is predominantly composed of steppe vegetation and the junipers and oaks dominate at higher altitudes (122).

THE OVERALL POLLEN SPECTRUM AND DISTRIBUTION OF POLLEN TYPES BY REGION IN TURKEY

The atmosphere was found to be represented by 29 of the most intense pollen types on the total of the percentages for the whole of the data reported from 54 stations (25-77) in Turkey (Table I). The sum of these pollen types belonging to 29 taxa represents more than 85% of the total pollen concentration detected in the atmosphere, when evaluated according to different regions. Of these pollen types, 20 belong to woody plants and nine are of herbaceous plants (Table I). Aeropalynological studies conducted in Turkey have generally reported higher pollen concentrations of woody plants in the atmosphere (123,124). The main reason for this may be floristic, but the wind-pollinated trees such as Cupressaceae or Pinaceae family members with a large number of pollen productions can be shown to guarantee their pollination. The trees with the most

prominent spread in the forests of Turkey are oaks (125). Likewise, the pollen of trees such as *Platanus* and *Populus*, which are widely used in park-garden afforestation, and the pollen of trees such as *Morus*, which are frequently used in culture, are expected to be the most common pollen types in the atmosphere (Table I).

Besides, Gramineae pollen is the third most common pollen type in the atmosphere after coniferous plants because of being a large number of pollen producers and

limited microscopic identification in family level. Among the pollen grains belonging to other herbaceous plants other than Gramineae, the highest concentrations were recorded from the Amaranthaceae and Urticaceae families (Table I).

In this review, data from 54 stations (25-77), using gravimetric and/or volumetric methods were evaluated concerning both the flora, phytogeography and palynological data. According to the findings, regions with

Table I. Atmospheric pollen types and their total quantities (%) in the established regions (N-North, W-West, S-South C-Central, E-East) (25-77).

	N	W	S	C	E	Mean
<i>Pinus</i>	20.28	28.24	14.88	30.97	11.90	21.26
Cupress./Taxaceae	13.44	13.57	45.77	13.64	12.71	19.83
<i>Quercus</i>	5.05	6.70	6.54	5.67	2.84	5.36
<i>Platanus</i>	3.97	7.65	4.58	6.48	2.56	5.05
<i>Morus</i>	1.13	1.94	5.10	1.67	9.11	3.79
<i>Olea</i>	0.01	7.01	4.42	0.00	0.67	2.42
<i>Populus</i>	4.12	0.78	0.13	1.92	2.43	1.88
<i>Betula</i>	3.85	0.06	0.91	0.75	2.98	1.71
<i>Alnus</i>	5.68	0.94	0.35	0.22	0.22	1.48
<i>Corylus</i>	5.70	0.56	0.01	0.13	0.07	1.29
<i>Fraxinus</i>	1.64	0.69	0.90	0.53	2.67	1.29
<i>Salix</i>	1.26	1.30	0.15	2.45	1.07	1.25
<i>Carpinus</i>	3.42	0.71	0.05	0.18	0.85	1.04
<i>Juglans</i>	0.58	1.04	0.21	1.27	1.32	0.88
<i>Acer</i>	0.23	0.89	0.69	1.05	0.80	0.73
<i>Fagus</i>	2.24	0.44	0.02	0.71	0.11	0.70
<i>Castanea</i>	1.67	0.70	0.07	0.20	0.02	0.53
<i>Pistacia</i>	1.10	0.57	0.47	0.07	0.03	0.45
<i>Ulmus</i>	0.45	0.36	0.08	0.18	0.72	0.36
<i>Ostrya</i>	0.70	0.27	0.04	0.002	0.03	0.21
Gramineae	9.43	10.29	5.24	11.72	20.23	11.38
Amaranthaceae	2.12	2.37	1.27	4.86	4.52	3.03
Urticaceae	2.06	0.85	1.42	1.19	3.83	1.87
<i>Plantago</i>	0.61	1.43	0.74	1.04	1.75	1.12
<i>Artemisia</i>	0.58	0.45	0.24	0.78	2.33	0.88
<i>Xanthium</i>	1.04	1.18	0.16	0.14	1.71	0.85
<i>Rumex</i>	0.32	0.43	0.21	0.53	1.44	0.59
<i>Mercurialis</i>	0.03	0.13	0.87	0.00	0.35	0.28
<i>Ambrosia</i>	0.50	0.00	0.04	0.00	0.27	0.16
Subtotal	93.23	91.57	95.57	88.32	89.53	91.64
Others	6.77	8.43	4.43	11.68	10.47	8.36

different properties were distinguished, as demonstrated by the modifications of phytogeographical regions (126) and geographical regions of Turkey, and divided into five main aeropalyno-geographically characteristic regions named as N, W, S, C and E (Figure 1).

Northern Turkey (N)

Amongst the flora of the northern part of Turkey, the most intense type of atmospheric pollen is *Pinus*. On the slopes of the Black Sea region, facing the Black Sea, *Pinus brutia* is most common in low altitudes, and *Pinus nigra* is spread in high elevations. In addition to this, the distribution of *Pinus sylvestris* and *Abies* is seen in the higher parts of the Eastern Black Sea region and the back part of the mountains. However, in the Colchis-Pontus part (the eastern part) of the Black Sea region, which is more humid and higher, there is a dense distribution of *Abies* and *Picea* from Pinaceae. At the same time, this group may have been recorded at a very high rate by some researchers because the entire vesiculate type pollen was assigned to the Pinaceae family. The dominating presence of European-Caucasus-like coniferous forests in N Turkey makes the highest amount of *Pinus* pollen inevitable in this region's atmosphere. Besides these, the humid part of the Black Sea region is dominated by woody taxa, can form broad-leaved forests such as *Fagus*, *Carpinus*, *Quercus*, *Alnus*, *Corylus*, *Betula* and characterized by flora in atmospheric pollen. It is expected that the pollen types belonging to the plants which are planted frequently in city centers like *Platanus* and for economic purposes like *Populus* are to be represented intensely in the atmosphere of N region. Also, wheat is a frequently planted product in agricultural lands in the Black Sea region and pollen

grains of Gramineae, Amaranthaceae, Urticaceae families are recorded as the most common herbaceous taxa in the atmosphere of the N Turkey region (Table I).

Western Turkey (W)

The area distinguished as Western Anatolia is under the influence of the Mediterranean climate and there is frequent occurrence of short stalks in *Pinus brutia* forests and maquis elements intensively in the low sections of this region. This condition is also reflected in the atmospheric pollen spectrum of the region. On the other hand, Western Anatolia region has been characterized by the highest Cupressaceae/Taxaceae, *Quercus*, *Platanus*, and *Olea* pollen concentrations. *Olea europaea*, due to economic prosperity, is the most frequently cultivated tree in this region. Western Anatolia has the highest number of olive trees in Turkey, and the highest levels of *Olea* pollen. Gramineae and Amaranthaceae pollen are the most intense pollen types of herbaceous plants (Table I) in the Western Anatolia region as they are in the Northern Anatolia region (Table I).

Southern Turkey (S)

The highest rates of atmospheric Cupressaceae/Taxaceae pollen levels are recorded in the Southern region of Turkey; moreover, nearly half of the total amount of pollen recorded in this area comes from these taxa. The Southern Turkey region is located in the Eastern Mediterranean basin, more similar to southern Europe, and the most common atmospheric pollen type is also reported as Cupressaceae/Taxaceae for the other countries of the Mediterranean basin (127). Accordingly, very high levels of Cupressaceae/Taxaceae pollen, which are indicated by

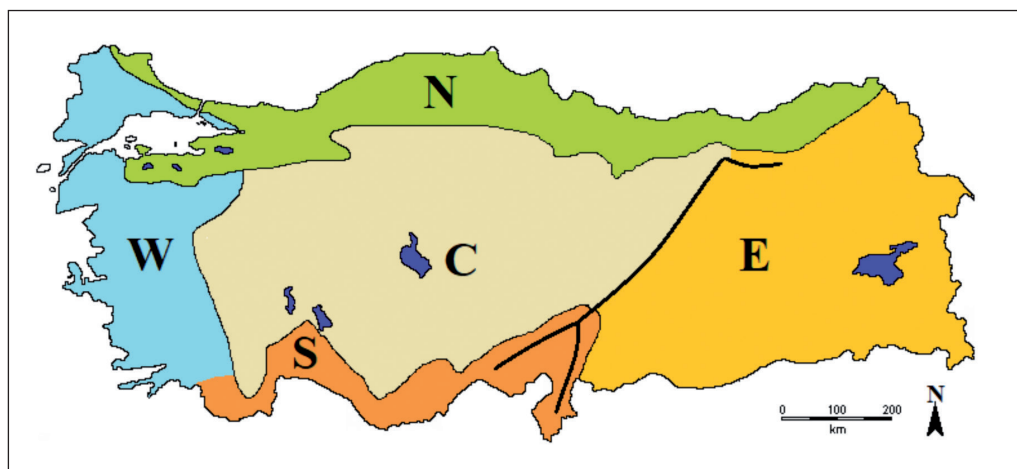


Figure 1. The map of five main aeropalynologically characteristic regions of Turkey (N-North, W-West, S-South C-Central, E-East), presented according to phytogeographical regions (126) and aeropalynological characteristics.

the aeropalynological studies from S Turkey, were found as an important characteristic data to be recorded (Table I). It is not surprising for *Pinus* and *Quercus* to be the most intense pollen types in the atmosphere of S Turkey, because the Mediterranean climate is dominant in this region and typically the sea-facing slopes are covered with *Pinus brutia* forests and/or maquis vegetation. In the area, where the olive tree plantation is the densest after the W region, olive tree pollen in the atmosphere is also recorded in considerable quantities. The mulberry tree in Turkey is mostly cultured on the route of the ancient silk road; airborne *Morus* pollen has been recorded most in the S region after the E region. As in the other areas, it is noted that Gramineae, Amaranthaceae, and Urticaceae pollen are the most intense herbaceous plants in the air of the S region (Table I).

Central Turkey (C)

The maximum amount of *Pinus* pollen level is recorded in the C region in Turkey. It is possible that the widespread *Pinus nigra* in this region leads to this situation. Unlike the coastal areas, pollens of herbaceous plants were detected in higher amounts in the C region (Table I). From this point of view, the plateau-shaped, high-altitude of C region suitable for wheat agriculture and also the non-agricultural open fields as a result of having anthropogenically-derived steppe vegetation may be the main reasons for atmospheric dominance of herbaceous pollen. Thus, the second highest pollen concentration of Gramineae pollen within all regions and the accompanying presence of other herbaceous plants such as Urticaceae and *Plantago* are characteristic and expected results for the C region. On the other hand, the widespread usage of *Cupressus* and *Platanus* in the urban centers in afforestation, and the formation of dry forests in small populations of *Quercus* in Central Anatolia can be attributed to the high amounts of these pollen types in the atmosphere of the C region (Table I).

Eastern Turkey (E)

The Eastern Anatolian part of Turkey represents high altitude, a region formed from mountains and plateaus. This region is much weaker concerning tree and forest assets than other parts of the country. Although trees such as Cupressaceae/Taxaceae and *Pinus* produce excessive amounts of pollen in the atmosphere of this region, it is clear that Gramineae pollen as a distinctive character has reached the highest levels in the E region of Turkey (Table I). It should also be noted that tree pollen is the

highest in all other regions, but Gramineae pollen has the highest share in total pollen amounts in the E region and Amaranthaceae and Urticaceae pollen are associated with it. Another remarkable feature of Eastern Anatolia is that *Morus*, *Fraxinus*, and *Artemisia* pollen are found in the highest levels in the E part. Besides, the highest *Populus* and *Betula* pollen counts after Northern Anatolia were also recorded in this region (Table I).

Overall, *Pinus*, Cupressaceae/Taxaceae and Gramineae pollen are the three most common pollen types for all regions of Turkey (Figure 2A-C). It has also been observed that *Quercus*, *Platanus* and *Morus* pollens from the woody plants, and Amaranthaceae and Urticaceae pollens from the herbaceous plants were recorded as common types in all regions. However, when examined in detail; tree pollens such as *Fagus*, *Carpinus*, *Alnus*, *Corylus*, *Betula* for the N region, high amounts of *Olea europaea* pollens for the W region, very high amounts of Cupressaceae/Taxaceae pollens for the S region, and very high levels of Gramineae pollens and significant amounts of *Morus*, *Fraxinus* and *Artemisia* pollens for the E region have been recorded characteristically (Table I).

DOMINANT POLLEN TYPES IN THE AIR OF TURKEY

Pollen Types of Woody Plants

- *Pinus/Pinaceae* (Pine)

The Pinaceae family is represented by four genera in Turkey (*Abies*, *Cedrus*, *Picea*, *Pinus*) (128). Of these, *Pinus* is the most widespread, and there are five different species with natural distribution, of which 3 have a vast distribution area (*P. brutia* Ten., *P. nigra* Arn., *P. sylvestris* L.) (125). From the fir genus, *Abies nordmanniana* (Stev.) Spach. spreads in Northern Anatolia, and *Abies cilicica* (Antoine et Kotschy) Carrière in Southern Anatolia. The only species of cedar is *Cedrus libani* A. Rich., which is distributed in the higher parts of the Southern Anatolian Taurus and spruce is naturally distributed in the higher parts of the Black Sea region.

Many researchers have identified pollen grains of Pinaceae members at a family level in aeropalynological studies because of their similar pollen morphology and similar allergenicity. However, some contradictions can be seen in the literature about the allergenicity of Pinaceae type pollens; some authors previously have suggested low allergenicity because of the large size of pollen grains, while

some older studies supported significant allergenicity (129). Therefore, all pine pollen allergy must be taken into account in patients who live in areas with high Pinaceae/*Pinus* pollen concentrations and are complaining of respiratory disease (130). Regarding the *Pinus* pollen, the allergy prevalences except the N region were found to vary from 2.00 to 27.50% depending on the area, but regarding the Pinaceae family pollen allergy, skin prick test results ranged between 2.60-14.50% in different regions of Turkey (Table II). When we look at the seasonal distribution of *Pinus* pollen of Turkey in general; atmospheric pollen reached the highest level in May, followed by April and June (124). Concerning the presence of *Pinus* pollen in the atmosphere, it was detected in the atmosphere in almost all seasons and regions (Table III).

• Cupressaceae/Taxaceae (Cypress)

The Cupressaceae and Taxaceae families are identified together in atmospheric samples due to their similar pollen morphologies. The naturally spreading genera of Cupressaceae in Turkey are *Cupressus* and *Juniperus*; the only native species of the *Cupressus* genus is *Cupressus sempervirens* L.. However, *Hesperocyparis arizonica* (Greene) Bartel (= *Cupressus arizonica*), which is not

naturally distributed in Turkey, is frequently used for park and garden and roadside afforestation (128, 131). Eight species of juniper genus show a natural distribution in Turkey and the most common species are *Juniperus oxycedrus* L. and *Juniperus excelsa* Bieb. (128). Finally, *Taxus baccata* L. is the only species with a natural distribution in the Taxaceae family and is more prevalent in northern Anatolia (128). On the other hand, some plants with allergenic importance, such as *Cryptomeria*, *Thuja*, and *Chamaecyparis*, which have no natural distribution in Turkey, are widely planted in parks and gardens as ornamentals (127,132,133). This family including a large amount of pollen-producing trees has always been one of the dominant pollen types in the aeropalynological studies conducted in Turkey (134). The pollen concentration of Cupressaceae/Taxaceae type pollens in the atmosphere is at very low levels in the summer period, but they are detected continuously in the atmosphere throughout the year (Table III). Allergic sensitivity rates for the Cupressaceae/Taxaceae type pollens were found to be 3.25-21.20% in Turkey and was highest in the S region (Table II). This data is parallel to aerobiological studies from the S region of Turkey, which is reported to have the highest concentrations of Cupressaceae/Taxaceae pollens in the atmosphere (45.77% regional average) (Table I).

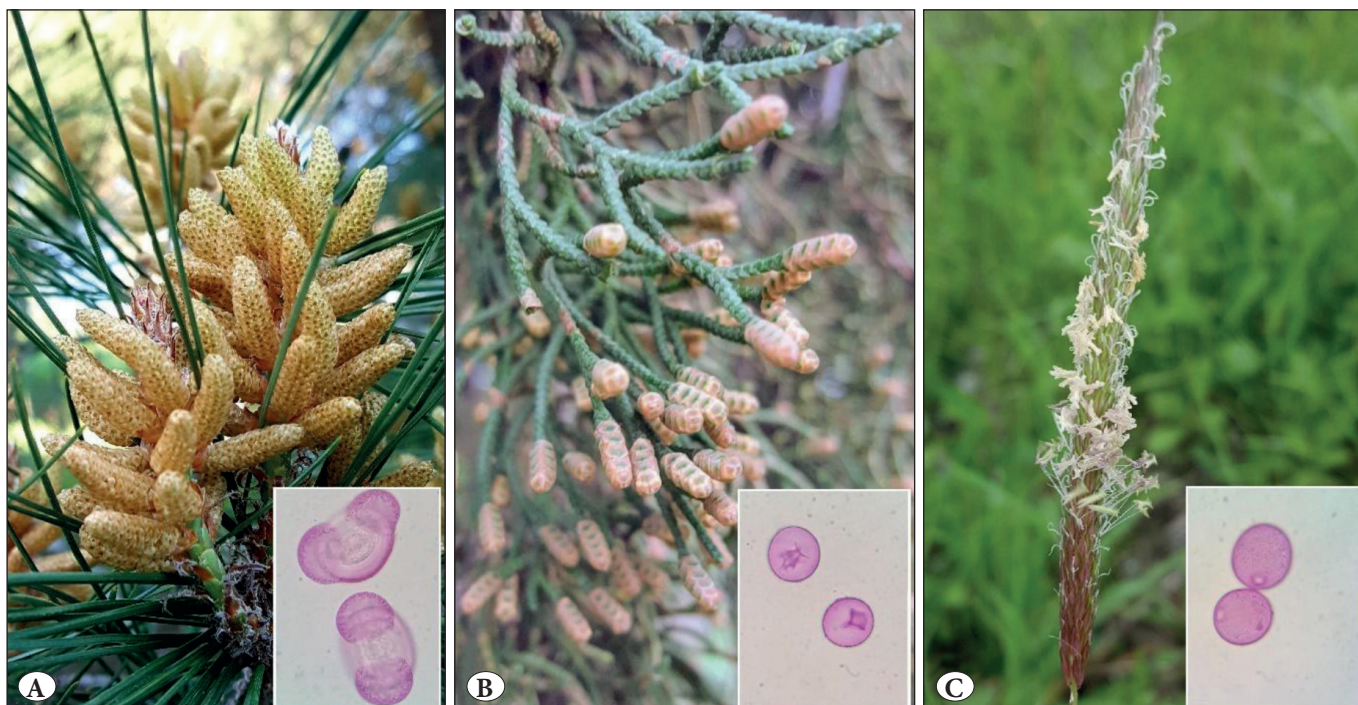


Figure 2. The three most common pollen types in the atmosphere in Turkey and their male flowers.

Cupressaceae/Taxaceae type pollen sensitivity is expected to occur in areas with high pollen concentrations. At the same time, it is known that increased cypress pollinosis arises from increased urban air pollution despite the constant levels of pollen in areas where urbanization is high (126).

• *Quercus* (Oak)

Quercus is the most common tree species in our country forests (125). A total of 20 species grow naturally in Turkey

and there are different species in almost every region (135-136). In all regions, it has always been found within predominant pollen types (usually in the spring) and it has a short pollination period, in contrast to conifers (Table III). In Turkey, *Quercus* pollen sensitivity was recorded at a rate between 3.09 to 22.20% and was reported at the highest rates in the S region (Table II). In all areas except the E region, the atmospheric pollen concentration of *Quercus* was found to be quite high (Table I). Atmospheric quantities of *Fagus* and *Castanea* pollen, which are in the

Table II. Sensitivity rates (%) for different pollen types in five different regions of Turkey (N-North, W-West, S-South C-Central, E-East); according to skin prick tests on sensitive individuals (78-121).

	N	W	S	C	E	Min.-Max. Values	
TREES	<i>Acer</i>	-	-	21.10	3.03-25.5	12.90	3.03-25.50
	<i>Alnus</i>	3.09	1.27-5.90	8.00	10.00	5.10	1.27-10.00
	<i>Betula</i>	5.23	3.81	9.80	1.70-18.20	12.90	1.70-18.20
	Betulaceae	2.30-23.50	7.79-8.10	2.40	6.7-18.2	8.50	2.30-23.50
	<i>Corylus</i>	6.00-14.73	3.09-8.30	-	1.80-17.80	3.20	1.80-17.80
	Cup/Tax	3.80	3.25-14.30	21.2	3.60	-	3.25-21.20
	<i>Eucalyptus</i>	-	-	16.30	-	-	16.30
	Fagaceae	19.40	-	-	2.58	-	2.58-19.40
	<i>Fagus</i>	3.56	2.60-3.45	16.80	-	12.90	2.60-16.80
	<i>Fraxinus</i>	2.61-3.10	4.55-8.30	19.20	19.00-20.00	8.60	2.61-20.00
	<i>Juglans</i>	-	-	-	11	-	11.00
	<i>Morus</i>	-	-	18.10	-	8.60	8.60-18.10
	<i>Olea</i>	7.60	2.80-30.00	6.00-42.80	1.10-44.20	33.3	1.10-44.20
	Oleaceae	-	-	-	4.55-58.20	-	4.55-58.20
	Pinaceae	-	2.60	-	14.5	-	2.60-14.50
	<i>Pinus</i>	6.20	2.00-14.00	4.40-27.50	2.90-25.30	24.70	2.00-27.50
	<i>Pistacia</i>	-	-	-	-	51.60	51.60
	<i>Platanus</i>	-	1.30-3.80	8.40-9.50	0.70-29.10	8.60	0.70-29.10
	<i>Populus</i>	1.66	3.09-5.80	30.00	1.60-21.80	22.6-26.00	1.60-30.00
	<i>Quercus</i>	9.03	3.09-3.80	20.90-22.20	14.5	16.10	3.09-22.20
<i>Salix</i>	9.26	3.90-7.20	31.30	1.10-18.20	16.10	1.10-31.30	
Salicaceae	-	4.50	-	3.03	-	3.03-4.50	
<i>Ulmus</i>	3.56	1.45-3.50	-	0.90-18.20	8.60	0.90-18.20	
HERBS	<i>Ambrosia</i>	-	32.00	5.00	-	-	5.00-32.00
	<i>Artemisia</i>	4.20-5.23	3.81-9.10	5.40-26.20	1.52-35.20	-	1.52-35.20
	Amaranthaceae	3.09	2.54-5.84	-	1.60-88.00	-	1.60-88.00
	Gramineae	10.70-34.20	11.30-54.00	12.30-60.00	9.50-100	8.62-77.50	8.62-100
	<i>Parietaria</i>	-	5.63	11.70	0.60-24.80	-	0.60-24.80
	<i>Plantago</i>	2.85-10.40	2.60-4.00	8.90	3.50-63.00	-	2.60-63.00
	<i>Rumex</i>	-	1.40-5.80	-	19.00	-	1.40-19.00
	<i>Urtica</i>	9.30-34.20	2.80-7.20	9.70	13.3-42.5	-	2.80-42.50
	Urticaceae	-	4.55	-	-	-	4.55
	<i>Xanthium</i>	-	-	34.60	-	-	34.60

Table III. Seasonal variation and dominant pollen types of five established regions (25-77).

	Early Spring	Spring	Summer	Fall
NORTH	Cupressaceae	Cupressaceae	Gramineae	Amaranthaceae
	<i>Corylus</i>	<i>Pinus</i>	<i>Pinus</i>	Gramineae
	<i>Alnus</i>	<i>Quercus</i>	Amaranthaceae	Compositae
	<i>Pinus</i>	Gramineae	Urticaceae	<i>Pinus</i>
	<i>Fraxinus</i>	<i>Carpinus</i>	Compositae	<i>Artemisia</i>
	<i>Betula</i>	<i>Alnus</i>	<i>Castanea</i>	<i>Xanthium</i>
	Compositae	<i>Betula</i>	<i>Plantago</i>	Urticaceae
	Gramineae	<i>Fagus</i>	<i>Ambrosia</i>	<i>Ambrosia</i>
	<i>Populus</i>	<i>Fraxinus</i>	Umbelliferae	Cupressaceae
<i>Ulmus</i>	<i>Platanus</i>	<i>Xanthium</i>	<i>Corylus</i>	
WEST	Cupressaceae	<i>Pinus</i>	Gramineae	Amaranthaceae
	<i>Corylus</i>	Cupressaceae	Amaranthaceae	Gramineae
	<i>Alnus</i>	Gramineae	<i>Pinus</i>	<i>Xanthium</i>
	<i>Fraxinus</i>	<i>Platanus</i>	<i>Olea</i>	Compositae
	<i>Pinus</i>	<i>Quercus</i>	<i>Plantago</i>	<i>Casuarina</i>
	<i>Populus</i>	<i>Olea</i>	Compositae	Cupressaceae/Tax
	Gramineae	<i>Alnus</i>	<i>Castanea</i>	<i>Cedrus</i>
	<i>Casuarina</i>	<i>Acer</i>	<i>Xanthium</i>	<i>Artemisia</i>
	Compositae	<i>Fraxinus</i>	<i>Cedrus</i>	Ericaceae
<i>Mercurialis</i>	<i>Ulmus</i>	<i>Ailanthus</i>	-	
SOUTH	Cupressaceae	<i>Pinus</i>	Gramineae	Gramineae
	<i>Pinus</i>	Cupressaceae	<i>Pinus</i>	Amaranthaceae
	<i>Alnus</i>	<i>Olea</i>	Amaranthaceae	Cupressaceae
	<i>Fraxinus</i>	<i>Morus</i>	<i>Olea</i>	<i>Casuarina</i>
	<i>Betula</i>	<i>Quercus</i>	Urticaceae	Compositae
	<i>Mercurialis</i>	Gramineae	<i>Artemisia</i>	<i>Cedrus</i>
	<i>Ulmus</i>	<i>Acer</i>	<i>Quercus</i>	<i>Pinus</i>
	<i>Casuarina</i>	<i>Platanus</i>	Compositae	<i>Betula</i>
	<i>Cedrus</i>	<i>Eucalyptus</i>	<i>Xanthium</i>	<i>Artemisia</i>
Ericaceae	<i>Ulmus</i>	<i>Typha</i>	Ericaceae	
CENTRAL	Cupressaceae	Cupressaceae	Gramineae	Amaranthaceae
	<i>Pinus</i>	<i>Pinus</i>	<i>Pinus</i>	Gramineae
	<i>Betula</i>	Gramineae	Amaranthaceae	Compositae
	<i>Alnus</i>	<i>Populus</i>	Compositae	<i>Pinus</i>
	Gramineae	<i>Platanus</i>	<i>Ailanthus</i>	<i>Artemisia</i>
	<i>Fraxinus</i>	<i>Betula</i>	<i>Plantago</i>	<i>Cedrus</i>
	<i>Corylus</i>	<i>Quercus</i>	<i>Artemisia</i>	<i>Betula</i>
	-	<i>Acer</i>	Leguminosae	-
	-	<i>Fraxinus</i>	<i>Platanus</i>	-
-	<i>Salix</i>	<i>Cedrus</i>	-	
EAST	Gramineae	Cupressaceae	Gramineae	Amaranthaceae
	Cupressaceae	<i>Pinus</i>	Amaranthaceae	Gramineae
	Amaranthaceae	Gramineae	<i>Pinus</i>	<i>Artemisia</i>
	<i>Pinus</i>	<i>Populus</i>	Urticaceae	<i>Pinus</i>
	<i>Cedrus</i>	<i>Morus</i>	Cupressaceae	<i>Xanthium</i>
	<i>Alnus</i>	<i>Betula</i>	<i>Artemisia</i>	<i>Cedrus</i>
	<i>Populus</i>	<i>Carpinus</i>	<i>Xanthium</i>	Compositae
	<i>Fraxinus</i>	<i>Salix</i>	<i>Plantago</i>	Urticaceae
	-	<i>Fraxinus</i>	Compositae	<i>Ambrosia</i>
-	<i>Quercus</i>	Umbelliferae	-	

same family with *Quercus*, were detected to be less than 1% of the total annual pollen index (Table I), but remarkable results of skin prick tests of different regions reported rates of 2.60-16.80% for allergic sensitivity to *Fagus* and 2.58-19.40% for sensitivity to Fagaceae pollen mix in Turkey (Table II).

• *Platanus* (Plane tree)

Platanus orientalis L. is the only species of plane trees in Turkey, and shows a natural distribution; they are planted as ornamental plants and shade trees in settlements as they are naturally found in forests and valleys. At the same time, *Platanus occidentalis* L., which is native to North America, and *P. x acerifolia* (Ait.) Willd., is considered as a hybrid of the east plane tree and west plane tree, can be seen on roadsides and parks (137,138). *Platanus* pollen is among the most common pollen types in the spring in all regions except the E region (Table III). It has been reported that the sensitivity to plane pollen in the Turkish population is 0.70-29.10%, with no data recorded from the N region; the highest sensitivity was reported at 0.70-29.10% from Central Turkey (Table II). When pollen density was evaluated according to the areas, atmospheric *Platanus* pollen amounts in W and C regions were found to be higher than in the other regions (Table I).

• *Morus* (Mulberry tree)

The mulberry tree is not a native plant in Turkey, but it is frequently planted in parks and gardens primarily for economic value and the decorative features of the cultural forms (136). Three species are grown (*Morus alba* L., *M. nigra* L., *M. rubra* L.), and the amount of pollen in the atmosphere was reported at the highest values in the E and S regions (Table I). Seasonally, *Morus* pollen was only recorded intensively in the spring in these two regions (Table III). Skin prick test results of *Morus* pollen in sensitive individuals were reported from the E and S regions, and the allergenic potential ranged from 8.6 to 18.10% with the maximum level in the S region (Table II).

• *Oleaceae* (*Olea europaea* - Olive, *Fraxinus* - Ash)

Olea europaea is the only species of olive tree that is both naturally distributed and cultivated in Turkey. Olive tree cultivation in Anatolia has been an economic activity for centuries, and 52% of the olive trees are located in the Aegean region (W region) (139,140). The highest amounts of *Olea* pollen were seen in the atmosphere of the W

(7.01%) and S (4.42%) regions of Turkey (Table I); this was found to parallel the distribution of the tree in Turkey. According to the seasons, it is reported that *Olea* pollen is seen intensely in the atmosphere of the W and S regions during the spring and summer, and the pollination period is rather short (Table III). From an allergic point of view, it has been shown that positive skin prick test results of sensitive individuals vary in the range of 1.10-44.20% in all regions, and the highest sensitivity rate was reported from the C region (Table II).

Four ash species from the Oleaceae family are distributed naturally in Turkey (*Fraxinus ornus* L., *F. excelsior* L., *F. angustifolia* Vahl., *F. pallisae* Wilmott) and they can be found in almost all coastal regions (141,142). Some of these species are essential forest trees and mostly decorative ornamental plants (141,142). *Fraxinus excelsior* and *F. angustifolia* bloom in the early spring with the spring dew and are recorded as most often documented and the earliest pollen type from the beginning of the year; *Fraxinus ornus* blooms at the end of spring. The amount of *Fraxinus* pollen in the atmosphere was reported at the highest levels in the E (2.67%) and N (1.64%) regions (Table I). According to studies carried out in Turkey related to *Fraxinus* pollen allergy; the highest sensitivities were recorded in C, varying from 2.61 to 20.00% for allergy prevalence. (Table II). On the other hand, *Fraxinus* and *Olea* are members of the Oleaceae family. In the allergy studies conducted in the C region, the allergenic prevalence of the Oleaceae family pollen mix was found to be in the range of 4.55-58.20% (Table II).

• *Salicaceae* (*Populus* - Poplar, *Salix* - Willow)

Naturally growing poplar species in Turkey are; *Populus alba* L., *P. tremula* L., *P. nigra* L., *P. euphratica* Olivier, *P. usbekistanica* Kom. and *P. x canescens* (Ait.) Sm.. Besides, due to the economic value, many poplar hybrids are brought to Turkey and planted (136). In the atmospheric pollen studies, *Populus* pollen was the most abundant pollen in the N (4.12%) and E (2.43%) regions (Table I). Seasonally, atmospheric concentrations of *Populus* were found to be high in the early spring and/or spring in all areas except S (Table III). Sensitivity studies based on skin prick tests against poplar pollen have reported an allergy prevalence of 1.60-30.00%, and the highest rate was recorded in the S region (Table II). N (1.66%) and E (22.60-26.00%) regions were reported as the most common sites of *Populus* pollen in the atmosphere (Table I).

Twenty-four native willow species are grown in Turkey, and many of these taxa are also planted as ornamental plants in parks and gardens. *Salix alba* L., *S. babylonica* L., *S. caprea* L., *S. fragilis* L., *S. cinerea* L. and *S. viminalis* L. are the most common willow species (136). Aeropalynological studies have shown that *Salix* pollen is seen most intensely in the atmosphere of the C region (2.45%) (Table I). At the same time, *Salix* pollen was recorded within dominant pollen types in the spring and early morning in C and E regions (Table III). In terms of allergy studies, allergy prevalence to *Salix* pollen in sensitive individuals generally ranges from 1.10 to 31.30% in Turkey, and the highest allergy prevalence is reported from the S region (Table II). Besides, since *Populus* and *Salix* belong to Salicaceae family, some allergy studies have been conducted at the family level, and the allergy prevalence is reported as 3.03% (in the C region) to 4.50% (in the W region) for Salicaceae pollen mix (Table II).

- **Betulaceae (*Betula* - Birch, *Alnus* - Alder, *Corylus* - Hazelnut, *Carpinus* - Hornbeam)**

Five species of birch trees in Turkey show natural distribution (*Betula pendula* Roth, *B. litwinowii* Doluch., *B. browicziana* Guner, *B. recurvata* (I.V.Vassil.) V.N.Vassil., *B. medwediewii* Regel) (143,144). *Betula* was among the dominant taxa in the N (3.85%) and E (2.98%) regions (Table I). When pollen density is evaluated according to the regions; *Betula* pollen is reported as present in the atmosphere except for W region in the early spring and/or spring period (Table III). The *Betula* pollen sensitivity rate in Turkey was found between 1.70 to 18.20%, and the maximum value has been reported from the C region (Table II).

Apart from *Betula*; *Alnus*, *Carpinus*, *Corylus* also take place in the Betulaceae family in Turkey (144). Two species of *Alnus* (*A. glutinosa* (L.) Gaertn., *A. orientalis* Decne.) are represented and when pollen density was evaluated according to regions, pollen concentration of *Alnus* in N region was found higher than the other regions with 5.68% (Table I). In addition, *Alnus* is among the dominant pollen types in all regions in the early spring and N and W regions in the spring. (Table III). In Turkey, *Alnus* pollen sensitivity ranges between 1.27 to 10.00%, and the maximum value has been reported from the C region (Table II).

Three species of hazel are distributed and planted in Turkey; especially in the North region (*Corylus avellana*

L., *C. colurna* L., *C. maxima* Mill.) (144). When the density of hazelnut pollen is evaluated according to the regions, it is seen that hazelnut pollen is recorded at higher rates (5.70%) in N region (Table I). If the seasonal atmospheric distribution is considered, *Corylus* pollen is reported to be among the most intense pollen types in the early spring in the N, W and C regions (Table III). In general, sensitivity to *Corylus* pollen range is recorded as 1.80-17.80% in Turkey, and the highest value has been reported from the C region (Table II).

Hornbeam tree is represented by two species (*Carpinus betulus* L. and *C. orientalis* Mill.) in Turkey (144) and is found the densest in the atmosphere of the N region (3.42%) (Table I). In addition, hornbeam pollen is only found as a dominant type in the N and E regions in the spring, but not in others (Table III).

Birch, followed by alder and hazel, has the greatest allergenic potency in this group of allergenic trees (145). Overall for the Betulaceae family pollen from the allergic point of view, the allergy prevalence to Betulaceae pollen mix has been reported in the range of 2.30 to 23.50% in Turkey in sensitive individuals (Table II).

Pollen Types of Herbaceous Plants

- **Gramineae (Grass)**

Economic importance, limited identification of pollen at the family level, having a large number of taxa and having the highest pollen-producing potentials after conifers are some of the reasons for the large quantities of Gramineae in the atmosphere. In this review, the maximum amount of Gramineae pollen in the atmosphere was recorded in the E region with a 20.23% regional mean value in Turkey, and was found to be 2-4 times higher than the other regions (Table I). Seasonally, grass pollen was recorded as the most intense herbaceous pollen type in almost all regions and all seasons (Table III). Regarding pollen sensitivity for Gramineae, the prevalence of allergies in the region E, where this pollen was recorded as the most dominant type, was recorded as 8.62-77.50%. In Turkey, it has been reported that the occurrence of grass pollen sensitivity is between 8.62 and 100.00% (Table II).

- **Amaranthaceae (=Chenopodiaceae)**

The most common genera of the Amaranthaceae family in Turkey are *Amaranthus*, *Chenopodium*, *Salsola*, *Atriplex*, *Beta* and *Sueda* (126,146,147). The maximum

amount of pollen of the family Amaranthaceae in the atmosphere was reported from the C (4.86%) and E (4.52%) regions in Turkey (Table I). Regarding the seasonal distribution of Amaranthaceae family pollen, they were recorded within the dominant taxa in almost all regions in the summer and autumn period (Table III). On the other hand, there are studies only from two regions of Turkey on Amaranthaceae pollen allergy in the literature. The allergy prevalence of Amaranthaceae pollen in area C, where the pollen was recorded at the highest level, was documented to be 1.60-88.00% and the prevalence was reported as the same overall (Table II).

• **Urticaceae (*Urtica* - Stinging nettle, *Parietaria* - Sticky weed)**

Urtica and *Parietaria* genera are known as the most common allergenic pollen types in the Urticaceae family. The maximum amount of Urticaceae pollen in the atmosphere was reported from the E region (3.83%) (Table I) (148). Seasonally, it was observed that Urticaceae pollen is among the dominant pollen types in the summer in all regions except the C and W regions, besides the N and E regions in the autumn (Table III). There is only one study on Urticaceae pollen allergy, with a reported prevalence of 4.55% in the W region. On the other hand, the prevalence of allergy to *Urtica* pollen was reported between 2.80-42.50% and 0.60-24.80% for *Parietaria* (Table II). In addition to these data, the allergy prevalence to Urticaceae pollen mix was reported only from the W part of Turkey with a rate of 4.55% (Table II).

• ***Plantago* (Plantain)**

There are 26 species of this genus, which grows naturally in Turkey and *Plantago lanceolata* L. is the most common species of this genus (126,149,150). Atmospheric *Plantago* pollen was reported as in higher levels from E (1.75%), W (1.43%) and C (1.04%) regions of Turkey (Table I). Seasonally, *Plantago* pollen was recorded within dominant taxa in the atmosphere in all regions except S in summer (Table III). Regarding the pollen allergy in Turkey, pollen prevalence were recorded between 2.60-63.00% for *Plantago* pollen with the highest value from C region (Table II).

Regionally dominant pollen types

On the other side, it was observed that pollen grains of some plants, which are grouped on the basis of regions, were recorded at higher levels and found within dominant

taxa regionally (Table III). For example, *Juglans* (in E, C, W regions), *Acer* (in W, S, C regions), *Pistacia* (in N region), *Ulmus* (in N, W, S regions), *Artemisia* (in E, W, N regions), *Rumex* (in E region) and *Mercurialis* (in W, S regions) pollen were recorded among dominant types (Table III).

In Turkey, walnut trees, especially *Juglans regia* species, grow naturally and are cultivated intensively due to the economic importance of its wood and seed (136-137). *Juglans* pollen is reported with the highest amount in the atmosphere of E (1.32%), C (1.27%) and W (1,04) regions; and only one work from the region C has been reported regarding allergenicity with an 11.00% prevalence (Table II).

Up to 10 species of maple are spread in Turkey; of these, *Acer negundo* L. and *Acer pseudoplatanus* L. are the most commonly used ornamental species in parks, gardens and roads in city centers (141). *Acer* pollen amount was found in the C region (1.05%) at the highest value in Turkey and recorded within the dominant pollen types on the regional basis (Table I). In general, although the pollen grains of the maple tree in the atmosphere were found in small quantities, the allergenic prevalence was reported as 3.03-25.50% from the S, C and E regions (Table II).

Six species represent the genus *Pistacia*, and the most common species in Turkey were *Pistacia lentiscus* L., *P. terebinthus* L. and *P. vera* L. (11, 151). From this point of view, it is seen in the literature that there is only one study on the prevalence of allergenic *Pistacia* pollen in Turkey. It has been reported remarkably in the E region with a rate of 51.60% (Table II).

Ulmus minor Mill. is the most common type of elm, presenting with four species in Turkey (133) and allergic sensitivity of 0.90-18.20% as reported by skin prick tests (Table II).

From herbaceous taxa; *Artemisia* (Compositae) pollen was recorded with a maximum atmospheric intensity of 2.33% from the E region (Table I). In general, about 1.52 to 35.20% prevalence of allergy has been reported from Turkey for *Artemisia* pollen (Table II).

Xanthium (Compositae) pollen was recorded in the atmosphere at high levels in the E (1.71%), W (1.18%) and N (1.04%) regions (Table I). Three main species in Turkey represent *Xanthium* (*X. strumarium* L., *X. orientale* L., *X. spinosum* L.) and it is widespread throughout the whole

country (152). There is only one study on the allergenicity of *Xanthium* pollen in Turkey, and a high prevalence of allergy has been reported with a value of 34.60% from the S region (Table II).

Mercurialis is represented in Turkey with three species (*Mercurialis annua* L., *M. ovata* Sternb. & Hoppe, and *M. perennis* L.), and these species are widely distributed (153). *M. annua* is especially characterized as an urbanized and ruderal plant. Although there is no study of pollen grains from Turkey regarding allergy to genus *Mercurialis*, it has already been reported as a significant allergenic pollen in Europe (154-156).

There are 36 taxa of the *Rumex* genus in Turkey, of which *R. acetosa* L. and *R. crispus* L. are the most widespread species (157). *Rumex* pollen was recorded in the atmosphere at all sites and as the atmospheric pollen with the highest values from region E (1.44%) (Table III). The allergy prevalence was found between 1.40-19.00% for *Rumex* pollen in Turkey, and the highest rate was reported from the C region (Table II).

POLLEN TYPES OF INVASIVES AND ALIENS

Ambrosia; has about 40 taxa around the world; and a total of five species (*A. maritima* L., *A. artemisiifolia* L., *A. trifida* L., *A. tenuifolia* Spreng. and *A. psilostachya* DC.) are distributed in Europe. *Ambrosia artemisiifolia*, commonly referred to as “Common Ragweed” or “Ragweed”, is the most common type in the world and Europe. In Turkey, *Ambrosia artemisiifolia*, a naturalized invasive species, is distributed mostly with small populations through North Anatolia, *Ambrosia maritima* is spread in the Mediterranean coast, and *Ambrosia tenuifolia* is spread in central Anatolia (158-160). Besides, it has been reported that the pollen of *Ambrosia* is among the most critical aeroallergens (161-164). Atmospheric *Ambrosia* pollen was reported in the summer from the S region (0.04%), in the summer and autumn terms from the N region (0.50%), and in the autumn term from the E region (0.27%) of Turkey. Regarding allergy prevalence rates, they were reported between 5.00 to 32.00% in general, and the highest recorded value was from the W region (Table II).

Ailanthus altissima (Mill.) Swingle; the origin of this tree is China, and it is cultivated widely in the temperate regions of the northern semi-arid region; it is also grown in many cities in Turkey and planted along the railways and naturalized over time (141). However, *Ailanthus* (tree

of heaven) has now emerged out of control in the vacant areas in especially urbanized regions, becoming an invasive species and rapidly spreading. *Ailanthus* pollen has been reported among the important allergens previously (165). In Turkey, this atmospheric pollen type is recorded among the dominant taxa in W and C regions in the summer term (Table III), but there is no literature on the allergenic prevalence of *Ailanthus* pollen from Turkey.

Hesperocyparis arizonica (Greene) Bartel (= *Cupressus arizonica*); the Arizona cypress, is a North American species of trees in the cypress family. It is native to the southwestern United States. In the wild, the species is often found in small, scattered populations, not necessarily in vast forests. The Arizona cypress is used extensively in parks, gardens and roadside afforestation due to easy rearing, high compatibility with the city, beautiful appearance and the seedling prices in Turkey. It is possible to see male flowers of Arizona cypress through the year while the native *C. sempervirens* blooms and pollinates in the spring. The airborne pollen of the Cupressaceae family is stated as an important aeroallergen (126), and it is thought that pollen types of Arizona cypress constitute an important risk especially for sensitive individuals living in the cities due to their presence in the air all year round and not seasonally.

Casuarina equisetifolia is naturally distributed in the tropical and subtropical regions of Australia and is often cultivated as an ornamental tree in parks, gardens and on the roadsides of the Mediterranean coast in Turkey. It was also frequently used as a wind curtain in coastal areas (137). Atmospheric “common rhu/horsetail tree” pollen has only been reported from W and S regions in autumn and winter (Table III). Although there is no work related to the allergy prevalence of this tree in Turkey, it is already reported as a well-known aeroallergen (166).

Eucalyptus camaldulensis Dehnh.; the natural distribution of this plant is in Australia, and it is widely used in southern Anatolia both for drying marshes and as ornamental plants (141). In Turkey, atmospheric *Eucalyptus* pollen was only reported in high levels in the spring from the S region (Table III), and pollen grains stated as an important aeroallergen (167). In the skin prick tests for *Eucalyptus* pollen, the prevalence was reported as 16.30% in sensitive individuals in Turkey (Table II).

Generally, among the tree pollen, *Morus* pollen was found intensely in the S and E regions. Atmospheric and

allergenic *Morus* pollen has not been included in allergenic atmospheric pollen and has not been evaluated in Europe, but it is found necessary to do so in Turkey because of the high airborne pollen levels. It is noteworthy that pollen belonging to the family Moraceae is in the 5th rank among all pollen types in Turkey. It is clear that further study is needed about the properties of these pollen allergens in Turkey in this respect. Also, the allergic importance of airborne Salicaceae pollen, such as *Salix* and *Populus*, and their cross-reactions with each other are known (168), but they are not listed among the atmospheric pollen types that are common in Europe (15,169). Therefore, it is obvious that *Populus* and *Salix* extracts must be present in allergen panels like *Morus*. Although not considered among the critical allergens and not included in the list of allergen pollen in Europe, there is a vast literature indicating that the *Pinus* pollen may cause allergies in sensitive individuals at high concentrations (170). Atmospheric pollen of *Pinus*, present in most regions and/or in the top rank, has to be considered as important aero-allergen since the sensitivity rates are up to 27.50% in Turkey (Table II). *Plantago* pollen from herbaceous plants also tends to differ with the high ratio in the dominant pollen in the atmosphere, compared to Europe. *Plantago* pollen, however, has to be taken seriously, since the skin prick test results reported from Turkey showed the allergenic prevalence of *Plantago* pollen sensitivities as up to 63.00% (Table II).

LIMITATIONS AND SUGGESTIONS

- Many studies have been conducted using the gravimetric or volumetric method and usually lasting 1-2 years to determine the atmospheric pollen in Turkey. Despite the presence of several atmospheric pollen studies of almost every region in Turkey, pollen sensitivity results of the skin prick tests are insufficient on a taxon basis from the allergic point of view, since most pollen extracts (except grass) are often used in the mix (e.g., tree mix, weed mix).
- Atmospheric pollen studies should be carried out continuously in at least one of the five regions in Turkey, and pollen forecasts should be made public via meteorological bulletins.
- Based on the results of this study, the pollen extracts, which are used for diagnosis and treatment in allergy clinics, should be re-examined at the regional level and ideal allergen panels must be reconstructed.

- In the centers where atmospheric pollen studies will be performed, it is necessary to apply the ideal allergen panel in allergy clinics synchronously and pollen-symptom scores need to be put forward. As a result, threshold values for the risk of pollinosis for each type of pollen can be established.
- There is no study that has been conducted on the effects of air pollution on pollen and pollen allergy in Turkey. As part of a multidisciplinary research, it is necessary to conduct air pollution studies at the centers where atmospheric pollen measurements are done/to be done, and to evaluate pollution-pollen sensitivity relations.
- In atmospheric pollen studies, it is necessary to determine the phenology for each taxon; whether pollen is sourced from plants in the region or not and it is also necessary to examine and take into consideration the long-distance transport.
- The primary examples of commonly used plants in the park-roadside plantation in Turkey are *Pinus*, *Cupressus*, *Platanus*, *Morus*, *Betula*, *Salix* and *Acer*. Besides, many cultivated plants, such as *Morus*, *Olea europaea*, *Corylus*, *Juglans*, *Populus*, and *Pistacia*, which have economic importance, are planted in large quantities, and almost all of these plants have highly allergenic pollen. To avoid the addition of more allergenic pollen load by planting in the city centers, it would be appropriate to plant locally by spreading the trees and to prefer fewer pollen-producing or female types.

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