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Modern pollen distribution of the Teke Peninsula forests: The case of the Ördübek Highland

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Abstract

This study was carried out in the Teke Peninsula, in *Cedrus libani* A. Rich. (Lebanon cedar), *Juniperus* L. sp. (Juniper) and *Quercus* L. sp. (Oak) mixed forest (Susuz Dağ-Elmalı-Antalya), which is located in the Mediterranean mountain ecosystem. The purpose of the study is to determine the modern pollen distribution (influx and percentage) of this forest and to create a basic calibration scheme for the fossil pollen studies. For the purpose of this study, two-year modern pollen distribution was monitored between the years 2015-2017 using the Tauber pollen traps and moss samples, which were placed at 6 different points in the study area. Furthermore, the surface sediment sample of Lake Avlan was obtained, and the accumulation characteristic of the modern pollen distribution in the lake was revealed. The principles of the European Pollen Monitoring Programme Protocol (EPMPP) were followed in the laboratory methodology. Surface sediment was analyzed according to the classical fossil pollen method. The majority of the pollen influx obtained from the Tauber pollen traps in the *Cedrus libani-Juniperus-Quercus* forest belongs to arboreal taxa (AP) (*Cedrus libani*, *Pinus* L. sp., *Quercus coccifera* L. and *Juniperus* sp.). The highest pollen influx of these taxa belongs to *Cedrus libani*. In the surface sediment sample obtained from Lake Avlan, the highest pollen influx belongs to *Pinus* sp. When the pollen influx values were compared for the years 2015-2016 and 2016-2017, the pollen influxes of the Tauber pollen traps in all sample areas were higher than the moss samples in 2015-2016 except for the two sample areas (CJQ-1 and CJQ-4). In parallel with the pollen influx in the study area, the majority of the modern pollen percentage distribution (84-94%) consists of woody taxa. Within these taxa, *Cedrus libani*, *Pinus* sp., *Quercus coccifera* and *Juniperus* sp. form almost all of the AP percentage.

Keywords: European Pollen Monitoring Programme, *Cedrus libani*, *Juniperus*, *Quercus*, Susuz Dağ-Elmalı, Lake Avlan.

Introduction

The observation of modern ecological processes (modern vegetation distribution, pollen production and distribution, climatic requirements of plants) with the pollen monitoring programmes is the most important point in order to perform paleoecological reconstructions based on the fossil pollen analysis better (Hicks 1986, Eastwood 1997, England 2006, Herzschuh and Birks 2010, Soepboer et al. 2010, Birks 2013, Brewer et al. 2013, Poska 2013, Seppa 2013, Roberts 2014). For this reason, modern data sets provide the creation of quantitative interpretation keys in the historical ecology (paleovegetation, palaeoclimate, paleological land use) and restructuring of the historical biodiversity development. However, the use of modern pollen characteristics has been very low in paleoecological reconstructions based on the fossil pollen analysis conducted in Southwestern Anatolia in Turkey (van Zeist et al. 1975, Bottema and Woldring 1984, Eastwood 1997, Sullivan 1989, Vermoere et al. 1999, Vermoere et al. 2002, Müllenhoff et al. 2004, Kaniewski et al. 2007, Bakker et al. 2011, Shumilovskikh et al. 2016).

Therefore, little is known about the distribution characteristics/sedimentation processes of the modern pollen grains in the forest vegetation of Turkey and the demonstration of the modern pollen influxes of the surface sediment samples obtained from the bottoms of the lakes. Furthermore, if no detailed research is done about the modern pollen characteristics in and around the forest vegetation, it is not known to what extent the production, distribution and sedimentation processes of the modern pollen grains are realized and how well they represent the current vegetation at the regional and local scale. In order to fill this gap, the "EPMPP" was created in 1996 and modern pollen-monitoring stations were established in many European countries in the last 22 years. EPMP studies have been started in accordance with this protocol in Turkey in 2011 (Karlıoğlu 2011, Karlıoğlu and Akkemik 2012, Karlıoğlu et al. 2014, Karlıoğlu et al. 2015, Doğan 2017, Şenkul and Doğan 2018, Şenkul et al. 2018a, Şenkul et al. 2018b).

In lake sediments, pollen grains are generally obtained from a larger area compared to traps, moss and soil samples (Wilmshurst and McGlone 2005). Considering from this aspect, various factors such as the size of the lake area (Davis and Brubaker 1973, Sugita 1994), pollen source area (Sugita 1993, Wang et al. 2014), the presence of rivers flowing into/out of the lake, the dominant wind direction over the lake and the sedimentary processes in the lake and the protection of pollen grains (Davis 1968, Davis et al. 1984) affect the distribution and composition of the pollen protected in the lake sediments. In this context, we focused on the reconstruction of the long-term history of paleovegetation, paleological land use, paleoclimate and paleoecological environmental changes in the Teke Peninsula, where the most fossil pollen studies were conducted in Turkey (van Zeist et al. 1975, Bottema and Woldring 1984, Eastwood 1997). However, contrary to the number of fossil pollen studies, there are no data about the modern pollen influxes/percentages in this site.

The purpose of this study is to determine the influx of the modern pollen sedimentation in the forest area and in the lacustrine area near the forest in the formation consisting of *Cedrus libani*, *Quercus* sp., and *Juniperus* sp. taxa in the Ördübek Highland in accordance with the EPMPP. This study will be a basic calibration scheme in order to better interpret the quantitative reconstructions of previous fossil pollen diagrams and future paleovegetation, paleoclimate and paleoecological changes in Southwestern Anatolia.

Material and Methods

Study area

The study area is located in the southern slope of Susuz Dağ, which is between the districts of Finike and Elmalı in Teke region in the southwest of Turkey (Figure 1). The southern border of the area is bounded by the Mediterranean Sea and the northern border by Susuz Dağ (2268 m). The study area, which is called the Ördübek Highland, and its surrounding are located between 1100-1200 meters of the mountainous mass between 0- 2300 m. The dominat woody plant species in the area are *Cedrus libani*, *Juniperus excelsa* M. Bieb., *Juniperus foetidissima* Willd., *Juniperus oxycedrus* L., *Quercus* *coccifera*, *Hippocrepis emerus* (L.) Lassen, *Lonicera* L. sp., *Styrax officinalis* L., and *Cotinus coggygria* Scop (Figure 2).

Climatic conditions are the leading factors that determine the distribution and characteristics of vegetation in the study area and its surrounding. The nearest meteorological stations are took place in Elmalı and Finike district centers. According to the data of the Finike Meteorology Station (1960-2015), the average annual precipitation is 961.4 mm, and the average temperature is 18.9 °C. According to the data of the Elmalı Meteorology Station (1958-2015), the average annual precipitation is 461.3 mm, and the average temperature is 12.9 °C (Table 1). Climatic factors such as elevation, aspect, distance from the sea and direction of mountains, temperature, precipitation, and wind vary within short distances within the study area. Under these conditions, the southward slopes of the mountains in the coastal area receive annual precipitation over 1000 mm.

Table 1. Long-year average temperature, humidity, and precipitation of the Elmalı and Finike stations (General Directorate of Meteorology).

Elmalı (1095 m) (1958-2015)	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**Year**
Average temperature (°C)	2.4	3.3	6.9	11.3	16.1	20.9	24.3	24.1	19.9	14.2	8.6	4.1	13
Average Humidity (%)	71	67.5	60.5	54.6	52.2	44.8	39.2	39.9	44.6	55.1	64	71.9	55.4
Precipitation (mm)	82.3	59.4	47.6	32.1	28	21.2	10.1	8	7.6	32.9	46.6	85.5	461.3
Finike (3 m) (1960-2015)													
Average temperature (°C)	11.1	11.4	13.3	16.5	20.7	25.2	28.0	27.8	24.4	20	15.7	12.5	18.9
Average Humidity (%)	69.6	69.8	69.9	68.8	68.5	62.6	61.2	62.5	63.9	66.5	68	69.8	66.8
Precipitation (mm)	223.7	149.8	85.3	45.2	20.1	8.3	2.2	1.3	11.3	64.9	120	229.3	961.4

Pollen Analyses

Modern pollen data from the Tauber pollen traps

In order to obtain modern pollen data, 6 Tauber pollen traps (Tauber 1974, Hicks and Hyvärinen 1986) were placed in the study area in 2015, and in the following year, traps were taken from the land, and new traps were placed in their place. Table 2 shows the codes, coordinates, elevation, vegetation and common plant species around the Tauber pollen traps.

Table 2. Location and vegetation information of the pollen traps and moss samples.

Pollen trap code	**Moss sample code**	**Latitude**	**Longitude**	**Elevation (m)**	**Type of vegetation**	**Common species**
CJQ-1-T	CJQ-1-M	36°31'24.50"N	29°58'38.12"E	1340	Forest	*Cedrus libani, Juniperus excelsa, Juniperus foetidissima, Juniperus oxycedrus, Quercus coccifera*
CJQ-2-T	CJQ-2-M	36°31'24.20"N	29°58'40.09"E	1334	Forest	
CJQ-3-T	CJQ-3-M	36°31'25.65"N	29°58'14.53"E	1392	Forest	
CJQ-4-T	CJQ-4-M	36°31'25.08"N	29°58'13.08"E	1392	Forest	
CJQ-5-T	CJQ-5-M	36°31'22.11"N	29°58'8.89"E	1388	Forest	
CJQ-6-T	CJQ-6-M	36°31'21.84"N	29°58'10.36"E	1382	Forest	

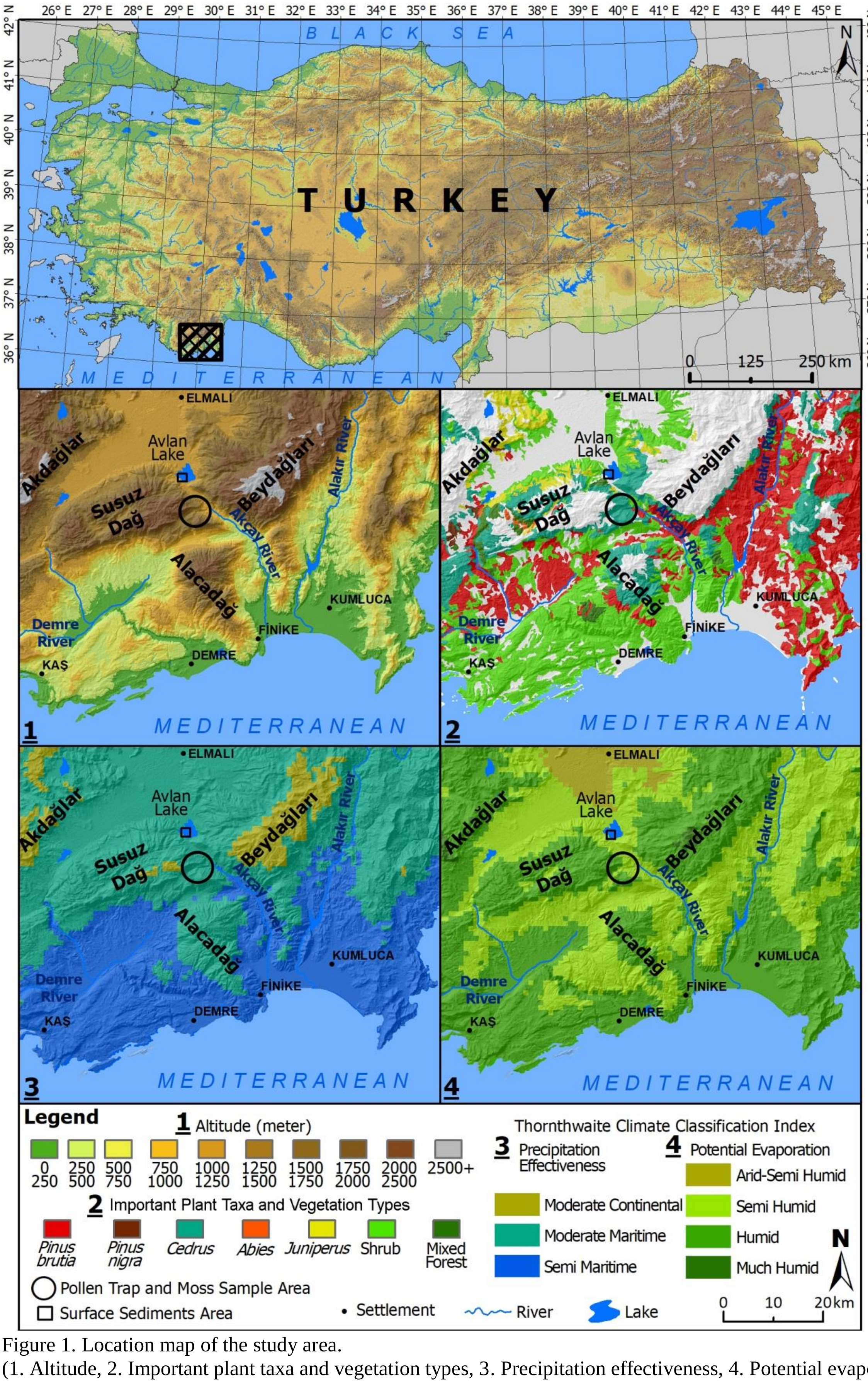

Figure 1. Location map of the study area.
(1. Altitude, 2. Important plant taxa and vegetation types, 3. Precipitation effectiveness, 4. Potential evaporation)

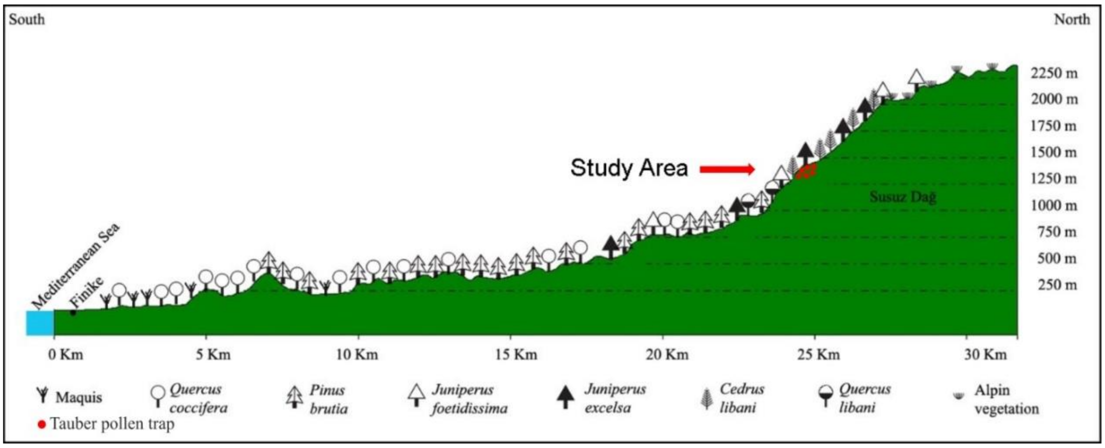

Figure 2. Mediterranean Sea-Susuz Dağ section and location of the Tauber pollen traps in the study area.

In the laboratory methodology applied to the Tauber pollen traps collected from the field, the principles of the EPMPP were followed. According to this protocol, the liquid in the Tauber pollen traps was filtered through a 180 mµ sieve. *Lycopodium* spore tablets dissolved in 10% HCl were added to the filtered liquid. The mixture of *Lycopodium* spore tablets dissolved with the liquid obtained from the traps was reduced to a single tube by centrifugation (for 5 minutes at 4000 rpm). Hot Potassium Hydroxide (10% KOH), Glacial Acetic Acid and acetolysis were applied to the remaining liquid in the single tube. After chemical procedures, the pollen grains in the tube were prepared using silicone oil (Hicks et al. 1996). Pollen counting and identification of pollen preparations were carried out with a computer-aided Leica DM750 branded light microscope, using x40 and x100 immersion lenses and 10x ocular lens. For pollen identification, the reference pollen preparations, pollen atlases (Moore et al. 1991, Reille 1995, Reille 1998, Reille 1999) were used, and PalDat (https://www.paldat.org) and Pollen info (https://www.polleninfo.org) websites were used. For each sample area, it was ensured that the counted land pollen (non-aquatic) was at least 200 (Hicks et al. 1996). The pollen influx per unit area of each taxon belonging to the samples was calculated and diagrammed using the Tilia 2.0.41 program (Grimm 2015).

Modern pollen data from the moss samples

A total of 6 moss samples were taken from the surrounding of the pollen traps placed at the points determined in the field. The principles of the EPMPP were followed in the laboratory methodology applied to moss samples obtained as a result of field studies. According to the protocol applied, Potassium Hydroxide (10% KOH) was added to the moss samples, and the samples were kept in a hot water bath, respectively. The moss samples taken from the water bath were filtered through a 180 mµ sieve, and the *Lycopodium* spore tablet was added to the filtered sample. The pollen liquid of the moss samples was reduced to a single tube by centrifugation (for 5 minutes at 4000 rpm). In the analysis of the Tauber pollen traps (procedures applied after reducing to a single tube), the procedures applied in the counting and the obtainment of diagrams were applied to the sample reduced to a single tube.

Modern pollen data from the surface sediment

Furthermore, a surface sediment sample was taken from Lake Avlan in 2017 with the Glew Corer sampler (Glew 1995), and the first 2 cm section of this sample was analyzed according to the classical fossil pollen method (Faegri and Iversen 1975, Moore et al. 1991).

Determination of plants around the pollen traps

Field studies were conducted between March and September in the years 2015-2017 in order to determine plant taxa around the pollen traps. In the study area, the principles of the EPMPP (Hicks et al. 1996) were applied to determine plant species around 0-10.5 m of each pollen trap within the forest area. According to these principles, the plant species in the 0-0.5 m, 0.5-1.5 m, 1.5-2.5 m, 2.5-3.5 m, 3.5-4.5 m, 4.5-5.5 m, 5.5-6.5 m, 6.5-7.5 m, 7.5-8.5 m, 8.5-9.5 m, 9.5-10.5 m circular area around the traps were identified and listed (Hicks et al. 1996).

Results

Pollen Influx from the Tauber Pollen Traps

According to the annual pollen influx data obtained from the CJQ-1-T sample area in Susuz Dağ-Finike for 2015-2016, the highest pollen influx belongs to *Cedrus libani* among the woody species with 4183 cm²/year. *Cedrus libani* is followed by *Pinus* sp. with 1701 cm²/year and *Juniperus* sp. with 1339 cm²/year, respectively. On the other hand, the pollen influx of herbaceous plants is very low (the most significant herbaceous plant pollen influx belongs to *Euphorbia* L. sp. with 251 cm²/year). In the CJQ-2-T sample area, the highest pollen influx belongs to the same woody and herbaceous taxa, but the annual pollen influxes are higher compared to the CJQ-1-T location. In the CJQ-3-T, the annual pollen influxes of *Cedrus libani*, *Pinus* sp., *Juniperus* sp. among the woody taxa were determined to be highest at this location among all sample areas. The annual pollen influx data of CJQ-4-T, CJQ-5-T, and CJQ-6-T among the sample areas belong to the same woody and herbaceous taxa. On the other hand, *Quercus coccifera* showed the highest pollen influx in this sample area only at the CJQ-5-T location with 1886 cm²/year (Figure 3). When the total annual pollen influxes among all sample areas were compared for the years 2015-2016, the highest annual pollen influx was determined in the CJQ-3-T sample area with 19949 cm²/year. The lowest annual pollen influx is in the CJQ-1-T with 8478 cm²/year. In all sample areas, the influx of herbaceous species in the CJQ-1-T sample area is quite low. At the CJQ-T location, the majority of the total pollen influx of the sample areas belongs to woody species (*Cedrus libani*, *Pinus* sp., *Juniperus* sp.). In the herbaceous species, the highest influx belongs to *Euphorbia* sp. in all sample areas (Figure 3).

In the years of 2016-2017, the highest pollen influx in the CJQ-1-T sample area belongs to woody species again (*Cedrus libani*, 4410 cm²/year; *Pinus* sp., 1440 cm²/year; *Quercus coccifera*, 776 cm²/year). The most important herbaceous plant pollen influx in the area belongs to *Euphorbia* sp. again with 488 cm²/year. No data could be provided for this location due to the damaged pollen trap placed in the CJQ-2-T sample area. In the CJQ-3-T, *Cedrus libani* has the highest pollen influx with 4916 cm²/year. *Cedrus libani* is followed by *Pinus* sp. (2396 cm²/year) and *Juniperus* sp. (2107 cm²/year), respectively. The most significant herbaceous plant pollen influx in the area belongs to *Euphorbia* sp. again (269 cm²/year) (Figure 3). At the CJQ-4-T, CJQ-5-T, and CJQ-6-T locations among the sample areas, the highest pollen influx for the years 2016-2017 belongs to the same woody taxa. At the CJQ-4-T and CJQ-6-T among these sample areas, the highest pollen influx of herbaceous plants belongs to the same species (*Euphorbia* sp.). In CJQ-5-T, herbaceous plants with a high pollen influx vary, while the highest influx belongs to the families of Caryophyllaceae and Poaceae (Figure 3).

When the total annual pollen influxes at the location of *Cedrus libani*-*Juniperus*-*Quercus* (CJQ-T) in Susuz Dağ-Finike were compared among all samples areas for the years 2016-2017, the highest pollen influx was determined in the CJQ-6-T sample area with 21706 cm²/year. The lowest total annual pollen influx was determined in the CJQ-1-T sample area with 8659 cm²/year. At the CJQ-T location, the majority of the total pollen influx of the sample areas belongs to woody species (*Cedrus libani*, *Pinus* sp., *Juniperus* sp.). In the herbaceous species, the highest influx belongs to *Euphorbia* sp. except for the CJQ-5-T sample area (Figure 3).

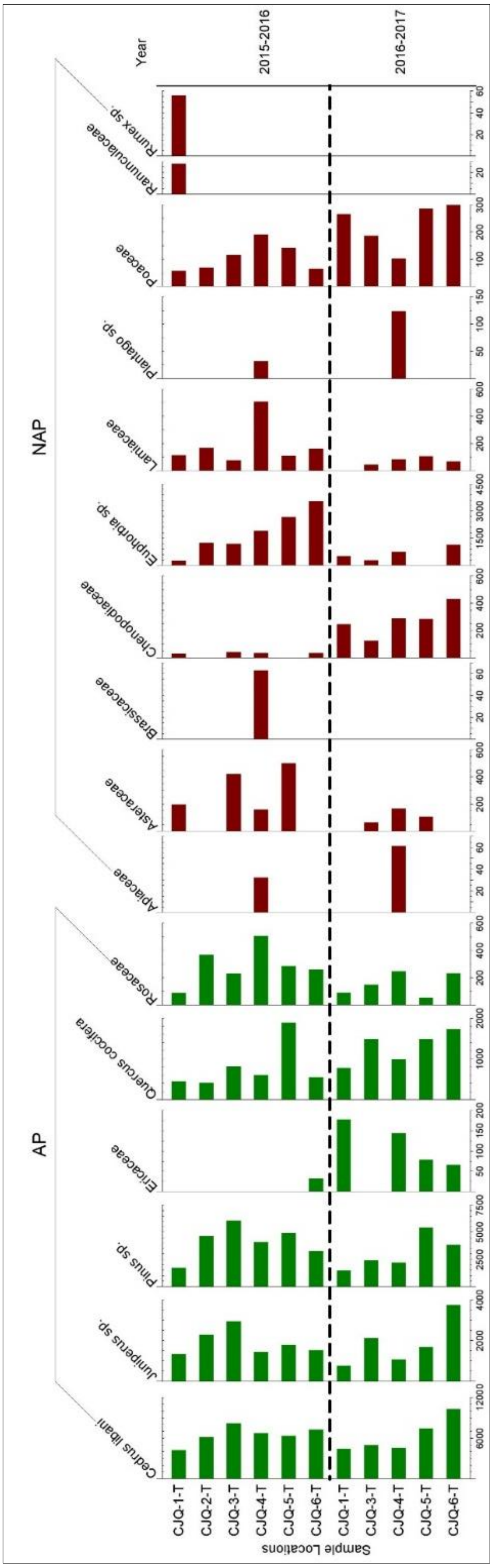

Figure 3. Pollen influx obtained from the Tauber pollen traps between 2015-2017 at the location of *Cedrus libani -Juniperus* sp.-*Quercus* sp. (CJQ).

Pollen Influx from the Mosses

In 2015-2016, the highest pollen influx in the CJQ-1-Y sample area belongs to *Cedrus libani* (2114 cm²/year) and *Pinus* sp. (1705 cm²/year) among the woody species. The herbaceous plant influx in the area is quite low compared to the woody plant influx. In the CJQ-2-Y and CJQ-3-Y sample areas, the highest pollen influx belongs to *Cedrus libani* among woody species, followed by *Pinus* sp. (Figure 4). In the CJQ-4-Y, CJQ-5-Y, and CJQ-6-Y sample areas, the highest pollen influx belongs to woody species (*Cedrus libani,* 3787 cm²/year; *Pinus* sp., 2702 cm²/ year; *Quercus coccifera*, 1404 cm²/ year). The most significant herbaceous plant pollen influx in these sample areas belongs to the Asteraceae family and *Euphorbia* sp. (Figure 4).

When woody plant influx data in all sample areas are compared for 2015-2016, the highest pollen influx belongs to *Cedrus libani, Pinus* sp., and *Quercus coccifera*. Although the herbaceous plant pollen influxes in these sample areas are very low, Asteraceae influx stands out (Figure 4).

In 2016-2017, the highest pollen influx in the CJQ-1-Y sample area belongs to woody species (*Cedrus libani*, 6843 cm²/year; *Pinus* sp., 1798 cm²/year). The herbaceous plant influx is quite low in the area, and the highest influx belongs to Asteraceae with 241 cm²/year. The moss sample of the CJQ-2-Y could not be analyzed due to the damaged trap in this area. In the CJQ-3-Y, the highest pollen influx belongs to woody species (*Cedrus libani*, 4417 cm²/year; *Pinus* sp., 1434 cm²/year, *Quercus coccifera*, 994 cm²/year). The herbaceous plant pollen influx is quite low. In the CJQ-4-Y sample area, the highest pollen influx belongs to woody species (*Cedrus libani*, 4964 cm²/year; *Quercus coccifera*, 2188 cm²/year). The highest herbaceous plant influx belongs to *Euphorbia* sp. (709 cm²/year). In the CJQ-5-Y, the highest pollen influx belongs to woody species (*Cedrus libani*, 4374 cm²/year; *Quercus coccifera*, 1133 cm²/year; *Pinus* sp., 775 cm²/year). The herbaceous plant pollen influx is low, and the highest influx belongs to Asteraceae with 278 cm²/year, and Poaceae with 119 cm²/year. In the CJQ-6-Y sample area, the highest pollen influx belongs to woody species (*Cedrus libani*, 3538 cm²/year; *Quercus coccifera*, 1321 cm²/year; *Pinus* sp., 1142 cm²/year). The highest herbaceous plant pollen influx belongs to Asteraceae with 470 cm²/year, Apiaceae and Poaceae taxa with 112 cm²/year (Figure 4).

When woody plant influx data in all sample areas are compared for 2016-2017, the highest pollen influx belongs to *Cedrus libani, Pinus* sp., and *Quercus coccifera*, while an increase is observed in the influx of *Juniperus* sp. compared to 2015-2016. The herbaceous plant pollen influxes in these sample areas have increased, and the highest pollen influx belongs to Asteraceae, *Euphorbia* sp. and Poaceae (Figure 4).

Pollen Influx from the Surface Sediment

In the pollen analysis of the surface sediment taken from Lake Avlan, the annual woody plant pollen influx is 25280 cm²/year. *Pinus* sp. (15535 cm²/year) is in the first place in this pollen influx, followed by *Cedrus libani* (7051 cm²/year), *Abies* Mill. sp. (917 cm²/year), *Castanea sativa* Mill. (516 cm²/year), *Quercus cerris* type (a group of deciduous oaks) (401 cm²/year), *Olea europaea* L. and *Ephedra* L. sp., respectively. Other important woody taxa, which have a small amount of pollen influx, include *Alnus* Mill. sp., *Ostrya carpinifolia* Scop., and *Salix* L. sp. In the pollen analysis of the surface sediment taken from Lake Avlan, the annual herbaceous plant pollen influx is 3382 cm²/year. The highest pollen influx belongs to *Ranunculus* L. sp. (1318 cm²/year), followed by *Anthemis* type (343 cm²/year). Other important herbaceous plant taxa, which have a small amount of pollen influx, are Brassicaceae, Caryophyllaceae, *Artemisia* L. sp., Chenopodiaceae, *Plantago lanceolata* L., and Poaceae (Figure 5).

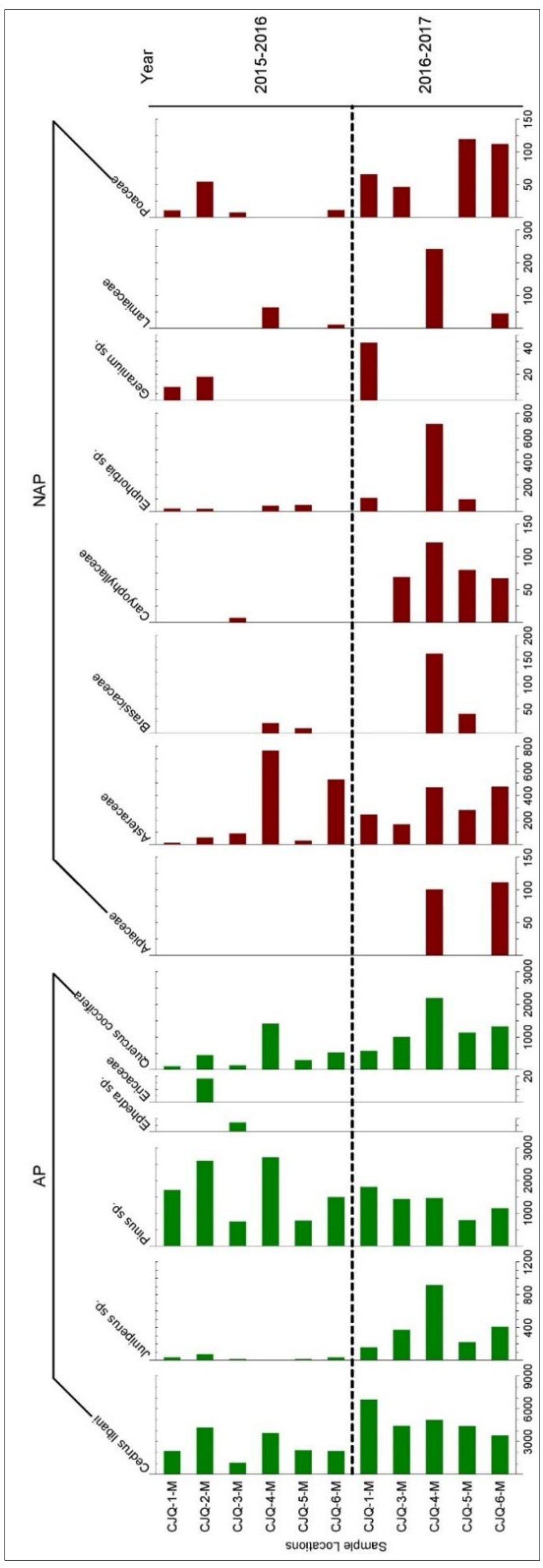

Figure 4. Pollen influx obtained from the moss samples between 2015-2017 at the location of *Cedrus libani* – *Juniperus* sp.-*Quercus* sp. (CJQ).

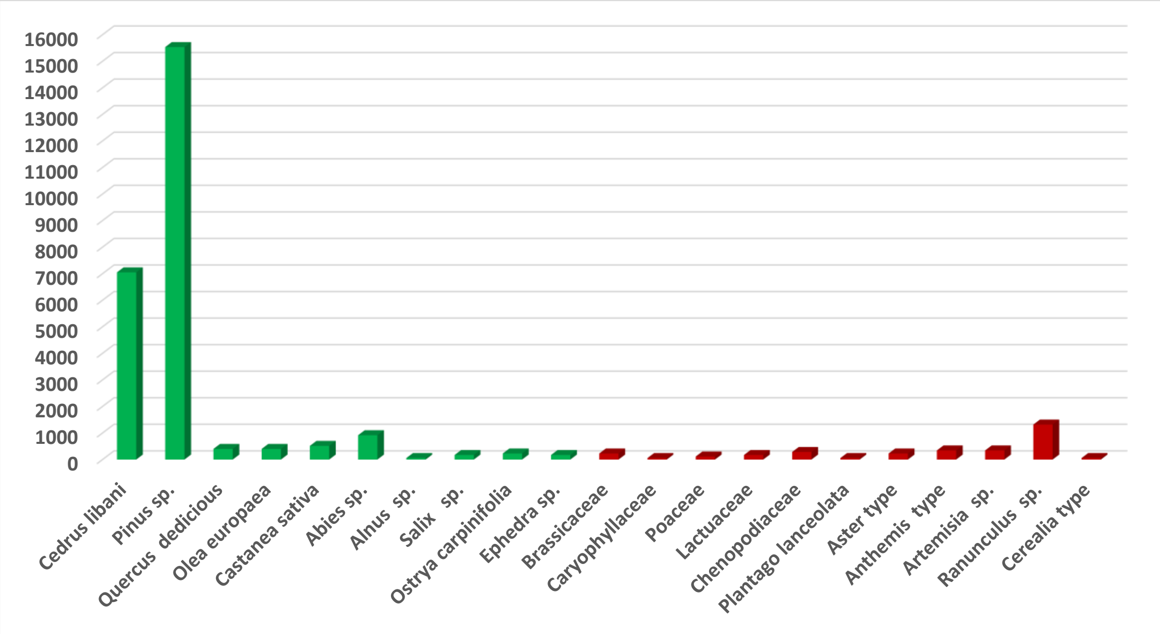

Figure 5. Pollen influx obtained from the surface sediment of Lake Avlan for 2017.

Findings of plant taxa

The woody species around the traps are composed of *Cedrus libani*, *Juniperus excelsa*, *Juniperus foetidissima*, *Juniperus oxycedrus*, *Quercus coccifera*, *Hippocrepis emerus*, *Lonicera* sp., *Styrax officinalis*, and *Cotinus coggygria*. In the pollen analysis, *Pinus* sp., which has a high and significant concentration, was not found around the traps. The herbaceous species vary in the sample areas because of the canopy cover of the woody species. Among the herbaceous species, *Vinca* L. sp., *Geranium* L. sp., *Salvia tomentosa* Mill., and *Lapsana* L. sp. are common species around the traps (Table 3).

Table 3. Plant taxa around the pollen traps.

Distance to Pollen Trap	Sample Received		
	CJQ-1-T	CJQ-2-T	CJQ-3-T
0-0.5 m			*Vinca* sp., *Scorzonera* (L.) sp., *Ornithogalum* (L.) sp.,
0.5-1.5 m	*Veronica* (L.) sp., *Geranium* (L.) sp.	*Cedrus libani*	*Ornithogalum* sp., *Silene italica*
1.5-2.5 m	*Juniperus excelsa*, *Veronica* sp., *Geranium* sp.	*Juniperus excelsa*	*Styrax officinalis*, *Ornithogalum* sp., *Salvia tomentosa*
2.5-3.5 m	*Cedrus libani*, *Juniperus excelsa*, *Geranium* sp.	*Juniperus excelsa*, *Juniperus oxycedrus*	*Quercus coccifera*, *Lonicera* sp., *Ornithogalum* sp.
3.5-4.5 m	*Cerastium* (L.) sp., *Lonicera* (L.) sp., *Geranium* sp.	*Juniperus excelsa*, *Juniperus oxycedrus*, *Salvia* sp.	*Cedrus libani*, *Quercus coccifera*, *Juniperus foetidissima*, *Lapsana* sp.
4.5-5.5 m	*Juniperus excelsa*, *Juniperus oxycedrus*	*Cedrus libani*, *Juniperus oxycedrus*, *Anthemis* sp.	*Vinca* sp., *Ornithogalum* sp., *Silene italica*, *Salvia tomentosa*, *Astragalus* (L.) sp.
5.5-6.5 m	*Juniperus oxycedrus*, *Geranium* sp., *Vinca* (L.) sp.	*Cedrus libani*, *Salvia* sp.	*Quercus coccifera*, *Juniperus excelsa*, *Juniperus oxycedrus*, *Geranium* sp., *Saponaria* (L.) sp.
6.5-7.5 m	*Juniperus foetidissima*, *Juniperus excelsa*, *Juniperus oxycedrus*, *Cerastium* sp., *Geranium* sp.	*Cedrus libani*, *Anthemis* sp., *Phlomis grandiflora* H.S. Thompson	*Juniperus foetidissima*, *Salvia tomentosa*, *Saponaria* sp., *Briza* (L.) sp., *Alyssum* (L.) sp.

7.5-8.5 m	*Cedrus libani*, *Juniperus foetidissima*, *Juniperus excelsa*, *Juniperus oxycedrus*, *Quercus coccifera*, *Cerastium* sp., *Geranium* sp., *Lamium* (L.) sp., *Salvia* (L.) sp., *Anthemis* (L.) sp.	*Cedrus libani*, *Juniperus excelsa*, *Juniperus oxycedrus*, *Quercus coccifera*, *Hippocrepis emerus*, *Salvia* sp., *Phlomis grandiflora*, *Silene italica* (L.) Pers., *Lamium* sp.	*Cedrus libani*, *Quercus coccifera*, *Juniperus excelsa*, *Juniperus foetidissima*, *Vinca* sp., *Ornithogalum* sp., *Silene italica*, *Lapsana* sp., *Geranium* sp., *Saponaria* sp., *Alyssum* sp., *Lapsana communis* L., *Lamium* sp., *Brachypodium* (L.) sp., *Ajuga* (L.) sp., *Cerastium* sp., *Anthemis rosea* Sm., *Erysimum* (L.) sp.
8.5-9.5 m	*Cedrus libani*, *Juniperus foetidissima*, *Juniperus oxycedrus*, *Hippocrepis emerus*, *Lonicera* sp., *Lamium* sp., *Anthemis* sp.	*Cedrus libani*, *Juniperus foetidissima*, *Silene italica*, *Lamium* sp.	*Cedrus libani*, *Quercus coccifera*, *Juniperus foetidissima*, *Lonicera* sp., *Ornithogalum* sp., *Lapsana* sp., *Geranium* sp., *Briza* sp., *Lapsana communis*, *Lamium* sp., *Cerastium* sp.
9.5-10.5 m	*Cedrus libani*, *Juniperus excelsa*, *Juniperus oxycedrus*, *Hippocrepis emerus*, *Cerastium* sp., *Lonicera* sp., *Vinca* sp., *Lamium* sp.	*Cedrus libani*, *Juniperus foetidissima*, *Juniperus oxycedrus*, *Silene italica*	*Quercus coccifera*, *Juniperus excelsa*, *Vinca* sp., *Lapsana* sp., *Lapsana communis*, *Lamium* sp., *Ajuga* sp.
	CJQ-4-T	CJQ-5-T	CJQ-6-T
0-0.5 m	*Vinca* sp., *Scorzonera* sp., *Ornithogalum* sp.	*Brachypodium* sp. *Geranium* sp.	*Brachypodium* sp. *Geranium* sp.
0.5-1.5 m	*Scorzonera* sp., *Ornithogalum* sp.	*Quercus coccifera*, *Geranium* sp., *Briza* sp., *Lapsana* sp.	*Quercus coccifera*, *Geranium* sp., *Briza* sp., *Lapsana* sp.
1.5-2.5 m	*Styrax officinalis*, *Ornithogalum* sp., *Salvia tomentosa*	*Cedrus libani*, *Juniperus foetidissima*, *Valeriana* (L.) sp., *Lamium* sp.	*Cedrus libani*, *Juniperus foetidissima*, *Briza* sp., *Valeriana* sp., *Lamium* sp.
2.5-3.5 m	*Quercus coccifera*, *Juniperus foetidissima*, *Lonicera* sp., *Ornithogalum* sp.	*Juniperus excelsa*, *Juniperus foetidissima*, *Brachypodium* sp., *Geranium* sp., *Valeriana* sp., *Ornithogalum* sp.	*Juniperus excelsa*, *Juniperus foetidissima*, *Brachypodium* sp., *Geranium* sp., *Valeriana* sp., *Silene* sp., *Ornithogalum* sp.
3.5-4.5 m	*Cedrus libani*, *Quercus coccifera*, *Juniperus foetidissima*, *Juniperus oxycedrus*, *Lapsana* sp.	*Quercus coccifera*, *Juniperus excelsa*, *Lapsana* sp., *Lamium* sp., *Alyssum* sp., *Aubrieta pinardii* Boiss., *Orchis* (L.) sp.	*Quercus coccifera*, *Juniperus excelsa*, *Lapsana* sp., *Alyssum* sp., *Aubrieta pinardii*, *Orchis* sp., *Lamium* sp.
4.5-5.5 m	*Juniperus foetidissima*, *Vinca* sp., *Ornithogalum* sp., *Silene italica*, *Salvia tomentosa*, *Astragalus* sp.	*Briza* sp., *Lapsana* sp., *Fibigia* (Medik.) sp., *Salvia tomentosa*, *Cerastium* sp.	*Briza* sp., *Lapsana* sp., *Fibigia* sp., *Salvia tomentosa*, *Cerastium* sp., *Silene* (L.) sp.
5.5-6.5 m	*Quercus coccifera*, *Juniperus excelsa*, *Geranium* sp., *Saponaria* sp.	*Valeriana* sp., *Phlomis grandiflora*, *Erysimum* sp.	*Phlomis grandiflora*, *Erysimum* sp., *Valeriana* sp.
6.5-7.5 m	*Salvia tomentosa*, *Geranium* sp., *Saponaria* sp., *Briza* sp.	*Juniperus foetidissima*, *Cotinus coggygria*, *Geranium* sp., *Aubrieta pinardii*	*Juniperus foetidissima*, *Cotinus coggygria*, *Geranium* sp., *Picnomon acarna* (L.) Cass., *Aubrieta pinardii*, *Salvia tomentosa*, *Allium* (L.) sp.
7.5-8.5 m	*Quercus coccifera*, *Juniperus excelsa*, *Juniperus foetidissima*, *Juniperus oxycedrus*, *Vinca* sp., *Ornithogalum* sp., *Silene italica*, *Lapsana* sp., *Geranium* sp., *Saponaria* sp., *Alyssum* sp., *Lapsana communis*, *Lamium* sp.,	*Cedrus libani*, *Juniperus excelsa*, *Juniperus foetidissima*, *Lamium* sp., *Ornithogalum* sp., *Cerastium* sp., *Phlomis grandiflora*, *Muscari* (Mill.) sp.	*Cedrus libani*, *Juniperus excelsa*, *Juniperus foetidissima*, *Cerastium* sp., *Phlomis grandiflora*, *Lamium* sp., *Picnomon acarna*, *Ornithogalum* sp., *Muscari* sp., *Salvia tomentosa*, *Allium* sp.

8.5-9.5 m	*Brachypodium* sp., *Ajuga* sp., *Cerastium* sp., *Anthemis rosea*, *Erysimum* sp. *Quercus coccifera*, *Juniperus foetidissima*, *Vinca* sp., *Ornithogalum* sp., *Geranium* sp., *Alyssum* sp., *Lamium* sp., *Anthemis rosea*, *Erysimum* sp.	*Juniperus excelsa*, *Lapsana* sp., *Lamium* sp., *Orchis* sp., *Salvia tomentosa*	*Quercus coccifera*, *Juniperus foetidissima*, *Geranium* sp., *Lamium* sp., *Picnomon acarna*, *Orchis* sp., *Cerastium* sp., *Muscari* sp.
9.5-10.5 m	*Quercus coccifera*, *Juniperus excelsa*, *Ornithogalum* sp., *Salvia tomentosa*, *Geranium* sp., *Briza* sp., *Lamium* sp.	*Cedrus libani*, *Fibigia* sp., *Salvia tomentosa*	*Juniperus foetidissima*, *Cerastium* sp., *Phlomis grandiflora*, *Lamium* sp., *Picnomon acarna*, *Erysimum* sp., *Allium* sp.

Comparison of the Pollen Influxes

According to the total pollen influx values obtained from the traps and the mosses for the years 2015-2017, the total pollen influxes obtained from the traps at all locations for 2015-2016 are higher than the total pollen influxes obtained from the mosses. In 2016-2017, the total pollen influxes of the moss are higher in only two sample areas (CJQ-1 and CJQ-4) (Figure 6).

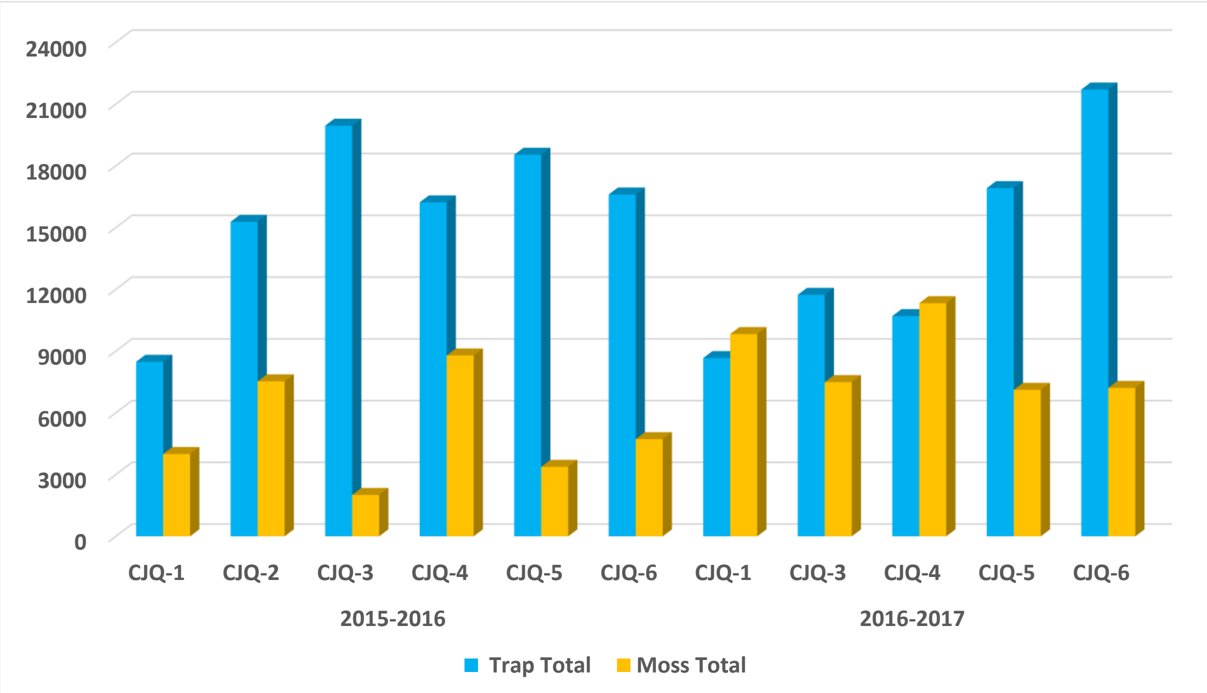

Figure 6. Total pollen influxes obtained from the traps and the mosses between 2015-2017 for all sample areas (cm^2/year) at the location of *Cedrus libani-Juniperus-Quercus* (CJQ).

When the pollen data at the location of *Cedrus libani-Juniperus-Quercus* for 2015-2017 are compared in terms of both sample areas and annual total pollen influx, the majority of pollen influx belongs to AP taxa (*Cedrus libani*, *Pinus* sp., *Quercus coccifera*, *Juniperus* sp.) (Figure 6). In all sample areas (in the Tauber pollen traps, moss samples), the highest influx between the years 2015-2017 belongs to *Cedrus libani*. However, in the surface sediment sample obtained from Lake Avlan, the highest influx belongs to *Pinus* sp. Pollen influx values at the location of *Cedrus libani*-*Juniperus*-*Quercus* (CJQ-Y) increased in all sample areas in 2016-2017.

In the study area, the modern pollen percentage for the Tauber pollen traps, the moss samples, and the surface sediment sample was obtained for 2016-2017 (Figure 7). According to these data, the pollen percentage of herbaceous species (for the Tauber pollen traps, moss samples, surface sediment sample) was low at the CJQ location. Therefore, the ratio of woody species was stated. The taxa with the highest pollen percentage in the CJQ-1-T sample area are *Cedrus libani* (46.4%), *Juniperus* sp. (16.8%), *Pinus* sp. (15.1%), and *Quercus coccifera* (8.1%). The ratio of AP is 89.5%, and the ratio of non-arboreal (NAP) is 10.5%. In the CJQ-2-T sample area, the trap was damaged. The taxa with the highest ratio in the CJQ-3-T are *Cedrus libani* (41.9%), *Pinus* sp. (20.4%), *Juniperus* sp. (17.9%), and *Quercus coccifera* (12.6%). The ratio of AP is 94.1%, and the ratio of NAP is 5.9%. The taxa with the highest ratio in the CJQ-4-T sample area are *Cedrus libani* (42.2%), *Pinus* sp. (20.4%), *Juniperus* sp. (9.9%), and *Quercus coccifera* (9.1%). The ratio of AP is 85.5%, and the ratio of NAP is 14.5%. The taxa with the highest ratio in the CJQ-5-T are *Cedrus libani* (43.8%), *Pinus* sp. (32%), *Juniperus* sp. (9.9%), and *Quercus coccifera* (8.7%). The ratio of AP is 95.4%, and the ratio of NAP is 4.6%. The taxa with the highest ratio in the CJQ-6-T sample area are *Cedrus libani* (47%), *Pinus* sp. (18%), *Juniperus* sp. (17%), and *Quercus coccifera* (8%) (Figure 7). The ratio of AP is 91.1%, and the ratio of NAP is 8.9% (Figure 8).

The taxa with the highest pollen percentage in the CJQ-1-Y sample area are *Cedrus libani* (69.6%), *Pinus* sp. (13.3%), *Quercus coccifera* (5.8%), and *Juniperus* sp. (1.5%). The ratio of AP is 94.2%, and the ratio of NAP is 4.7%. Since the trap was damaged in the CJQ-2-Y sample area, no analysis was performed. The taxa with the highest ratio in the CJQ-3-Y are *Cedrus libani* (58.9%), *Pinus* sp. (19.1%), *Quercus coccifera* (13.2%), and *Juniperus* sp. (4.9%). The ratio of AP is 96.2%, and the ratio of NAP is 3.8%. The taxa with the highest ratio in the CJQ-4-Y are *Cedrus libani* (43.8%), *Quercus coccifera* (19.3%), *Pinus* sp. (12.8), and *Juniperus* sp. (8%). The ratio of AP is 84%, and the ratio of NAP is 16%. The taxa with the highest ratio in the CJQ-5-Y sample area are *Cedrus libani* (61.4%), *Quercus coccifera* (15.9%), *Pinus* sp. (10.8%), and *Juniperus* sp. (3%). The ratio of AP is 91.3%, and the ratio of NAP is 8.7%. The taxa with the highest ratio in the CJQ-6-Y are *Cedrus libani* (49%), *Quercus coccifera* (18.3%), *Pinus* sp. (15.8%), and *Juniperus* sp. (5.5%) (Figure 7). The ratio of AP is 88.8%, and the ratio of NAP is 11.2% (Figure 8).

In the surface sediment sample obtained from Lake Avlan, taxa with the highest pollen percentage were *Pinus* sp. (54.2%) and *Cedrus libani* (24.6%). The pollen percentages of *Quercus coccifera* and *Juniperus* sp. were not found (Figure 7). The ratio of AP is 88.8%, and the ratio of NAP is 11.2% (Figure 8).

When the modern pollen percentage obtained from the Tauber pollen traps, moss and surface sediment samples at the location of *Cedrus libani*-*Juniperus* sp.-*Quercus* sp. are evaluated (Figure 7 and 8), 78.8 to 96.2% of the pollen percentage distribution consists of four woody taxa (*Cedrus libani*, *Juniperus* sp. *Pinus* sp., and *Quercus coccifera*). 84 to 96.2% of the pollen percentage distribution in the samples of the Tauber pollen traps, mosses, and surface sediments consists of the AP ratio (Figure 7 and 8).

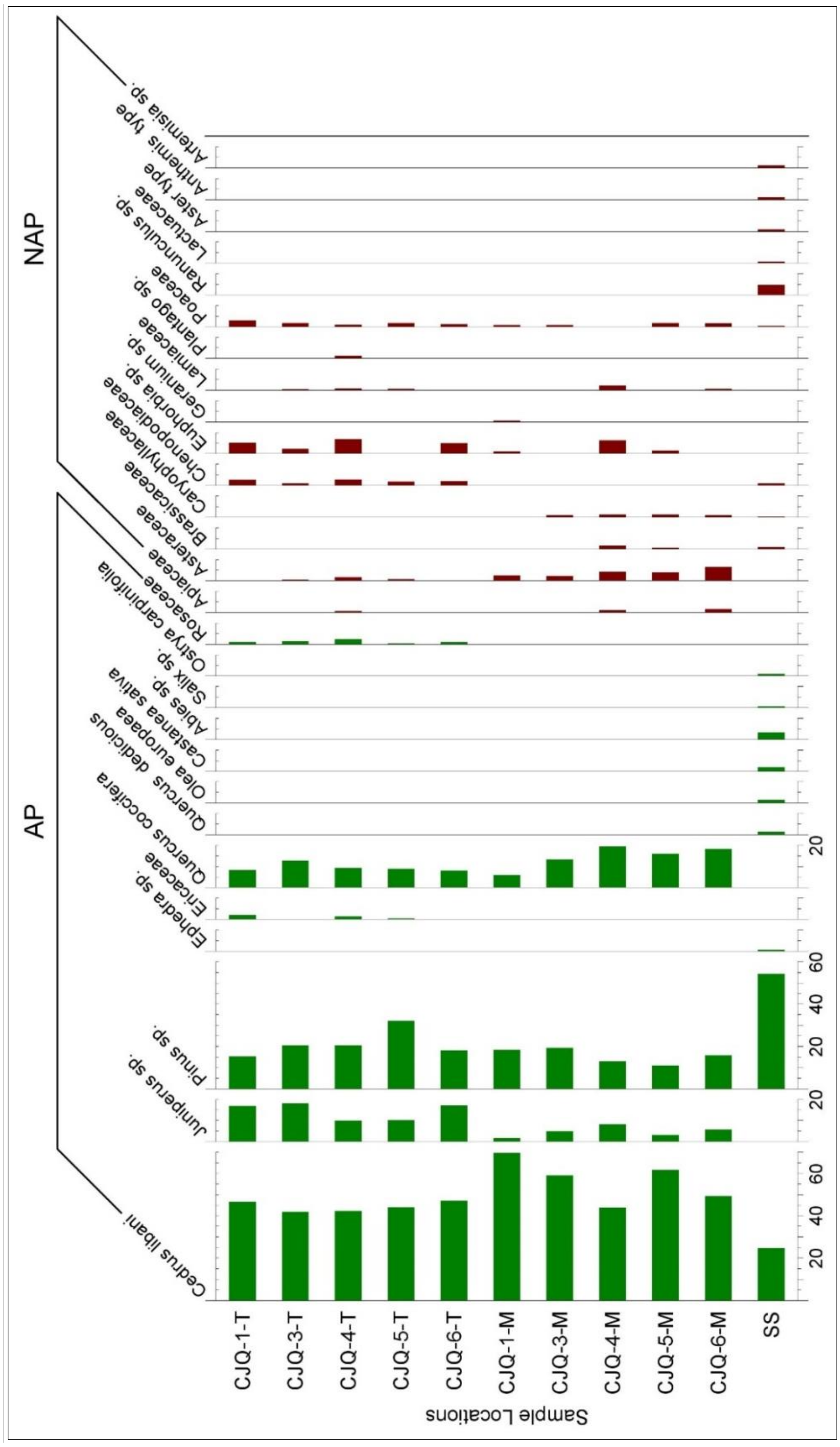

Figure 7. Pollen percentage obtained from the samples of Tauber pollen traps, mosses and surface sediment (for 2016-2017) at the location of *Cedrus libani-Juniperus sp.-Quercus sp.* (CJQ).
(CJQ-1-T, CJQ-3-T, CJQ-4-T, CJQ-5-T and CJQ-6-T belong to Tauber pollen traps, CJQ-1-M, CJQ-3-M, CJQ-4-M, CJQ-5-M and CJQ-6-M belong to mosses, SS belongs to the surface sediment sample).

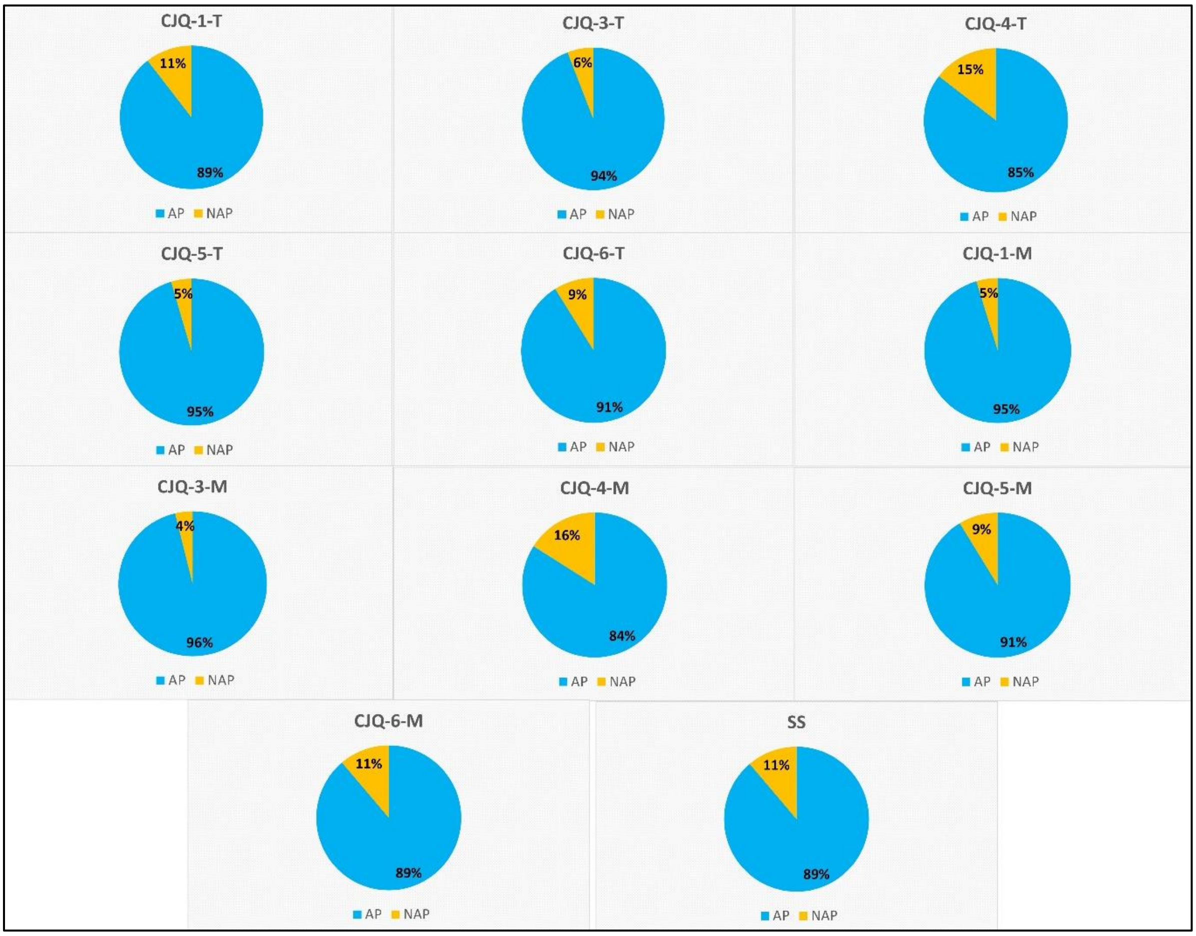

Figure 8. Comparison of the pollen percentages obtained from the samples of Tauber pollen traps, mosses and surface sediment (for 2016-2017) in terms of AP and NAP.

Discussion and Conclusion

Woody taxa (*Cedrus libani*, *Juniperus*, and *Quercus coccifera*) and herbaceous taxa (*Euphorbia*, Caryophyllaceae, Poaceae, Asteraceae, Lamiaceae, Brassicaceae, and Apiaceae), which have the highest pollen influx between the years 2015-2017 in the Tauber pollen traps and moss samples, are found in the vegetation. The modern pollen influxes obtained from this study reflect the vegetation. Although *Pinus* sp. is not found in the vegetation, it is among the taxa with the highest influx. While *Pinus* sp. produces a large amount of pollen, it can easily be carried by the wind at very long distances with the help of bubble vesicles (Faegri and Iversen 1989, Szczepanek et al. 2017). According to this information, the modern pollen influxes reflect the local vegetation structure, and they show that the transport of *Pinus* sp. to the field is quite important.

According to the modern pollen percentage values obtained in the *Cedrus libani*-*Juniperus*-*Quercus* forest, the majority of modern pollen percentage distribution (between 84% and 94%) in the study area consists of AP taxa. Among these taxa, *Cedrus libani*, *Pinus* sp., *Quercus coccifera*, *Juniperus* sp. account for almost all of the AP percentage. *Cedrus libani* has a percentage of more than 41% in the modern pollen AP percentage obtained from the Tauber pollen traps and moss samples. However, the percentage of *Cedrus libani* decreased to 24.6% in the surface sediment sample obtained from Lake Avlan. *Pinus* sp., which has an average value of 18% in the Tauber pollen traps and moss samples, has a percentage of 54.2% in the surface sediment sample. In the study of Bottema and Woldring (1984) the percentage of *Pinus* pollen was higher than *Cedrus* pollen in the top zone of the pollen diagram obtained from Lake Avlan. As a result of this study, the pollen percentages obtained from the Tauber pollen traps, moss, and surface sediment samples were compared with the study of Bottema and Woldring (1984) the taxa with the highest woody pollen percentage were found to be the same (*Cedrus, Pinus, Quercus,* and *Juniperus*). In this context, by carrying out the modern pollen monitoring studies at different vegetation points, previously obtained fossil pollen diagrams have become more comfortable to interpret.

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