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# Soil chemistry and microbial activity after a surface fire in a mixed temperate forest

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**Abstract**

Fire-affected soils have recently received more attention in soil science because some of the atmospheric $CO_2$ emissions have directly been driven from soils during fires and climate change has increased fire frequency in many ecosystems of Earth. However, low-intensity surface fires and their effects on soil properties have been relatively less studied in comparison to moderate to high-intensity crown fires. In this study, the effect of a surface fire on the chemical and biological properties of soil with a thick organic layer was investigated in a mixed forest stand dominated by *Castanea sativa*, *Fagus orientalis* and *Pinus nigra ssp. pallasiana* in Bursa Province, Turkey. Soil samples were taken from burned and unburned (control) sites in three periods: December 2011, July 2012, and November 2013. Samples were analyzed to determine some chemical and biological properties in the soil. We tested the effect of fire and period on each variable by two-way ANOVA analysis. The results indicated that Nt and OM were not affected by fire, while C / N ratio decreased. The difference between the periods was significant as regards OM and acid phosphatase enzyme activity. Fire resulted in a significant increase in soil pH, Ca, Mg and no significant change in $P_2O_5$. Although we found that surface fires limited the effect on soil properties, we concluded that there might be positive interactions between increased available nutrients in the soil and the burning of soil with relatively low severity. Prescribed fire can be proposed as a management tool to mitigate fire risks and short-time enrichment of available soil nutrients in these ecosystems.

**Key words:** C / N ratio, enzyme activities, forest, soil nutrients, and surface fire.

## Inroduction

Soil holds vast reserves of carbon, which is two times more than the one held by the atmosphere, and provides food and fresh water security besides hosting biodiversity; therefore, it deserves much greater attention as the biggest environmental matter from the perspective of both climate change and human health (Mol and Keesstra 2012, Keesstra et al. 2016.) The effects of fire on soil are substantially caused by changes in nutrient amounts and cycles (Giardina et al. 2000, Knoepp et al. 2004). Temperate forest soils usually have low nutrient availability while the most limiting nutrient is Nitrogen (N) (Knoepp et al. 2004). Maintenance of plant growth depends on the internal cycling of nutrients in native forests (Perala and Alban 1982, Cole 1995). Due to the consumption and/or

alteration of forest floor and woody fuels through prescribed burning or wildfire, both the quantity of nutrient-containing materials and the patterns of nutrient release change, and this process may indirectly affect soil nutrients (Knoepp et al. 2004). The release of available nutrients through the combustion of organic matter may be a significant natural source of plant growth (Kara and Bolat 2009). In fact, the decomposition rates on forest-floor may increase after burning, releasing $NH_4^+$ and other nutrients (Schoch and Binkley 1986, Khanna et al. 1994, Raison et al. 1990, Boydak et al. 1996). Decreasing decomposition rates due to the limited available organic matter after fire may eliminate this response in time (Raison et al. 1990). Since burning alters the nutrient status of soil; some other components of burning such as ash and debris nutrient content and quantity, nutrient loss with ash, amount of non-plant available nutrients' conversion into mineral forms due to thermal transformation, microbial biomass and activity (Giardina et al. 2000) (i.e. microbial enzyme activity, C and N mineralization rates) depend on nutrient status and they also deteriorate because of fire.

Many studies have been conducted on the effects of wildfire or prescribed fire on the physical and chemical (Eron 1977, Eron and Gürbüzer 1988, Neyişçi 1989, Neyişçi et al. 2002, Kantarcı et al. 1986, Kutiel and Shaviv 1992, Boydak et al. 1996, Esquilin et al. 2008, Gürlevik et al. 2009, Tavşanoğlu and Gürkan 2010, Yıldız et al. 2010) and biological (Akburak et al. 2017, Acea and Carballas 1996, Hernandez 1997, Villar et al. 2004, Kara and Bolat 2009) properties of soil in coniferous forests of Mediterranean and temperate zones, where crown fire regimes are dominant. Many ecosystems that are not exposed to frequent crown fires such as tropical and temperate broadleaved rainforests were also studied to explore the effects of fire on soil properties (Turgay et al. 2002, Barreiro et al. 2015). However, relatively less attention has been given to post-fire changes in soil's physical, chemical and microbial properties in mixed temperate forests where surface fire regimes prevail (see Knoepp et al. 2004, Swallow 2009). There is a lack of information especially about the changes in enzyme activity as an early and sensitive indicator (Taşkın anda Kızılkaya, 2006) and its relation with nutrient mineralization in the soil after burning of the forest floor following surface fires.

Temperate deciduous forests are among the most threatened ecosystems on Earth. Fire is one of the major disturbances affecting forests of temperate zone (Frelich 2002), whereas high-intensity crown fire is rare in these ecosystems (Matlack 2013). Therefore, fire return intervals are more than 800 years for crown fires, while decreasing as short as 21 years for surface fires (Brown et al. 1999).

The aim of this study was to assess the effects of surface fire on the chemical and biological properties of soil in a mixed temperate forest. Due to the low-intensity of surface fires in temperate forest ecosystems (Matlack 2013), we hypothesized that fire had a little effect on soil properties in these forests and, if any, post-fire regeneration would occur in a very short time. To test these hypotheses, we collected and analyzed soil samples for two years after fire in a burned mixed deciduous-coniferous forest in the northwest of Turkey, and we determined the changes in the chemical and biological properties of the soils.

## 1. Materials and methods

### 2.1. Study area

The study was conducted in a mixed broadleaved-coniferous forest in Uludağ, Bursa, northwest Turkey (40°09'27" N, 29°10'01" E, 630-870 m).


Figure 1. The location of the study area.

The dominant trees of the forests in the study area were *Castanea sativa* (sweet chestnut), *Fagus orientalis* (oriental beech) and *Pinus nigra* ssp. *pallasiana* (Anatolian black pine). About 78 ha forest area was burnt by a low-severity surface fire in December 2011. The study area is located on non-calcareous volcanic substrates and the soil texture consists of 70% sand, 12% silt, and 18% clay. The climate is sub-Mediterranean with 3-months dry period.

### 2.2. Soil sampling

The field studies were conducted in the burned and unburned sites of the study area to collect soil samples. The first sampling was conducted just one week after the fire (in December 2011) to assess the immediate effect of fire on soil properties. The second and the third samplings were performed seven months (in July 2012) and two years (November 2013) following the fire, respectively.

In each field study period, a total of 54 soil samples were taken from the surface distributed evenly to three replicate plots of 1 ha in size during the abovementioned periods. Sampling depth was determined as 0-15 cm and 15-30 cm considering the change in the soil surface roughness and the thickness of the organic layer. Three soil sampling points were determined randomly through a transect line in each plot. A group of soil samples were sieved (2 mm mesh) and stored at 4° C for soil biological analysis.

### 2.3. Soil analysis

Soil pH was determined in a 1 : 5 (v / v) soil/water solution (TS ISO 10390 2013). Soil electrical conductivity (EC) was determined in a 1 : 5 (m / v) soil/water solution (TS ISO 11265 1996). Total organic carbon (Corg) content was measured by Walkley-Black (TS 8336 1990) and, organic matter by multiplying Corg with 1.72. Total carbonate ($CaCO_3$) was determined by volumetric

method (TS 8335 ISO 10693 1996). Available phosphorus ($P_2O_5$) was determined according to the method of Bray-Kurtz (TS 8338 1990), and available K was determined by flamephotometer in $NH_4OAc$ extract according to the method described by Turkish Standard TS 8341 (1990). Ca and Mg were also extracted with $NH_4OAc$ and determined by atomic absorption spectrometer (Kacar 2009). Total N (Nt) content was determined by Kjeldahl digestion with the Kjeltec Auto 1030 Analyzer (Tecator 1987), and water content was determined gravimetrically after the soil was oven-dried for 24 h at 105°C (TS ISO 11465 1997). Acid phosphatase and β-D glucosidase activities were determined using 1.5 g of soil on a field-moist basis according to Dick and Tabatabai (1992).

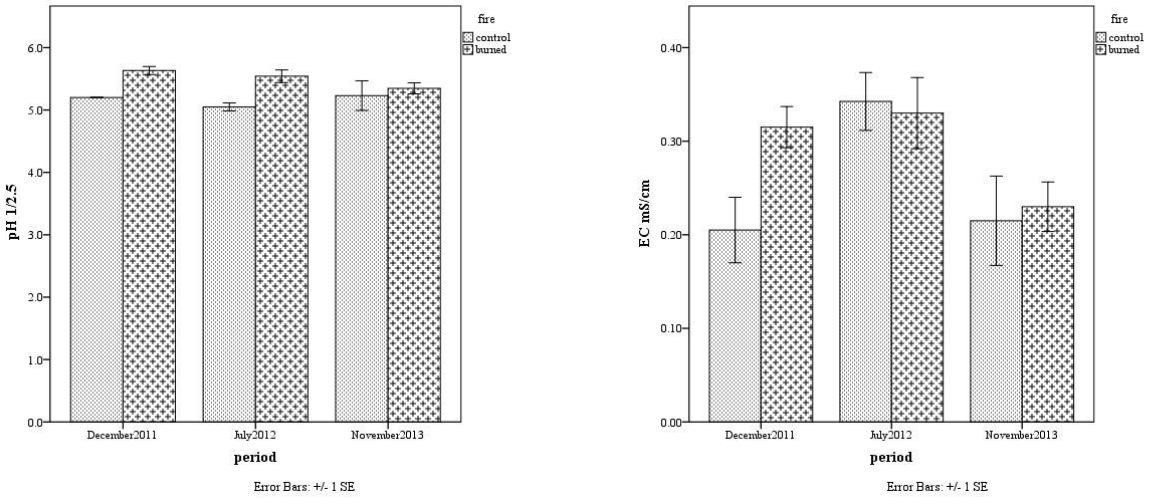
### 2.4. Statistical analysis

Two-way analysis of variance (ANOVA) was conducted for the significance level of differences between the burned and unburned sites and between the periods as regards soil properties. Kolmogorov-Smirnov and Levene tests were applied to test the normality and homogeneity of variances, respectively. Data were $1/\sqrt{}$ transformed when they were not distributed normally. When parametric conditions were not met after the transformation, non-parametric Kruskal-Wallis test was performed. Associations between the soil parameters were determined by Pearson correlation analysis. All statistical analyses were conducted by using SPSS (version 21) (Özdamar 2004).

## Results

Soil pH significantly increased in the burned sites immediately (from 5.2 to 5.6), and seemed not to change (5.0 and 5.5, respectively) ($F = 10.2$, $P=0.003$) in seven months after the fire. However, the difference disappeared (5.2 and 5.3, respectively) and the pH level in the burned site was the same with that of the unburned site in two years (Figure 2a).

The change in EC after the fire was statistically not prominent ($F = 1.04$, $P>0.05$) but the variation in this parameter was significant between the periods ($F = 4.98$, $P=0.011$). However, a week later after the fire, there was a significant increase in EC in the burned soil (Figure 2b).

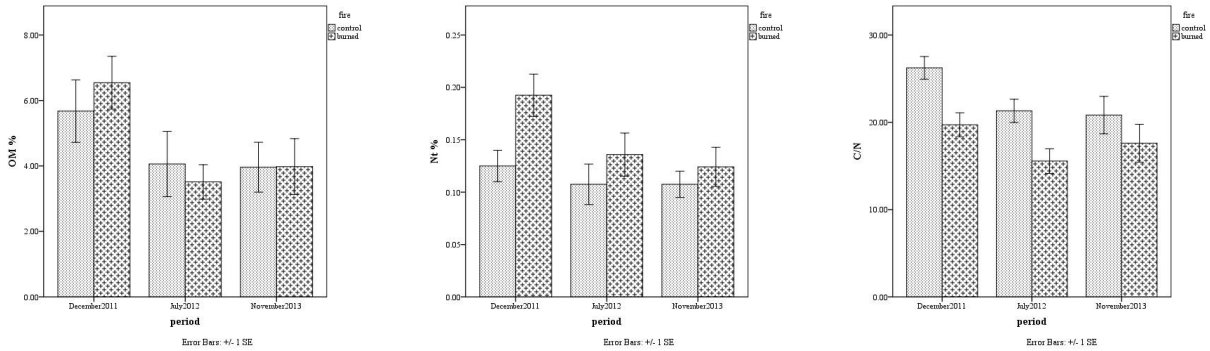



(a) (b)

Figure 2. Soil pH (a) and EC (b) levels in the burned and unburned (control) soils after fire.

No signficant difference was observed in organic matter content (OM) between the control and burned plots ($F = 0.01$, $P > 0.05$) but it was significantly different between the periods (Figure 3a, $F = 5.9$, $P = 0.005$). Although there was an insignificant increase in total nitrogen (Nt) amount immediately after fire ($F = 2.8$, $P > 0.0.05$), the variation in Nt amounts was consistent with OM change in time (Figure 3a and b, $F = 4.2$, $P = 0.022$).

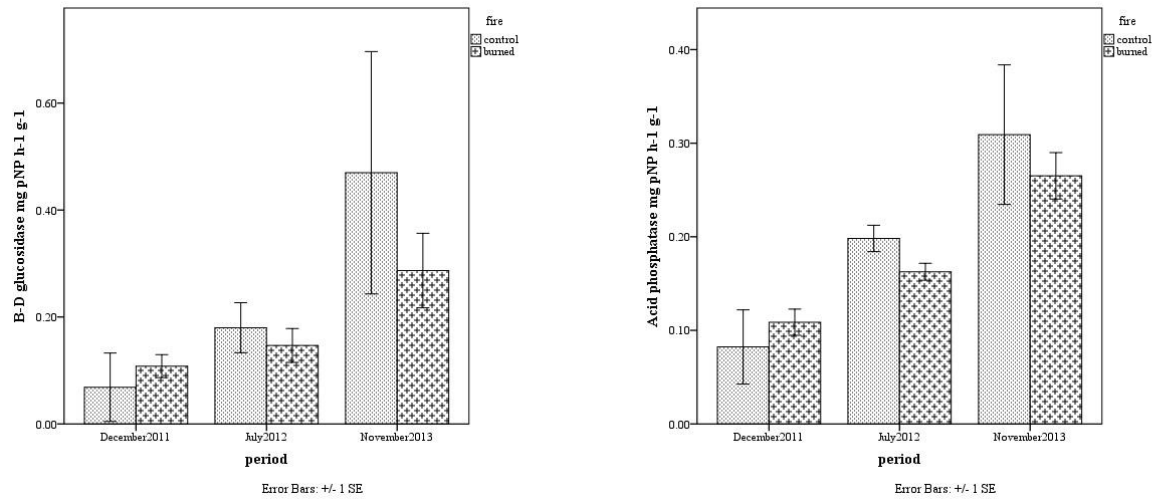
C / N ratio decreased significantly in all burned areas ($F = 6.33$, $P = 0.02$) but the differences between the periods were insignificant (Figure 3c, $F = 1.57$, $P > 0.05$). The difference in ratios between the control (26.24) and burned soils (19.71) went on in time with a decreasing trend. Two years later, they were 20.83 and 14.95 in the control and burned areas, respectively.




(a) (b) (c)

Figure 3. Soil OM (a), Nt (b) levels and C/N (c) in the burned and unburned (control) soils after fire.

No difference was observed in enzyme activities (β-D glucosidase and acid phosphatase) due to fire ($F = 0.67$, $P > 0.05$). However, the period effect on both of them was significant ($F = 6.12$, $P = 0.005$). The highest amount of acid phosphatase was in the last period (0.28 mg pNP $h^{-1}$ $g^{-1}$), while the minimum amount was found in the first period (0.15 mg pNP $h^{-1}$ $g^{-1}$). β-D glucosidase activity was compatible with acid phosphatase (Figure 4a, b).




**(a)** **(b)**

Figure 4. (a), (b) Soil enzyme activities in the burned and unburned (control) soils after fire.

Fire effect on Ca (F = 5.13, P = 0.029) and Mg (F = 16.94, P < 0.001) was found to be significant. These nutrients both increased after burning (Figure 5a, b). The mean value of Ca was 840.4 ppm and 1296.5 ppm, while Mg was 103.1 ppm and 196.8 ppm, respectively, in the control and burned soils.

K amounts in the soil were not affected by either the fire (F = 0.72, P > 0.05) or the period (F = 1.22, P > 0.05) (Figure 5c,). There was a significant difference only in Na amounts between the periods (F = 4139.1, P < 0.001). It was 96.25 ppm in July 2012. In the first and the last periods, which were in autumn, Na amounts were found to be 3.7 and 5.7, respectively (Figure 5d).

There was an insignificant increase in available phosphorus amounts after fire, which was found to be 20.08 ppm in the burned soils and 9.5 ppm in the control soils in the first period (a week later after fire) (Figure 5e, F = 0,69, P > 0.05), while they were 8.13 ppm and 6.73 ppm in the last period (two years after fire).

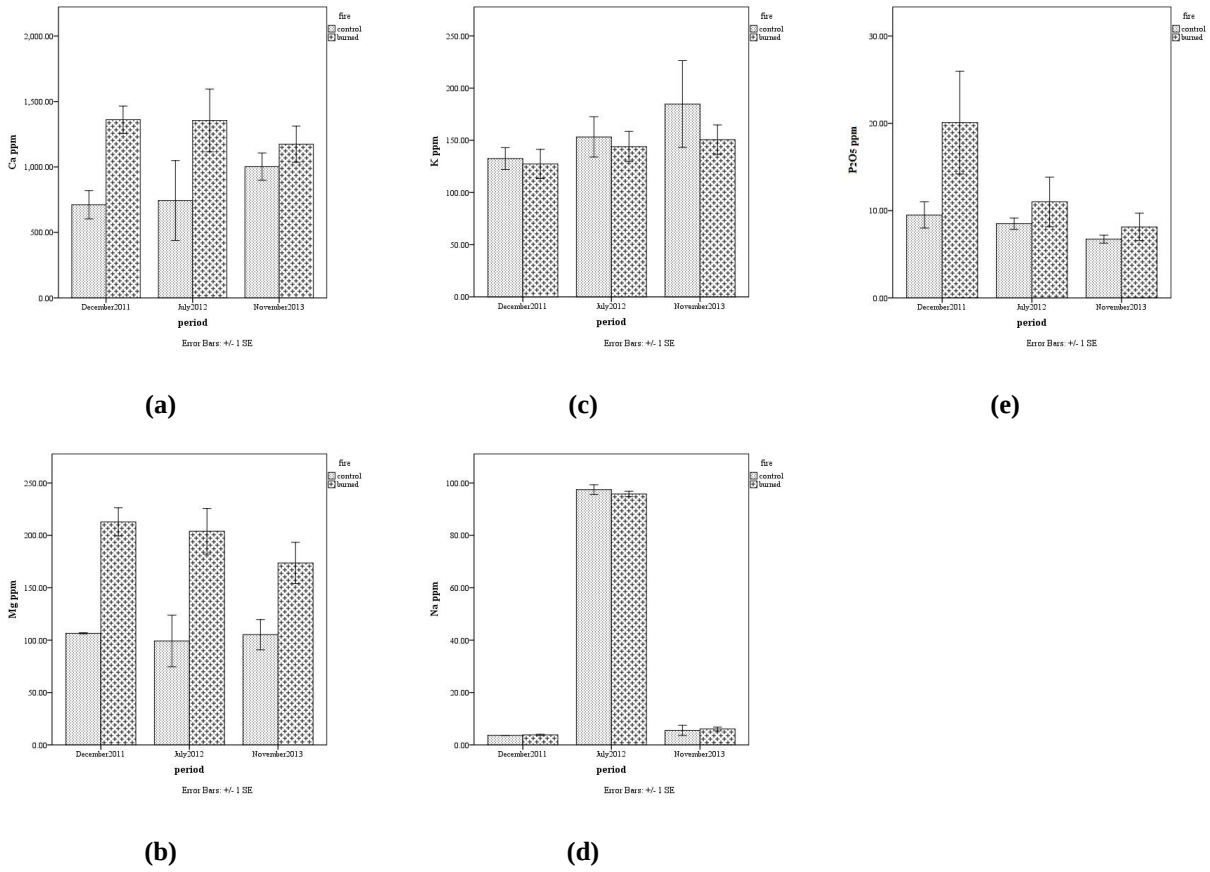



Figure 5. Soil Ca (a), Mg (b), K (c), Na (d) and $P_2O_5$ (e) in the burned and unburned soils after fire.

According to the correlation analysis (Table 1), there were positive linear correlations among pH, Nt, $P_2O_5$, EC, Ca, Mg, whereas there was a negative relationship between pH and acid phosphatase enzyme activity. OM was correlated with Nt, C/N, $P_2O_5$, EC, Ca, Mg and K, although there was no relation between Nt and C/N ratio. β-D glucosidase was correlated with acid phosphatase and K.

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Table 1. Pearson correlation coefficients (r) among measured variables in the study area. Asterisks refer to the level of significance; *, P < 0.05; **, P < 0.01.

| | pH | OM | Nt | C/N | $P_2O_5$ | EC | β-D Glucosidase | Acid Phosphatase | Ca | Mg | K | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | .279 | **.527**$^{**}$ | -.280 | **.424**$^{**}$ | **.489**$^{**}$ | -.253 | **-.317**$^{*}$ | **.595**$^{**}$ | **.681**$^{**}$ | -.078 | -.036 |
| OM | | 1 | **.837**$^{**}$ | **.584**$^{**}$ | **.577**$^{**}$ | **.404**$^{**}$ | .130 | -.188 | **.580**$^{**}$ | **.382**$^{**}$ | **.478**$^{**}$ | -.262 |
| Nt | | | 1 | .087 | **.725**$^{**}$ | **.555**$^{**}$ | .076 | -.269 | **.812**$^{**}$ | **.701**$^{**}$ | **.363**$^{*}$ | -.140 |
| C/N | | | | 1 | .031 | -.043 | .138 | .102 | -.075 | **-.386**$^{**}$ | **.387**$^{**}$ | -.195 |
| $P_2O_5$ | | | | | 1 | **.382**$^{**}$ | -.079 | -.261 | **.570**$^{**}$ | **.461**$^{**}$ | .263 | -.095 |
| EC | | | | | | 1 | .101 | -.174 | **.524**$^{**}$ | **.566**$^{**}$ | .067 | **.327**$^{*}$ |
| β-D Glucosidase | | | | | | | 1 | **.661**$^{**}$ | .175 | -.009 | **.310**$^{*}$ | -.132 |
| Acid Phosphatase | | | | | | | | 1 | -.019 | -.268 | .284 | -.091 |
| Ca | | | | | | | | | 1 | **.734**$^{**}$ | **.368**$^{*}$ | .024 |
| Mg | | | | | | | | | | 1 | -.018 | .011 |
| K | | | | | | | | | | | 1 | .037 |

## 2. Discussion

Soil pH increases immediately after fire in most cases, declining to prefire levels in several months, years, or decades (Fisher and Binkley 2000). In this study, a prominent increase in soil pH might be related to Ca and Mg increase with fire due to the release of nutrients caused by the combustion of organic matter. The thick ash layer on the burned area was likely the most important source of these nutrients (Pereira P. 2012).

The availability of nutrients is influenced directly by geochemical factors and indirectly by microbial activity (Fisher and Binkley 2000). Positive correlations were found between pH and Nt, $P_2O_5$, Ca, and Mg (Table). Previous studies found highly significant positive correlations between pH and exchangeable Ca and Mg (Finzi et al. 1998, Quilchano and Maranon 2002).

Many studies reported that organic matter content of the soil decreased after fire (Eron 1977, Eron and Gürbüzer 1988, Neyişçi, 1989, Boydak et al., 1996, Certini, 2005, Neff et al. 2005, Tavşanoğlu and Gürkan 2010). On the other hand, the natural or artificial reintroduction of vegetation called secondary ecological succession, which has high net primary productivity, may lead to the recovery of soil organic matter in burned areas in a short time (Certini 2005). Soil organic carbon increase after fire may stem from the incorporation of unburned residues in mineral soil, the transformation of fresh organic materials to more recalcitrant forms, and the increase of N-fixer species in the burned areas (Johnson and Curtis 2001). There was no significant increase in organic matter amount after fire though it was significant in terms of the period. Our results showed that the second and the third periods were not very different from each other while the difference between the first and the last two periods was considerable in terms of soil organic matter content. The immediate increase in OC after burning might be due to the formation of charcoal depending on incomplete combustion of organic matter (Kaptanoğlu Berber 2014). The insignificant difference between the last two periods probably derived from leaching of charcoal and recovery of the forest floor after a low-severity surface fire.

The difference between the burned and unburned areas seemed insignificant in terms of Nt. However, fire resulted in relatively higher Nt amounts in the first period. It has been found that fire increases the nitrogen amounts (Boydak et al. 1996, Altun et al. 2004, Esquilin et al. 2008, Kara and Bolat 2008, Yıldız et al. 2010), which may be due to increased biological nitrogen fixation after fire (Kutiel et al. 1987, Kara and Bolat 2009).

Contrary to OM and Nt, C / N ratio was affected significantly by fire (P = 0.017). After burning, C / N ratio was observed to decrease (Figure 3c). This result might depend on insignificant decrease in organic carbon content and is the evidence of the increased nitrogen mineralization after fire (Tecimen 2011, White 1986, Çepel 1975). Kantarcı (2000) reported that decomposition was very low when C / N ratio was greater than 30, C / N values ranging from 15 to 25 and values lower than 15 represented ongoing decomposition and very fast mineralization, respectively. Therefore, mineralization accelerated from lower values to higher values after surface fire.

Although increases in $P_2O_5$ amounts in burned soils were reported (Kutiel and Shaviv 1992, Boydak et al. 1996, Esquilin et al. 2008, Yıldız et al. 2010), no significant differences between the burned and unburned soils as regards available phosphorus could be observed, which was confirmed in a study conducted in *Pinus douglasiana* Martínez-dominated forest stands in central-western Mexico 8 years, 28 years, and 60 years following a high-severity fire (Quintero-Gradilla et al. 2015). However, an immediate increase was observed after fire in burned areas in the first period, which diminished to the same levels in the unburned areas in last two periods. Increasing spatial variability in ash with time as a result of water erosion (Pereira et al. 2012) and/or overland flow (Dorta Almenar et al. 2015) could cause a decrease in $P_2O_5$.

EC values increased insignificantly after fire, but the difference between the periods was significant. Similar values were found in the first and second periods. Heating of soil with fire in the first period and under summer conditions in the second period might result in relatively warmer soils. The release of cations might be stimulated by the decomposition at rising temperatures. EC (saturated-extract electrical conductivity) values increased and decreased with exchangeable Ca, exchangeable Mg, and cation exchange capacity (McBride et al. 1990). A positive correlation was found between EC and Ca, Mg, and Na was in this study (Table). It was reported that cations like Ca, K, and Mg increased after fire (Khanna et al. 1994, Kutuel and Naveh 1987, Giardina et al. 2000, Knoepp et al. 2004).

Enzyme activities are influenced negatively by fire in most of the cases (Hernandez et al., 1997; Barreiro et al., 2015). Although there was no significant variation in β-D glucosidase and acid phosphatase activity after burning in this study, the period effect was significant. An increase in enzyme activities was observed depending on the period. It might stem from seasonal differences between November and July in the first year and climate changes year by year. The impact of fire on biological properties of soil depends strictly on soil moisture (Certini, 2005). The temperatures reached with fire might suppress the enzymes in a week following the fire and in later periods; little rainfall might result in low enzyme activity. It was reported that temperature and water potential of soil together may be better predictors of phosphatase activity than either one alone (Krämer and Green, 2000).

Acid phosphatase is released from plant roots although alkaline phosphatase is excreted by soil microorganisms (Okur et al. 2009, Krämer and Green, 2000) and affected by soil pH directly (Bilen, 2010). This enzyme activity reached a peak in the last period two years after the surface

fire. It might be caused by root system development during the secondary vegetation over this period. Periodical variation in phosphatase activity might be related to $P_2O_5$ variation as well; phosphatase activity increased when $P_2O_5$ amount decreased in soil (Figure 3b and 4e). Although fire did not likely result in high level of $P_2O_5$ in the soil, it might prevent microbial excretion of phosphatase (Clarholm, 1993). In fact, an insignificant but negative correlation was observed between these parameters.

Although periods might likely cause some changes, the results in this mixed forest soil demonstrated that there was no considerable change after surface fires. However, increases in some nutrients such as Ca and Mg were observed in addition to decreasing C / N ratio back to optimum levels in terms of mineralization. These changes may provide more higher amount and availability of nutrients for the new vegetation. We found a significant increase in soil pH as a consequence of a fire in the first period, which continued in the second period. A shift in pH levels back to its pre-fire condition could be observed in this study similar to the report of Trabaud (1983) and Durán et al. (2008). However, it seemed that even in the case of low-intensity surface fire, more than two years were needed to observe such a return in soil Ca, Mg level, and C / N ratio.

This study draws attention to the importance of fire severity on forest soils and is aimed to improve our knowledge on fire-affected soils in the ecosystems susceptible to surface fire. We concluded that surface fire effect on soil properties was limited. Soil properties did not considerably change after fire in the area except some exchangeable cations like Ca and Mg. Management intervention to the burned forest floor after low-severity surface fires is not recommended. Furthermore, considering the advantages of natural regeneration of dominant tree species thanks to the enrichment of available nutrients or reduction of fire risk by limiting fuel accumulation, prescribed fires can be effectively used without any damage to soil in these ecosystems as a management tool.

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# The Effects of cultivation area and altitude variation on the composition of fatty acids of *Laurus nobilis* L. berries in Nothern Turkey and Abkhazia

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**Abstract**

The aim of the study was to determine and compare the fatty acids contents of Laurel berries (*Laurus nobilis* L.) grown in Trabzon, Bartın, Samsun and Abkhazia. Fleshy parts of laurel berries and seeds were analyzed separately to reveal yields of fixed oils. Three altitude ranges were determined for the study and samples were collected from the ranges that can be found from these elevations where the altitude is 0-100m, 100-300m and 300-600m. Automatic extraction technique was used for getting fixed oil and the amount and the composition of the oil was identified by using GC-FID. The results showed that the fixed oil yield of fleshy parts of berries ranged between 28.37% and 42.08%. The highest amount of fixed oil yield in fleshy part was obtained in Bartın (0-100 m). The fixed oil in of seeds ranged between 16.26% and 22.81%. The highest amount of fixed oil yield in seeds was obtained in Bartın (100-300 m). According to GC-FID results, oleic acid (27.06 % - 48.93%) was the most abundant fatty acid, lauric acid (0.49% -1.35 %) was the least abundant fatty acid in the fleshy parts of laurel berries. In seeds, lauric acid was the most common fatty acid (32.37%-44.49%) and arachidic acid (0.87%-1.17%) was the least fatty acid. According to results, it is thus deduced that, the amount and content of fixed is affected by cultivation area, altitude variation and the parts of laurel berry

**Keywords:** Fatty acid, fleshy, laurel berry, seed.

**Özet**

Çalışmanın amacı Trabzon, Bartın, Samsun, Hatay ve Abhazya'da yetişen defne meyvelerinden elde edilen sabit yağın içeriğinin belirlenerek çıkan sonuçların yetişme yeri ve yükseklik farkına göre karşılaştırmaktır. Çalışma için 0-100m, 100-300 m ve 300-600 m olarak üç ayrı yükseklik aralığı belirlenmiş ve bu yükseltilerden bulunabilen aralıklardan örnekler toplanmıştır. Defne meyvelerinde etli kısımlar ve tohum kısımları ayrılarak çalışılmıştır. Çalışmada sabit yağlar otomatik ekstraksiyon tekniği ile elde edilmiş olup, sabit yağların içeriklerinin belirlenmesinde GC-FID cihazı kullanılmıştır. Sonuçlara bakılacak olunursa, defne meyvesi etli kısmından elde edilen sabit yağ miktarı %28.37 ile %42.08 aralığında değişmektedir. En yüksek sabit yağ oranı etli kısım için Bartın 0-100m'den elde edilmiştir. Tohumlarda ise sabit yağ miktarı %16.26 ve %22.81 aralığında değişmektedir. En yüksek sabit yağ oranı tohum için Bartın 100-300m'den elde edilmiştir. GC-FID sonuçlarına göre, oleik asit (%27.06 - %48.93) defne meyveleri etli kısmında en yüksek miktarda bulunan yağ asitlerinden olmuş olup laurik asit ise (%0.49 - %1.35) oranı ile defne meyveleri etli kısım örneklerinde en düşük miktarda bulunan yağ asitlerinden olmaktadır. Tohum sonuçlarına bakıldığında ise laurik asit (%32.37 - %44.49) ile tohumda en yüksek miktarda bulunan yağ asitlerinden olmuş olup, araşidik asit (%0.87 - %1.17) oranı ile tohum örneklerinde en düşük miktarda bulunan yağ asidi olarak saptanmıştır. Çalışmanın sonuçları defne meyvesinin etli kısmında ve tohum kısmında bulunan sabit yağ miktarının ve içeriğinin defne meyvesinin yetişme yeri ve yüksekliğe göre değiştiğini desteklemektedir.

**Anahtar Kelimeler:** Defne meyvesi, etli kısım, tohum, yağ asidi.

## Introduction

Since ancient times the leaves and berries of the *Laurus nobilis* L. have been known. Laurel is a very important medicinal and aromatic plant in Turkey and nearby regions. Laurel is an evergreen tree, 3-10 m in height and the leaves have an aromatic odor. The leaves about 5-10 cm long and 2-5 cm broad. The shapes of the leaves are firm and like a spearhead. The edges of leaves are wavy and short-handed (Baytop 1999). The shape of laurel berry is elliptical, and it is 1.5 cm long and about 1 cm thick, containing a single seed. Berries are one seeded olive or chickpea size. The weight of the kernel varies with the weight of the whole berry, and this ratio is generally around 70%. In the most inner part of the berry, the core consists of the endocarp, the fleshy part (mesocarp) and the outer shell (pericarp) between the core and the fleshy part (Yazıcı 2002). Leaves of this plant have essential oil and berries have fixed oil and a little bit essential oil. The chemical content of these oils were closely examined, and it was found that volatile compounds and non-volatile fatty acids have many benefits for human health. Because of this, this plant have been used for medicinal applications from ancient times (Yazıcı 2002).

Fixed oil is semi-solid in hot seasons and has a special aroma. It melts at about 32-36 °C (Riaz and Asraf 1987, Baytop 1999).The chemical composition of laurel berry fixed oil comprises from saturated fatty acids and unsaturated fatty acids. There is a high amount of lauric acid in the structure of the laurel berry. The areas of usage of lauric acid are food and cosmetic industry (Erickson, 1990, Baytop 1999). Due to the fact that the pericarp and the nucleus do not develop in a proportional manner during berry development the fatty acid composition does not change much until maturing period but there are huge variations in fatty acid ratios (Timur 2001). Laurel berry fixed oil occurs ending of the esterification reactions glycerin and fatty acids, and it is liquid and solid. It is insoluble in water but soluble in organic solvents. In many countries, laurel berries are used as folk medicines for the treatment of various disease. Conventionally, laurel berries using for stimulating blood flow in the pelvic area and uterus and treating hysteria and also crushed fresh berry is consumed a lot for the treatments of hemorrhoidand ulcer (Simic et al 1989, Tuzlacı and Erol 1999, Tuzlacı and Erol, 2000).

The fragrant oil obtained from the berry is used in veterinary, pharmaceutical and perfumery industries. When laurel berry is mixed with palm kernel oil and coconut oil, it can treat skin diseases (Baytop 1983, Gang et al, 1993). Laurel fixed oil is commonly used on the treatment of sprains, rot and rheumatism and also fixed oil has parasiticidic property (Hoppe 1944, Leyel 1984, Boukef 1986, Tuzlacı and Erol 1999). Laurel berries are generally used in perfumed soap and hair care products since having antidandruff activity and also laurel oil treats eczema, skin eruptions and scaling (Hafızoğlu and Reunanen 1933).

Although there are many studies related with isolation and biological activity of laurel leaf essential oils, there has been little work on its berries. From this point of view, the present paper aims to determine fatty acids compositions of laurel berries which are grown in eastern, western and central Karadeniz region and Abkhazia.

## Material and Methods

### Plant material

The areas where the laurel berries were collected are given in Table 1. It was about 500 gr samples were collected for each altitudes. Fleshy berries were collected in September and October, 2014. They were stored at +4 ºC until analyzes. Collected berries were separated into seeds and fleshy parts. Since they have high moisture content, they have been oven-dried at 70 ºC for 3 days. After that, the berries

were weighed and moisture contents were determined separately. After they were dried seeds and fleshy parts (mesocarps) of laurel berries were ground with plant grinder (Waring and Retsch-ZM 200).

Table 1. Locations and altitudes of collected laurel berries.

| **Location** | **Altitude (m)** | | |
|---|---|---|---|
| | **0-100** | **100-300** | **300-600** |
| Trabzon | 20 | - | - |
| Samsun | 77 | - | - |
| Bartın | 10 | 200 | 400 |
| Abkhazia | 50 | - | - |

**Extraction**

Fixed oils were obtained by using automatic Foss Soxtec Extraction device. 2.5-3 gr samples were subjected to extraction procedure (seeds and pericarps). Hexane was used as a solvent for the extraction (70-90 ml). Extraction was completed in 4 stages. First stage was boiling of solvent, it was about 25 min. Second, extraction, it was about 30 min. Third, ending of extraction and recovery of solvent, it was about 15 min and last was drying, it was about 10 min. Total time for extraction of fatty oil was about 80 minutes. Then the fatty oil were dried and stored in the dark at room temperature until use.

**Fatty acids methyl esters**

Because of the polar nature of the fatty oil of laurel, In order to analyze fatty oil in GC-FID, It is necessary to perform the fatty oil methylation process. For methylation process, firstly 0.1 gr fixed oil was added into the glass tubes and 500 ml $CH_3OH$+65 gr KOH solution was prepared.1 ml of methanolated KOH was added to each of 0.1 g fixed oils and vortexed. After the saponification reaction was started, 10 ml hexane was added each of tubes in two steps and each tube was vortexed and mixed. The methyl esters were centrifuged at 7000 rpm for about 5 minutes to pass to the solvent phase. The top phase was taken to be injected into the GC-FID.

**GC-FID analysis**

The GC–FID analysis was carried out with Shimadzu GC 2025 Technocroma capiller TRCN 100 column (60mx0.25 mmx0.25 μm) was used with helium as carrier gas (0.8ml/min) for analysis of fatty acid methyl esters. GC oven temperature was kept at 80°C and programmed to 140°C at a rate of 3°C/min, and kept constant at 140 °C for 1 min and then programmed to 240 °C at a rate of 3 °C/min and kept constant at 240 °C for 5 min. The injector temperature was set at 250°C and FID detector temperature was 250°C.In the analysis, the split ratio was determined as 50:1. Total duration time was 61 minutes. Prior to the analysis, a Supelco Fame 37 Internal standard was used and a calibration chart of each fatty acid component was drawn and retention times were determined. The obtained chromatograms were evaluated in the internal standard frame given in advance to the device. (Özkaya et al 2014)

**Results**

**Fixed Oil Yield of Fleshy Parts of Berries and Seeds**

The amount of fixed oil obtained from the fleshy parts of laurel and seeds are shown in Table 2.

Table 2. The average yields fixed oil of fleshy parts and seeds of *Laurus nobilis* L. berries

| Fleshy Part | | Seed | |
|---|---|---|---|
| Sampling area | Total Amount of Oil (ml/100 gr) | Sampling Area | Total Amount of Oil (ml/100gr) |
| Bartın 10 m, $B_1$ | 42.08±0.3450 | Bartın 10 m | 19.15±0.0120 |
| Bartın 200 m, $B_2$ | 34.89±0.1783 | Bartın 200 m | 22.81±0.3100 |
| Bartın 400 m, $B_3$ | 28.37±0.0328 | Bartın 400 m | 16.53±0.1197 |
| Abkhazia 50 m, $A_1$ | 29.28±0.3979 | Abkhazia 50 m | 19.69±0.0713 |
| Trabzon 20 m, $T_1$ | 29.31±0.4705 | Trabzon 20 m | 16.26±0.1804 |
| Samsun 77 m, $S_1$ | 29.80±0.1849 | Samsun 77 m | 21.31±0.1125 |

## GC-FID Analysis

The results of the GC-FID analysis of fleshy parts and seeds of laurel berries fixed oils are shown in Table 3 and Table 4.

Table 3. Fatty acid composition of flesh parts of berries.

| **FLESHY PART** **Fatty Acid** | | **RT*** | **$T_1$** | **$S_1$** | **$A_1$** | **$B_1$** | **$B_2$** | **$B_3$** |
|---|---|---|---|---|---|---|---|---|
| C-12:0 | Lauric Acid | 17.58 | 1.30 | 0.49 | 1.35 | - | 0.57 | 0.62 |
| C-16:0 | Palmitic Acid | 28.67 | 32.61 | 20.70 | 25.74 | 30.22 | 29.53 | 33.07 |
| 16:1 $\Delta^9$ | Palmiteloic Acid | 29.97 | 1.14 | 0.83 | 0.41 | 1.48 | 0.78 | 1.33 |
| C18:0 | Stearic Acid | 33.63 | 2.11 | 1.32 | 2.68 | 1.23 | 1.05 | 0.81 |
| 18:1 $\Delta^9$ | Oleic Acid | 34.75 | 30.19 | 48.93 | 36.43 | 35.21 | 36.56 | 27.06 |
| 18:2 $\Delta^{9,12}$ | Linoleic Acid | 36.56 | 29.37 | 24.80 | 30.05 | 29.21 | 29.18 | 34.39 |
| 18:3 $\Delta^{9,12,15}$ | α-Linolenic Acid | 38.64 | 2.15 | 1.68 | 2.19 | 1.76 | 1.42 | 2.03 |

RT*: Retention Time

Table 4. Fatty acid composition of seeds of berries.

| **SEED** **Fatty Acid** | | **RT*** | **$T_1$** | **$S_1$** | **$A_1$** | **$B_1$** | **$B_2$** | **$B_3$** |
|---|---|---|---|---|---|---|---|---|
| C10:0 | Capric Acid | 12.08 | - | 0.83 | 0.52 | - | 0.96 | 0.72 |
| C12:0 | Lauric Acid | 17.58 | 32.37 | 42.94 | 33.06 | 36.1 | 44.49 | 37.07 |
| C14:0 | Myristic Acid | 23.04 | 1.14 | 1.73 | 1.24 | 1.45 | 1.61 | 0.94 |
| C16:0 | Palmitic Acid | 28.67 | 8.81 | 9.84 | 10.90 | 7.59 | 6.80 | 6.85 |
| C16:1$\Delta^9$ | PalmiteloicAcid | 29.97 | - | 0.45 | 0.75 | - | 1.33 | - |
| C18:0 | Stearic Acid | 33.63 | 1.30 | 2.39 | 3.06 | 1.30 | 1.03 | 0.99 |
| 18:1 $\Delta^9$ | Oleic Acid | 34.75 | 29.50 | 23.87 | 26.99 | 29.39 | 24.46 | 26.15 |
| 18:2 $\Delta^{9,12}$ | Linoleic Acid | 36.56 | 23.73 | 15.45 | 20.49 | 20.8 | 18.27 | 24.35 |
| 18:3 $\Delta^{9,12,15}$ | α-LinolenicAcid | 38.64 | 0.91 | 0.58 | 0.70 | 0.72 | 0.48 | - |
| C20:0 | Arachidic Acid | 39.04 | 0.92 | 0.87 | 1.10 | 1.04 | 0.95 | 1.17 |

RT*: Retention Time

Table 5. Total % fatty acid composition of fleshy parts of berries

| **TFA*(%)** | **$T_1$** | **$S_1$** | **$A_1$** | **$B_1$** | **$B_2$** | **$B_3$** |
|---|---|---|---|---|---|---|
| ∑SFA (Saturated Fatty Acid) | 36.02 | 22.51 | 29.77 | 31.45 | 31.15 | 34.50 |
| ∑USFA (Unsaturated Fatty Acid) | 31.33 | 49.76 | 36.48 | 36.69 | 37.34 | 28.39 |
| ∑PUFA (Polyunsaturated Fatty Acid) | 31.52 | 26.48 | 32.24 | 30.97 | 30.60 | 36.42 |

TFA*: Total Fatty Acid (%)

Table 6. Total % fatty acid composition of fleshy parts of berries.

| **TFA*(%)** | **T1** | **S1** | **A1** | **B1** | **B2** | **B3** |
|---|---|---|---|---|---|---|
| ∑SFA (Saturated Fatty Acid) | 44.54 | 58.60 | 49.88 | 47.48 | 55.81 | 47.74 |
| ∑USFA (Unsaturated Fatty Acid) | 29.50 | 24.32 | 27.74 | 29.39 | 24.46 | 26.15 |
| ∑PUFA (Polyunsaturated Fatty Acid) | 24.64 | 16,30 | 21.19 | 21.52 | 18.75 | 24.35 |

TFA*: Total Fatty Acid (%)

## Discussion

The fixed oil yield of fleshy parts of berries range between 28.37% and 42.08%. The highest amount of fixed oil yield in fleshy part was obtained in Bartın 10 m. The fixed oil yield of seeds ranges between 16.26% and 22.81%. The highest amount of fixed oil yield in seeds was obtained in Bartın 200m.

According to the results of analysis, the most abundant fatty acids for fleshy parts of berries were oleic acid (27.06%-48.93%) and linoleic acid (29.18%-34.39%) from unsaturated fatty acids and also palmitic acid (20.70%-33.07%) from saturated fatty acids. The least amount of fatty acids were lauric acid (0.49%-1.35%) and palmitic acid (0.41%-1.48%) from saturated fatty acids.

According to the fixed oil analysis obtained from the seeds of laurel berries, lauric acid (32.37%-44.49%), oleic acid (23.87%-29.50%), linoleic acid (15.45%-24.35%) were the most abundant fatty acids. α-Linoleic acid (0.48%-0.91%), palmiteloic acid (0.45%-1.33%) were the least amount of fatty acids. Tables 5 and 6 show the total amount of fatty acids according to the types of fatty acids.it is observed that the amount of unsaturated fatty acids is higher for all regions in fleshy parts of berries. Table 6 shows that saturated fatty acids predominantly exist in laurel seeds.

When the study areas are examined within itself, it can be said that the oil yield is affected by the altitude. As the height increases for Bartın, the amount of fixed oil in flesh part decreases. The situation is little bit different for seeds as seen from the results of fixed oil yield for seeds. As the height (altitude) increases the amount of fixed oil in seeds, first increased and later decreased. The highest fixed oil yield in seeds was obtained in Bartın in the range of 200 m with fat yield 22.81%. The least amount was obtained as 16.26% in Trabzon 20 m. There are lots of factors affecting the production of fatty oil in plants. It can be explained as an environmental, geographical, physiological, genetic, political and social factors (Bozan and Karakaplan 2007).

Nurbaş and Bal reported that, the extraction yields of laurel berries which were purchased from İzmir, 32.12% for whole berry. Beis and Dunford reported oil yields for Muğla region as varied from 14 to 28% and also they reported that, lauric (43.10%-44.80%), oleic (37.2%,37.3%) and linoleic acid (14.7%,13.3%) most abundant fatty acids for the berries of laurel for two methods respectively (supercritical $CO_2$ extraction and solvent extraction). They indicated that oil yield depends on the method and particle size used for oil recovery. As long as particle size increases, extraction yield decreased (Beis and Dunford 2006).

Bozan and Karakaplan (2007) reported fixed oil yield as 16.30% for pericarp, 23.40% for seed. Bal et al. reported for whole berry as 34.80% saturated fatty acids, 62.40% unsaturated fatty acid. Ozcan et al. (2010) reported that 40.79% linoleic acid, 38.08% lauric acid as major fatty acids for laurel seeds. Marzouki et al (2008) reported that lauric acid (27.7%) was the most abundant fatty acid for whole berry by Supercritical $CO_2$ extraction technique.

The results obtained with regard to fat yields and amount of fatty acids in our study are consistent with the literature, but the data obtained in present study is partially superior than previous reports. In this study characterization of fatty acids composition of laurel berry fat was different because we analyzed berry in two part: fleshy part and seed. According to the results of analysis, unsaturated fatty acids and polyunsaturated fatty acids are predominant in the fleshy part of laurel berry and saturated fatty acids are mostly found in the seed part. Therefore, with automatic solvent extraction method, the extraction time was shortened and the solvent was recovered with this method. Environmentally sensitive work has been performed by recovering the solvent.

## Conclusions

There is a first report for Abkhazia and Trabzon. The chemical compositions of seeds and fleshy parts of berries were determined. For the present study the overall results indicated that the extraction of the laurel berry (fleshy part and seed) can be successfully performed by automatic extraction technique. Thanks to this technique, extraction time is shortened and solvent is recovered. Thus, it can be driven a profit both time and chemicals. So this method can be called environmentally friendly. On the other hand, Bartın is a convenient city for Karadeniz region for manufacturing laurel berry oil. Because the fixed oil yields are the highest for both seed and fleshy parts and also chemical characterizations of fixed oils are non-negligible.

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# Antioxidant and oxidant potential of *Rosa canina*

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**Abstract**

The present study aimed to determine the total antioxidant status, total oxidant status and oxidative stress index of the ethanol extracts obtained from the fruits of *Rosa canina* L. plant collected in Erzincan province (Turkey). In this context, the fruit samples of the plant were extracted with ethanol (EtOH) using a Soxhlet device. Total antioxidant status (TAS), total oxidant status (TOS) and oxidative stress index (OSI) were determined using Rel Assay kits. It was determined that the TAS value of the plant was 4.602 mmol/L, the TOS value was 6.294 μmol/L and the OSI was 0.138. As a result, *R. canina* exhibited high antioxidant activities.
**Keywords:** *Rosa canina*, antioxidant, oxidant, medicinal plant.

## Introduction

Live organisms are equipped with a defense system to neutralize free radicals and other reactive oxygen species (ROS). This system in living organisms includes catalase, enzymes such as superoxide dismutase and glutathione peroxidase, and compounds such as vitamins E and C. One of the most significant indicators of a healthy body is the balance between the free radicals and antioxidative defense system. However, in cases where the antioxidant system is insufficient, oxidant compounds cannot be inhibited, leading to oxidative stress. Depending on the level of oxidative stress, various disorders such as diabetes, cardiologic disorders and cancer could occur. Supplementary antioxidants could inhibit or prevent oxidative stress. Several researchers investigated natural antioxidants that could be consumed antioxidant supplements (Fransen et al. 2012; Yumrutas et al. 2015; Rezaeian et al. 2015; Selamoglu et al. 2016; Bal 2018).

Rosehip or *Rosa canina* is a plant indigenous to large areas in Europe, North Africa and West Asia. It is a perennial and deciduous shrub with spinous, thin stems and could grow up to 2-3 meters high. The colors of the flowers range between light pink/white and dark pink. The

flowers have 5 leaves and the flower diameter is between 4 and 6 centimeters. Ripe fruits are red-orange in color. *R. canina* is considered to be a valuable source for polyphenol and vitamin C (Selahvarzian et al. 2018). Due to its nutritional content, rosehip supplements have positive effects on certain chronic diseases such as osteoarthritis, rheumatoid arthritis and cancer (Fan et al. 2014).

The present study aimed to investigate the total antioxidant status (TAS), total oxidant status (TOS) and oxidative stress index (OSI) of *Rosa canina* L. collected in Erzincan province (Turkey). It was suggested that the results would contribute the production of antioxidant agents.

## Materials and Methods

*R. canina* samples were collected in Erzincan province (Turkey). The flower sections of the plant were dried in an incubator at 40°C. Then, the samples were extracted using ethanol (EtOH) in a Soxhlet device (Gerhardt EV 14). The samples were then condensed in a rotary evaporator and stored at +4ºC until the experiments were conducted (Heidolph Laborota 4000 Rotary Evaporator).

## TAS, TOS and OSI Tests

Plant TAS, TOS and OSI values were determined using Rel Assay kits (Assay Kit Rel Diagnostics, Turkey). The TAS value was calculated as mmol Trolox equiv./L and Trolox was used as the calibrator (Erel, 2004). TOS value was calculated as μmol $H_2O_2$ equiv./L and hydrogen peroxide was used as the calibrator (Erel 2005). The following formula was used to calculate the OSI (arbitrary unit: AU) and expressed as a percentage (Erel 2005).

$$\text{OSI (AU)} = \frac{\text{TOS, μmol } H_2O_2\text{equiv./L}}{\text{TAS, mmol Trolox equiv./L X 10}}$$

## Results and Discussion

In order to minimize the adverse effects caused by synthetic food preservatives on humans, researchers and food industries focused on natural preservatives and the interest in natural antioxidant sources increased. Some plants are significant natural sources due to their antioxidant properties (Proestos et al. 2013; Selamoglu et al. 2017; Nageen et al. 2018). Thus, the determination of natural antioxidant sources is quite important. In the present study, antioxidant and oxidant status of EtOH extracts obtained from the fruits of *R. canina* plant were determined. The study data are presented in Table 1.

Table 1. TAS, TOS and OSI Values

| | TAS mmol/L | TOS μmol/L | OSI TOS/(TAS*10) |
|---|---|---|---|
| *R. canina* | 4.602±0.215 | 6.294±0.191 | 0.138±0.010 |

* Values are presented as mean±SD; number of fruit samples n=6, experiments were made in 5 parallels

There are no previous studies on TAS, TOS and OSI of *R. canina*. Oxidative stress studies conducted on different plants suggested that mean TAS value of *Mentha longifolia* subsp. *longifolia* EtOH extract was 3.628 mmol/L, mean TOS value was 4.046 μmol/L and mean OSI value was of 0.112 (Sevindik et al. 2017). In a different study, it was determined that the TAS value of *Salvia multicaulis* was 6.434 mmol/L, TOS value was 22.441 μmol/L and OSI value was 0.349 (Pehlivan and Sevindik 2018). It was observed that the TAS value of *R. canina* was higher when compared to *M. longifolia* subsp. *longifolia*, and lower than *S. multicaulis* based on the above-mentioned studies. In another study conducted with MeOH extracts, the TAS values of *Muscari aucheri*, *Tulipa armena* var. *lycica* and *Bellevalia gracilis* were determined as 1.61, 1.34 and 1.66 mmol/L, respectively (Yıldırım et al. 2013). Compared to the above-mentioned studies, the TAS value of *R. canina* was higher. Thus, it could be suggested that the antioxidant potential of *R. canina* was high. Furthermore, the low oxidative stress levels of the plant indicated that the endogenous antioxidants in the plant significantly inhibited the endogenous oxidants.

## CONCLUSION

In the present study, the total antioxidant status, total oxidant status and oxidative stress index of *R. canina* were determined. The present study findings demonstrated that the plant possessed a strong antioxidant potential. Furthermore, it was determined that the plant had low oxidative stress levels and the antioxidant defense mechanism was strong. In conclusion, *R. canina* has antioxidant potential and it could be consumed as a natural antioxidant source.

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# *Ribes aureum* Pursh (Grossulariaceae): A new record for the flora of Turkey

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**Abstract**

Turkey has a rich flora with more than 10.000 plant species. During a field trip to Kars some herbarium species were collected from the genus *Ribes* L. After doing detailed studies on morphological description, photos and distribution map of the samples, it was realized that the samples were belonging to a new species, which is unknown in Turkey. All of the morphological features are belonging to *Ribes aureum* Pursh. After checking herbarium materials and published literatures on this species, a new record has been provided as *Ribes aureum* to the Flora of Turkey (A9, Kars).

**Key words**: New record, *Ribes aureum*, Grossulariaceae, Kars

***Ribes aureum* Pursh (Grossulariaceae); Türkiye Florası için yeni bir tür kaydı**

**Özet**

Türkiye, 10.000'den fazla bitki türü ile zengin bir bitki örtüsüne sahiptir. Kars'a yapılan arazi çalışmasında bazı *Ribes* örnekleri toplanmıştır. Morfolojik tanımı, fotoğrafları ve örneklerin yayılış haritası ile ilgili ayrıntılı çalışmalar yapıldıktan sonra, örneklerin Türkiye'de bilinmeyen yeni bir türe ait olduğu belirlenmiştir. Örneklerin tüm morfolojik özellikleri*Ribes aureum* türüne aittir. Herbaryum materyallerini ve yayınlanmış literatürleri de kontrol ettikten sonra Türkiye Florasın'a (A9, Kars) *Ribes aureum* olarak yeni bir kayıt yapılmıştır.

**Anahtar Kelimeler:** Yeni kayıt, *Ribes aureum*, Grossulariaceae, Kars

## Introduction

Turkey's flora has been studied for more than a hundred years and found more than 10.000 species (Please use a new reference). New observations and studies on flora of a given region reveal new species and new records (for example, Akkemik and Yılmaz, 2016). Within the woody plant genera, *Ribes* is one of the most important genera because of having edible fruits. *Ribes* is a cosmopolitan genus that includes seven subgenera; subgen. *Berisi*a (Spach.) Jancz. includes dioecious species, subgen. *Parrilla* Jancz. has functionally dioecious species, and subgen. *Ribes*, subgen. *Coreosma* (Spach.) Jancz., subgen. *Grossularioides* Jancz., subgen. *Grossularia* (Mill.) Pers., and subgen. *Oligocarpa* Vals. have hermaphroditic flowers (Janczewski, 1907). The genus has about 150 species (Mabberley, 1997). Approximately two-thirds of the species are distributed in northern temperate and subtropical areas from North America, Europe, eastern Asia, and northern Africa (Janczewski, 1907).

Turkey has 7 of the species belonging to the genus *Ribes*. They are *R. anatolicum, R. multiflorum* subsp. *multiflorum, R. nigrum, R. orientale, R. petraeum, R. rubrum* and *R. uva-crispa* (Chamberlain, 1972; Behçet, 2001; Mataracı, 2012; Eminağaoğlu 2014). During floristic surveys in Kars (Fig. 1), from April 2014 to May 2016, some interesting *Ribes* specimens were collected. Within these plant samples, some belonging to the genus *Ribes* revealed different morphological characteristics from the native *Ribes* species. The purpose of the present study is to share the identification results of these species and describe a new record for the flora of Turkey.

## Material and Methods

During a field trip to Kars-Kağızman, many samples were collected from different plant species. When it was realized some different features in samples of the genus *Ribes*, about 10 herbarium specimens were collected from three different localities of the genus. Photos of the living material were taken with a Sony DSCR1 digital camera. Geographical positions were identified using a Magellan eXplorist 710 GPS, and insert in the Fig. 1. and the samples collected were deposited in the herbaria VANF (acronyms according to Thiers 2016), and in the personal herbarium of the author (private Herbarium of Mehmet Fırat).

Identification of the samples were performed using the most related references (e.g. Flora of Turkey) (Davis et al. 1988) and compared with the reference specimens in VANF, In identification process, the leaf shape and dimensions, shoot features, bud arrangement and bud scale features, flower and fruit features were studied.

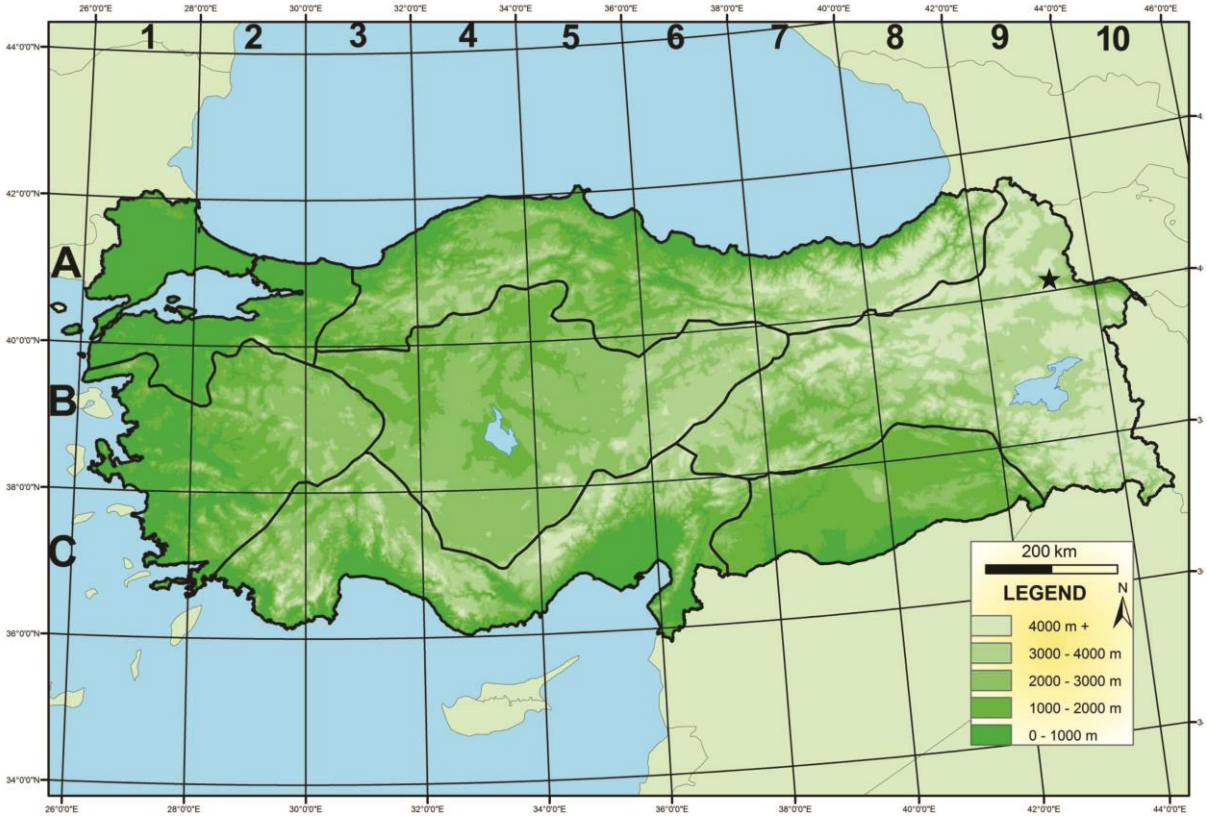


Figure 1. Distribution map of *Ribes aureum* (★) in Turkey.

**Results and Discussion**

The features used in identification provided that the samples were belonging to *Ribes aureum*. Because this species is lacking in the flora of Turkey it was evaluated as a new record for the flora of Turkey. Description, distribution and some other features of *Ribes aureum* were given below:

**Description:** *Stems* erect or rounded shrub 1-3 m tall, without spines, the branches reddish and hairless to finely short-hairy when young, hairless and dark gray with age. *Leaves*: alternate, finely short-hairy to hairless when young, but with age thick, pale green, and usually hairless except for few hairs on the edges, broadly triangular-ovate to ovate, with a broadly wedge- to somewhat heart-shaped-base, 2-5 cm broad, mostly 3-lobed less than half their length, the segments entire or with 2-5 rounded teeth. *Flowers*: fragrant, 5-18 in clusters equaling or longer than the leaves. Flower stalks up to 8 mm long, jointed under the ovary. Calyx hairless, golden yellow, cylindrical, 6-8 mm long, the 5 calyx lobes oblong-elliptic, spreading, 5-7 mm long. The 5 petals yellow to orange or reddish, oblong-obovate, erect. The 5 stamens about equaling the petals, the filaments about equal to the anthers. Styles joined almost to the stigmas, hairless. *Fruits*: berries, hairless, round, about 7 mm long, red to black, rarely yellow, palatable (Kamarov 1971).

**Habitat:** Near district center at the garden (Naturalized plant) 1200-1300 m.,

**Phenology:** Flowering time is from April to May and fruiting from June to July.

**Distribution in Turkey:** Kars (Kağızman) province

**General distribution:** Austria, Great Britain, Canada, Czech Republic, Croatia, Finland with Ahvenanmaa, France, Germany, Hungary, Italy, Former Yugoslavia, Lithuania, Norway, United State, Mexico, Poland, The Russian Federation, Romania, Slovakia, Slovenia and New to Turkey.

**Vernacular name:** *Ribes aureum* is called as Kurdish name “Yasemina zer” by the local people of the Kars (Kağızman) province, but celled other Kurdisk name for *Ribes* "Kişmiş", "Hengura mîrçikan", "Qolinc", And Turkish name "Frenk üzümü" (Fırat, 2013).

**Ethnobotanical usage**: The flowers are used to smell pleasant, ripe berries are eaten raw and made from sherbet, also eaten by birds.

**Other specimens examined:** *Ribes aureum.* TURKEY. A9 Kars: Kağızman Province, at the natural garden, 1294 m, 40°10′03″ N, 43°08′11″ E, coll. 25 April 2014, *M. Fırat 30535* (VANF, Herb. M. Fırat), A9 Kars: Kağızman Province, at the natural garden, 1294 m, 40°10′03″ N, 43°08′11″ E, coll. 9 May 2016, *M. Fırat 32659* (VANF, Herb. M. Fırat).


Figure 2. *Ribes aureum*: A,B. habitus; C,E leaves; D, F, E. flowers; H. young fruit

## Conclusion

With this new record, *Ribes aureum*, total number of species in the genus *Ribes* increased to eight in Turkey. Together with the new species the identification key was renewed as follows:

1. Shrub, spines.....***2***

2. Flowers in axillary clusters of 1-3.....***R. uva-crispa***

2. Flowers panicle in clusters of 8-15 .....***R. anatolica***

1. Shrub, unarmed.....***3***

3. Flowers dioecious; axis of inflorescence glandular-hairy.....***4***

4. Buds ovoid, obtuse; fruit glandular-hairy..... ***R. orientale***

4. Buds elongate, acute; fruit glabrous.....***R. alpinum***

3. Flowers hermaphrodite; axis of inflorescence glabrous..... .....***5***

5. Leaves covered beneath with sessile aromatic glands; fruit purplish-black....***R. nigrum***

5. Leaves without sessile glands, fruit red.....***6***

6. Hypanthium nearly flat.....***7***

7. Calyx ligulate.....***R. multiflorum***

7. Calyx lanceolete or spathulate.....***R. rubrum***

6. Hypanthium campanulate.....***8***

8. Flowers 20-40.....***R. biebersteinii***

8. Flowers 5-15.....***R. aureum***

The previous studies and this new record proved that the genus deserves much attention particularly on its taxonomy, and this new species should be included in the new version of the Flora of Turkey.

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# Vermicomposting in Turkey: Challenges and opportunities in future

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**Abstract**
Turkey has been undergoing positive agricultural transformations since the 2011. Its agricultural sector today is developing new techniques and products. One of the best examples of this is the production of vermicompost and its use in agriculture. Turkey is on both Asian and European continents (Eurasia) with approximately 81 million people. Turkey has 24 million hectares of agriculture land (excluding pastures+ meadows, including total arable land and under permanent crops). However, there is little data available on vermicompost production in Turkey. The production of vermicompost started after 2011. The average solid vermicompost production in 2017 was about 20000 tonnes produced by 15 plants with official production permits by the Republic of Turkey Ministry of Agriculture and Forestry. New legislation in Turkey published in legislative review no 30341 in February 2018 regulates the industry. Turkey aims to be among the top three producers of this fertility amendment by 2023. In addition to the officially sanctioned operations, there are approximately 4200 unauthorized vermicompost producers in Turkey. Interest in and production of vermicompost is likely going to increase. Research showed that there are many positive effects on soil quality and plant growth, although the mechanisms by which it improves the soil-plant systems are not yet fully understood. The use of vermicompost is important for the sustainability of agriculture. The main aim of the paper is to demonstrate and share reasonable causes for the increased interest in vermicompost and earthworms.
**Keywords:** Agriculture, soil, waste, earthworm, vermicompost**.**

## Introduction

Turkey is one of the few countries in the world that is self-sufficient in terms of agricultural food. The country's water resources, fertile soils, high agricultural technologies, determined farmers; all are contributing for a successful agricultural sector. However, organic matter levels of agricultural soils are gradually decreasing and the industry is relying on synthetic fertilizers and pesticides (Bellitürk and Sağlam, 2005). These can adversely affect soil quality and environment. Judicial use of chemical fertilizer is used based on soil fertility analyses can ameliorate the environmental effects. Vermicompost, an organic amendment, may help rehabilitate lands on small farms currently affected by adverse environmental conditions or off-set the high cost associated with chemical fertilizers, pesticides and oil in some parts of Turkey. Some of the main problems in Turkey's agro ecosystems are insufficient organic matter, changes in soil pH values, soil salinity and misuse of agricultural and converted forest land. By replacing chemical fertilizers with vermicompost organic matter may be built and pH may increase. Additional benefits of vermicompost include the disease resistance and avoiding early season deficiencies that are sometimes observed in organic agriculture (Bellitürk and Bağdatlı, 2016).

As it is well known that chemical fertilizers are playing vital role for higher agricultural production. In Turkey, both production and use of this fertilizer are increasing day by day (Bellitürk et al., 2017b; Bellitürk, 2018). However, in the present scenario the overuse of fertilizers is posing environmental problems which are often difficult to overcome in developing countries (Sutton et al., 2011; Sun et al., 2012; Bellitürk, 2017). Vermicompost is now often presented as an attractive alternative to chemical fertilizers (Bellitürk et al., 2015; Bidabadi et al., 2016; Mengistu et al., 2017; Bellitürk et al., 2017a; Yılmaz and Bellitürk, 2018). At the larger scale of regional food systems, fertilizing with vermicompost means recycling nutrients in food waste, agricultural and industrial wastes that would otherwise be taken to landfills. Compost can thus reduce chemical fertilizer use. The increasing cost of chemical fertilizers has prompted farmers in Turkey to rethink their soil fertility practices. New, improved practices will include vermicompost (Bellitürk et al., 2017b).

The organic waste management has improved in Turkey. The number of conventional composting plants has increased since 2000 and the number of vermicomposting plants has increased since 2010 in Turkey (Bellitürk, 2018). An example is the Aegean Region and Marmara Region. There is an increasing number of unregulated composting/vermicomposting operations, estimated at over 4500, that may represent a risk to soils and groundwater. The vast majority of these small scale operations (approximately 95%) are small scale vermicompost producers. There are only fifteen regulated and legally authorized vermicomposting plants, the number of plants that produce legally authorized vermicompost is only 15 at present. This number needs to increase for Turkey to become a leading producer of vermicompost by 2023 (Bellitürk, 2018).

The amount of solid vermicompost increased from 5000 tonnes in 2015 to about 20000 tonnes in 2017 by legally authorized plants despite the lack of academic research on this subject. The number of academic studies in this field is also increasing nowadays. Namık Kemal University has great contribution to this subject in Turkey. According to the data obtained, solid and liquid vermicompost have been successfully used to improve yield and quality of crops, vegetables, fruits and landscape plants (Görres and Bellitürk, 2012; Açıkbaş and Bellitürk, 2016; Zahmacıoğlu et al., 2017; Açıkbaş and Bellitürk, 2017; Barlas and Bellitürk, 2017). Vermicompost can be called the "Second Green Revolution" by completely replacing the destructive agrochemicals (Sinha et al., 2010).

"Vermicomposting-Vermitechnology-Vermiculture Movement" has multiple objectives in Turkey. These include organic waste (especially animal wastes) management, and improved sustainability of agricultural production.

The objective of the present research is to evaluate the vermicompost sector in Turkey nowadays. Another aim of the research is to show why the interest in vermicompost has been increasing day by day in Turkey.

**What exactly are Vermicompost and Vermicomposting?**

"Vermi" is the Latin for "worm". Vermicompost (worm manure) is a nutritive organic fertilizer which must be used for fertilizing as an agricultural input. Vermicomposting (worm composting) is a biological process. Vermicomposting research focuses on the feedstock selection and effect on plant growth, not only in Turkey but also worldwide (Bellitürk, 2017; Bellitürk, 2018). Vermicompost is an important slow-release organic fertiliser for protection of Turkey agricultural soils. In contrast, vermiculture focuses on the worms themselves, and promotes the production of worm biomass maybe for sale as feed for animals or for sale to new vermicomposting operations. Different livestock animals

and fishes have shown excellent production success when fed with vermi-meal or earthworm meal (Guerrero, 2009). Vermitechnology is a promising technique for organic waste recycling.

Vermicompost is a nutrient-rich, earthy-smelling, microbiologically-active organic amendment that results from the interactions between earthworms and microorganism during the gut passage of organic matter (Dominguez, 2004). However, the nutrient and humus content of solid vermicompost is variable. Vermicompost produced legally in Turkey was found to have high nutrient content as shown in Table 1 (Bellitürk, 2018). It was found that there was excellent plant growth as well as improved marketable yield in many crops (Yan et al., 2013; Açıkbaş and Bellitürk, 2016; Zahmacıoğlu et al., 2017; Açıkbaş and Bellitürk, 2017; Barlas and Bellitürk, 2017; Bellitürk et al., 2017b). Vermicompost reduces pollution by providing a valuable substitute for chemical fertilizers (Karmakar et al., 2012) and releasing its nutrients slower than synthetic fertilizers. The value of a vermicompost can be based both upon its nutrient and organic matter content. According to Edwards (1995), biological activity of useful microorganisms in vermicompost is 10 to 20 times greater than that of soil. Vermiculture is the process of culturing earthworms, especially for the purpose to convert organic waste into fertilizer.

Table 1. Agrochemical (or nutrient) compositions of food, cow and sheep waste vermicompost (solid) which is produced in Turkey (on averages in the country).

| Nutrient elements and some other contents | Food waste vermicompost | Cow manure vermicompost | Sheep manure vermicompost |
|---|---|---|---|
| Nitrogen (%) | 1.95 | 1.75 | 1.60 |
| Phosphorus (%) | 1.73 | 1.01 | 0.41 |
| Potassium (%) | 1.32 | 0.74 | 0.37 |
| Calcium (%) | 2.35 | 2.80 | 2.18 |
| Magnesium (%) | 0.62 | 0.98 | 1.06 |
| Zinc (%) | 0.035 | 0.043 | 0.041 |
| Manganese (%) | 0.09 | 0.12 | 0.18 |
| Organic matter (%) | 41.00 | 51.00 | 43.00 |
| EC (Soluble salts) (dS/m) | 4.60 | 6.85 | 8.46 |

Vermicompost, contrary to conventional compost, is the product of an accelerated bio-oxidation of organic matter using epigeic earthworm populations without passing through a thermophilic stage (Dominguez et al., 1997). While mature compost may take as long as 6-8 months to produce, vermicompost produced with modern technologies can be ready in 3-4 months or less.

**Which Species of Earthworms?**

Earthworms improve soil fertility and significantly support agricultural productivity (Sinha et al., 2010). Shortly earthworms play an integral part in agriculture. Earthworms are classified into epigeic, endogeic and anecic species based on their ecological functions (Brown, 1995; Bhatnagar and Palta, 1996). Epigiec species live at the surface of the soil, usually in organic matter rich horizons (James and Guimaraes, 2011) of forest or pasture soils. These worms do not create burrows and cast at the soil surface. Endogeic earthworms live in the mineral soil and make horizontal burrows. The cast is mainly found under the ground. Anecic earthworms make deep, vertical burrows. They introduce organic wastes from the surface into their burrows. The best earthworm species for vermicomposting are epigeic. They are most suited for vermicomposting because they move into wastes newly applied at the top of earthworm bins, are usually very prolific in their reproduction, and are voracious feeders (Bouché, 1977). Epigeic earthworms have been bred since about 2010 for use in vermicomposting-vermiculture in Turkey. Academic studies on the number and species of earthworm are still continuing in Turkey, although much of the earthworm studies focus on the taxonomy of earthworms in genera.

Four species are used in Turkey: *Eisenia fetida*, *Eisenia andrei*, *Dendrobaena venata*, *Lumbricus rubellus*. Patil et al. (2018) reported that, between the two species of earthworms, *Eudrilus euginae* species of earthworm found superior over *Eisenia foetida* species of earthworm in respect of most of the parameters studied. However, the use of *Eudrilus euginae* species is not widespread in Turkey's vermicomposting industry. The most frequently used species of compost worm is the *Eisenia fetida* which is naturally predisposed towards high rates of reproduction and their bodies are more resistant than other species used in Turkey. They can also be obtained from some villages (in non-arid regions of the country) where vermicomposting is already being done.

**What are Common Vermicomposting Feedstocks Used in Turkey?**

Many organic wastes have been converted into vermicompost by different species of epigeic earthworms which include cow manure, cattle manure, horse waste, leaves, paper mill wastes, yard wastes, sheep-goat manure, sawn grass, prunings, forest product sawdust, commercial mulch, ground rice waste, tea-coffee wastes and other agricultural residues (Bellitürk et al., 2015; Bellitürk, 2016). There are a lot of studies on different livestock animals, and fishes have shown excellent results of feeding the animals with vermi-meal or earthworm meal (Guerrero, 2009). Turkish academicians and researchers are interested in this issue very much.

Many domestic, agricultural, and industrial organic waste can be used for vermicomposting. However, some wastes such as citrus, onion-garlic, and meat-bone should not be used for this purpose. The pH value of the earthworm feed is also very important. There is many organic waste products that can be used in vermicomposting in Turkey. The nuisance wastes have to eliminated and develop a valuable product in Turkey. Therefore, vermicompost represents an efficient and very important recycling for waste management in Turkey.

**High-Technology Vermicomposting Systems in Turkey**

Vermicompost may be produced using different technologies. The traditional open systems of vermicomposting have been based on beds, boxes or windrows on the ground containing materials up to 70-80 cm high and 1-2 m wide, but such methods have numerous drawbacks and are not efficient as well as posing potential pollution problems. Since epigeic earthworms a surface dweller which works in the upper layers of the soil (approximately 15-20 cm deep), the feedstock should not be piled higher than 60-70 cm deep (Bellitürk, 2018). The official regulation does not allow this. But the vast majority of vermicompost producers use this method. However, companies that produce vermicompost in Turkey according to the rules generally use modern machine system. There is increased interest in developing automated vermicomposting systems. Engineers at the Riverm Ltd. Company, Tekirdag province, a leading designer of efficient earthworm waste harvesting system, base their system on the principles of automated continuous flow reactors, also known as RHS (Fig. 1). RHS is generally 20 m long; 1.2 m wide, 60 cm deep and on a steel frame, with plywood or water resist material sides. These work automatically with electronic control units controlling (parameters of harvest, temperature, humidity). This system has been widely used in Turkey for 6 years and is officially certified in Turkey. Although this system leverages the ecology of epigeic earthworms and reduces the chance of pollution, it currently has a high price. Engineering research to reduce the price is currently conducted at Riverm Company. According to Edwards (2011a), academic and economic studies have shown that such reactors have more profitable economic potential to produce vermicompost than either windrows or ground bed systems. Legal arrangements also support production by these reactors in Turkey.

Figure 1. Automated continuous flow reactor system (RHS) developed by Riverm Company.

The system designed and developed by Riverm Company in Tekirdag province. This system is economically somewhat costly. In Turkey, finished vermicompost has to undergo a heat treatment with special devices if it is to be certified (Fig. 2). This is to ensure that the vermicompost is not to contaminate crops with pathogens (Bellitürk 2018). In other countries, heat treatment of feedstocks is applied prior to feeding the compost to the worms. This conserves the mesophilic microbial community that is thought to be essential for some of the functions of vermicompost.

Figure 2. Heat treatment (sterilization) machine developed by Riverm Company, Turkey.

There are several methods of harvesting vermicompost in the country. In continuous flow reactors such as the one used at Riverm, the compost is harvested using a slicing knife at the bottom of the reactor. Usually 5 cm of vermicompost is removed. This bottom layer should not contain many epigeic worms as they tend to congregate at the surface. However, some worms are still found in the harvested layer. Because separating earthworms from the compost is laboriously but necessary (Edwards, 2011b), Riverm has developed a machine that simplifies the separation (Fig. 3).

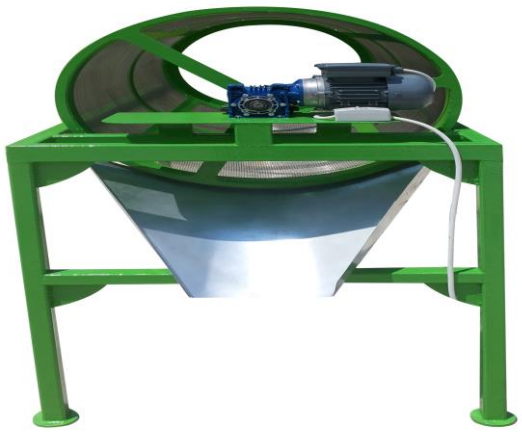

Figure 3. Rotating vermicompost separation system developed by Riverm Company, Turkey.

It is important to dry the vermicompost after the harvest so that it can be packaged stored and transported without it losing its fertility. Special ventilators are used for drying (Fig. 4). Finished compost should contain less than 35% moisture which reduces transport cost and facilitates mechanical application.

Figure 4. Ventilator for solid vermicompost drying.

**What is the Economic Position of the Vermicompost Sector in Turkey?**

This section provides an overview of the economic activity, employment and costs of the vermicompost sectors in Turkey in a favourable national context. There are not many academic studies on the economic value of the vermicompost in Turkey. However, the price of vermicompost vary considerably based on their technology, sterility, organic-waste sources, ranging through animal manures, domestic food wastes, and food technological wastes organic wastes (Arancon and Edwards, 2011). Solid vermicompost is currently sold at prices from about 2000 TL-3000 TL per ton in Turkey (TL: Turkish Lira). Liquid vermicompost sold at prices from about 25000 TL-60000 TL per ton in the country. Although, conventional compost is considerably cheaper, from about 1000 TL per ton, yield improvements are disproportionally higher with vermicompost due its high available nutrient density. Part of the economic equation is also the sale of excess worms. Some of these may be harvested from vermicomposting operations. However, some dedicated vermiculture operations also exist in Turkey.

In spite of the relatively high price, the vermicompost market has been growing rapidly for 7 years with 15 plants operating legally in Turkey in 2018. The growth of vermicompost comes with considerable job creation in the sector. The number of jobs in the vermicompost industry varies depending on the company and the location of the plants. Employment in the vermicompost sector is now distributed across all regions.

According to the all economic calculations, the application of vermicompost to the crops, fruits and greenhouse vegetables are more profitable than conventional compost in Turkey conditions (Erdil and Bellitürk, 2017). Current prices of solid and liquid vermicompost are an important factor to consider in deciding the most appropriate vermicompost as well as correct application rates. Turkish farmers are more likely to adopt vermicomposting if the selling price of solid-liquid vermicompost in Turkey decreases. Farmers should consider, however, that the benefits of vermicompost are not only plant nutritional but that the disease resistance attributed to vermicompost reduces the cost of chemical pesticides as well.

The better yields obtained when vermicompost instead of regular compost is applied is likely due to the fact that vermicompost has greater nutrient densities than compost. Also, in contrast to traditional compost, nutrients in vermicompost become available more quickly. Its application also improves chemical, physical, microbiota and biochemical properties of the soil (Vivas et al., 2009). Vermicompost contains biochemical substances that promote plant growth, soil amendment and resistant against plant diseases (Noble and Coventry, 2005). However, for Turkish farmers, vermicompost price is still perceived as high even though studies have shown that it provides greater yield and better quality produce. As a solution to the problems, farmers who are using vermicompost should be encouraged by Turkish government. Vermicompost can also be sued in combination with other fertility amendments. Austin (2015) found that vermicompost as a part of a starter ix for seedlings can increase yields substantially. Greater acceptance of vermicompost by farmers may come with more education and an understanding that sustainable farming also protects the environment. Studies on fcrop responses to vermicompost application should also include economic evaluations such as cost –benefit analyses (Austin, 2015). Given the low organic matter content of Turkish soils, more organic fertilizers such as vermicompost should be applied to maintain soil quality.

**Conclusions**

Vermicompost is rich in organic matter, which plays a vital role in soil fertility, and contains all essential plant nutrients in sufficient proportions. Vermicompost products are suitable for large and small scale production, from commercial crop production to kitchen gardens. Its use may also benefit agroforestry systems such as tree nut production on forest commission land. The new concept and trend are “ecological agriculture” in Turkey. Agricultural productivity is also decreasing due to global warming. Building organic matter content in soils is one way of combating climate change. Ecological agriculture is also of great importance for reducing the adverse effects of global warming. Vermitechnology, vermiculture and also vermicomposting provides the best answer for ecological agriculture, which is synonymous with “sustainable agriculture”.

Both chemical and also organic fertilizers are important tools for agricultural development in support of food security and for maintaining soil productivity. Worm farming is said to be the fastest growing agricultural industry in the country with economic benefits like job creation. Maintaining the expansion of the industry requires great effort and academic . Training courses for vermicompost producers and farmers have been regularly held at Namık Kemal University, Turkey for the last 2 years. Numerous scientific presentations are held in national and international congresses in this

country. Increasing agricultural productivity of soils is a major target over the coming decades. This is especially the case for agricultural lands that are affected by reducing soil organic matter where the crop, vegetable and fruit yields remain relatively low. Vermicompost application might help soil and plant to overcome this problem. The effects of vermicomposting on soil, plant and environmental will be considered in more detail in the future studies. This study thus presents as assessment of the economic, environmental and future impact of the sector, in terms of sustainable agricultural activity.

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**Competing Interests**

The author declares that he has no competing interests.

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# Some soil physical and chemical properties of natural stands and plantations at different ages of stone pine in Biga (Çanakkale-Turkey)

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**Abstract**

Soil physical and chemical properties were compared in stone pine (*Pinus pinea* L.) plantations vs neighboring natural sites. The pine plantations were selected at ages of 3, 10, 20 and 30 in Biga (Çanakkale-Western Turkey) to harvest adequate sampling plots and the natural sampling plots were settled to the vicinity of the plantation plots. The soils were investigated in terms of chemical such as pH and EC (µS/cm) and physical such as soil volume weight, fine soil weight and skeleton weight (g/L) which were taken from 0-5 and 5-15 cm depths from 9, 5, 8 and 8 sites (30 sites in total) for 3, 10, 20 and 30-year-old sampling plots. We assumed that, plantation causes decrease at pH, EC, soil volume weight, fine soil weight and increase at skeleton weight which would have occurred because of tillage and in contrast, the soils in natural sites, should have the opposite properties of plantation sites. The results revealed that; pH was lower in natural plots than plantation at 20-year-old sites (no significant difference in other plots), EC did not show any significant difference between natural and plantation sites. Soil volume weight was higher in plantation plots than natural lands at 10 and 20-year-old sites; fine soil weight was higher in natural land which is in concordance with our hypothesis; and skeleton weight of natural sites was one third of plantation sites. The results showed that; soil chemical and physical properties do not alter immediately after the plantation of a natural site but is an efficient factor on soil.

**Keywords:** Stone pine, soil chemical properties, soil physical properties, Biga.

## Introduction

Pine plantations in Mediterranean regions have widely been applied for their socio-economical attribute and conversion of shrublands to latter successional stages. Pausas et al. (2004) discussed and evaluated the traditional pine plantations in terms of social demands and their adaptable features to Mediterranean specific ecosystem properties such as drought and fire sensitivity with conclusion of alternative tree + shrub species combinations. Studies by Öztürk (1995) and Öztürk et al. (2002, 2008, 2010 and 2011) revealed that, pine plantations have shown a seriously increase at plantation of semiarid Mediterranean regions. Semiarid areas of Turkey are subject to interest of land management authorities to be assessed as more profitable lands within providing a response to social demand and resistant ecosystems to soil

loss with erosion, fire (fire resistant species) and drought (deep root developing species are chosen preferentially).

Maquis lands occupy the majority vegetation type of the Mediterranean ecosystems, and they are fire and drought adapted. Even though; conversion of natural shrublands or maquis lands to the plantations is a globally common application to optimize the benefits from a given site. The plantations are expected to extensive utilization of ecosystem resources such as water, nutrients and below and above ground spaces, but review on plantations' effects on semiarid areas do reveal generally negative effects; enhanced runoff and soil loss thus within nutrient and organic matter loss; improvement on soil properties are extremely limited and additionally fauna is also affected negatively from plantations (Maestre and Cortina 2004). In the study by Andrés and Ojeda (2002), the diversity of woody and soft stem bearing plants are significantly lower in pine plantations compared to adjacent Mediterranean heathlands, which cause to ecosystem susceptibility in terms of floral and faunal biodiversity.

Plantation is an alteration of current ecosystem thorough soil treatments and by introducing some new species. According to the study by Perez-Bejarano et al. (2010); the soil properties differed under contrasting forest and shrub species that of (*Pinus halepensis* Mill, *Quercus coccifera* L., *Juniperus oxycedrus* L. and *Rosmarinus officinalis* L.) significantly on advantageous of *P. halepensis* and *Q. coccifera* while, they manifest the promotional effect of semiarid conditions and shrub species. Southern Marmara region is characterized mainly semi-drought climate and drought-fire adapted vegetations with typical Mediterranean tree species Pinus brutia and shrubby oak species. The study site is dominated by *Pinus brutia* Ten., *Arbutus andrachne* L., *Phillyrea latifolia* L., *Pistacia* spp., *Cistus* spp. Main goal of the current study is to investigate the effects of different aged plantations on soil physical and chemical properties and to reveal practical results to enlighten the future studies.

## Material and Methods

### Study site

The study area is located at southern Marmara region in Biga province (Çanakkale-Turkey), lies thorough north to south. According to the long term meteorological observation results; annual average, minimum and maximum temperatures are 14.0; 5.6 (January) and 23.1$^{o}$C (July); annual average minimum and maximum precipitation values are 666; 12 (July) and 113 mm (January) respectively (Anon. 2017). The soils are mainly weathered formations of Pliocene rocks and also the accumulated deposits of volcanic rocks originated from Pliocene age (Yıkılmaz et al., 2002; Akkaya, 2008). The dominating vegetation type in study area are Calabrian pine and accompanying Mediterranean shrub species in locations where primary vegetation type exist and damaged Calabrian pine forests are replaced with secondary shrubby maquislands with species of *Arbutus andrachne* L., *Phillyrea latifolia* L., *Pistacia* spp., *Cistus* spp., *Laurus nobilis* L., *Paliurus spina-christi* Mill., Rhus spp., Rhamnus spp., Quercuscoccifera L., Oleaeuropaea L., Tamarix spp., *Quercus ithaburensis* subsp. *macrolepis* (Kotschy) Hedge &Yalt.) and *Quercus cerris* L. (Topçuoğlu, 1966).

### Soil samples

The soil samples were collected from 4 different locations to obtain the gradual age pattern. The ages of the plantations are 3, 10, 20 and 30 and the natural lands are mainly covered with native multiannual shrub and annual herbal species (Table 1). The soil samples were collected along a transect from native to plantation lands per 10 m intervals; from 0-5 and 5-15 cm depths with stainless steel cores to get intact samples. The samples were stored in polyethylene bags till conveyed to laboratory and then they are subjected to soil analyzes. Soils were ground and sieved following air dried and weighed before and after the skeleton has been removed. The bulk (volume) weight of the samples were detected prior to grounding the soils. pH and EC were measured in pHmeter and EC meter from 1:2.5 soil solution.

Table 1. Distribution of number of sampling sites to age classes.

| Age | Site names | Number of sampled plots | Natural land | Plantation land |
|---|---|---|---|---|
| 3 | Pekmezli | 9 | 4 | 5 |
| 10 | Kepekli | 5 | 3 | 2 |
| 20 | Ortuluce | 8 | 3 | 5 |
| 30 | Ilyasalan | 8 | 3 | 5 |

**Statistics**

Data collected, classified and interpreted to detect the statistical relations in between the treatments. The soil analysis results were compared in terms of age, soil depth and natural vs plantation subplots by ANOVA in JMP 13v. The homogeneity of variances was tested, and the results were subjected to Tukey HSD at p 0.001 and 0.05 significance levels.

**Results**

*Chemical properties*

According to a comparison between the natural and plantation sampling plots, pH showed a significant difference for the plots at age of 20 where pH was slightly lower in natural lands than plantation plots ($p<0.05$) (Figure 1-I). At other aged plots, we did not find any significant difference when compared natural vs plantation. The comparisons made to see the differences according to age, the data for natural and plantation plots were pooled but the depths were investigated separately; the results showed that; the pH was significantly higher at 10-year-old plots in 0-5 cm (p: 0.0007) and at 3-year-old plots at 5-15 ($p<0.0001$) depth soils (Table 2).

Electrical conductivity did not show significant difference between natural and plantation sampling plots. The results obtained with natural + plantation pooled for depth series of samples showed that; the EC is decreasing with the age (highest at youngest plots and lowest at older plots) for both 0-5 (p: 0.0194) and 5-15 cm (p: 0.0464) soils (Table 2).

Table 2. Comparison of soil physical and chemical characteristics of sampled plots (Volume weight, Fine soil weight and skeleton weights are as kg/L).

| Depth | Age | pH | EC | Vol W | Fine S W | Skl W |
|---|---|---|---|---|---|---|
| 0-5 cm | 3 | 5,87b | 107,6a | 1160,5ab | 1081,9a | 78,7b |
| | 10 | 6,69a | 101,5ab | 1143,6ab | 784,7b | 358,9a |
| | 20 | 6,12b | 97,0ab | 1334,6a | 960,2ab | 374,4a |
| | 30 | 5,83b | 52,7b | 1005,5b | 891,4ab | 114,2b |
| 5-15 cm | 3 | 6,9bc | 85,5a | 1270,2ab | 1195,1a | 75,1c |
| | 10 | 6,18a | 86,0a | 1364,2ab | 724,1c | 640,0a |
| | 20 | 5,77b | 81,2a | 1393,3a | 938,2bc | 455,2b |
| | 30 | 5,41c | 53,5a | 1175,5b | 1067,7ab | 107,9c |

The letters connect each parameter per depth separately. The significances for 0-5 cm; pH 0.0007; EC 0.0194; Vol W 0.0008; Fine S W 0.0132 and Skl W $p<0.0001$ and for 5-15 cm; pH $p<0.0001$; EC 0.0464; Vol W 0.0418; Fine S W 0.0012 and Skl W $p<0.0001$.

*Physical properties*

Volume weight of soils showed a significant difference at 10 and 20-year-old plots where the volume weight of the soils were lower in natural sample plots than plantation plots ($p<0.05$) (Figure 1-II). The natural + plantation plots pooled data results showed that, the volume weight is highest in 20-year-old plots and lowest in 30-year-old plots in both 0-5 cm (p: 0.0008) and 5-15 cm (p: 0.0418) depth of soils (Table 2).

Fine soil weight showed a significant difference at 3-year-old sites with slightly higher weighing in natural lands (1273 g/L) than plantation plots (1038 g/L). In 10, 20 and 30-year-old sampling plots, we did not reach to any significant difference between natural and plantation plots. When the natural and plantation data pooled and the sites with different ages were compared between each other, the results showed that; the highest soil volume weight has been detected in 3-year-old sites and the lowest fine soil weight in 10-year-old sites in both 0-5 cm (p: 0.0132) and 5-15 cm (p: 0.0012) depth of soils (Table 2).

The skeleton weight in natural sites (33 g/L) was more than one third of plantation sites (107 g/L). When the natural and plantation data pooled and the sites with different ages were compared between each other, the results showed that the lowest skeleton weight was detected in 3-year-old sites and the highest skeleton weight in 10-year-old sites for both 0-5 cm (p: 0.0008) and 5-15 cm (p: 0.0418) depths respectively (Table 2).

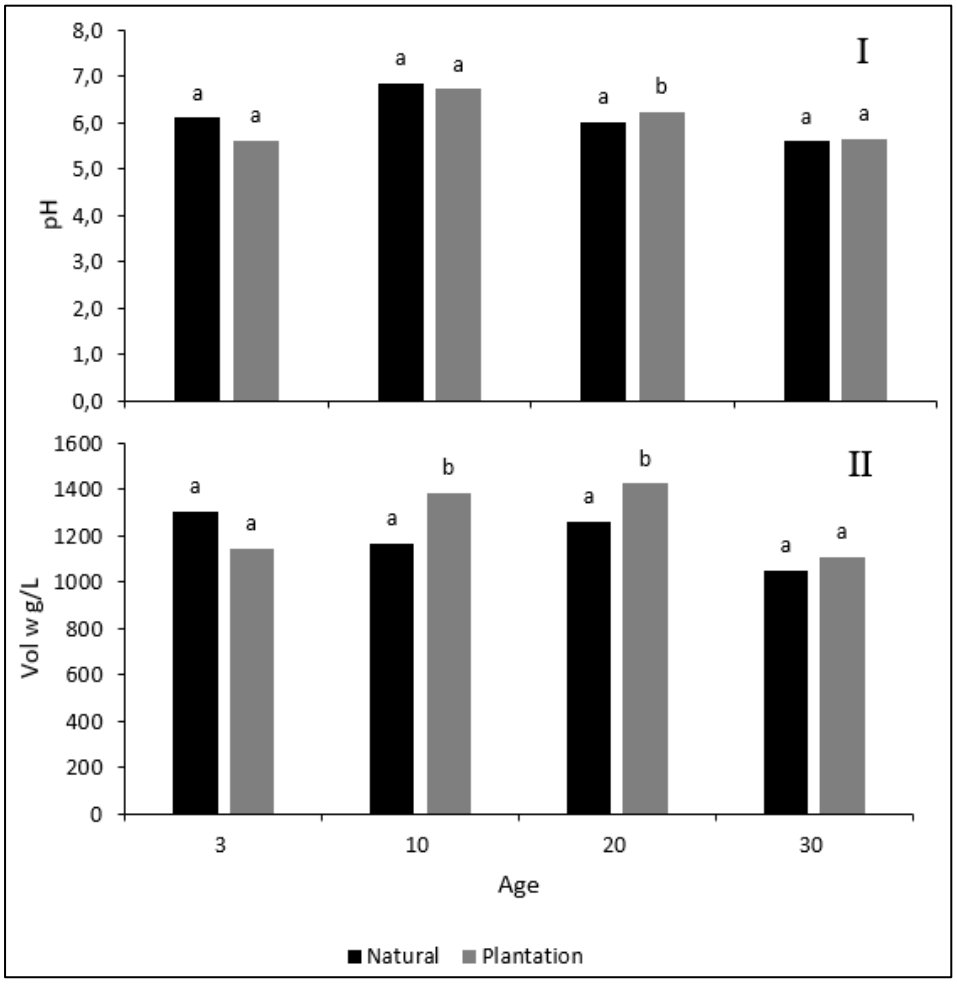


Figure 1. Comparison of pH and soil volume weight (g/L).

## Discussion and Conclusion

Plantation may differ soil pH depending on the plant species type and decomposition byproducts. The sites planted with stone pine are expected to decrease the pH by acidic humic substances. Indeed, in the study by Berthrong et al. (2009) stated that; afforestation of a non-forested land with pine trees or with other tree combinations deplete the soil cation saturation resulting in decrease in buffer capacity of soil and pH. Over soil cation leaching because of tillage may cause to reduction in pH. Plus, uptake of the cations by plants may cause to decreased pH. In our study, the soil pH was lowest in 30-year-old plantation sites while the differences between natural and plantation sites, pH was slightly but significantly lower in natural sites than plantation (pH 6.12 vs 6.18 at natural and plantation sites respectively). In the study by Tecimen et al. (2017), they detected particularly lower plant diversity in plantation sites. Despite the lower diversity, the species composition may have caused to decrease at soil pH.

Site preparation prior to plantation supposed to be the most efficient factor on soil physical properties and subsequently in combination with soil tillage the plantation of the trees alters the soil chemical properties. According to the review study by Blanco-Canqui and Ruis (2018), no tilling is responsible to reduction of bulk density up to 13% at upper soil depths. In the study by Su and Zhao (2003) stated that; plantation with shrub species improved soil water holding capacity and decreased soil volume weight. Singh et al. (2001) found that; soil bulk density decreased along the age of the afforested landslide site from 1.74 to 1.15 g/L at ages 1 to 58 respectively whereas mature forest has slightly lower soil bulk density. The results obtained from our study revealed that, the volume weight at natural lands vs plantation plots did not show any significant difference at immediate comparison (3-year-old plantation compared to natural sites). But at 10 and 20-year-old stands the volume weight values were higher at plantation sites than the naturally grown sites. When the natural and plantation data pooled the differences between sites in terms of age of trees showed that, volume weight was highest in 20-year-old sites for both 0-5 cm and 5-15 cm depth of soil. The fine soil weight values were higher at 3-year-old natural sites compared to plantation sites and again the chrono-sequential comparisons revealed a higher fine soil weight at 3-year-old natural sites compared to others, when the natural and plantation data pooled. Studies on soil physical properties of plantations conclude that; the density (volume weight) of plantation sites are generally higher in initial years and progressively this value decreases to the density of natural field level. However, our results showed that, the highest volume weight among the sequential sites has been seen at 10 and 20-year-old stands.

We concluded that, stone pine plantation causes slight alteration at soil density and soil pH both of which are higher at plantation sites than the natural sites. Currently studied ecosystem possesses low soil cations and the tree species chosen for plantation are contented that may not exploit the soil cations and may particularly support the soil ecosystem with providing a shelter for floral and faunal diversity.

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# Contributions to the knowledge autumnal lepidoptera species of Dağlıca (Hakkari, Southeastern Turkey) with two poorly known noctuid moths

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**Abstract**
This paper evaluates a collection of autumnal Lepidoptera species from Dağlıca vicinity of Hakkari Province. A total of 58 species are examined belonging to 9 families. Off all, 33 species in Dağlıca vicinity and 21 species in Hakkari Province are determined for the first time. All the species are listed alphabetically within the families, together with synonyms and studied materials. Furthermore, distribution of endemic and poorly known two noctuid species, *Ostheldera arne* L. Ronkay & Varga, 1994 and *Hakkaria varga* (Hacker, [1987]) are discussed and, their adults and genital pictures are illustrated.
**Key words:** Fauna, Lepidoptera, Dağlıca, Hakkari, Turkey.

**Özet**
Bu makale, Hakkari İlinin Dağlıca bölgesinin sonbahar Lepidoptera faunasına ait bir koleksiyonunu değerlendirmektedir. Toplamda, 9 familya içerisindeki 58 tür incelenmiştir. Bunlardan 33 tür Dağlıca'da, 21 tür Hakkari'de ilk kez tespit edilmiştir. Tüm türler familyaları içerisinde alfabetik olarak, sinonimleri ve incelenen örnekleri ile birlikte listelenmiştir. Bununla birlikte, endemik ve az bilinen iki noctuid türü, *Ostheldera arne* L. Ronkay & Varga, 1994 ve *Hakkaria varga* (Hacker, [1987])'nın dağılışları tartışılmış, ergin ve genital resimleri eklenmiştir.
**Anahtar kelimeler:** Fauna, Lepidoptera, Dağlıca, Hakkari, Türkiye.

## Introduction

Dağlıca vicinity is located in Hakkari Province within the south-east of Turkey. It is very near to the northern border of Iraq and surrounded by steep mountains. Hakkari is an extremely mountainous region, and is one of the most challenging areas in Turkey regarding the studies on nocturnal Lepidoptera species due to security and geographical conditions.

Autumn species of Dağlıca is sufficiently not known. However, some recent studies have attempted to useful in this respect. Kemal et al. (2017, 2018) are listed 189 spring species of 25 families in 2017 and subsequently, 390 species of 35 families from Dağlıca vicinity in 2018. Furthermore, according to studies published at irregular intervals, totally 1012 Lepidoptera species were known in Hakkari Province (Koçak and Kemal 2015, 2018; Kemal and Koçak 2018). The results in this paper concluded that 21 species are new to fauna of Hakkari Province and 33 species are new to fauna of Dağlıca vicinity. Moreover, endemic and poorly known two noctuid species, *Hakkaria varga* (Hacker, [1987]) (fig. 1)

and *Ostheldera arne* L. Ronkay & Varga, 1994 (fig. 2), which are active in autumn, have also been determined in the research region.

The genus *Ostheldera* Nye, 1975 is the sister group of *Asteroscopus* Boisduval, 1828 and comprises 6 species: *O. gracilis* (Osthelder, 1933); *O. persa* Ronkay & Varga, 1994; *O. arne* Ronkay & Varga, 1994; *O. minna* Ronkay & Varga, 1994; *O. kondara* Varga & Ronkay, 1991 and *O. pakistana* Ronkay, Ronkay & Gyulai, 2011 (Ronkay et al. 2011). In Turkey, two of them, *O. arne* L. Ronkay & Varga, 1994 and *O. gracilis* (Osthelder, 1933) are known (Koçak and Kemal 2018).
*Ostheldera arne* L. Ronkay & Varga, 1994 is known from a relatively small area extending from southeastern Turkey to north-west Iran. Type locality of the species is 5 km south of Hakkari, 1800 m, holotype of male in coll. M. Fibiger (Ronkay et al. 2011). *Hakkaria varga* (Hacker, [1987]) was firstly described in *Polymixis* genus by Hacker in 1987. After that Ronkay and Varga (1990) transferred this species in a newly created genus ‘‘*Hakkaria*’’. The genus is represented by a single species which belongs to another phyletic line, being transitional between the generic groups *Polymixis* and *Dasypolia* (Ronkay and Varga 1990). It represents phyletic line of unique combination of features. Until now, the species is only known in its type locality that is Şırnak Province, Tanin Mountain, Elkek Passage, 7 km from Uludere, 2200 m, 15.09.1985 (leg. and coll. H. Hacker). After long years, the second locality of these rare species have been found in Dağlıca vicinity, Hakkari Province, south-easternmost of Turkey with this study.

**Material and Methods**

Samples were collected from Dağlıca vicinity of Hakkari Province on 19 September 2016, 1280 m, 37°22'22"N 44°04'57"E, 21-22 September 2017, 1130 m, 37°23'09"N 44°04'46"E and 3-7 October 2017, 1350 m, 37°22'41"N 44°05'05"E, in step areas containing sparse oaks, with a simple UV light trap system (UV strip led, 12V 7Ah battery and a transparent box). After field studies, pinned specimens were stretched and diagnosed according to these sources: De Freina and Witt (1987), Fibiger (1990, 1993, 1997), Ronkay and Varga (1990, 1994), Hesselbarth et al. (1995), Ronkay et al. (2001, 2011), Hausmann (2001, 2004), Hacker et al. (2002), Goater et al. (2003), Mironov (2003), Zilli et al. (2005), Fibiger and Hacker (2007), Leraut (2006, 2009), Fibiger et al. (2009, 2010), Hausmann and Viidalepp (2012). Identified materials are preserved in the Biology Laboratory of Batman University and special collection of the author in Batman Province.

In the results part, species are presented in alphabetical order within the families. New records in Dağlıca vicinity are marked with an asterisk (*) symbol and likewise new records in Hakkari Province are marked with a plus ($^{+}$) symbol after the name of the species.

**Results**
**Butterflies:**

**Argynnidae**
***Argynnis pandora*** ([Denis & Schiffermüller], 1775)
**Synonym(s):** *pandora* [Denis & Schiffermüller], 1775; *maja* Cramer, 1775 nec Fabricius, 1775; *cynara* Fabricius, 1777; *cyrnea* Schwerda, 1926; *transcaucasica* Moucha, 1967; *deserticola* Gross & Ebert, 1975. **Material studied:** 3♂♂, 19.IX.2016; 1♂, 03.X.2017.

**Satyridae**
***Chazara briseis*** (Linnaeus, 1764)

**Synonym(s):** *briseis* Linnaeus, 1764; *daedale* Bergsträßer, 1780; *bataia* Fruhstorfer, 1909; *interjecta* Verity, 1916; *variabilis* Varin, 1958; *pictonica* Varin, 1958. **Material studied:** 1♂, 22.IX.2017.

**Moths:**

**Arctiidae**
***Axiopoena karelini*** Ménétriés, 1863*
**Synonym(s):** *karelini* Ménétriés, 1863; *transcaucasia* Sheljuzhko, 1926; *manissadjiani* O.Bang-Haas, 1927. **Material studied:** 1♀, 22.IX.2017.

**Ctenuchidae**
***Dysauxes famula*** (Freyer, 1836)*
**Synonym(s):** *famula* Freyer, 1836; *hyalina* Freyer, 1845; *ragusaria* Zickert, 1904*; herthina* Stauder, 1921; *burgeffi* Draudt, 1931; *taurica* Draudt, 1931; *pseudoservula* Naufock, 1933; *pontica* Friese, 1959; *sofiata* De Laever, 1983; *lucana* De Laever, 1983. **Material studied:** 4♂♂ 3♀♀, 21.IX.2017; 2♀♀, 04-07.X.2017.

**Geometridae**
***Aplocera plagiata*** (Linnaeus, 1758)
**Synonym(s):** *plagiata* Linnaeus, 1758; *pallidata* Staudinger, 1879. **Material studied:** 3♂♂, 19.IX.2016; 1♂ 06.X.2017.

***Apochima diaphanaria*** (Püngeler, 1904)
**Synonym(s):** *diaphanaria* Püngeler, 1904. **Material studied:** 5♂♂ 3♀♀, 22.09.217; 3♂♂ 05-07.X.2017.

***Charissa dubitaria*** (Staudinger, 1892)*
**Synonym(s):** *dubitaria* Staudinger, 1892. **Material studied:** 3♂♂ 4♀♀, 21.IX.2017; 2♀♀, 03-05.X.2017.

***Charissa onustaria*** (Herrich-Schäffer, [1852])* +
**Synonym(s):** *onustaria* Herrich-Schäffer, [1852]; *oneraria* Guenée, [1858]. **Material studied:** 2♂♂ 2♀♀, 21.IX.2017.

***Chesistege korbi*** (Bohatsch, 1910)
**Synonym(s):** *korbi* Bohatsch, 1910. **Material studied:** 3♂♂, 04.X.2017.

***Coenotephria schneideraria*** (Lederer, 1855)* +
**Synonym(s):** *schneideraria* Lederer, 1855; *taurica* Staudinger, 1901; *eteocretica* Rebel, 1906. **Material studied:** 2♂♂ 4♀♀, 21.IX.2017; 5♀♀, 06.X.2017.

***Crocallis elinguaria*** (Linnaeus, 1758)* +
**Synonym(s):** *elinguaria* Linnaeus, 1758; *trapezaria* Boisduval, 1840. **Material studied:** 3♂♂ 5♀♀, 22.IX.2017; 2♀♀, 04-06-07.X.2017.

***Ennomos quercarius*** (Hübner, [1813])* +
**Synonym(s):** *quercaria* Hübner, [1813]. **Material studied:** 2♂♂ 1♀, 04.X.2017.

***Eumera hoeferi*** Wehrli, 1934* [+]
**Synonym(s):** *#höferi* Wehrli, 1934; *hoeferi* Wehrli, 1934; *#hoferi* Wiltshire, 1937. **Material studied:** 2♀♀, 21.IX.2017.

***Glossotrophia sacraria*** (A.Bang-Haas, 1910)
**Synonym(s):** *sacraria* A.Bang-Haas, 1910. **Material studied:** 3♂♂ 5♀♀, 22.IX.2017; 3♂♂, 05-06.X.2017.

***Gnophos pseudosnelleni*** Rjabov, 1964*
**Synonym(s):** *pseudosnelleni* Rjabov, 1964. **Material studied:** 2♂♂ 6♀♀, 22.IX.2017; 1♂ 1♀, 05-07.X.2017.

***Idaea degeneraria*** (Hübner, [1799])
**Synonym(s):** *degeneraria* Hübner, [1799]; *degenerata* Treitschke, 1828; *floridaria* Turati, 1913. **Material studied:** 3♂♂ 2♀♀, 03-04.X.2017.

***Odontognophos zacharius*** (Staudinger, 1879)* [+]
**Synonym(s):** *zacharia* Staudinger, 1879. **Material studied:** 1♂, 03.X.2017.

***Scopula immistaria*** (Herrich-Schäffer, [1852])
**Synonym(s):** *#elisabetharia* Heydenreich, 1851; *immistaria* Herrich-Schäffer, [1852]. **Material studied:** 3♂♂ 1♀, 04-05.X.2017.

***Scopula marginepunctata*** (Goeze, 1781)
**Synonym(s):** *marginepunctata* Goeze, 1781; *conjugata* Borkhausen, 1794; *aniculosata* Rambur, 1829; *puellaria* Boisduval, 1840; *mutaria* Heydenreich, 1851; *promutata* Guenée, [1858]; *promutaria* Morris, 1861; *apertaria* Walker, [1863]; *madoniata* Fuchs, 1901; *pastoraria* De Joannis, 1891. **Material studied:** 3♂♂ 2♀♀, 19.IX.2016; 2♂♂ 21.IX.2017; 3♂♂, 04-07.X.2017.

**Lasiocampidae**
***Lasiocampa eversmanni*** (Kindermann, 1843)
**Synonym(s):** *eversmanni* Kindermann, 1843; *eversmanni* Freyer, 1844; *attrita* Stshetkin, 1960. **Material studied:** 3♂♂ 2♀♀, 21.IX.2017; 3♂♂, 03-04.X.2017.

***Lasiocampa grandis*** (Rogenhofer, 1891)
**Synonym(s):** *grandis* Rogenhofer, 1891. **Material studied:** 2♂♂ 1♀, 22.IX.2017; 3♂♂, 04.X.2017.

***Trichiura stroehlei*** Zolotuhin, 2007*
**Synonym(s):** *stroehlei* Zolotuhin, 2007. **Material studied:** 2♂♂, 04.X.2017.

**Lemoniidae**
***Lemonia pia*** Püngeler, 1902
**Synonym(s):** *pia* Püngeler, 1902. **Material studied:** 3♂♂ 1♀, 05.X.2017.

**Noctuidae**
***Agrochola lactiflora*** (Draudt, 1934)* [+]
**Synonym(s):** *lactiflora* Draudt, 1934; *fibigeri* Hacker & Moberg, 1989. **Material studied:** 3♂♂ 1♀, 04-05.X.2017.

***Agrochola humilis*** (Fabricius, 1787)*
**Synonym(s):** *#humilis* [Denis & Schiffermüller], 1775; *humilis* Fabricius, 1787. **Material studied:** 2♀♀, 03.X.2017.

***Allophyes renalis*** (Wiltshire, 1941)*
**Synonym(s):** *renalis* Wiltshire, 1941; *crassicornis* Brandt, 1941. **Material studied:** 2♂♂, 05.X.2017.

***Ammoconia caecimacula*** (Fabricius, 1787)* +
**Synonym(s):** *caecimacula* Fabricius, 1787; *millegrana Esper, [1790]; respersa* Brahm, 1791; *rhaeticaria* Dannehl, 1926; *marsicaria* Dannehl, 1929. **Material studied:** 2♂♂, 07.X.2017.

***Autophila ligaminosa*** (Eversmann, 1851)* +
**Synonym(s):** *ligaminosa* Eversmann, 1851; *caucasica* Herz, 1904. **Material studied:** 3♂♂ 2♀♀, 21.IX.2017, 3♂♂, 04.X.2017.

***Catocala elocata*** (Esper, [1787])
**Synonym(s):** *elocata* Esper, [1787]; *marita* Hübner, [1813]; *nurus* Hübner, [1822]. **Material studied:** 1♂, 22.IX.2017.

***Chersotis margaritacea*** (Villers, 1789)* +
**Synonym(s):** *margaritacea* Villers, 1789; *i-intactum Hübner, [1803]; #abruzzensis* Corti & Draudt, 1933; *espunensis* Calle, 1982. **Material studied:** 2♂♂ 1♀, 03-05.X.2017.

***Chersotis obnubila*** (Corti, 1926)*
**Synonym(s):** *obnubila* Corti, 1926; *maraschi* Corti & Draudt, 1933 (p.61) nec Corti & Draudt, 1933 (p.58); *ebertorum* Koçak, 1980. **Material studied:** 2♂♂, 05-07.X.2017.

***Dichagyris amoena*** (Staudinger, 1892)
**Synonym(s):** *amoena* Staudinger, 1892; *flavida* Corti & Draudt, 1933. **Material studied:** 3♂♂ 3♀♀, 03-04.X.2017.

***Dichagyris fredi*** (Brandt, 1938)
**Synonym(s):** *fredi* Brandt, 1938. **Material studied:** 3♂♂ 1♀, 21.IX.2017; 2♂♂, 03-07.X.2017.

***Dichagyris singularis*** (Staudinger, 1877)
**Synonym(s):** *singularis* Staudinger, 1877. **Material studied:** 11♂♂ 5♀♀, 19.IX.2016, 3♂♂, 21-22.IX.2017; 5♂♂, 03-04-05.X.2017.

***Dichagyris nachadira*** (Brandt, 1941)* +
**Synonym(s):** *nachadira* Brandt, 1941. **Material studied:** 3♂♂ 2♀♀, 03-04.X.2017.

***Dichonia aeruginea*** (Hübner, [1803])* +
**Synonym(s):** *aeruginea* Hübner, [1803]; *mioleuca* Geyer, [1828]; *chioleuca* Treitschke, 1835; *mesembrina* Schawerda, 1913. **Material studied:** 3♂♂, 04-05.X.2017.

***Dryobotodes carbonis*** (F.Wagner, 1931)* +
**Synonym(s):** *carbonis* F. Wagner, 1931; *taurica* Osthelder, 1933; *europaea* Pinker, 1976. **Material studied:** 2♂♂ 1♀, 05-06.X.2017.

***Episema korsakovi*** (Christoph, 1885)
**Synonym(s):** *korsakovi* Christoph, 1885; *paenulata* Christoph, 1885. **Material studied:** 2♂♂ 1♀, 06-07.X.2017.

***Eugnorisma enargiaris*** (Draudt, 1936)
**Synonym(s):** *enargiaris* Draudt, 1936. **Material studied:** 3♂♂ 1♀, 21.IX.2017; 1♀, 04-07.X.2017.

***Gortyna flavago*** ([Denis & Schiffermüller], 1775)* +
**Synonym(s):** *flavago* [Denis & Schiffermüller], 1775; *ochracea* Hübner, 1786; *lappae* Donovan, 1801; *ochraceago* Howarth, 1809; *cinerea* Goossens, 1880. **Material studied:** 2♂♂, 04.X.2017.

***Hakkaria varga*** (Hacker, [1987])* + (fig. 1)
**Synonym(s):** *varga* Hacker, [1987]. **Material studied:** 1♂, 03.X.2017, slide no. 576♂.

***Helicoverpa armigera*** (Hübner, [1808])
**Synonym(s):** *obsoleta* auct. nec Fabr., 1775; *barbara* Fabricius, 1794 [rejected]; *armigera Hübner, [1808]; pulverosa Walker, [1857]; uniformis Wallengren, 1860; rama* Bhattacherjee & Gupta, 1972. **Material studied:** 2♂♂, 06-07.X.2017.

***Hoplodrina ambigua*** ([Denis & Schiffermüller], 1775)
**Synonym(s):** *ambigua* [Denis & Schiffermüller], 1775; *plantaginis* Hübner, [1813]; *uniformis* Swinhoe, 1885. **Material studied:** 7♂♂ 3♀♀, 22.IX.2017; 2♀♀, 03-07.X.2017.

***Lacanobia thalassina*** (Hufnagel, 1766)* +
**Synonym(s):** *thalassina* Hufnagel, 1766; *humeralis* Haworth, 1809; *achates* Hübner, [1813]. **Material studied:** 2♂♂, 06-07.X.2017.

***Luperina rjabovi*** (Kljutschko, 1967)* +
**Synonym(s):** *rjabovi* Kljutschko, 1967. **Material studied:** 4♂♂ 1♀, 03-07.X.2017.

***Melanchra persicariae*** (Linnaeus, 1761)*
**Synonym(s):** *persicariae* Linnaeus, 1761; *sambuci* Hufnagel, 1766; *graphica* Geoffroy, 1785; *accipitrina* Esper, [1788]. **Material studied:** 2♂♂, 03.X.2017.

***Metopodicha ernesti*** Draudt, 1936*
**Synonym(s):** *ernesti* Draudt, 1936; *achaemenica* Wiltshire, 1941. **Material studied:** 3♂♂ 1♀, 22.IX.2017; 1♀, 03.X.2017.

***Ostheldera arne*** L. Ronkay & Varga, 1994* (fig. 2)
**Synonym(s):** *arne* L. Ronkay & Varga, 1994. **Material studied:** 1♂ 1♀, 04.X.2017; slide no. 575♂, 581♀.

***Oxytripia stephania*** Sutton, [1964]
**Synonym(s):** *stephania* Sutton, [1964]; *danilevskyi* Miljanovsky, 1973. **Material studied:** 2♂♂, 04.X.2017.

***Polymixis rufocincta*** (Geyer, 1828)* +
**Synonym(s):** *rufocincta* Geyer, [1828]; *farinosa* Freyer, 1848; *mucida* Guenée, 1852. **Material studied:** 3♂♂, 21.IX.2017; 1♀, 06.X.2017.

***Polymixis manisadjiani*** (Staudinger, 1881)
**Synonym(s):** *manisadjiani* Staudinger, 1881. **Material studied:** 4♂♂, 19.06.2016; 1♂, 22.IX.2017.

***Polymixis rosinae*** (Bohatsch, 1910)* +
**Synonym(s):** *rosinae* Bohatsch, 1910; *paradisiaca* Boursin, 1944; *gilva* Sukhareva, 1976; *paravarga* L.Ronkay, 1990; *himalaya* Hacker & Weigert, 1990. **Material studied:** 1♂ 2♀♀, 04.X.2017.

***Pseudenargia regina*** (Staudinger, 1892)* +
**Synonym(s):** *regina* Staudinger, 1892. **Material studied:** 4♂♂, 1♀ 22.IX.2017; 3♂♂, 03-07.X.2017.

***Scotochrosta pulla*** ([Denis & Schiffermüller], 1775)
**Synonym(s):** *#pulla* [Denis & Schiffermüller], 1775. **Material studied:** 2♂♂, 06.X.2017.

***Xanthia cypreago*** (Hampson, 1906)* +
**Synonym(s):** *cypreago* Hampson, 1906. **Material studied:** 3♂♂, 05-07.X.2017.

***Zethes brandti*** Janzon, 1977
**Synonym(s):** *nemea* Brandt, 1938 (p.p.); nemea sensu Koçak, 1977; *brandti* Janzon, 1977. **Material studied:** 1♂, 06.X.2017.

**Saturniidae**
***Saturnia caecigena*** Kupido, 1825
**Synonym(s):** *caecigena* Kupido, 1825; *unicolor* Schultz, 1910; *wiskotti* Niepelt, 1914; *derosata* Schawerda, 1914. **Material studied:** 4♂♂ 1♀, 22.IX.2017; 5♂♂, 03-05-07.X.2017.

***Saturnia naessigi*** (De Freina, 1992)*
**Synonym(s):** *naessigi* De Freina, 1992. **Material studied:** 5♂♂ 2♀♀, 05-06-07.X.2017.

**Discussion and Conclusion**

This study contributes to Lepidoptera species of Dağlıca vicinity (Hakkari), which is one of the hardest region in Turkey because of geographical and security conditions. And, the research will also contribute to the determining of Lepidoptera fauna of Turkey.

In this paper, autumnal Lepidoptera species of Dağlıca vicinity are examined faunistically. Totally, 58 species are evaluated belonging to Argynnidae (1), Satyridae (1) and, Arctiidae (1), Ctenuchidae (1), Geometridae (15), Lasiocampidae (3), Lemoniidae (1), Noctuidae (33), Saturniidae (2) families. Among them, 33 species are determined as new to the fauna of Dağlıca vicinity and 21 species are detected as new to the fauna of Hakkari Province. A large part of the collected species are composed of Noctuidae and Geometridae families. Thus, the number of Lepidoptera species reached 1033 in Hakkari Province.

Moreover, distributionally endemic and poorly known *Hakkaria varga* (Hacker, [1987]) (fig. 1) and *Ostheldera arne* L. Ronkay & Varga, 1994 (fig. 2) species are assessed. *O. arne* was known a small area from south-eastern Turkey (Hakkari) to north-west Iran (Miyane, Azerbaijan Prov.) (Ronkay et al. 2011). *H. varga* was known only type locality, Şırnak Province (Turkey) so far (Hacker 1987). The second locality of these rare species have been discovered in Dağlıca vicinity, near to the type localities of the species. Both species are distributed in a very limited area and their populations are very low-density. By this way, these new data also contribute to the spreading area of the species.

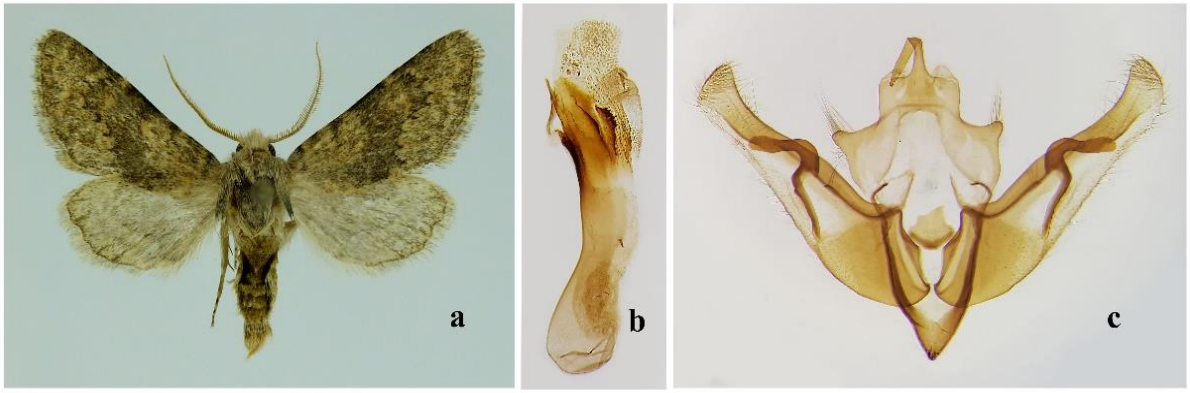


Figure 1. *Hakkaria varga*, a. adult male, b-c. male genitalia (slide no. 576♂), b. aedeagus, c. genital capsule.

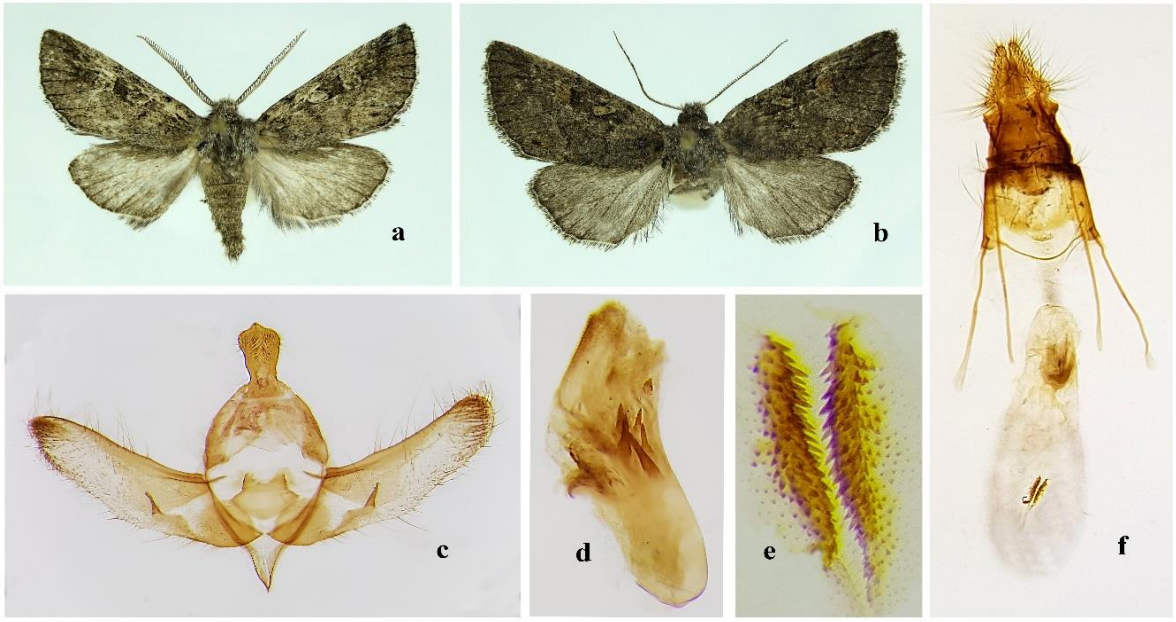


Figure 2. *Ostheldera arne*, a. adult male, b. adult female, c-d. male genitalia (slide no 575♂), c. genital capsule, d. aedeagus, e. signum, f. female genitalia (slide no. 581♀).

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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 | |

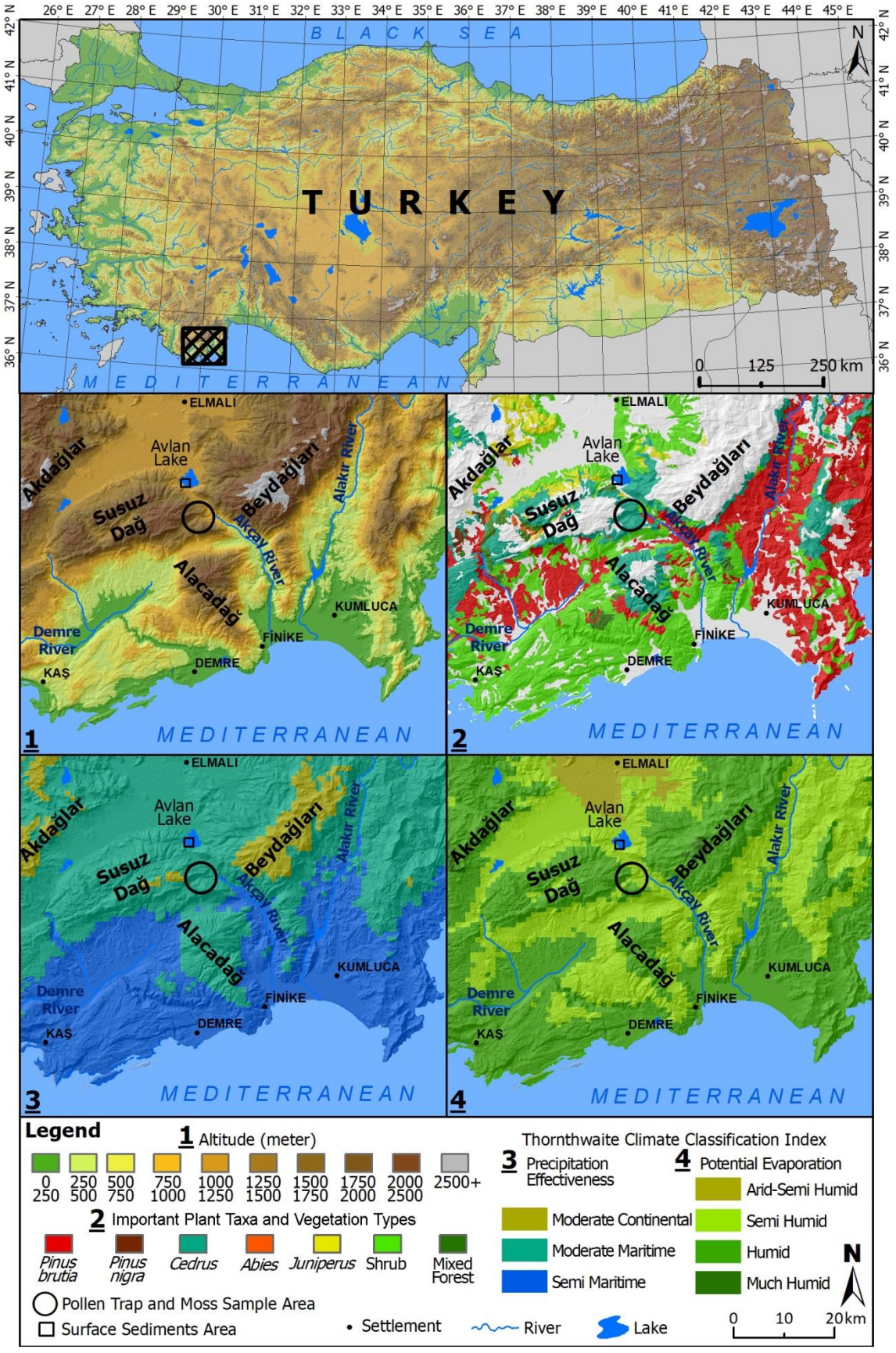


Figure 1. Location map of the study area.
(1. Altitude, 2. Important plant taxa and vegetation types, 3. Precipitation effectiveness, 4. Potential evaporation)

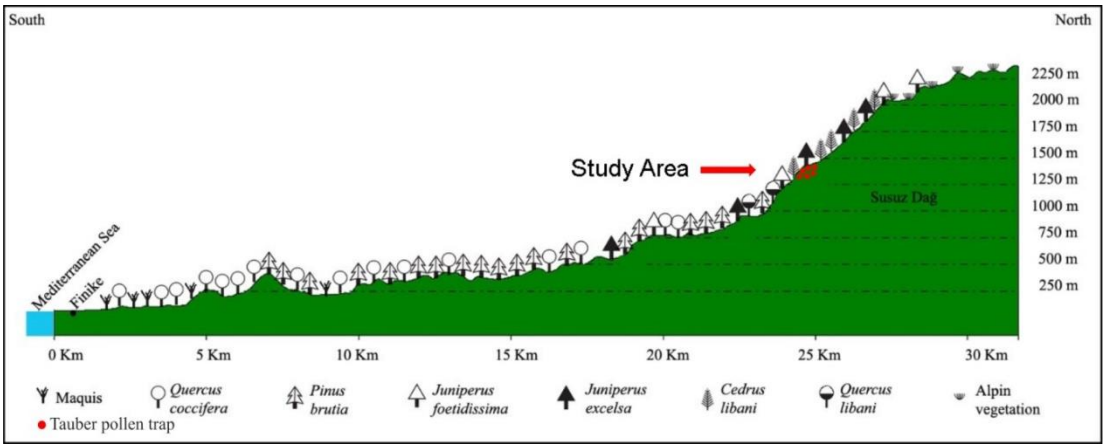

Figure 2. Mediterranean Sea-Susuz Dağ section and location of the Tauber pollen traps in the study area.

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).

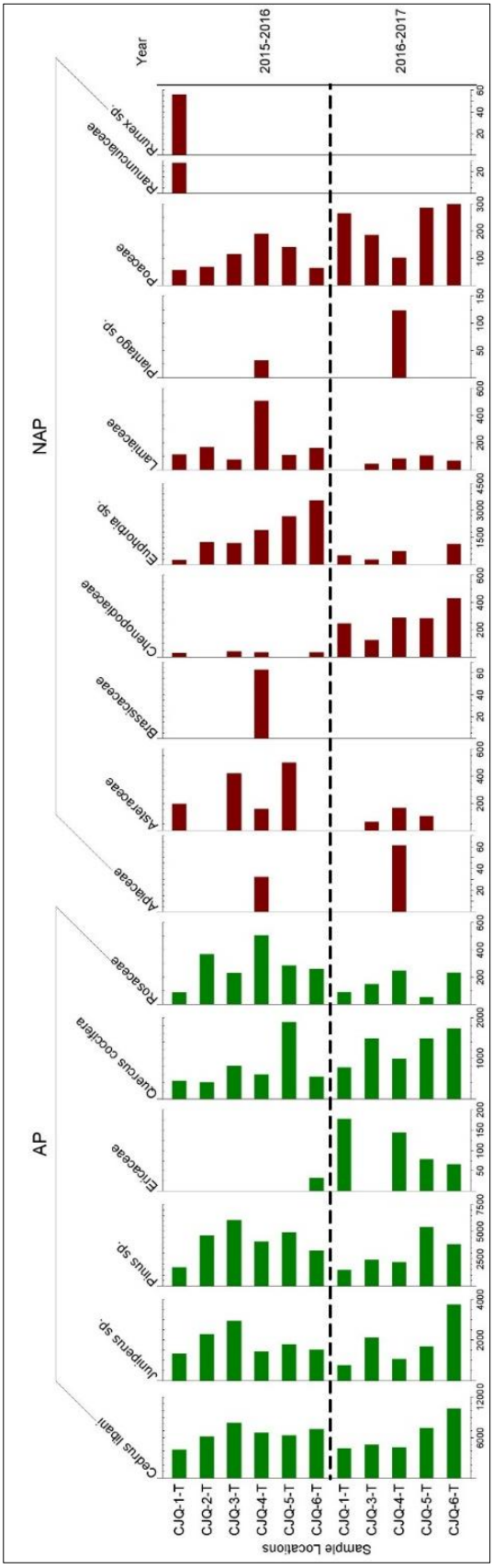


**Figure 3.** Pollen influx obtained from the Tauber pollen traps between 2015-2017 at the location of *Cedrus libani -Juniperus* sp.-*Quercus* sp. (CJQ).

**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).

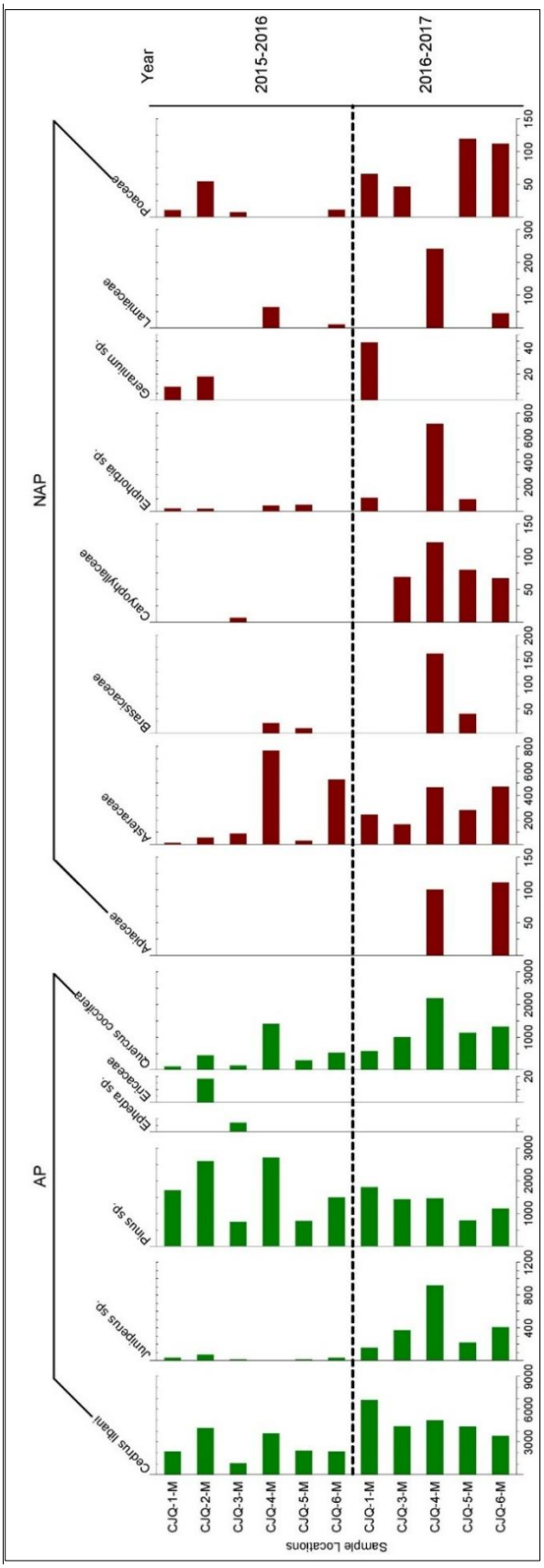


Figure 4. Pollen influx obtained from the moss samples between 2015-2017 at the location of *Cedrus libani* – *Juniperus* sp.-*Quercus* sp. (CJQ).

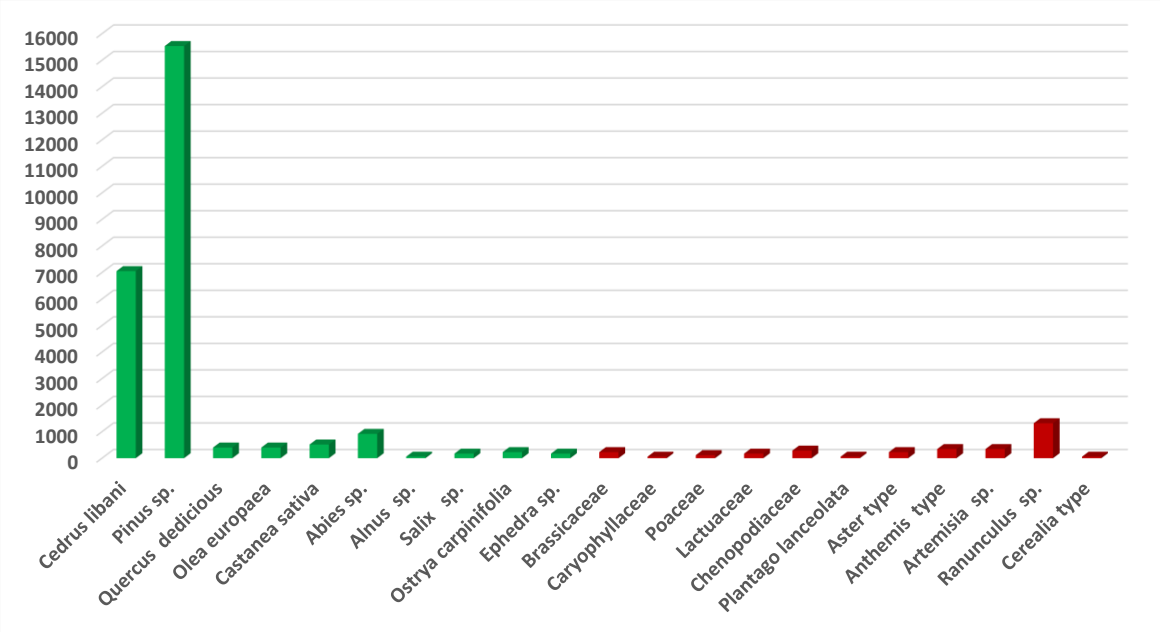


Figure 5. Pollen influx obtained from the surface sediment of Lake Avlan for 2017.

**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).

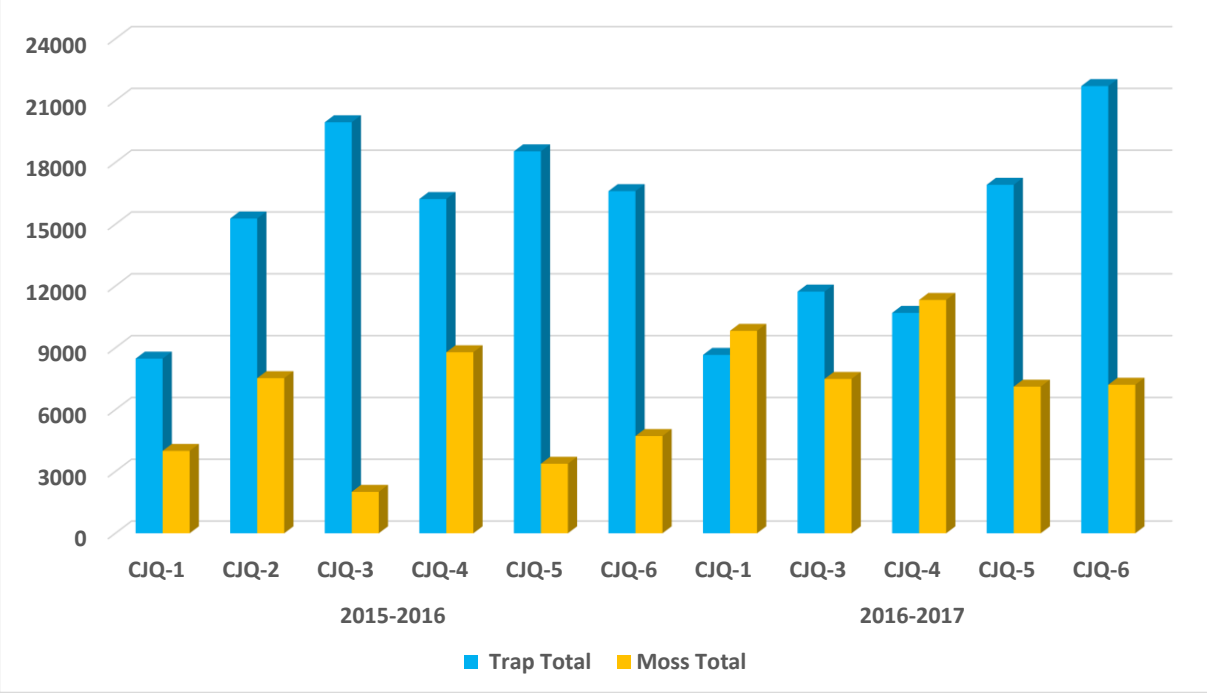


Figure 6. Total pollen influxes obtained from the traps and the mosses between 2015-2017 for all sample areas ($cm^2$/year) at the location of *Cedrus libani-Juniperus-Quercus* (CJQ).

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).

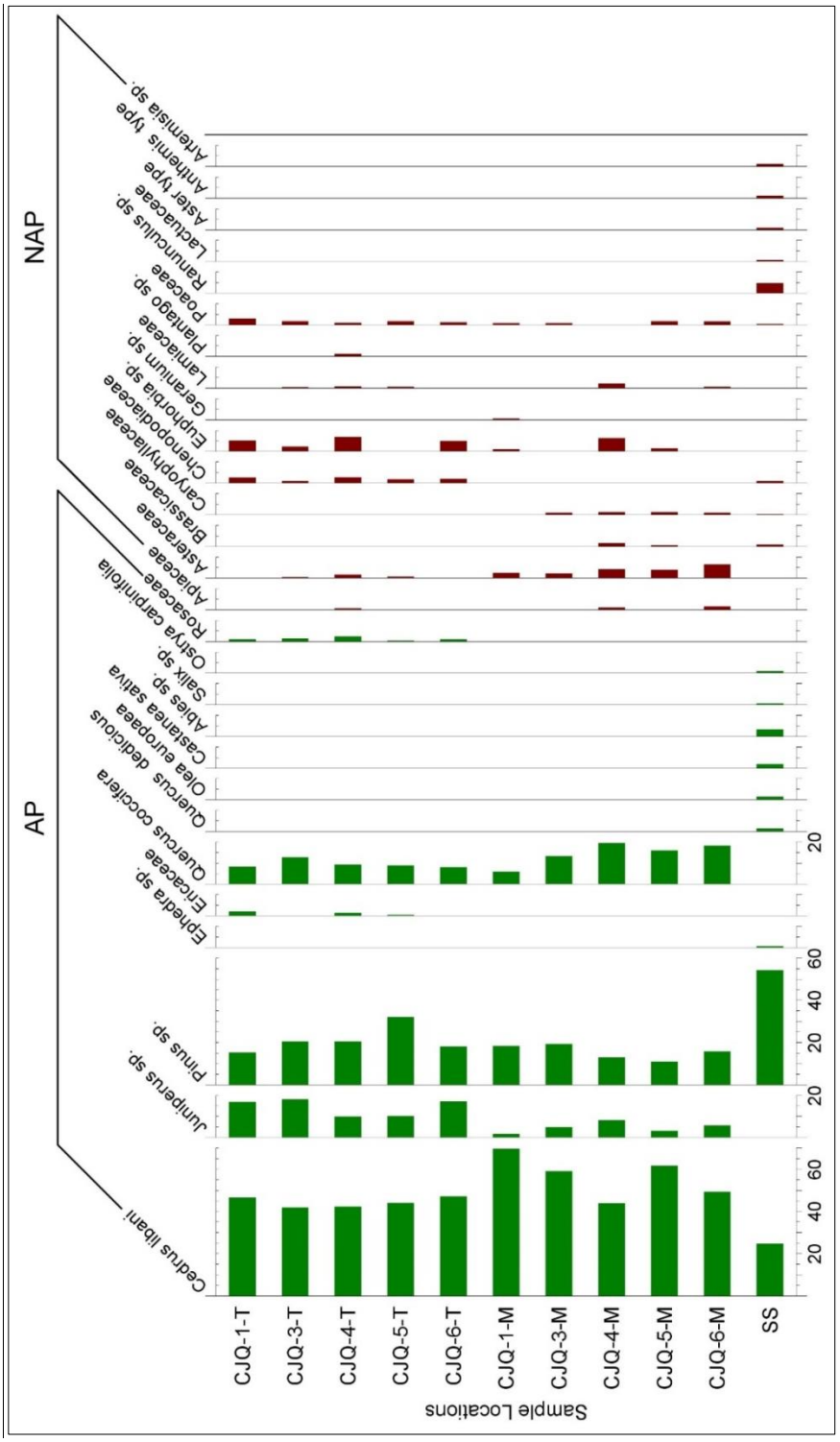


Figure 7. Pollen percentage obtained from the samples of Tauber pollen traps, mosses and surface sediment (for 2016-2017) at the location of *Cedrus libani-Juniperus sp.-Quercus sp.* (CJQ).
(CJQ-1-T, CJQ-3-T, CJQ-4-T, CJQ-5-T and CJQ-6-T belong to Tauber pollen traps, CJQ-1-M, CJQ-3-M, CJQ-4-M, CJQ-5-M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

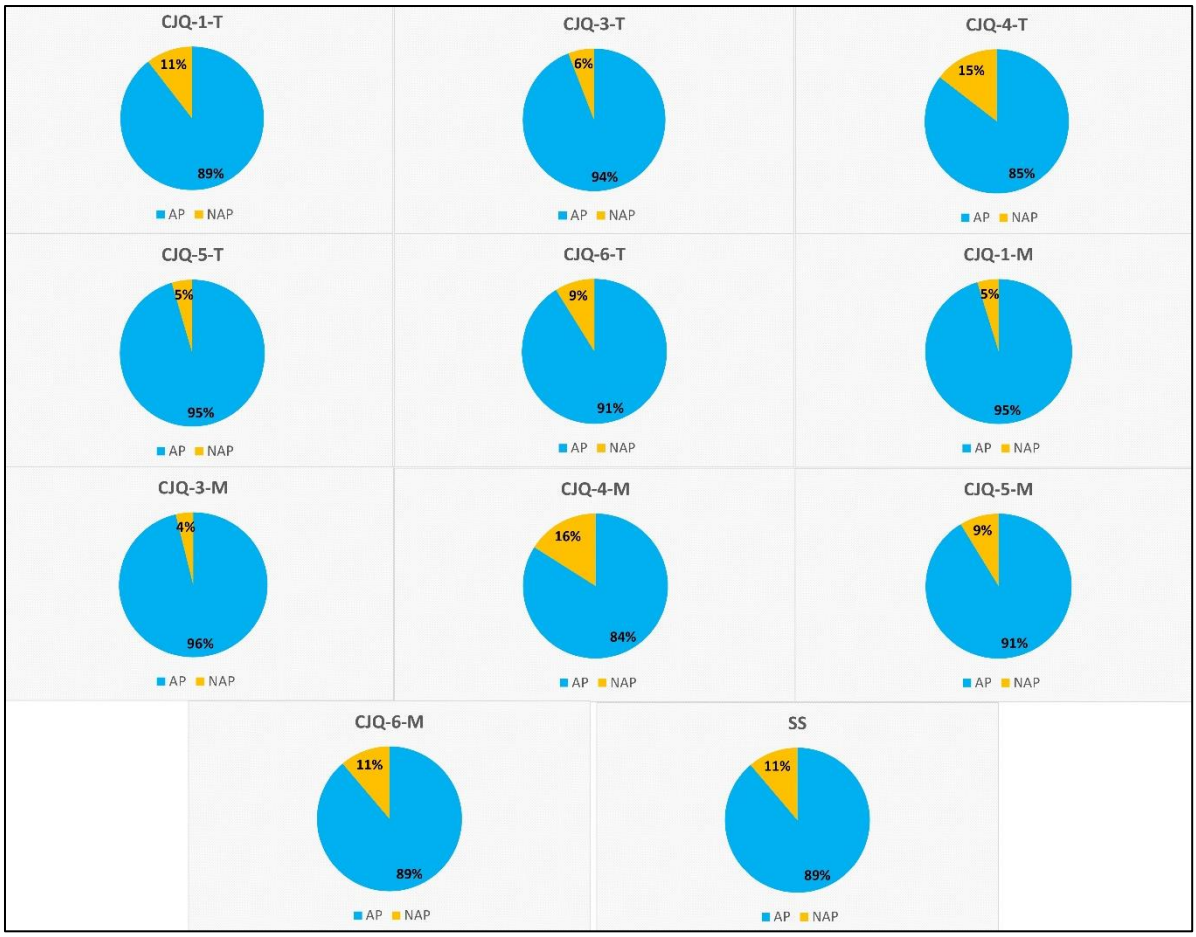


Figure 8. Comparison of the pollen percentages obtained from the samples of Tauber pollen traps, mosses and surface sediment (for 2016-2017) in terms of AP and NAP.

**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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