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AEROBIOLOGICAL INVESTIGATION IN BITLIS, TURKEY

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Abstract: A continuous aeropalynological survey of the atmosphere of Bitlis was carried out from January 2001 to December 2002 by means of the gravimetric method using Durham apparatus. Weekly pollen grains in per cm^2 were calculated. During two years, a total of 3,323 pollen grains/cm^2 which belong to 46 taxa, 21 of total belong to arboreal (AP) and 25 of total non-arboreal (NAP) plants, and unidentified pollen grains were recorded. In 2001, 1,833 pollen grains and in 2002, 1,490 pollen grains were recorded. Total pollen grains consist of 39.39% AP, 59.28% NAP plants and 1.32% unidentified pollen grains. Gramineae, Urticaceae, *Juglans* spp., *Quercus* spp., Umbellifereae, Cupressaceae/Taxaceae, *Fraxinus* spp., *Salix* spp., *Plantago* spp., *Pinus* spp., *Rumex* spp., Moraceae and Chenopodiaceae/Amaranthaceae were responsible for the greatest amounts of pollens in the investigated region. 58.38% of total pollen grains were appeared during May and June.

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Key words: Bitlis, pollen calendar, pollen fall, Turkey.

INTRODUCTION

Hay fever is a common allergenic disease affecting almost 15% of the human population around the world. These diseases appear especially in flowering periods of plants. Most human exposures are to pollen types, which occur in the air in relatively high amounts [11]. Knowledge of the abundance of allergenic pollen types and their pollination seasons is useful to allergologists who can correlate hay fever symptoms with the presence of allergenic pollen in the atmosphere [23]. Furthermore, pollen calendars are important for studies on phenology, ecology, pollination biology, etc. [22].

Atmospheric pollen has been measured for many years at various locations in the world and annual pollen calendars have been prepared in many countries [10, 20, 25]. Atmospheric pollen surveys have been carried out in different cities of Turkey by Bicakci *et al.* [1-7].

The main aim of this study is to assess seasonal appearance of pollen grains, and to make quantitative and qualitative analysis of pollen fall belonging to arboreal and non-arboreal taxa in the Bitlis atmosphere.

MATERIAL AND METHODS

The city of Bitlis (41°33'-43°11'E; 37°54'-38°58'N), an important tobacco production centre in Turkey (Fig. 1), is situated among the mountains on a high plateau, at an altitude of approximately 1500 m above sea level, in a valley which is west of Van Lake in Eastern Anatolia Region which has nearly 400,000 inhabitants. Bitlis is located in a narrow valley with high, rocky mountains rising 2000 m above sea level. The Bitlis river runs through the city. The climate, according to Thornthwaite's humidity index, is rainy and hot. The rainfall in the region is 605-1041 mm; annual average temperature is 9.7ºC; the coldest month is January, and the hottest is July [15].

Phytogeographically the area is in the Irano-Turanian flora sector. The main vegetation types are forests and anthropogenic steppes. The forest area is mainly characterized by *Quercus* L., in particular *Q. infectoria* subsp. *boissieri* Reuter in higher parts (over 1800 m) of the area. In lower parts and at stream banks *Salix* spp., *Juglans* spp., *Platanus* spp., *Cupressus* spp., *Taxus* spp., *Populus* spp., *Betula* spp., *Erica* spp., *Pistacia* spp. and *Ulmus* spp.

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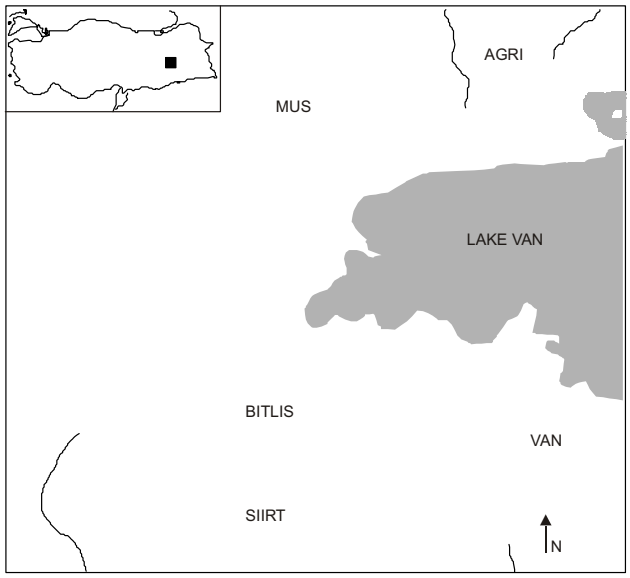

Figure 1. Map of Bitlis, Turkey.

form the main clumps of trees. Herbaceous vegetation is characterized mainly by taxa such as: Gramineae, Cruciferae, Chenopodiaceae, *Ranunculus* spp. Compositae, etc.

The studies were undertaken from January 2001 to December 2002 in Bitlis city. Durham apparatus was used. The apparatus was located at 10 m height above ground level. The slides were mounted and stained in glycerine jelly mixed with basic fuchsine [9] and examined microscopically weekly.

The pollen was counted at a magnification of ×400. Counts were made at one week, and total weekly counts were converted to the number of pollen grains per cm^2 of air pollen calendar of Bitlis was given. In the calendar, pollen grains of per cm^2 was showed as 1-9 low, 10-49 moderate and 50≥ high.

RESULTS

The total pollen concentration registered during the sampling period was 3,323 grains/cm^2. In 2001, 1,833 pollen grains and in 2002, 1,490 pollen grains were recorded. The results of pollen count for both years are shown in Tab. 1. The counts include over 46 different pollen types (21 AP and 25 NAP). A total of 1970 pollen grains have been found as NAP (59.28%), 1309 as AP (39.39%), and 44 as unidentified (1.32%) (Tab. 1, Fig. 2).

The general trend shows an increase in pollen counts from spring to summer and reaching a maximum in early summer. 58.38% of total pollen was recorded in May and June. In late summer, pollen concentration starts to decrease due to the scarcity of flowering plants. Noticeable is the very small number of grains observed from autumn until early spring (Tab. 2).

The main pollen producers in the atmosphere of Bitlis were NAP such as Gramineae, Urticaceae, Umbelliferae, *Plantago* spp., *Rumex* spp., Chenopodiaceae/Amaranthaceae and Compositae. They form 54.56% of the total

Table 1. Annual totals of pollen counts for Bitlis, 2001-2002

	2001	2002	2001-2002	%
Arboreal Plants (AP)				
Juglans sp.	160	158	318	9.57
Quercus sp.	163	77	240	7.22
Cupress./Tax.	128	25	153	4.60
Fraxinus sp.	71	51	122	3.67
Salix sp.	47	68	115	3.46
Pinus sp.	23	68	91	2.74
Moraceae	58	19	77	2.32
Platanus sp.	48	2	50	1.50
Betula sp.	24	7	31	0.93
Populus sp.	30	0	30	0.90
Ailanthus sp.	3	19	22	0.66
Rosacea	10	5	15	0.45
Acer sp.	9	2	11	0.33
Oleacea	4	6	10	0.30
Ulmus sp.	2	7	9	0.27
Pistacia sp.	5	0	5	0.15
Cedrus sp.	1	2	3	0.09
Abies sp.	0	2	2	0.06
Aesculus sp.	0	1	1	0.03
Alnus sp.	1	1	2	0.06
Corylus sp.	0	2	2	0.06
Total	787	522	1309	39.39
Percent	23,68	15,71		
Non-arboreal Plants (NAP)				
Gramineae	632	205	837	25.19
Urticaceae	117	292	409	12.31
Umbellifera	35	203	238	7.16
Plantago sp.	64	45	109	3.28
Rumex sp.	44	39	83	2.50
Chenopodiaceae/ Amaranthaceae	53	24	77	2.32
Compositae	41	19	60	1.81
Caryophyllaceae	5	19	24	0.72
Artemisia sp.	8	14	22	0.66
Rubiaceae	16	6	22	0.66
Boraginaceae	13	1	14	0.42
Sangiusorba sp.	2	12	14	0.42
Taraxacum sp.	2	11	13	0.39
Cruciferae	0	11	11	0.33
Ranunculacea	0	6	6	0.18
Papaver sp.	1	4	5	0.15
Cyperacea	4	0	4	0.12
Leguminosae	0	4	4	0.12
Onobrychis sp.	2	2	4	0.12
Echium sp.	0	3	3	0.09
Labiatae	0	3	3	0.09
Xanthium sp.	0	3	3	0.09
Centaurea sp.	1	1	2	0.06
Thalictrum sp.	1	1	2	0.06
Typha sp.	0	1	1	0.03
Total	1041	929	1970	59.28
Percent	31.33	27.96		
Unidentified	5	39	44	1.32
Total	1833	1490	3323	100.00
Percent	55.16	44.84	100	

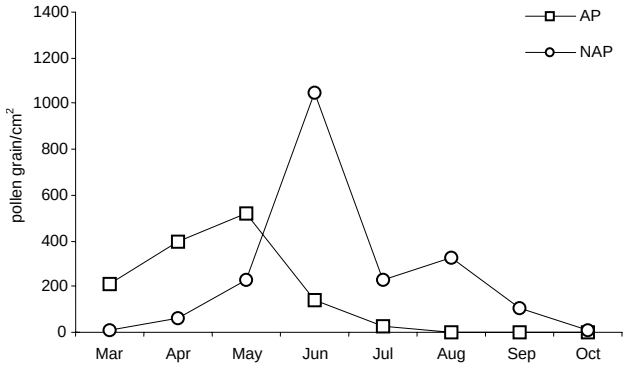

Figure 2. Monthly total variation in AP and NAP pollen grains in the atmosphere of Bitlis (2001-2002).

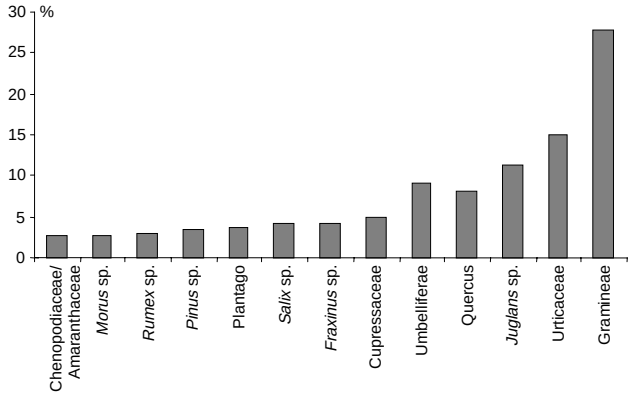

Figure 3. Total biannual percentage values of the main pollen types in the atmosphere of Bitlis.

pollen grains. From AP *Juglans* spp., *Quercus* spp., Cupressaceae/Taxaceae, *Fraxinus* spp., *Salix* spp., *Pinus* spp., Moraceae and *Platanus* spp. in the atmosphere of Bitlis making up 35.08% of the total (Tab. 1, Fig. 2, 3).

The airborne pollen patterns of each taxon show marked seasonality although Gramineae is present in the air throughout the year (Tab. 2). This continuous pollen emission is due to the presence of different species that flower at different times.

A noticeable change in monthly pollen composition was observed during the sampling period (Tab. 3, Fig. 4). Only those taxa accounting for more than or equal to 5% of the total monthly counts were analyzed for each month. In figure 4, 89.64% of total pollen is represented by only 15 taxa, these were therefore considered representative of the pollen spectrum. In decreasing order of importance they are; Gramineae, Urticaceae, *Juglans* spp., *Quercus* spp., Umbelliferae, Cupressaceae/Taxaceae, *Fraxinus* spp., *Salix* spp., *Plantago* spp., *Pinus* spp., *Rumex* spp., Moraceae, Chenopodiaceae/Amaranthaceae, Compositae ans *Platanus* spp. (Fig. 3, Tab. 2).

In March, the earliest pollen grains in the atmosphere of Bitlis were noted and 14 different taxa identified. The main AP pollen grains, such as *Fraxinus* spp., Cupressaceae/Taxaceae, *Populus* spp., *Betula* spp. were observed in this month. The number of pollen grains increased in April, May and reached their maximum levels in June (35.90%). (Fig. 2, 5, Tab. 2).

In April, 19 taxa were identified, 10 of them belonged to AP. *Quercus* spp. (20.00%), *Salix* spp. (15.00%), Cupressaceae/Taxaceae (14.00%), Gramineae (11.00%), *Fraxinus* spp. (11.00%), *Platanus* spp. (9.00%), *Juglans* spp. (8.00%) released high amounts of pollen into the atmosphere throughout their pollination period, and were responsible for more than 88.00% of the total pollen grains in April (Fig. 4).

The numbers of pollen grains increased in May. 19 taxa were recognized (10 AP, 9 NAP). *Juglans* spp. (33.00%) was identified as dominant pollen taxon in May. Pollen grains of Gramineae (24.00%), *Quercus* spp. (18.00%) and *Salix* spp. were found with other dominant pollen taxa in the atmosphere of Bitlis in May (Tab. 3).

Table 2. The highest pollen concentrations in consecutive months and their yearly composition (%), Bitlis, Turkey.

	Spring			Summer		Autumn			
	March	April	May	June	July	August	September	October	Total (%)
Gramineae	0.03	1.56	5.39	14.78	1.84	0.84	0.66	0.09	25.19
Urticaceae	–	–	0.12	3.67	1.69	6.74	0.09	–	12.31
Juglans sp.	0.03	1.14	7.49	0.84	0.03	–	–	0.03	9.57
Quercus sp.	0.18	2.86	3.97	0.21	–	–	–	–	7.22
Umbelliferae	–	–	0.84	5.54	0.27	0.27	0.24	–	7.16
Cupressaceae	1.59	1.90	0.78	0.27	0.06	–	–	–	4.60
Fraxinus sp.	2.11	1.47	0.09	–	–	–	–	–	3.67
Salix sp.	–	2.08	1.38	–	–	–	–	–	3.46
Plantago sp.	0.03	–	0.12	1.87	1.02	0.21	0.03	–	3.28
Pinus sp.	–	0.12	0.57	1.99	0.06	–	–	–	2.74
Rumex sp.	–	–	0.15	2.02	0.18	0.15	–	–	2.50
Chenopodiaceae/ Amaranthaceae	–	–	–	0.27	0.27	0.51	1.23	0.03	2.32
Moraceae	0.15	0.21	1.05	0.90	–	–	–	–	2.32
Compositae	–	–	–	0.93	0.15	0.45	0.24	0.03	1.81
Platanus sp.	0.30	1.20	–	–	–	0.00	–	–	1.50
Others	2.08	1.35	0.51	2.62	2.08	0.75	0.81	0.15	10.35
Total	6.50	13.90	22.48	35.90	7.65	9.93	3.31	0.33	100.00

Table 3. Relative variation in pollen composition throughout the year. Pollen types attending equal/more than 5% of monthly total counts are included.

	March	April	May	June	July	August	September	October
Ailanthus sp.					7			
Artemisia sp.								20
Betula sp.	10							
Caryophyllaceae							8	9
Cedrus sp.								10
Chenopodiac/Amaranthac.						5	38	10
Compositae							7	10
Cupres./Tax.	25	14						
Fraxinus sp.	32	11						
Gramineae		11	24	41	24	8	20	30
Juglans sp.		8	33					10
Pinus sp.				6				
Plantago				5	13			
Platanus sp.		9						
Populus sp.	12							
Quercus sp.		20	18					
Rumex sp.				6				
Salix sp.		15	6					
Umbelliferae				15			7	
Urticaceae				10	22	69		
Other types	21	12	19	17	34	18	20	

In June, the pollen grains reached their maximum levels. 27 pollen taxa (8 AP and 19 NAP) were found in the atmosphere of Bitlis. The reason for the increase of both AP and NAP, especially in herbaceous plants, produced high amounts of pollen grains into the atmosphere, started to pollination. Gramineae dominate the pollen spectrum of Bitlis in June. The presence of this pollen type is consistently important, reaching 41.00% (of total % 14.78) in June. Its main pollen season occurs when temperatures are at the highest. Pollen grains of Umbelliferae (15.00%), Urticaceae (10.00%), *Rumex* spp., *Pinus* spp. and *Plantago* spp. (5.00%) were identified as high amount in June (Tab. 3).

In July, the amount of pollens was lower than it was in springtime and early summer. The reason for this decrease was correlated with the end of the pollination periods of many AP which released high amounts of pollen into the air. 19 taxa (3 of them AP) were found in July (Tab. 3).

In August, 11 taxa were identified (1 of them AP); Urticaceae (69.00%) was dominant. Gramineae (8.00%) and Chenopodiaceae/Amaranthaceae (5.00%) were found in the atmosphere of Bitlis during this month (Tab. 3).

In September and October, Gramineae spp., Chenopodiaceae/Amaranthaceae, Caryophyllaceae and Compositae were recorded as dominant taxa (Tab. 3).

Pollen grains were not recorded in the atmosphere of Bitlis in November, December, January and February (Fig. 2).

The types of pollens present in the atmosphere of Bitlis are shown in the form of a pollen calendar in Fig. 4, based on the total weekly counts of pollen/cm^2 in 2001-2002.

The followings are the 15 taxa which produced the greatest amount of pollens in the atmosphere of Bitlis:

1) Gramineae: Pollen grains of this family constituted 25.19% of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). Pollen grains were recorded during the greater part of the year. The pollen season started in the first week of March and ended in the second week of October. The highest values were noted in May and June (Fig. 4).

2) Urticaceae: Pollen grains of this family constituted 12.31% of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). The pollen season started in the last week of May (week 21) and ended in the last week of September (week 38). The peak value was noted in August (Fig. 4).

3) *Juglans* spp.: Pollen grains of this genus constituted 9.57 % of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). It started in the last week of March (week 13) and lasted until the first week of July (week 27). The highest values were recorded in May (Fig. 4).

4) *Quercus* spp.: Pollen grains of this genus constituted 7.22 % of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). Pollen production was continued from the third week of March (week 12) to the second week of June (week 23). The highest counts were recorded in first week of May (week 18) (Fig. 4).

5) Umbelliferae: Pollen grains of this family constituted 7.16 % of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). Pollen grains were recorded second week of May (week 19) and lasted until the third week of September (week 37). The highest value was recorded first week of June (week 22) (Fig. 4).

6) Cupressaceae/Taxaceae: Pollen grains of this family constituted 4.60% of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). The pollen season started in the third week of March and lasted first week of July. The highest counts were recorded from last week of March to first week May (Fig. 4).

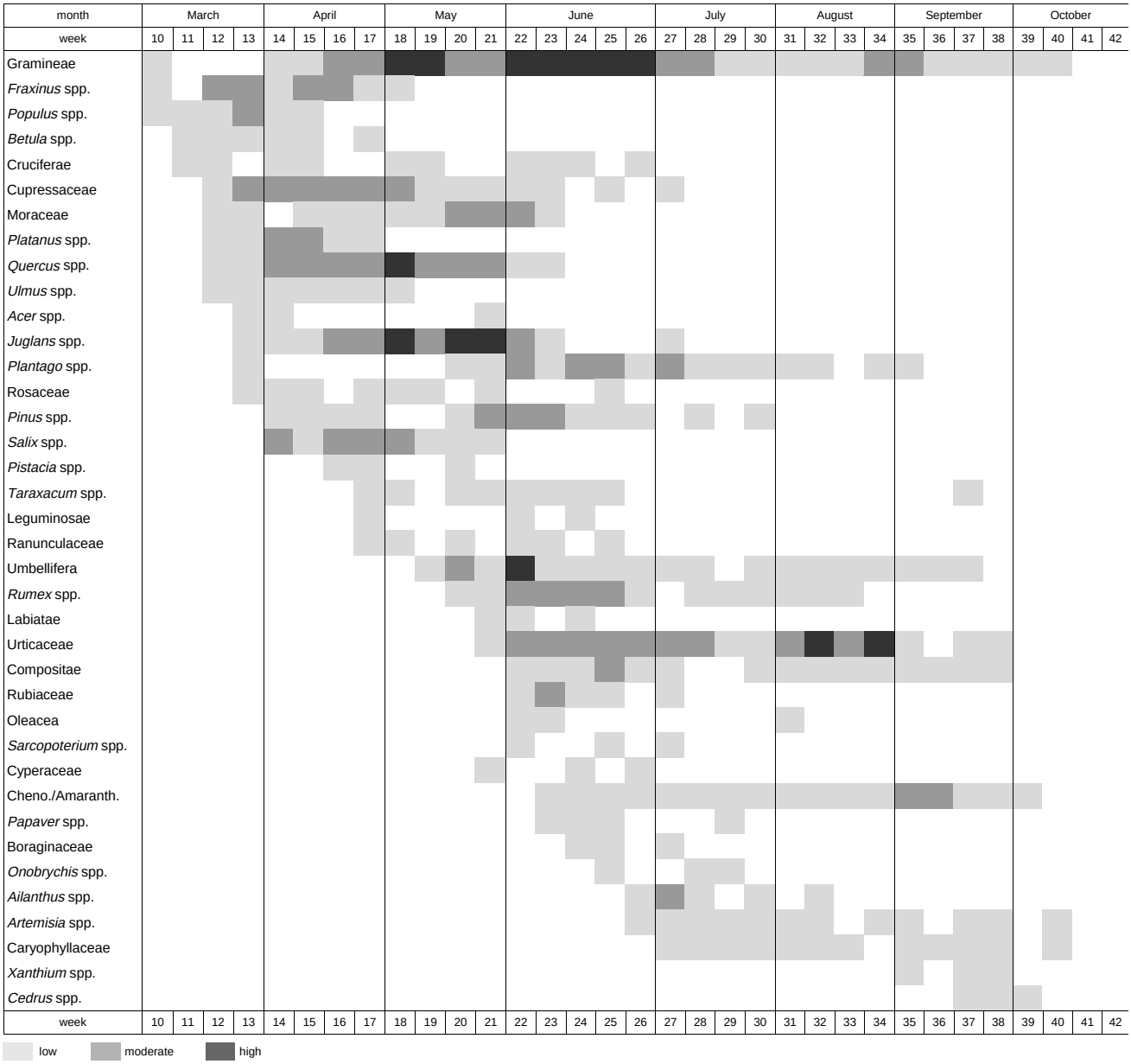

Figure 4. Pollen calendar for Bitlis (2001-2002).

7) *Fraxinus* spp.: Pollen grains of this genus constituted 3.67% of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). Pollen production started in first week of March and lasted until the first week of May (Fig. 4).

8) *Salix* spp.: Pollen grains of this genus constituted 3.46% of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). The pollen season started in first week of April (week 14) and lasted until the last week of May (Fig. 4).

9) *Plantago* spp.: Pollen grains of this genus constituted 3.28% of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). Pollen production continued from the last week of March to first week of September (Fig. 4).

10) *Pinus* spp.: Pollen grains of this genus constituted 2.74% of total pollen in the atmosphere of Bitlis (Fig.3, Tab. 2). The pollen season started in first week of April and lasted until the last week of July (week 30). The highest values were noted in May and June (Fig. 4).

11) *Rumex* spp.: Pollen grains of this genus constituted 2.50% of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). Pollen grains were recorded for first time in third week of May (week 20) and for the last time in the third week of August (week 33). The peak season was June (Fig. 4).

12) Moraceae: Pollen grains of this family constituted 2.32% of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). Pollen production of this family started in the third week of March (week 12) and lasted until the second week of June (Fig. 4).

13) Chenopodiaceae/Amaranthaceae: Pollen grains of this family constituted 2.32% of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). Pollen production continued from the second week of June and first week of October (week 39).The highest counts were recorded in the first two weeks of September (Fig. 4).

14) Compositae: Pollen grains of this family constituted 1.81% of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). Pollen production started in first week of June, and lasted until the last week of September (Fig. 4).

15) *Platanus* spp.: Pollen grains of this genus constituted 1.50% of total pollen in the atmosphere of Bitlis (Fig. 3, Tab. 2). Pollen season was very short, it started in the third week of March and lasted until the last week of April (week 17) (Fig. 4).

DISCUSSION AND CONCLUSION

The symptoms of pollen allergy confirm a good correlation with the airborne pollen count [24]. However, the most important factors conducive to pollen allergy are genetic and environmental, especially the composition of the pollen flora in the air [21]. Variation of tree flora are reflected in the quantitative and qualitative composition of pollen fall [13, 14]. Trees belong to the main pollen producers because of their common incidence and large pollen production per anther, inflorescens or individual tree [19]. These pollens can be transported in the air over large areas. Herb plants - Gramineae, Urticaceae, Chenopodiaceae/Amatanthaceae, and *Artemisia* spp. - are common, and the pollen production by these taxa is also large.

At the investigated sites, a smaller number of pollen grains was counted in 2002 than in 2001 (Tab. 1). This was probably a result of substantial differences in weather conditions between these two years. The number of taxa determined did vary between the years (Tab. 1). In 2001, fewer taxa were identified than in 2002.

NAP pollen types were dominant in the atmosphere of Bitlis; this is due to the vegetation characters and geographical location of the city. It was observed that Gramineae (grass) pollens were the most dominant types in Bitlis and reached their peak level in June. Similarly, Gramineae pollen (18.12%) was determined as the chief constituent in Madras city (India) [17], and the highest peaks for Gramineae occurred in June in Tirana (Albania) [12]. According to Szczepanek's data, the annual highest mean of annual total was reached by Gramineae and *Betula* spp. [28]. In the investigated area, Gramineae pollen was followed by Urticaceae. Kasprzyk [16] numbered *Urtica* spp. and Gramineae among the taxa producing the most pollen grains in Ostrowiec Świętokrzyski. Urticaceae pollen grains were identified in high levels and as important allergens in the other European regions [8]. Other important allergenic pollens such as *Quercus* spp., Cupressaceae/Taxaceae, *Fraxinus* spp. were also found in high levels in the atmosphere of Bitlis. According to other studies carried out in Europe: Pinaceae, *Alnus* spp., *Betula* spp., *Quercus* spp., Gramineae, *Artemisia* spp. in Jyvaskylan, Finland [18], and Gramineae, Urticaceae, Oleaceae, *Artemisia* spp. were found in Ascoli Piceno, Italy [20]. The dominant airborne species have been determined to be Gramineae, *Alnus* spp., *Artemisia* spp., *Urtica* spp., *Betula* spp., *Quercus* spp. in Leiden, The Netherlands [27]; *Betula* spp., *Quercus* spp., Gramineae, Urticaceae in Vienna, Austria [26], *Pinus* spp., *Olea* spp., *Platanus* spp., Gramineae, Cupressaceae, Taxaceae, *Quercus* spp., *Acer* spp., *Morus* spp., *Xhanthium* spp., *Castanea* spp., Chenopodiaceae, Amaranthacea, *Coryllus* spp., *Artemisia* spp., *Urtica* spp. and *Fraxinus* spp. in Bursa [6].

Pollen grains of 46 taxa were determined during the pollen season in the atmosphere of Bitlis, 15 of them formed about 89.64% of the spectrum. In the region investigated, pollen grains were recorded during 8 months of the year and reached their maximum levels in June. The presented pollen calendar for the region in this paper may be useful for allergologist and patients who suffer from pollinosis and allergy.

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