

AIRBORNE POLLEN CALENDAR OF IZMIR - TURKEY

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Abstract: A qualitative and quantitative evaluation of pollen concentration in the atmosphere of Izmir metropolitan area is presented. Investigations were undertaken from November 1998 to October 1999 using gravimetric method. The aeroplynological studies revealed that at lower level (1.60 m) pollen from 29 woody and 30 herbaceous taxa were determined, whereas at higher level (20 m) pollen from 26 woody and 24 herbaceous taxa were recorded. At lower level, dominating woody species were *Pinus*, *Quercus*, *Oleaceae*, Cupressaceae/Taxaceae; herbaceous species were Gramineae, Chenopodiaceae/Amaranthaceae, Cruciferae and *Plantago*. At higher level, *Pinus*, Cupressaceae/Taxaceae, Gramineae, Chenopodiaceae/Amaranthaceae, Cruciferae and *Plantago* pollens were dominant. *Morus*, *Oleaceae*, *Quercus*, Chenopodiaceae/Amaranthaceae, Gramineae and *Plantago* showed highest concentration and their allergic degree was very high. Annual pollen calendar of the area is shown.

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Key words: pollen calendar, pollen, Izmir.

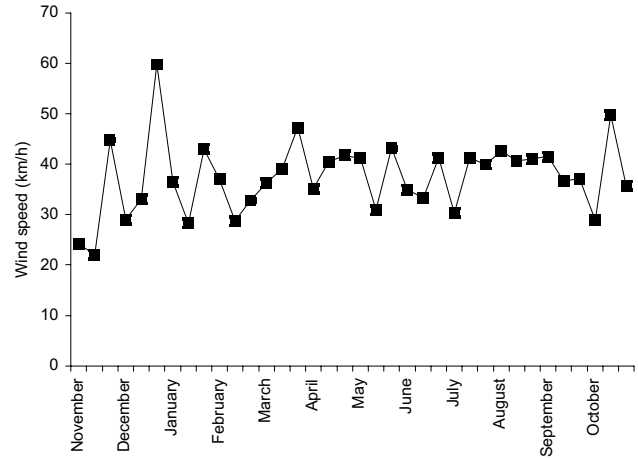
INTRODUCTION

Izmir metropolitan area lies between 37° 40'–28° 20' N; 26° 10'–28° 30' E in the western part of Turkey. In the present study, a pollen calendar of this area has been investigated because it shows a fast demographic development and is situated just on the coast of Aegean sea, with florostically rich mountains lying around it. The city experiences a typical Mediterranean climate (Fig. 1, 2, 3). The area is dominated by *Pinus brutia* forests distributed sparsely from 0–600 m but forming dense stands between 600–900 m on the hilltops and mountainous slopes. The species determined by us revealed that *Pinus brutia* and *Pinus nigra* ssp. *pallasiana* dominate on the slopes of mountains at higher altitudes. The maquis elements like *Quercus coccifera*, *Pistacia lentiscus*, *P. terebinthus*, *Olea europaea* var. *sylvestris*, *Phillyrea latifolia*, *Calicotome villosa*, *Spartium junceum*, *Cercis siliquastrum*, *Ceratonia siliqua*, *Crataegus monogyna*, *Myrtus communis*, *Laurus*

nobilis, *Arbutus unedo*, *A. andrachne*, *Erica arborea* and *Paliurus spina-christi* are met with as associates of *Pinus brutia* forest formation between 0–750 m. At a lower level, phrygic elements such as *Sarcopoterium spinosum*, *Asphodelus aestivus*, *Coridothymus capitatus*, *Lavandula stoechas*, *Cistus creticus* and *Origanum onites* are widely distributed in the study area [16, 28, 29]. Many woody taxa are distributed in parks and alongside roads. Mandarin orchards are found around Narlıdere area. Other cultivated species are oranges, pears, plum and olives. During the last two decades much work has been done in the field of aeroplynology in Turkey. Greater attention is being paid now towards the preparation of pollen calendars as the number of allergic patients in Turkey has recently been increasing faster rate. To date several papers have been published notable among them being [3, 5, 6, 7, 8, 9, 12, 16, 17, 19, 25, 26]. The present investigation was undertaken to fill the gap. Studies were followed on a weekly basis for 1 year with the aim of presenting a pollen calendar of Izmir-metropolitan area.

Table 1. Pollen taxa found in the atmosphere of Izmir (lower level - 1.60 m) during the period of study.

Taxa	Total pollen grains	
	Pollen grains/cm ²	%
Woody taxa		
<i>Pinus</i>	2,598	57.3
<i>Quercus</i>	530	11.7
Oleaceae	240	5.3
Cupressaceae/Taxaceae	119	2.6
<i>Eucalyptus camaldulensis</i>	74	1.6
Rosaceae	36	0.8
<i>Ailanthus</i>	35	0.8
<i>Corylus</i>	29	0.6
<i>Morus</i>	24	0.5
<i>Platanus orientalis</i>	19	0.4
<i>Alnus glutinosa</i>	14	0.3
<i>Casuarina equisetifolia</i>	12	0.3
<i>Ulmus</i>	11	0.2
<i>Erica</i>	10	0.2
<i>Salix</i>	10	0.2
<i>Pistacia</i>	8	0.2
<i>Populus</i>	8	0.2
<i>Sophora japonica</i>	8	0.2
<i>Juglans regia</i>	7	0.2
<i>Acer</i>	4	0.09
<i>Schinus molle</i>	4	0.09
<i>Acacia cyanophylla</i>	2	0.04
Cistaceae	2	0.04
<i>Laurus nobilis</i>	2	0.04
<i>Sarcopoterium spinosum</i>	2	0.04
<i>Arbutus andrachne</i>	1	0.02
<i>Castanea sativa</i>	1	0.02
<i>Ligustrum vulgare</i>	1	0.02
<i>Nerium oleander</i>	1	0.02
Total (woody pollen)	3,820	84.05
Non-woody taxa		
Gramineae	350	7.7
Chenopodiaceae/Amaranthaceae	61	1.3
Cruciferae	55	1.2
<i>Plantago</i>	49	1.08
<i>Anthemis</i>	39	0.9
Compositae	34	0.7
<i>Malva sylvestris</i>	18	0.4
<i>Rumex</i>	13	0.3
<i>Xanthium strumarium</i>	12	0.3
<i>Papaver</i>	9	0.2
Cyperaceae	8	0.2
<i>Typha</i>	7	0.2
Leguminosae	6	0.13
Fumariaceae	5	0.11
Juncaceae	5	0.11
Urticaceae	4	0.08
Umbelliferae	3	0.06
<i>Cardaria</i>	2	0.04
Labiatae	2	0.04
<i>Calendula</i>	1	0.02
<i>Campanula</i>	1	0.02
<i>Carduus</i>	1	0.02
Caryophyllaceae	1	0.02
Centaurea	1	0.02
<i>Ecbalium elaterium</i>	1	0.02
<i>Hypocoum</i>	1	0.02
Ranunculaceae	1	0.02
Rubiaceae	1	0.02
Scrophulariaceae	1	0.02
<i>Taraxaum</i>	1	0.02
Total (non-woody pollen)	685	15.29
Total (woody and non-woody pollen)	4,505	99.34
Unidentified	30	0.66
Total	4,535	100

**Figure 1.** Annual wind speed data of Izmir from November 1998 to October 1999.

MATERIAL AND METHODS

Field studies were undertaken from November 1998 to October 1999 around the metropolitan centre of Izmir. Durham samplers were placed in the school centre (1.60 m) and school building (20 m). The slides smeared with glycerine-jell stained with safranin were changed weekly [11]. For identification, a B-3000 binocular was used and counting conducted on a 20 × 20 mm (4 cm²) area of the slide which was extrapolated to 1 cm². The identification of pollen taxa was carried out with the help of reference slides from 800 taxa distributed in the area, prepared according to Wodehouse [30]. Identification was followed using the books on palynology [13, 14, 22, 23, 24]. Meteorological data was obtained from the National Meteorological Directorate in Ankara.

RESULTS

During the period of study, pollen from 29 taxa of woody species and 30 herbaceous taxa at lower level (1.60 m), and 26 and 24 taxa of these respectively were determined at higher level. The highest concentration at the lower level was that of *Pinus* (57.3%), *Quercus* (11.7%), Oleaceae (5.3%) and Cupressaceae/Taxaceae (2.6%), together with herbaceous representatives such as Gramineae (7.7%), Chenopodiaceae/Amaranthaceae (1.3%), Cruciferae (1.2%), *Plantago* (1.08%), *Anthemis* (0.9%) and Compositae (0.7%) (Tab. 1). At higher level (20 m), woody taxa dominating were *Pinus* (57%), *Quercus* (12%), Cupressaceae/Taxaceae (4.8%), Oleaceae (4.4%), *Morus* (2.4%), *Eucalyptus camaldulensis* (1.8%) and the herbaceous ones were Gramineae (6%), Chenopodiaceae/Amaranthaceae (1.7%), Cruciferae (1.3%) and *Plantago* (1.2%) (Tab. 2). The number of pollens in the atmosphere from herbaceous taxa at both levels was highest during April, May and August, whereas pollens from woody taxa dominated during April, May and March at the lower level, and May, April and March at the higher level (Fig. 4, 5). In all, 4,535 pollen per cm² were detected at lower level. Out of

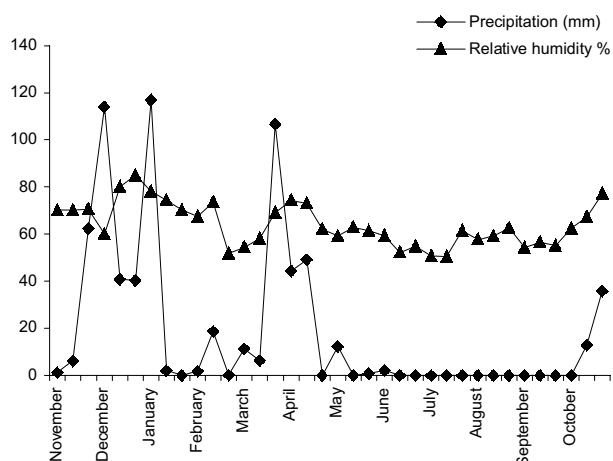


Figure 2. Annual precipitation and relative humidity data of Izmir from November 1998 to October 1999.

these, 3,820/cm² belong to woody taxa and 685/cm² to the herbaceous taxa. Tree pollens at this height were 84.05%, Gramineae pollens 7.7%, and other herbaceous taxa 7.59%. At higher level, total pollen concentration was 6,240 per cm², out of which 5,449 (87.32%) came from woody taxa and 761 (12.2%) from herbaceous taxa. At this level, percentage pollen concentration per cm² varied as follows; woody taxa (87.32%), herbaceous taxa (6.2%) and Gramineae (6%) (Fig. 6, 7). At lower level, pollen of 8 taxa were determined in the atmosphere during November, but *Corylus* dominated during the 4th week. Pollen of only 4 taxa were observed during December, once again dominated by the same trees. During January, the number of pollen went up to 7 taxa but their density was very low. Cupressaceae/Taxaceae topped the list in February followed by *Alnus glutinosa* during the 4th week. In March, the number of taxa went up to 24 with Cupressaceae/Taxaceae dominating during 2nd week, followed by *Pinus* during the last 2 weeks. Out of other taxa pollen, Rosaceae members were abundant (Fig. 8). The month of April was found to be the richest of all with 38 taxa and high density values, out of which 3,872 pollen belonged to *Pinus*. These were followed by a high density of *Anthemis* and Gramineae towards the end of April. During May, pollen from 30 taxa were recorded, the highest number once again belonged to *Pinus*, followed by *Quercus*, Oleaceae, Gramineae, Cruciferae and *Morus* as compared to other taxa. The number went down to 14 taxa during June, dominated by Oleaceae and *Pinus*. In July, pollen from 18 taxa were recorded with *E. camaldulensis* and *Sophora japonica* dominating towards the end. Only 9 taxa were observed in August with the highest number of Chenopodiaceae/Amaranthaceae pollens, 6 taxa in September dominated by *Casuarina equisetifolia* in the 3rd week, and 3 taxa in October with a high density of *Casuarina equisetifolia* and *Corylus*. In general, the longest pollen period on a weekly basis in a year was recorded for *Pinus* (32 weeks) followed by Gramineae (33 weeks), Cupressaceae/Taxaceae (28 weeks), Chenopodiaceae/Amaranthaceae (29 weeks), *Corylus* (20 weeks) and

Table 2. Pollen taxa found in the atmosphere of Izmir (higher level – 20 m) during the period of study.

Taxa	Total pollen grains	
	Pollen grains/cm ²	%
Woody taxa		
<i>Pinus</i>	3,555	57
<i>Quercus</i>	749	12
Cupressaceae/Taxaceae	300	4.8
Oleaceae	276	4.4
<i>Morus</i>	149	2.4
<i>Eucalyptus camaldulensis</i>	113	1.8
<i>Ailanthus</i>	91	1.5
<i>Alnus glutinosa</i>	41	0.7
Rosaceae	35	0.6
<i>Corylus</i>	20	0.3
<i>Platanus orientalis</i>	20	0.3
<i>Ulmus</i>	18	0.3
<i>Casuarina equisetifolia</i>	15	0.2
<i>Erica</i>	14	0.2
<i>Pistacia</i>	9	0.14
<i>Populus</i>	9	0.14
<i>Juglans regia</i>	8	0.13
<i>Sarcopoterium spinosum</i>	7	0.1
<i>Salix</i>	6	0.1
<i>Acer</i>	5	0.08
<i>Laurus nobilis</i>	2	0.03
<i>Nerium oleander</i>	2	0.03
Cistaceae	2	0.03
<i>Acacia cyanophylla</i>	1	0.02
<i>Castanea sativa</i>	1	0.02
<i>Tilia</i>	1	0.02
Total (woody pollen)	5,449	87.32
Non-woody pollen		
Gramineae	373	6
Chenopodiaceae/Amaranthaceae	109	1.7
Cruciferae	82	1.3
<i>Plantago</i>	75	1.2
Leguminosae	24	0.4
<i>Taraxacum</i>	19	0.3
<i>Rumex</i>	13	0.2
Compositae	12	0.2
Cyperaceae	9	0.14
Fumariaceae	9	0.14
<i>Xanthium strumarium</i>	8	0.13
<i>Typha</i>	7	0.11
Juncaceae	6	0.1
<i>Anthemis</i>	3	0.05
Umbelliferae	3	0.05
<i>Campanula</i>	1	0.02
<i>Centaurea</i>	1	0.02
<i>Cichorium intybus</i>	1	0.02
<i>Erodium</i>	1	0.02
<i>Euphorbia</i>	1	0.02
Labiatae	1	0.02
<i>Melilotus</i>	1	0.02
<i>Mercurialis</i>	1	0.02
<i>Papaver</i>	1	0.02
Total (non-woody pollen)	761	12.2
Total (woody and non-woody pollen)	6,210	99.6
Unidentified	30	0.48
Total	6,240	100

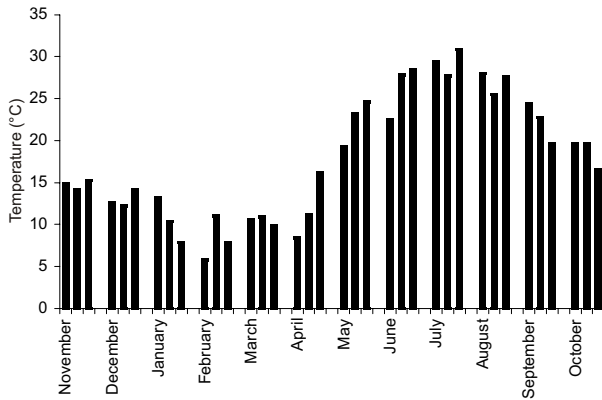


Figure 3. Annual temperature data of Izmir from November 1998 to October 1999.

Compositae (18 weeks). The pollen from trees dominated at this level from the first week of April until 4th week of May. The herbaceous pollens were observed in huge density only in the 3rd week of April and 4th week of May. No pollen from herbaceous taxa was recorded in the 4th week of December, 3rd and 4th week of January, 4th week of February and October (Fig. 8). At higher level, only pollen from 7 taxa were recorded in November and 4 taxa in December. The latter showed lowest density. In January and the February the numbers went up to 7 and 8 taxa respectively, with a dominance of Cupressaceae/Taxaceae during the 2nd and 3rd week of January and 4th week of February, together with *Alnus glutinosa*. Cupressaceae/Taxaceae pollens topped the list in March among 19 taxa recorded, in particular in the 2nd week. The first 2 weeks during this month showed a dominance of *Alnus glutinosa* and Rosaceae, whereas the 4th and 5th weeks had more *Pinus* pollen. The number of taxa nearly doubled during April (31 taxa) with a predominance of *Pinus* followed by Cupressaceae/Taxaceae in the 2nd week, *Pinus* in the 3rd week, *Morus* and *Pinus* during the 4th week. The last 2 weeks in April had the highest density of Gramineae. The number of taxa in May was 31, with a maximum record of *Pinus* followed by Oleaceae, Gramineae, *Quercus* and *Plantago* (Fig. 9). A decrease was observed in June (18 taxa), still with a dominance of *Pinus* and Gramineae.

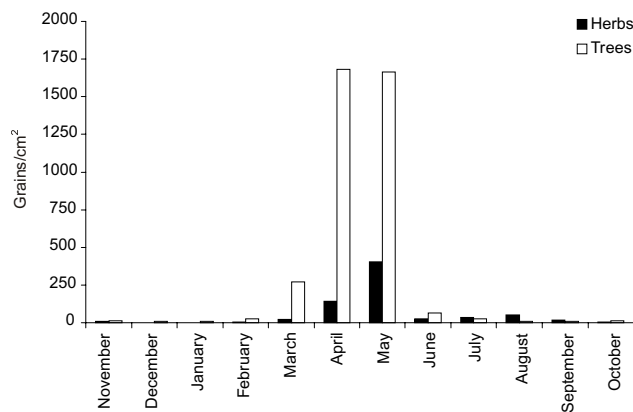


Figure 4. Total monthly variation in atmospheric pollen in Izmir metropolitan area (low level, 1.60 m).

Table 3. Pollen concentration of some taxa in Izmir and their degree of allergy.

Plant taxa	Allergic degree	Pollen concentration in the atmosphere
Woody taxa		
<i>Acer</i>	*, ***	1
<i>Alnus glutinosa</i>	**	2
<i>Arbutus</i>	*	1
<i>Castanea sativa</i>	**	1
<i>Corylus</i>	**	1, 2
Cupressaceae/Taxaceae	*	3, 4
<i>Erica</i>	***	1
<i>Juglans regia</i>	**	1
<i>Ligustrum vulgare</i>	**	1
<i>Morus</i>	**	2, 3
Oleaceae	***	3
<i>Pinus</i>	*	4
<i>Pistacia</i>	*	1
<i>Platanus orientalis</i>	**	2
<i>Populus</i>	*	1
<i>Quercus</i>	***	3, 4
Rosaceae	*, ***	2
<i>Salix</i>	*	1
<i>Tilia</i>	**	1
<i>Ulmus</i>	**	1
Non-woody Taxa		
Chenopodiaceae/Amaranthaceae	**, ***	2, 3
Cyperaceae	*, **, ***	1
Gramineae	*, **, ***	3, 4
<i>Mercurialis</i>	**	1
<i>Plantago</i>	*, ***	2, 3
<i>Rumex</i>	**	1
<i>Taraxacum</i>	*, **	1
<i>Xanthium strumarium</i>	**	1

* - low allergic, ** - medium allergic, *** - highly allergic, 1 - very low pollen concentration, 2 - Medium pollen concentration, 3 - high pollen concentration, 4 - higher pollen concentration.

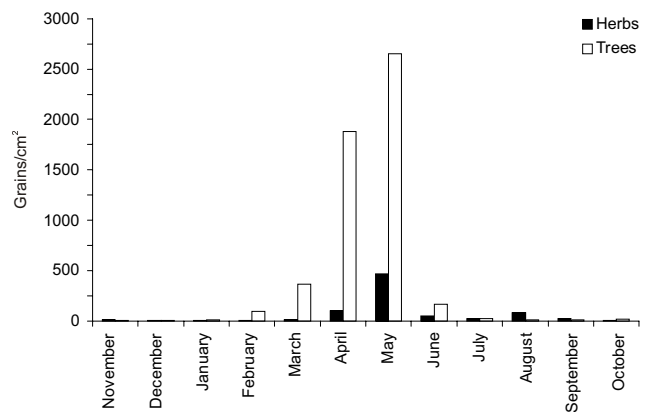


Figure 5. Total monthly variation in atmospheric pollen Izmir metropolitan area (high level, 20 m).

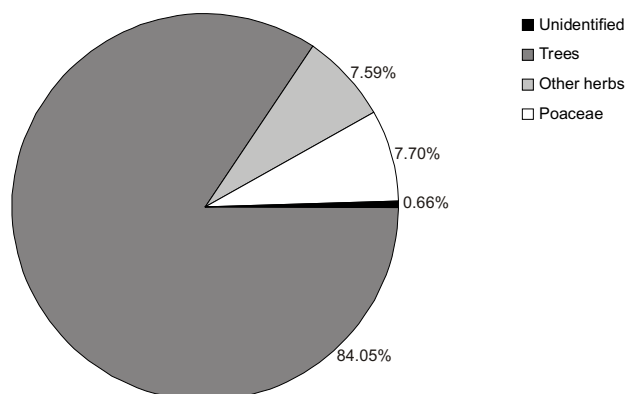


Figure 6. Pollen percentage (cm²) of major plant groups (lower level, 1.60 m).

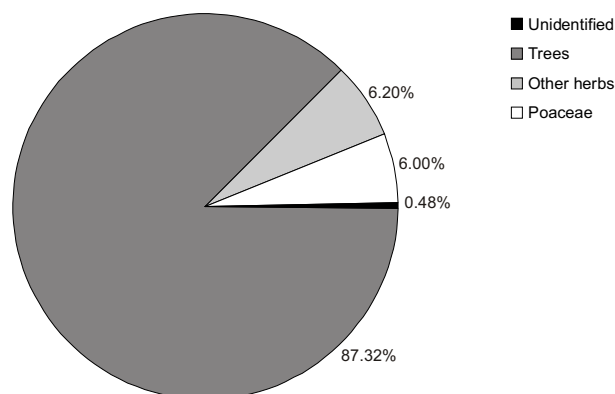


Figure 7. Pollen percentage (cm²) of major plant groups (higher level, 20 m).

During the 2nd week *Taraxacum* and Gramineae dominate together with woody codominants like *Eucalyptus camaldulensis*, Oleaceae, *Pinus* and *Quercus*. In the 3rd and 4th weeks *Eucalyptus camaldulensis*, Gramineae and *Pinus* dominated. In July the number went down to 15 taxa, still with a dominance of *Pinus* and Gramineae in the first 2 weeks followed by Chenopodiaceae/Amaranthaceae in the 3rd week. Only 9 taxa were observed in August, with a highest density of Chenopodiaceae/Amaranthaceae pollens. September, too, was poor in pollen density with only 9 taxa recorded. However, Chenopodiaceae/Amaranthaceae were common during 1st and 3rd weeks followed by *Casuarina equisetifolia* and Gramineae in the 3rd week. The number of taxa observed in October was 6, with a dominance of *Casuarina equisetifolia* during the 1st week. An evaluation of pollen distribution on an annual basis revealed that the longest pollination periods were observed in Gramineae (41 weeks), *Pinus* (38 weeks), Chenopodiaceae/Amaranthaceae (31 weeks), Cupressaceae/Taxaceae (27 weeks), *Plantago* (12 weeks), Compositae (16 weeks), *Morus* (14 weeks) and *Quercus* (15 weeks). A dominance of pollen from tree taxa is seen at this level during the 2nd, 3rd and 4th weeks of March, 2nd to 4th week of April, the whole of May and 3rd week of June. The pollen from herbaceous taxa dominated during the 3rd and 4th week of April, particularly the 2nd and 4th weeks of May and the 3rd of August. However, in the 4th week of November, 1st week of December and January and 4th week of August no tree pollens were recorded and similarly herbaceous pollens were also not observed during the 1st week of December, 1st and 2nd weeks of February and the last week of October (Fig. 9).

DISCUSSION

In our investigations, pollen of woody species was higher in general at both levels as compared to herbaceous ones. The former produce more pollen than the latter. Pollen percentage was lower in November and December because pollination is not common during these months. During mid-February, pollination in Cupressaceae/Taxaceae starts and pollen concentration increases rapidly at higher level. Towards the end of February these taxa are joined

by *Alnus glutinosa*, thus bringing the pollen concentration of woody taxa to its highest level. This is followed by an increase in the concentration of *Pinus* pollen during the 3rd and 4th weeks of March (Fig. 8-9), when wind speed increases (Fig. 1) and rains are frequent which add to this increase [1]. Most of the plants in the area start pollinating in mid-April and May, thus we find *Morus*, Oleaceae, *Pinus* and *Quercus* together with Chenopodiaceae/Amaranthaceae, Cruciferae, Gramineae, Leguminosae and *Plantago* dominating at both heights. Pollen distribution showed a good correlation with relative humidity and rise in temperature during the study period (Fig. 2, 3). Concentration decreases in June and July when most of the species in this area complete their pollination. This is particularly true for woody taxa during July, but herbaceous species show a relatively higher concentration. Chenopodiaceae/Amaranthaceae start pollinating in mid-summer, and as such, August and September show a dominance of their pollen at both levels (Fig. 8-9), followed by *Casuarina equisetifolia* during mid-September until mid-October. In July and August, in particular the 3rd and 4th weeks, temperature (Fig. 3) and wind velocity (Fig. 1) show an increase thus producing a positive effect on the pollination. Similar findings have been reported by other workers [23]. Pollen concentration at high (20 m) and low (1.60 m) levels of basic plant groups is given in Figures 3-4. These figures clearly show that woody species dominate as compared to herbs.

Total pollens counted earlier during a study period of 1 year (1996–1997) in Izmir reported that at higher level the number was 3,302/cm², out of which 2,938 (89%) belonged to the woody and 344 (10.4%) to herbaceous taxa. At the lower level, the numbers were 2,510/cm², out of which 1,851 (73.7%) were woody and 635 (25.3%) herbaceous ones [17].

Similar tree species have been reported with highest pollen numbers in the atmosphere from Izmir [16], but the ratio is reported to be only 58.69%, which is lower than our findings. Studies undertaken in Manisa, Kırıkkale and Ankara report from these areas 84.6%, 80%, and 76 % pollen densities respectively, which also coincide with ours [2, 18, 19].

Other gravimetric investigations from Bursa-Görükle Campus area (1991–1992) report 60.9% pollen belonging

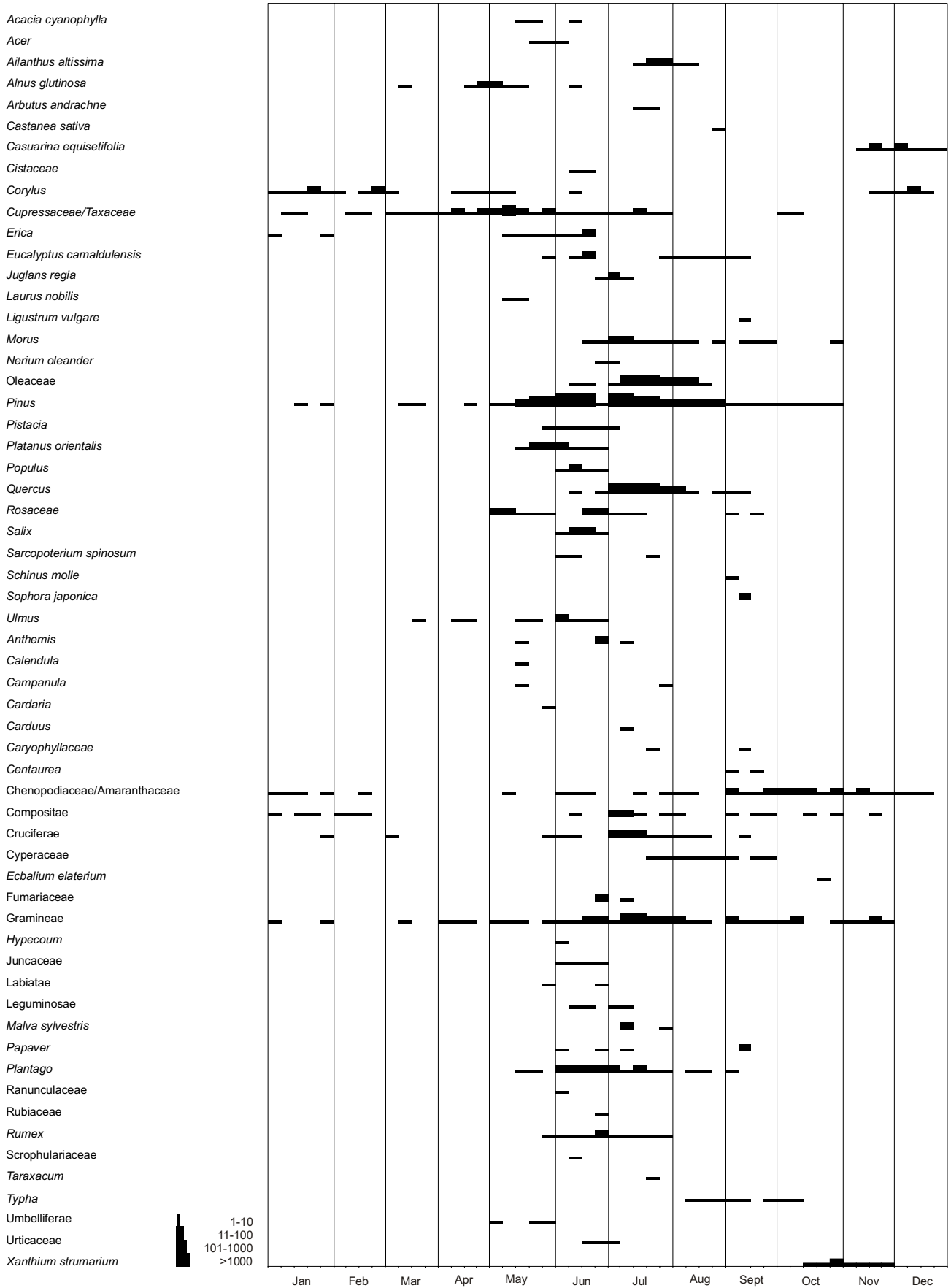


Figure 8. Annual pollen calendar of Izmir at lower levels (1.60 m) (grains/cm²).

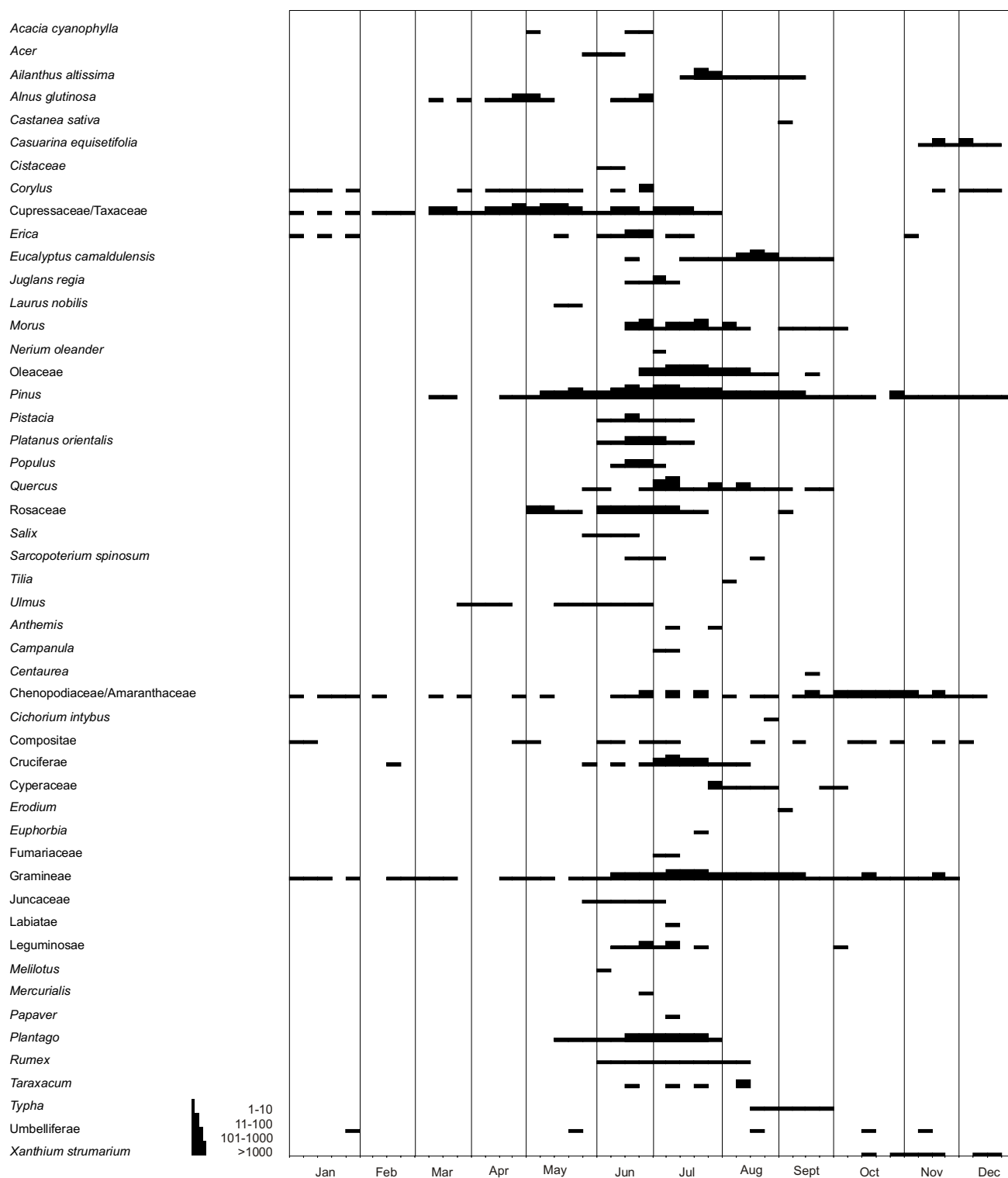


Figure 9. Annual pollen calendar of Izmir at higher level (20 m) (grains/cm³).

to woody taxa and 39.1% to the herbaceous ones. The pollens of woody taxa such as *Pinus*, *Quercus*, *Platanus orientalis*, *Olea europaea* and those of *Gramineae*, *Plantago*, *Chenopodiaceae/Amaranthaceae*, *Urticaceae*, *Compositae* are reported to show higher concentration as compared to others [6]. The results of our woody taxa are much higher, but those of herbaceous ones are lower than these values.

The studies covering the central part of Bursa city (1991) report 70.1% pollen of woody and 27% of herbaceous taxa dominated by *Pinus*, *Cupressaceae/Taxaceae*, *Abies nordmanniana*, *Platanus orientalis*, *Olea europaea*, *Gramineae*, *Urticaceae*, *Chenopodiaceae/Amaranthaceae*, *Artemisia* and *Compositae* pollens [5], which are very close to our findings except for Euro-Siberian element *Abies nord-*

manniana which is not found in our area. The pollen concentrations reported from Balıkesir and Isparta also resemble ours, being 70.92% and 71% for woody and 24.87% and 25% for herbaceous taxa respectively. These areas are dominated by *Pinus*, Cupressaceae/Taxaceae, *Platanus orientalis*, *Quercus*, Gramineae, Urticaceae, *Plantago*, Compositae and Chenopodiaceae/Amaranthaceae [7, 9]. Although these findings are also very close to ours, the results covering the studies from Samsun report a very low concentration (18.64%) compared to our findings [31].

The only volumetric study undertaken in Ankara using Burkhard Spore Trap (1993–1994) report 46,175/m³ pollens of woody and 11,560/m³ of herbaceous taxa, dominated by Pinaceae, Cupressaceae/Taxaceae, *Platanus orientalis*, *Populus*, *Acer*, Gramineae, Chenopodiaceae/ Amaranthaceae, Compositae, *Rumex* and Umbelliferae [27]. This area shows more dominance of Irano-Turanian elements compared to our area which lies in the Mediterranean.

The concentration of the allergic pollen groups such as *Morus* [20], Oleaceae [21], *Quercus* [4], Chenopodiaceae/ Amaranthaceae [20], Gramineae [10] and *Plantago* [11] together with the other 22 taxa is presented in Table 3. Some taxa from Chenopodiaceae/Amaranthaceae give positive reaction in allergic tests. These are reported to be medium to highly effective in this connection [4]. The pollen of *Alnus glutinosa* and *Platanus orientalis* which give medium allergic reaction are also found in relatively higher numbers. The low allergenic taxa such as *Acer*, *Populus*, *Salix*, *Traxacum* and *Urtica*, although very low in concentration in our study area, are also effective. *Castanea sativa*, *Corylus*, *Juglans regia*, *Ulmus*, *Mercurialis*, *Rumex* and *Xanthium strumarium* show medium allergic reaction.

CONCLUSION

The number of pollens in the atmosphere from herbaceous taxa at both levels was highest during April, May and August, whereas, pollens from woody taxa dominated during April, May and March at the lower level and April, May and March at the higher level. An annual pollen distribution calendar of taxa Chenopodiaceae/Amaranthaceae, Gramineae, Oleaceae, *Quercus* and *Plantago*, which show higher density as well as allergenic action, is presented here for use by for the allergic patients in and around the metropolitan area.

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