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Determination of pre-harvest sprouting tolerance and quality traits of the bread wheat landraces

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Yerel ekmeklik buğday çeşitlerinin hasat öncesi çimlenme toleransı ve kalite özelliklerinin belirlenmesi

Abstract: In this study, pre-harvest sprouting tolerance and some quality characteristics of some wheat landraces and modern varieties in Turkey were determined. In Eskişehir, Karaman and Samsun locations of Turkey, 126 genotypes were tested in the 2014-2015 growing seasons, and 48 genotypes were tested in the 2015-2016 and 2016-2017 growing seasons in two-replication experiments. Data regarding germination index, protein content, sedimentation volume and falling number of genotypes were observed. Physical properties of grain, the number of days to spike, and plant height were also investigated. The difference between genotypes was found to be statistically significant for all traits. We found the germination index of the genotypes varied between 0.19 and 0.70 for the 2015-2016 and 2016-2017 growing seasons, respectively. The average germination index value of red kernel genotypes is lower than white kernel genotypes. The landraces from Turkiye included in the research were taller and harvested lately. In comparison, modern genotypes are in the first place regarding sedimentation volume. The landraces had higher protein content but lower protein qualities than modern cultivars. The grain hardness of landraces was lower than that of modern cultivars in the three years. We found positive relationships between the germination index, grain filling time, thousand-grain weight, and grain color. Protein content, sedimentation volume, falling number, and grain hardness are negatively and significantly related to the germination index. The results showed that white kernel Clark's Cream and red kernel Karakılçık (1) genotypes could be used as gene sources for pre-harvest sprouting tolerance breeding in bread wheat.

Key words: Pre-harvest sprouting, bread wheat, landrace, quality characteristics

Özet: Bu çalışmada, Türkiye'deki bazı buğday yerel çeşitler ve modern çeşitlerin hasat öncesi filizlenme toleransı ve bazı kalite özellikleri belirlenmiştir. Türkiye'nin Eskişehir, Karaman ve Samsun lokasyonlarında 2014-2015 yetiştirme sezonlarında 126 genotip, 2015-2016 ve 2016-2017 yetiştirme sezonlarında ise 48 genotip iki tekerrürlü denemelerde test edilmiştir. Genotiplerin çimlenme indeksi, protein içeriği, sedimantasyon hacmi ve düşme sayısına ilişkin verileri alınmıştır. Tanenin fiziksel özellikleri, başaklanma gün sayısı ve bitki boyu da araştırılmıştır. Genotipler arasındaki farkın tüm özellikler açısından istatistiksel olarak önemli olduğu belirlenmiştir. Genotiplerin çimlenme indeksinin 2015-2016 ve 2016-2017 yetiştirme sezonları için sırasıyla 0,19 ile 0,70 arasında değiştiği tespit edilmiştir. Kırmızı taneli genotiplerin ortalama çimlenme indeksi değeri beyaz taneli genotiplere göre daha düşük bulunmuştur. Araştırmaya dahil edilen Türkiye'deki yerel çeşitlerin daha uzun boylu ve hasada kadar geçen sürenin daha uzun olduğu belirlenmiştir. Tüm genotipler karşılaştırıldığında modern çeşitler sedimantasyon hacmi açısından ilk sıralarda yer almışlardır. Yerel çeşitler modern çeşitlere göre daha yüksek protein içeriğine ancak daha düşük protein kalitesine sahiptir. Üç yılda yerel çeşitlerin tane sertliği modern çeşitlerden daha düşük olmuştur. Çimlenme indeksi, tane doldurma süresi, bin tane ağırlığı ve tane rengi arasında pozitif ilişki olduğu belirlenmiştir. Protein içeriği, sedimantasyon hacmi, düşme sayısı ve tane sertliği çimlenme indeksi ile negatif ve önemli ölçüde ilişkilidir. Sonuçlar, beyaz taneli Clark's Cream ve kırmızı taneli Karakılçık (1) genotiplerinin ekmeklik buğdaylarda hasat öncesi çimlenme toleransı ıslahında gen kaynağı olarak kullanılabileceğini göstermiştir.

Anahtar Kelimeler: Hasat öncesi çimlenme, ekmeklik buğday, yerel çeşit, kalite özellikleri

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1. Introduction

The increase in the world population and global climate changes have increased the importance of wheat in the food supply. Wheat, which has a wide range of use as a food source and ease of storage, has wide adaptability and biodiversity (Shewry and Hey, 2015). In recent years, tolerance studies against stress factors that cause yield and quality decrease in wheat have gained importance. In this context, landraces and wild species are of great significance as genetic resources.

Local gene resources are essential in ensuring genetic improvement in wheat breeding programs (Xu et al., 2019).

Local gene sources are used intensively for grain yield, adaptation, and quality characteristics in breeding programs, also used in breeding for abiotic and biotic stress factors. Especially the climate changes experienced in recent years and the anticipated stress factors (Marcińska et al., 2013; Aghanejad et al., 2015) necessitate new genetic resources. Climate changes may cause drought and heavy rainfall in some locations. Changes in the precipitation regime will make tolerance to pre-harvest sprouting crucial for many regions.

Especially in our regions that receive precipitation during the maturity period of wheat, sprouting reduces the quality and price of the product. In addition to our areas with high annual rainfall during the summer months, the number of heavy rains and floods in the world has increased in recent years (Nonogaki et al., 2018). It has been reported that the economic losses that may occur due to the climatic conditions of the pre-harvest sprouting cannot be readily estimated. The severity of these losses depends on the physiological maturity period, precipitation, and the number of cloudy days after rain (Aghanejad et al., 2015).

Seed color is one of the breeder's essential phenotypic traits regarding tolerance to pre-harvest sprouting. Tolerance to pre-harvest sprouting generally depends on the post-harvest dormancy characteristic of the genotype, the climatic conditions after flowering, the morphological characteristics of the spike, and stress factors (Barrero et al., 2015; Wang et al., 2019). Due to the pleiotropic effect between the seed color and post-harvest dormancy, white kernel wheat is generally more susceptible to sprouting than red kernel wheat (Mares et al., 2005; Zhu et al., 2019). Some studies have shown that seed color and post-harvest dormancy are also genetically controlled by independent QTLs (Zhu et al., 2019; Tai et al., 2021). There are also studies in which the relationship between dormancy and red kernel color is not partially observed (Zhou et al., 2017; Gautam et al., 2021). Some researchers found that dormancy genes were independent of grain color in their research on hybrids of red x white kernel genotypes (Lin et al., 2016; Yang et al., 2019). Liu et al. (2008) determined a significant QTL carried by the winter bread wheat variety Rio Blanco, which is used effectively for dormancy. Another study published in 2018 determined that a white Danby cultivar had one major and three minor QTLs for resistance to germination in the spike (Shao et al., 2018).

The pre-harvest sprouting is a genetically complex trait. The trait with low heritability is also significantly affected by the environment. Therefore, breeding studies on this subject are also challenging. Except for the 1D chromosome in bread wheat, the other chromosomes carry the quantitative trait region or genes for resistance to the pre-harvest sprouting. However, chromosomes 3A, 3B, 3D, and 4A had more important for dormancy. In a study, a major QTL related to dormancy was detected on chromosome 3A (*QPhs.ccsu3A.1*) (Kulwal et al., 2005; Wang et al., 2018). The pre-harvest sprouting has also been the subject of many molecular studies (Cabral et al., 2014; Lin et al., 2015; Abe et al., 2019; Miao et al., 2019).

In a study from Canada, the spring wheat genotypes were tested for pre-harvest sprouting and reported that breeders could use both white and red material for pre-harvest sprouting resistance (Rasul et al., 2012). Ogbonnaya et al. (2008) determined two significant QTLs for resistance to germination in the white kernel CN10955 gene source and stated that this source is helpful for marker-assisted selection. Studies also advocate that red kernel wheat should be used as a genetic source for resistance to the pre-harvest sprouting in white kernel wheat (Lawson et al., 1997).

Breeders need effective and reliable methods to measure pre-harvest sprouting.The tests to measure the resistance to pre-harvest sprouting are the germination tests on the grain or the spike and the determination of the falling number. Germination tests can be done in the laboratory for artificial climate conditions and in the field under the rain (Bassoi et al., 2006; Zeeshan et al., 2018). Gavazza et al. (2012) used a rain simulator in the greenhouse to test the resistance of the pre-harvest sprouting in wheat. Researchers reported that this artificial precipitation method is suitable for determining pre-harvest sprouting resistance.

The pre-harvest sprouting can adversely affect the agronomic characteristics of wheat and the milling and final product quality of the harvested grain. Since the quality of germinated wheat is not at an acceptable level, its price is generally low (Shu et al., 2015). Kruger and Tipples (1982) reported that only a tiny amount of germinated grain in a batch of wheat could adversely affect the quality of the flour. The parameters used by the flour industrialist to determine the germination degree of the spike are generally the falling number and α-amylase activity (Stoy, 2019). Germinated grains will have a lower falling number (Ral et al., 2016; Newberry et al., 2018). When the falling number value of wheat is less than 220 – 250 sec., it is not suitable for bread making, and millers do not use wheat with this characteristic as raw material (Olaerts and Courtin, 2018).

Within the scope of the research, the landraces bread wheat varieties collected from Turkey and advanced lines developed from landrace populations, and modern bread wheat varieties were used as plant materials. We determined falling number, grain hardness, and tolerance to pre-harvest sprouting. In addition, we collected data for plant height, heading date, thousand-grain weight, sedimentation value, size analysis, and protein content.

2. Materials and Method

2.1. Trial locations

Trials were conducted in Karaman (37°01′23″N- 33°05′39″E), Eskişehir (39°39′31″N- 31°2′13″E), and Samsun (41°17′25″N- 36°20′1″E) locations in Turkey. In Eskişehir and Samsun, the trials were carried out at Agricultural Research Institutes and KaramanoğluMehmetbey University in Karaman. We paid attention to the fact that the locations had different climatic characteristics during the grain filling period. Thus, it has been tried to ensure the genotype x environment interaction. As a result of the study, we tested the genotypes in nine environments, three years x three locations.

Samsun is a location with high relative humidity, likely to receive precipitation in the summer months and naturally pre-harvest sprouting. However, there was no rain during research period in the Samsun location, which received rainfall during the harvest period for many years. The Eskişehir location represents Turkey's western gateway and is geographically central to most research materials. The Karaman location allowed the testing of genotypes in terms

of low α-amylase activity due to its common relative humidity. As expected, the amount of precipitation falling during the growing season was most observed at the Samsun location. In terms of total annual rainfall, the Karaman location received 221 mm of rain in the 2015-2016 growing season and experienced one of the driest winters and springs in its history.

Regarding average temperature and relative humidity, the highest average belongs to the Samsun location. Karaman province is the location with the lowest relative humidity averages. Eskişehir location experienced its wettest season in the 2014-2015 growing season in the experiments conducted.

2.2. Plant material

Bread wheat varieties registered in Turkey and abroad and landrace were used as plant material in the research. Trials included 126 materials in the first year of the study. Forty-eight of the genotypes with the lowest average germination index and falling number values obtained in the first year of the study were selected. These materials were used in the trials in the second and third years of the project (Table 1). As control cultivars, Clark's Cream (dormant), Halbert (semi-dormant), HD2329 (non-dormant), Altındane (non-dormant), Demir2000 (red kernel control), Sönmez2001 (red kernel control), Tosunbey2000 and Tahirova2000 (white kernel control) cultivars were used. Clark's Cream variety originates from the USA, and Halbert is resistant to sprouting, originating from Australia. HD2329 is a genotype used as a sensitive parent in mapping populations where sprouting is investigated. In addition, control cultivars selected according to the first year's results and sensitive to pre-harvest sprouting were also included (Kırik (2) and Kocabuğday).

2.3. Trials

In the first year of the study, 126 genotypes included in the trials carried out in three different locations were sown manually in 2 meter-long rows without repetitions and in a single row. In the project's first year, the trials were planted in an augmented trial design and four blocks. The experiments included control varieties in each block. Forty-eight genotypes selected according to the first year's results were planted by hand in two replications in two rows and 1.5 meters long rows according to a randomized block design (Munkvold et al., 2009).

We used herbicides to control weeds. The fertilizer program has been optimized not to lie down the tall landraces. Six kg da pure phosphorus and 8 kg da nitrogen fertilization in Karaman and Eskişehir locations and 10 kg da nitrogen fertilization in Samsun have been applied. We gave half of the nitrogen fertilizer at planting and the other half during the stem elongation period. Since the land belonging to the research institute where the experiments were carried out in the Samsun location is rich in phosphorus, phosphorus fertilization was not done in this location. In all areas, pesticides were applied against fungal diseases and spreading. In the winter and spring of 2016, we irrigated the experiments three times due to the intense drought in Karaman. While irrigation was done twice in Karaman in 2017, irrigation was done once in 2015. Irrigation was done once in 2017 at the Eskişehir location, and there was no irrigation at the Samsun location.

Table 1. Wheat genotypes used in the research

No	Genotype	Modern/Landrace	Collected location	No	Genotype	Modern/ Landrace	Collected location
1	Sukezmez	Landrace (L)		25	Kırik (3)	L	Erzurum/Toprakkale
2	Göderedi (1)	L	Konya	26	Kocabuğday	L	Burdur
3	Kobak (1)	L	Kütahya	27	Göderedi (2)	L	Karaman
4	Yektay406	L		28	Şahman	L	Aksaray
5	Mv18	Modern (M)		29	Demir2000	M	
6	Kırik (1)	L	Erzurum/Güzelsu	30	Sarı misli	L	
7	Tosunbey	M		31	Gülümbür	L	Kütahya
8	Çalıbasan (1)	L	Kütahya	32	4-11	L	
9	Sarı Buğday (1)	L		33	Ak702	L	
10	Clark's Cream	M		34	Sönmez2001	M	
11	Kırik (2)	L	Erzurum/Güllüce	35	Çalıbasan (2)	L	Yozgat
12	Akbuğday (1)	L	Aksaray	36	Kobak (2)	L	Kütahya
13	Kırmızı Buğday (1)	L	Aksaray	37	Buğday	L	Konya
14	Kabak Buğday	L	Balıkesir	38	Atay85	M	
15	Halbert	M		39	Urumeli	L	
16	Akbuğday (2)	L	Afyon	40	Zincirli	M	
17	Nevzatbey	M		41	Müfitbey	M	
18	Karakılçık (1)	L	Konya	42	Bogruala	L	
19	Esperia	M		43	Bezostaja	M	
20	Kırmızı Buğday (2)	L	Isparta	44	Arıbuğday	L	Uşak
21	No name	L	Aksaray	45	Karakılçık (2)	L	Çanakkale
22	Topbaş	L	Erzurum	46	Tir Line	L	
23	Altındane	M		47	Sarı Buğday (2)	M	Yozgat
24	HD2329	M		48	Altay2000	M	

2.4. Examined agricultural and quality characteristics

To determine the plant height, we measured the distance from the soil surface to the tip of the last spikelet. Grades are given between 1 and 9 according to the lying ratio of the plants in the rows. From January 1 until approximately 50% of the plants in the plot are heading was determined and expressed as the heading days (Tavella, 1978; Bohn et al., 1998). We counted the days from the heading date to physiological maturing to determine the grain filling time. One hundred seeds from each genotype were counted twice with an automatic seed counting machine (Chopin - Numigral-I), and we calculated the average of 1000 seeds by multiplying by 10 (g). Grain color was measured using the HunterlabColorflex Color measuring device. L (brightness), a (redness), and b (yellowness) values were used to determine color changes (Coşkuner et al., 2002). Amylolytic (α-amylase) activities of flours obtained from wheat were determined using a falling number tester (Falling Number 1500, Perten Instruments, Sweden) (AACC Method 56-81B) (AACC, 2000). The moisture content of wheat was determined using Dickey-John-GAC Plus (AACC Method 55-10) and expressed as a percentage. 100 g of grain was sieved for 5 minutes in a shaking system (Pfeuffer – Sortimat) with 2.8, 2.5, and 2.2 mm sieves. The proportional size distribution was obtained by separately weighing the remaining part on each sieve and in the collecting bowl. Uniformity was determined by considering the remaining material on two successive sieves (2.2+2.5 mm or 2.5+2.8 mm) (Köksel et al., 2000; Elgün et al., 2002).

We used the TA-TXPlus Texture analyzer for grain hardness analysis. Ten grains of approximately equal size from each genotype were crushed to calculate average resistance values. The protein content of wheat flour was determined using the flour module of the Perten Inframatic 9500 device (Perten Instruments, Sweden) and expressed as a percentage in dry matter. Sodium dodecyl sulfate (SDS) sedimentation volumes, which are indicators of wheat flour quality, were measured using the modified AACC method (AACC Methods 56-70) (Maghirang et al., 2006; Sayaslan et al., 2006).

2.5. Germination tests

We performed germination tests to determine the dormancy levels of the genotypes. The grains threshed from the ears were used in the germination test. As a morphological indicator of physiological maturity, the green color in glumes turns yellow (Hanft and Wych, 1982). Harvested ears were dried at room temperature (20-23 °C) for five days. We used an air conditioner in the room. The threshed grains were not immediately tested for germination and stored at -20 °C to prevent them from losing their dormancy properties. There were 50 seeds in each petri dish. We established the germination tests with one replication in the first year. Two replications in the second and third years were carried out in a plant growth cabinet kept at an ambient temperature of 20 °C and 90% relative humidity. The germination test was carried out in sterile Petri dishes with filter papers (Whatman No 2). Before the seeds were taken for the germination test, they were sterilized with 1% sodium hypochlorite and then washed with sterile water. 8-10 ml of pure water was added to the Petri dishes at the rate to wet the seeds, and the seeds were kept constantly moist. We took the seeds to the germination test in the dark. The germination test took seven days. The germinated seeds were counted every day at the start of the germination time and taken from the Petri dishes. The germination index was calculated according to the formula below (Walker-Simmons and Sesing, 1990):

General Germination Index = $7 \times n_1 + 6 \times n_2 + 5 \times n_3 + 4 \times n_4 + 3 \times n_5 + 2 \times n_6 + 1 \times n_7$ / Total test days x total grain count

n_1, n_2, ..., n_7 represents the number of grains germinated on the first, second……. and seventh days of the germination test. The maximum germination index is 1.0, indicating that the genotype is not dormant. The minimum value is 0.0, which indicates that the genotype is dormant.

2.6. Evaluation of data

The data obtained from the experiments were analyzed in the Jump statistical program using the Augmented design in the first year and the randomized blocks experimental design in the second and third years using the Jump 12.0.1 program (Patterson and Hunter, 1983; Munkvold et al., 2009). Since there was a recurrence in the first year of the experiment, the values could not be transformed, and the coefficient of variation was calculated by applying the square root transformation only for the values where the locations were combined. In calculating the LSD value, the data obtained from analyzing the values without transformation were used. The student's t-test was used to compare the data. Since the dimensional analysis values have 1 in the under-sieve values, the coefficient of variation was calculated using the square root transform values.

3. Results

In the 2014-2015 growing season, the first year of the research, 126 genotypes were grown in three locations, and the obtained seeds were tested for germination. Forty-eight genotypes with low germination index values were selected for trials in three areas in the 2015-2016 and 2016-2017 growing seasons.

3.1. Germination index

According to the data obtained in the 2014-2015 growing season, the average germination index values in Eskişehir, Karaman, and Samsun locations were 0.40, 0.40, and 0.42, respectively. All of the genotypes in the first place regarding high germination index values are white-grained genotypes. The germination index values of the genotypes in the experiment for the 2015-2016 and 2016-2017 growing seasons are given in Table 2 and the variance analysis values are shown in Table 3. According to the results of the 2015-2016 and 2016-2017 growing seasons, we found the statistical differences between the average germination index of the genotypes, the interaction of genotype x location, and genotype x years (Table 3).Karakılçık (1), Bezostaja, Clark's Cream, Kobak, Demir2000, Göredeli (1), Sukezmez, MV18, and Sönmez2001 genotypes had the lowest average germination index values, respectively (Fig. 1). Clark's Cream is the only genotype with white kernel color among these cultivars. While the germination index average of the white-grained genotypes is 0.53, the average of the red-grained genotypes is 0.40 (Fig. 2). These results show that this cultivar originating from the USA can be used for resistance to the pre-harvest sprouting in Turkey.The genotypes with the highest average germination index are

Table 2. Average data of the genotypes included in the study for the 2015-2016 and 2016-2017 growing seasons

Analyzed Agricultural Characteristics		2015-2016			2016-2017			Average
		Eskişehir	Karaman	Samsun	Eskişehir	Karaman	Samsun	
Germinating index	Average	0.23	0.34	0.42	0.51	0.59	0.70	0.46
	Range	0.08-0.66	0.06-0.85	0.06-0.82	0.15-0.71	0.19-0.86	0.35-0.81	0.19-0.70
	LSD	0.11	0.21	0.19	0.12	0.12	0.09	0.09
	CV	%10.3	%15.9	%11.4	%6.11	%4.95	%3.27	%14.1
Heading date	Average	138	139	132	157	148	137	142
	Range	130-145	123-147	121-140	152-161	142-154	126-143	133-147
	LSD	1.31	2.87	1.21	1.74	5.45	1.21	1.69
	CV	%0.47	%1.02	%0.45	%0.55	%1.83	%0.43	%1.48
Grain filling date	Average	38	36	44	35	40	52	41
	Range	33-48	31-41	36-54	31-41	35-46	48-58	37-47
	LSD	1.63	1.99	3.41	1.52	4.09	1.95	1.40
	CV	%2.11	%2.75	%3.83	%2.19	%5.04	%1.87	%4.27
Failing number	Average	381	310	327	373	385	291	344
	Range	332-400	245-352	215-397	351-400	356-400	112-372	296-385
	LSD	31	34	54	22	23	38	23
	CV	%4.0	%5.4	%8.2	%3.0	%3.0	%6.5	%8.2
Grain color value	Average	403	356	353	-	-	-	371
	Range	272-514	277-438	283-450	-	-	-	303-441
	LSD	29	92	31	-	-	-	33
	CV	%3.6	%12.8	%4.4	-	-	-	%7.8
Plant height	Average	117.5	63.2	122.6	122.4	105.4	122.4	108.9
	Range	85-132	33-82	65-150	81-146	70-135	78-144	68-127
	LSD	4.44	15.9	16.7	4.36	12.5	6.97	7.40
	CV	%1.87	%12.5	%6.80	%1.77	%5.90	%2.82	%6.09
Sedimentation volume	Average	19	23	12	14	16	17	17
	Range	6-35	8-36	5-37	6-32	5-30	5-33	5-32
	LSD	7.0	3.8	4.4	2.4	2.9	2.2	2.1
	CV	%18.4	%8.4	%18.5	%8.7	%9.1	%6.7	%15.6
1000 grain weight	Average	39	29	29	37	39	44	36
	Range	28-45	16-38	18-42	27-45	26-49	35-52	28-41
	LSD	3.2	7.8	5.6	4.8	4.2	4.5	2.7
	CV	%4.11	%13.8	%9.5	%6.6	%5.4	%5.0	%9.5
Grain hardness	Average	16.5	25.4	17.8	16.9	15.2	19.2	18.5
	Range	13.01-24.7	17.4-34.4	12.7-23.5	12-23.9	10-21.4	14.1-25.5	13.9-23.9
	LSD	3.2	9.8	4.6	2.3	1.9	2.9	2.1
	CV	%9.8	%19.3	%12.9	%6.8	%6.1	%7.5	%14.4
Average sieve analysis	Average	4	-	17	7	6	5	8
	Range	1-18	-	5-47	1-41	3-28	1-14	3-25
	LSD	5.7	-	13.3	8.7	10.3	3.3	5.9
	CV	%31.6	-	%16.1	%33.8	%36.3	%16.4	%26.0
Grain moisture content	Average	11.2	-	11.8	10.8	10.5	11.5	11.1
	Range	9.3-12.2	-	9.4-13	10.5-11.2	10.3-10.8	10.4-12.1	10.2-11.7
	LSD	1.0	-	1.2	0.3	0.5	0.5	0.4
	CV	%4.6	-	%5.2	%1.2	%2.2	%2.0	%3.5
Protein content	16.9	21.6	15.7	14.4	15.1	17.6	16.9	16.9
	14.4-20	18.3-23.9	14.3-19.5	12.6-16	12.8-16.8	15.1-22.1	15.4-19.8	14.4-20
	1.98	2.54	1.78	1.80	1.04	1.49	0.84	1.98
	CV	%5.8	%5.8	%5.6	%6.2	%3.4	%4.2	%6.2

Kırik (2), Tir line, Kocabuğday, Kırik (1), Altay2000, Yektay406, SarıBuğday (2), Kırik (3) and HD2329 genotypes, respectively. Among these genotypes, the only red-grained genotype is the Tir line. HD2329 genotype also has a high germination index value, 0.58.

The genotype numbers according to the germination index averages in the locations are given in Fig. 1. While the number of genotypes between 0-0.30 is highest in Eskişehir and Samsun locations, the number of genotypes between 0.31-0.50 is higher in Karaman location. However, the number of genotypes in the ranges of 0.51-0.70 and 0.71< is higher in Samsun location compared to Eskişehir and Karaman locations.Wang et al.

3.2. Plant height

The average plant height of the genotypes, including the local material selected from different regions of Turkey and passed through certain selection stages, varied between 64-115 cm for three locations in the 2014-2015 growing

season. Esperia, Zincirli, HD2329, Altındane, Adana99, and Mv18 genotypes are the shortest plants according to the mean values, respectively. The genotypes with the longest plant height are Clark's Cream, KaşıkçıBuğday, SarıBuğday, Çomak, Karakılçık and Göderedi, respectively.

According to the results of the trials carried out in the 2015-2016 and 2016-2017 growing seasons, it was determined that the difference between genotypes and plant height was significant for the genotype x location interaction, while the genotype x year interaction was not significant (Table 3). The plant height was 108.9 cm according to the average of the six circles, and the average plant height values changed between 63.2 cm and 122.6 cm according to the average of the locations (Table 2). We obtained the shortest plant height average of 63.2 cm in the Karaman location in 2016 (Table 2). Karaman experienced one of its history's driest winter and spring seasons in the relevant year. At the same time, considering the general average, the location with the shortest plant height is the Karaman location.

3.3. Heading date

For the 2014-2015 breeding season, the average heading date of genotypes is 145 in all locations. According to the results in the 2015-2016 and 2016-2017 growing seasons, we statistically found the differences between heading dates for genotypes. The interaction of genotype x year and genotype x location are also crucial for the number of days to heading (Table 3). The average heading day of the trials in six environments harvested in 2016 and 2017 was 142 days (Table 2). The earliest heading date was obtained in Samsun in the 2016-2017 growing season with 132 days. We received the latest heading date in Eskişehir in the 2016-2017 growing season with 157 days (Table 2). Heading time varies between 133 and 147 days. According to the mean values, the earliest heading genotypes were HD2329, Esperia, Topbaş, Mv18, Çalıbasan (1), Sönmez2001, Halbert, and Nevzatbey, respectively. In contrast, the latest heading genotypes were Kabak, Zincirli, Sukezmez, Kobak (2), Kocabuğday, Atay85, Bogruala, and Göderedi (1, 2). The landraces often headed late.

3.4. Grain filling time

In the experiment conducted in three different locations in the 2014-2015 growing season, the average grain filling time of the genetic material was 35.3 days, and the average grain filling time in Eskişehir, Karaman, and Samsun locations was 39.9, 33.2, and 33.3 days, respectively. Grain filling time varied between 32 and 40 days according to the locations' average. The genotypes with the shortest grain filling period according to the average of the three locations are Sönmez2001, Kabak, Topbaş, Gülümbür, Akbuğday, Domaniç, and KırmızıAkbuğday. The genotypes with the longest grain filling periods in the experiments are Tir line, Şahman, Akbuğday, Kıraç66, Kobak, Çalıbasan, and Müfitbey, respectively.

We found the differences between the grain filling times of the genotypes in these years, the interaction of genotype x years, and genotype x location to be significant at 1% (Table 3). According to the locations' average, the grain filling time is 41 days. Grain filling time varied between 31-48 days in Eskişehir, 31-41 days in Karaman, and 36-54 days in Samsun in 2016 and 2017 (Table 2). While the shortest grain filling time was experienced at the Eskişehir

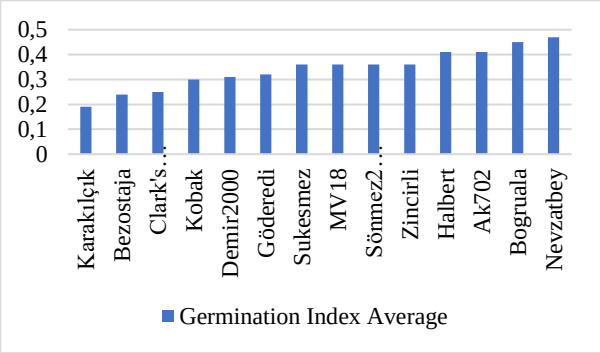

Fig.1. Germination index average of some genotypes

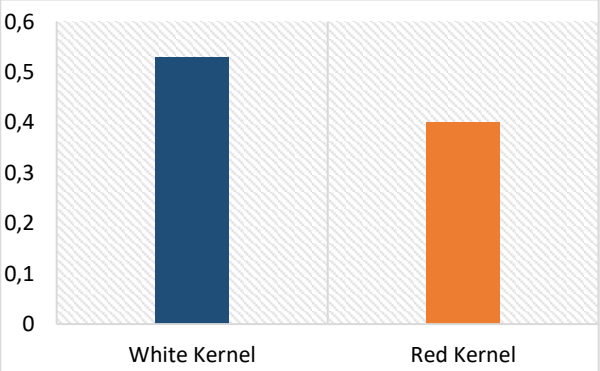

Fig.2. Germination index averages of red and white grain genotypes in six environments

location with an average of 35 days in 2017, the longest grain filling time was shared at the Samsun location with 52 days (Table 2). According to the results and average values obtained from the 2015-2016 and 2016-2017 growing seasons, the genotypes with the shortest grain filling time are Kabak Buğday, Akbuğday (2), Göderedi (1), Kobak (1), Akbuğday (1), Kocabuğday, Şahman, Clark's Cream, and Kirik (2, 3) are listed. The order of the genotypes with the longest grain filling time is HD2329, Tosunbey, Çalıbasan (1), Halbert, Yektay406, Mv18, Esperia, Topbaş, Altay2000 and Nevzatbey.

3.5. Protein content

In the trials in the 2014-2015 growing season, the average protein content was determined as 12.2%, 15.1% and 13.9% in Eskişehir, Karaman and Samsun locations, respectively. The protein content varied between 11.6% and 17.9% according to the average of the locations.The genotypes with the highest protein content were listed as MV18, Altındane, KırmızıBuğday, Elbistan, SarıBuğday, Kırik, Sarı Misli and Gülümbür, respectively. The genotypes with the lowest protein content are Tosun21, Atay85, Altay2000, KaşıkçıBuğday, Akbuğday, KırmızıBuğday, ES86-7 and Topbaş, respectively.

In the trials conducted during the 2015-2016 and 2016-2017 growing seasons, we found the differences between the protein content of the genotypes, the interaction of genotype x year, and genotype x location to be statistically significant (Table 3). The lowest average protein content was obtained at the Eskişehir location, with a rate of 14.4% in 2017. The highest average was obtained from the Karaman location, with a rate of 21.6% in 2016 (Table 2). As a result of a dry winter and spring in the Karaman location in 2016, plants and seeds remained very small. The

Table 3. Variance analysis table for agricultural and quality characteristics of 2015-2016 and 2016-2017 growing seasons

		Year	Location	Rep.	Genotype	Year x Location	Genotype x Year	Genotype x Location	Error
Source of variation					**SD**				
		1	**2**	**1**	**7**	**2**	**47**	**94**	**381**
Germination index	MS	6.520	0.989	0.004	0.101	0.019	0.020	0.016	0.008
	F	759.3**	115.2**	0.492	11.73**	2.22	2.43**	1.96**	
Heading date	MS	17362.2	9192.4	1.479	134.7	2271.5	11.0	14.0	4.41
	F	3933.8**	2082.8**	0.335	30.5**	514.7**	2.50**	3.17**	
Grain filling date	MS	1068.5	7361.5	2.57	67.9	1571	6.64	11.7	3.05
	F	350**	2411**	0.84	22.3**	514**	2.17**	3.82**	
Failing number (sn)	MS	14560.4	220576.5	47.8	104393.5	62099.5	306.3	2167.3	797.7
	F	18.3**	276.5**	0.06	5.56**	03.2**	1.63**	2.72**	
Grain color value (Chroma)	MS	-	75965.3	118.8	7815.4	-	-	2769.6	835.1
	F	-	90.9**	0.14	9.4**	-	-	3.3**	
Plant Height	MS	35344.0	87348.3	756.3	2719.1	25587.0	50.8	169.9	44.0
	F	804**	1987**	17.2**	61.9**	882**	1.16	3.86**	
Sedimentation volume	MS	910.0	1171.2	14.7	432.5	1824.5	11.4	6.9	6.66
	F	136.6**	175.8**	2.2	64.9**	273.9**	1.71**	2.5**	
1000 grain weight(g)	MS	8513.1	950.2	0.478	147.2	3891.9	25.8	19.9	11.6
	F	735**	82**	0.04	12.7**	336**	2.22**	1.72**	
Grain hardness (kg)	MS	1111.4	622.5	107.4	91.0	2015.6	8.04	8.18	7.08
	F	157.0**	87.9**	15.2**	12.9**	284.7**	1.14	1.16	
Average sieve analysis (%)	MS	2311.3	2819.1	245.9	170.8	-	62.9	54.0	19.9
	F	116.4**	141.9**	12.4**	8.60**	-	17**	2.72**	
Grain moisture content (%)	MS	31.7	20.2	1.8	18.6	-	0.70	0.33	0.15
	F	210.0**	133.4**	11.8**	5.3**	-	4.7**	2.2**	
Protein Content (%)	MS	800.4	367.5	18.4	8.65	823.2	2.30	2.02	1.09
	F	737.2**	338.4**	17.0**	7.97**	758.1**	2.1**	1.9**	

protein ratio was relatively high in small grains. The protein content was 16.9%, according to the average of the six locations (Table 2). The genotypes with the highest average protein content are MV18, Kırik (1, 3), Kocabuğday, Zincirli, Gülümsür, Çalıbasan (2), Akbuğday (2), No name, Urumeli, Arıbuğday, Şahman, Sarımisli and Nevzatbey. The genotypes with the lowest protein content are Atay85, Sönmez2001, Sukezmez, Kırik (2), Yektay402, Altay2000, Tosunbey, Halbert and KırmızıBuğday (1, 2).

3.6. Sedimentation volume

The average sedimentation volume of the genotypes is 23 ml in the 2014-2015 growing season. According to the locations' average, the sedimentation volume ranged from 5 ml to 44 ml. The highest mean sedimentation volume was obtained from Altındane, MV18, Esperia, Kamçı, Göderedi, Şahman, Adana99, Bezostaja, Tosunbey, and Kırik genotypes, respectively. The genotypes in question are the genotypes known to have superior quality characteristics.

In the trials conducted in the 2015-2016 and 2016-2017 growing seasons, the differences between the sedimentation volume values of the genetic material, the interaction of genotype x year, and genotype x location were found to be significant at the level of 1% (Table 3). According to the average of the trials conducted in Eskişehir, Karaman, and Samsun locations in 2016 and 2017, the average sedimentation volume of the genotypes varied between 5 ml and 32 ml (Table 2). The lowest average sedimentation volume was obtained at the Samsun location in 2016 with 12 ml; the highest average sedimentation volume was received at the Karaman location in 2016 with 23 ml (Table 2). The genotypes with the highest sedimentation volume are MV18, Esperia, Altındane, Nevzatbey, Bezostaja, Tosunbey, Clark's Cream, Müfitbey, Sukezmez, and Kırik (3) genotypes, respectively. Modern varieties, known to be superior in terms of quality characteristics, took the first place in terms of sedimentation volume. Göderedi (1), Kırik (2), Kabak Buğday, Kobak (1,2), Ak702, Yektay406, Urumeli, Gülümbür, 4-11, Çalıbasan (2) and KırmızıBuğday (2) were in the last place in terms of low sedimentation volume. The landraces such as Ak702 and Yektay406 were preferred in biscuit production in the past. Sedimentation volume values are arithmetically relatively low for some genotypes. The fact that the grinding process was carried out by breaking the seeds with a cyclone mill may have been effective in this result.

3.7. Falling number

The average falling number of the genotypes for the 2014-2015 growing season varied between 309 seconds and 400 seconds. The device gives 400+ results for values above 400 in falling number readings. For this reason, we took this value as 400 for statistical analysis.

In the years when the experiments were carried out with two replications, the differences between the falling number values of the genotypes and the interactions of

genotype x year and genotype x location were found to be significant at the level of 1% (Table 3). The falling number relative to the average of six locations is 344 sec. We obtained the lowest falling number with 291 sec. from the Samsun location in 2017 and the highest with 385 sec. from the Karaman location in 2017, on average. The falling number of the genotypes varied between 296 sec and 400 sec for all environments (Table 2).

The genotypes with the lowest falling number for the 2016 and 2017 harvesting years are Sönmez2001, Şahman, 4-11, Kocabuğday, Tir line, Topbaş, Çalıbasan (1), Göderedi (1) and Akbuğday (2), respectively. Clark's Cream, Zincirli, Müfitbey, MV18, Esperia, Bezostaja, Demir2000, Beyaz Buğday (1), SarıBuğday (2, 1), and Kobak (2) genotypes have the highest falling number (Tables 2 and 3). The falling number relative to the average of six locations is 344 sec. Since there was no rain during the harvest period in the years when the experiments were carried out, germination activity did not start under field conditions. The average falling number is high. However, lower averages were obtained from the Samsun location, where the relative humidity is high. Genotypes with a high falling number mean are generally dormant or red-grained genotypes.

The correlation analysis between the falling number and the germination index values in the 2016 and 2017 harvest year data showed a negative and significant relationship between the two features, with -0.19**. Another importance of the falling number in wheat quality is that additives should be added to the flours obtained from wheat with a very high falling number to increase enzyme activity.

3.8. 1000-Thousand-grain weight

The average thousand-grain weight of the three locations was 39 g in the 2014-2015 growing season, and the thousand-grain weights of the genotypes ranged from 29 g to 56 g. The landraces from Anatolia had extreme values for thousand-grain weight.

In the 2015-2016 and 2016-2017 growing seasons of the study, the differences between the thousand-grain weights of the genotypes and the interactions of genotype x year and genotype x location were found to be statistically significant (Table 3). According to the average of the trials in the mentioned years, the thousand-grain weight is 36 grams. While the highest thousand-grain weight was obtained at the Samsun location in 2017, the Karaman and Eskişehir locations had the lowest thousand-grain weight averages in 2016 (Table 2). The drought in the Karaman location in 2016 effectively kept the grains small.

As given in Table 2, the thousand-grain weight values varied between 28 g and 43 g, according to the locations' average. Genotypes with the lowest averages of thousand-grain weight are MV18, Zincirli, Halbert, 4-11, Topbaş, Ak702, Kobak (1), Kabak wheat, Nevzatbey, and No name, respectively. Urumeli, KırmızıBuğday (2), Çalıbasan (2), Bezostaja, Karakılçık (2), SarıBuğday (2,1) Gülümbür, Buğday, Sukezmez and Göderedi (1,2) genotypes had the highest values of thousand grain weight. Although genotypic sources related to thousand-grain weight have been determined in recent studies, thousand-grain weight is significantly affected by agriculture and climatic factors (Shahwani et al., 2014).

3.9. Grain hardness

In many countries, grain hardness is an essential quality criterion and a standard in wheat classification. The average grain hardness in the 2014-2015 growing season was 16.8 kg. The genotypes' grain hardness ranged from 12.2 kg to 25.4 kg. Ak702, İri Çalıbasan, Ağsunteri, Sukezmez, Akbuğday, Arıbuğday, Kobak, Kabak wheat, Yektay406, Çalıbasan and ES26 are the soft-grained genotypes with the lowest values of grain hardness. Genotypes with high grain hardness are HD2329, Tahirova2000, Demir2000, Atay85, Alpu2000, Bezostaja, Tosunbey, Altındane, Adana99, and Tir lines, respectively.

The average of six trials showed that the grain hardness was 18.5 kg (Table 2). Grain hardness was an average of 16.5 kg in 2016 and 16.9 kg in 2017 in the Eskişehir location. These values were 25.4 kg in 2016 and 15.2 kg in 2017 for Karaman, 17.8 kg in 2016, and 19.2 kg in 2017 for Samsun.

The grain hardness varied between 13.9 kg and 24.8 kg for all environment averages. While the landraces were in the first place for low grain hardness in the three years, modern cultivars took the first place in terms of high grain hardness. The varieties Ak702 and Yektay406 were preferred for biscuit production in the years when produced in the past. Atay85 variety has high grain hardness, and millers did not prefer this variety in the past due to its hardness.

3.10. Seed size analysis

Size distribution and homogeneity analysis give information about the size distribution of grains of a genotype. This trait is vital for milling wheat and the products' standards. In the experiment carried out in the 2014-2015 breeding season, the under-sieve analysis values of the genotypes varied between 1% and 5%. While the genotypes with the highest average sieve average were Zincirli, No Name, Ağsunteri, Şahman, Albostan, Sarı Misli, and 4-11, the lowest sieve values were obtained from Kobak, Clark's Cream, Çalıbasan, Akbuğday, Domaniç, and Göderedi genotypes, respectively.

In the last two years of the study, the difference between the average sub-sieve values of the genotypes was found to be statistically significant. In addition, the interactions of genotype x year and genotype x location (year) are also significant (Table 3). In the 2016 and 2017 harvest years, the lowest sieve analysis values were obtained in the Eskişehir location in 2016 with 4%, and the highest value was obtained from the Samsun location with 17% in 2016. In 2017, the average under-sieve values in Samsun, Karaman, and Eskişehir locations were 5%, 6%, and 7%, respectively (Table 2). Bezostaja, SarıBuğday (2), Sukezmez, SarıBuğday (1), Kırik (2), Sönmez2001 and Çalıbasan (2) genotypes had the lowest sieve average, respectively, while the highest values were 4-11, Zincirli, Kabak Buğday, Şahman, Ak702, Esperia, KırmızıBuğday (1) and Kirik (3), respectively. Although the sieve values increase with the shrinkage of the grains in disease epidemics, drought or lodging conditions, they also vary depending on the small grain and low thousand-grain weight in some genotypes.

3.11. Grain moisture content

The grain moisture content of genotypes varied between 10.2 and 11.9% in the 2014-2015 growing season. The moisture content of the products obtained from the Samsun

location, which has the highest rainfall and relative humidity, is higher than the averages of other locations.

Genotype x year and genotype x location (year) interactions are also important for grain content (Table 3). The difference between the average grain moisture content of the genotypes in the study in the 2015-2016 and 2016-2017 growing seasons was statistically significant. The average grain moisture content is 11.2% in Eskişehir and 11.8% in Samsun in the 2016 harvest year. The 2017 harvest year was 10.8%, 10.5%, and 11.5% for Eskişehir, Karaman, and Samsun locations, respectively (Table 2).The general average of the locations was 11.1%, and the grain moisture content varied between 10.2% and 11.7%.

The genotypes with the lowest grain moisture content according to the six environmental averages are Zincirli, Bogruala, Demir2000, Arıbuğday, Kocabuğday, and Göderedi (2), respectively.The highest grain moisture content was obtained from Yektay406, Sukezmez, Kabak Buğday, HD2329, Tosunbey, Çalıbasan (1) and SarıBuğday (1) genotypes.

3.12. Grain color

The average Chroma color values in the 2014-2015 growing season at Eskişehir, Karaman, and Samsun locations were 168, 165, and 152, respectively. The color values of the genotypes varied between 109 and 194. The genotypes with the lowest values in terms of chroma color values are Demir2000, Sönmez2001, Bezostaja, Esperia, KırmızıBuğday,SarıBuğday, Sarımisli, No Name and Urumeli, respectively.The visible grain color of these genotypes is red. Genotypes with the highest values in terms of chroma color value are Akbuğday, P8-6, Ak702, KırmızıBuğday,Beyaz Buğday and Hatip Buğday, respectively. The visible grain colors of these genotypes are white.

The difference between the average Chroma color values of the genotypes in the study in the 2015-2016 and 2016-2017 growing seasons was found to be statistically significant. Genotype x location interaction is also important for color values (Table 3). Chroma color values varied between 303 and 441 according to the location averages of the genotypes in the 2016 harvest year (Table 2). Genotypes with the lowest mean values in terms of chroma color value are Demir2000, Sönmez2001, Esperia, Bezostaja, Çalıbasan (2), and SarıBuğday (1) genotypes, respectively. The visible grain color of these genotypes is red. Genotypes with the highest average values in terms of chroma color values are Altay2000, Karakılçık (2), Arıbuğdayı, Kırik (1), Çalıbasan (1), No Name and Topbaş genotypes, and the visible grain colors of these genotypes are white.

3.13. Correlation analysis between properties

The data relating to the correlation analysis obtained using the replication data of the genotypes in the research in the 2015-2016 and 2016-2017 growing seasons are given in Table 4. The table did not include values related to plant height, considering that the relationship between plant height and the investigated characteristics would not be significant.

We found a positive relationship between germination index and grain filling time, thousand-grain weight, and grain color (Table 4). These results suggest that the germination index of genotypes with a more extended grain filling period may be higher.However, since the genetic source of the post-harvest dormancy trait of the genotypes in this study is not known, it is difficult to comment on the effect of grain filling time.However, the fact that the genotypes with high Chroma color values are white-grained and the germination index of the white-grained varieties is generally high makes the relationship between these two features significant. Another property that has a positive relationship with the germination index is the thousand-grain weight. It is known that the genotypes with a high thousand-grain weight have high germination power. This positive relationship was obtained due to the germination index values of the coarse-grained genotypes that are not tolerant to pre-harvest sprouting.

Properties that are negatively and significantly related to the germination index are protein content, sedimentation volume, falling number, and grain hardness (Table 4). The relationship between the germination index and the falling number is explainable. Because of the low alpha-amylase activity of genotypes tolerant to germination in the pre-harvest sprouting, the falling numbers are generally low. The relationship between protein content, sedimentation volume, and grain hardness is challenging to explain.

Table 4. Data from the 2015-2016 and 2016-2017 growing seasons

Agronomic Properties	Germination index	Heading date	Grain filling date	Protein Content	Sedimentation volume	Failing number	1000 grain weight	Grain hardness	Grain color value	2.8+2.5 mm sieve	2.5+2.2 mm sieve
Germination index Heading date	0.10*										
Grain filling date	0.43**	-0.58**									
Protein content	-0.22**	-0.34**	-0.01								
Sedimentation volume	-0.15**	-0.21**	0.04	0.42**							
Failing number	-0.19**	0.38**	-0.38**	-0.40**	0.01						
1000 grain weight	0.30**	0.14**	0.28**	-0.26**	-0.12**	0.04					
Grain hardness	-0.09*	-0.27**	0.02	0.45**	0.38**	-0.29**	-0.20**				
Grain color value	0.12*	0.09	-0.01	-0.13*	0.03	0.21**	0.27**	0.22**			
2.8+2.5 mm sieve	0.11*	0.10*	0.06	0.05	0.19**	0.04	0.81**	0.04	0.31**		
2.5+2.2 mm sieve	-0.26**	0.13**	-0.40**	-0.28**	0.01	0.30**	-0.68**	-0.18**	-0.13	-0.60**	
Sieve	-0.05	-0.18**	0.09*	0.04	-0.19**	-0.14**	-0.69**	0.03	-0.28**	-0.91**	0.30**

Heading date has a statistically significant correlation coefficient with many examined features (Table 4). For example, the longer grain filling times of the early genotypes make the negative relationship between these two characteristics significant. However, relationships with other traits are difficult to explain. There is an important positive relationship between grain filling time and thousand-grain weight. The grain weight of the genotypes increases when the grain filling time is prolonged. Grain filling time also has a negative and significant correlation coefficient with the falling number. This value shows that genotypes with longer grain filling times generally have lower falling numbers.

While it had a positive and significant correlation coefficient with protein content, sedimentation volume, and grain hardness, it showed a negative and significant correlation coefficient with the falling number and thousand-grain weight (Table 4). The negative relationship between thousand-grain weight and protein content may be due to small grains' relative increase in protein content. High protein content can increase grain hardness. Sedimentation volume and grain hardness are scientifically related to protein content.

4. Discussions

Grain color is an influential factor in seed dormancy due to the pleiotropic effect. Many genotypes with white kernel and post-harvest dormancy have been reported (Shao et al., 2018). In this study, a pleiotropic effect was also observed for these properties. When the genotypes in the experiment are grouped according to grain color, the average germination index of the white-grained genotypes is 0.53, while the average germination index of the red kernel genotypes is 0.40. Similarly, in the studies conducted by Rasul et al. (2012), it was found that the germination index of the red kernel genotypes was lower. In this study, Clark's Cream, Zincirli, Ak702, Halbert, Bogruala, Nevzatbey, and 4-11 varieties with white grains were found to have a germination index below 0.50. Among the red kernel genotypes, Tir line, Beyaz Buğday (2), KırmızıBuğday (1), and Kabak buğdayı have relatively high germination index values. However, researchers have determined that dormancy genes also act independently of grain color in their research on red × white kernel hybrids (DePauw and McCaig, 1983). We could not find a dormant white-grained landrace in the material we used in this research.

While the red kernel Karakılçık (1) genotype had the lowest germination index, the white kernel Karakılçık (2) genotype collected with the same name reached a germination index value of 0.55. This result shows that lines with different phenotypic and genotypic characteristics can be developed within the local populations with the same name in Turkey.Genetic variation within local populations is desired by wheat breeders and is an essential resource for wheat breeding programs. Karakılçık (1) and American-origin Clark's Cream genotypes had germination indexes of 0.35 and 0.49, respectively, in the Samsun location in 2017, when the germination index was the highest. These two sources can be used in breeding programs as a source of tolerance for pre-harvest sprouting, especially in coastal areas with high relative humidity.

Genotypes with an average germination index value of less than 0.50 and white kernel color can be expected to tolerate pre-harvest sprouting under conditions where the amount of rain is not high and the number of days off after rainfall is low. In field conditions, the amount of precipitation falling during the harvest period, the number of rainy days, and the number of cloudy days after rain are also crucial for tolerance to pre-harvest sprouting (Nyachiro et al., 2002). While many genotypes can germinate if the precipitation amount per square meter is high and the number of cloudy days after precipitation is high, genotypes tolerant to pre-harvest sprouting have an essential advantage in case of low precipitation amount and duration.

As a result, it is a significant advantage to prefer genotypes with red kernels and post-harvest seed dormancy in regions with high relative humidity as in the world. However, if some white-grained genotypes find a large cultivation area in risky areas, developing new varieties using white-grain dormant varieties becomes inevitable.

The genotypes with the shortest plant height according to the location averages are Zincirli, Esperia, HD2329, Altındane, Mv18, Nevzatbey, Halbert and Tosunbey, respectively, while the tallest plant heights are Sukezmez, Karakılçık (1), Şahman, Urumeli, Kırik (2), Gülümbür, Çalıbasan (2), 4.11, Arıbuğday, SarıBuğday (2) and Clark's Cream are genotypes. Although plant height is genetically controlled by dwarfing genes, it is influenced by many climate and environmental factors (Thomas, 2017; Okada et al., 2019). All genotypes with tall plant heights are Anatolian landraces except Clark's Cream. It is an expected result that local Anatolian landraces have high plant height.

Although genotypic factors affect the grain filling period, the effect of the climatic conditions experienced in this period is much more critical. In the years when heat and drought stress are encountered during the grain filling period, the grain filling times of the early and late genotypes may have relative values. The grain filling time affects the dormancy characteristics of the genotypes (Mares and Mrva, 2014). The correlation analysis between the grain filling time and germination index shows a positive and important relationship (0.43**). The study determined that Clark's Cream variety, which is resistant to germination, showed a tolerant response to germination tests before harvest in the Samsun location, where the germination index and grain filling time were the longest.

The effect of environmental variance on protein ratio is higher than its effect on protein quality (Taghouti et al., 2010; Tekdal et al., 2017). Genotypes with extraordinarily high and low values in terms of protein content are usually the landraces. However, there are genotypes with genetically high protein content independent of the environment, such as the Atlas66 variety.Therefore, evaluating the material included in the project as a genetic resource is essential.The presence of genotypes with higher protein content than varieties such as Bezostaja, Esperia, Altındane and Tosunbey, which are crucial in Turkey in terms of quality characteristics, shows the potential of using the material used in the project as a gene source in wheat breeding programs.

A remarkable result in sedimentation volume is that the genotypes, already known as high quality in the wheat industry, are modern varieties and rank first in terms of quality characteristics. This result may be due to modern breeding studies and the high heritability of the

sedimentation volume. Another exciting development is that local genotypes with similar names have different sedimentation volumes. Because village populations are genotypically different alleles, it is natural to find genotypes carrying different HMW-GS unit combinations in the same population, especially regarding quality characteristics. This result is expected for the landraces populations.

Although quality has a broad meaning in wheat, it varies greatly depending on the product used as raw material. The landrace genotypes included in the study have low values in terms of protein quality, which has a potential for biscuit wheat research. Karakılçık genotype has the lowest germination index value and has an average sedimentation volume of 14 ml. The fact that Clark's Cream and MV18 genotypes, which have a low germination index value, are in the top ranks in terms of sedimentation volume will increase the potential of using these genotypes as genitors for bread wheat breeding programs.

Most of the landrace bread wheat in Turkey are white grained. There is a close relationship between germination and grain color in pre-harvest sprouting (Zhu et al., 2019; Tai et al., 2021). Due to the pleiotropic effect between dormancy genes and grain color, red kernel genotypes are generally more resistant to germination in the harvest period spike. However, recent studies have shown that white kernel genotypes also have effective QTLs in harvest dormancy. It is of great importance that white kernel genotypes have dormancy characteristics, especially in countries such as Australia, where white kernel wheat breeding is essential.

5. Conclusions

Within the scope of the research, we screened the genotypes, including the landraces, for tolerance to pre-harvest sprouting. During the 2014-2015, 2015-2016, and 2016-2017 growing seasons, some agronomic and quality characteristics of the genotypes were determined in the trials carried out in Eskişehir, Karaman, and Samsun locations.In addition, genotypes that were tolerant or sensitive to germination in the pre-harvest spike, which originated from abroad or in Turkey, were also included in the trial set.

Genotypes that are tolerant to the pre-harvest sprouting and have the lowest average germination index are Karakılçık (1), Bezostaja, Clark's Cream, Kobak, Demir2000, Göderedi (1), Sukezmez, MV18, and Sönmez2001 genotypes, respectively. These genotypes had very low germination index values except for the Samsun location in 2017. Karakılçık (1) and Clark's Cream genotypes had germination indexes of 0.35 and 0.49, respectively, in the Samsun location in 2017. These genotypes can be used in pre-harvest sprouting tolerance studies. The mapping population can be developed to determine the genetic source of the pre-harvest sprouting tolerance of the Karakılçık (1) genotype. Genotypes with white kernel color and average germination index below 0.50; Clark's Cream, Zincirli, Ak702, Halbert, Bogruala, Nevzatbey, and 4.11. These genotypes can tolerate germination in the spike in years when the rainfall is not high during the harvest period. The germination index of white kernel genotypes increases more than red kernel genotypes. This study observed a pleiotropic effect between grain color and seed dormancy.

However, tolerance responses to germination were also experienced in the pre-harvest sprouting, regardless of grain color. For this reason, we recommend growing primarily red-grained varieties in coastal areas with a risk of pre-harvest sprouting. Examples of these genotypes are Clark's Cream and Tir line.

Turkey, which is the gene center of wheat, is very rich in landrace resources, and these resources have been used as a gene source in many country breeding programs. We determined the quality characteristics of the materials in the study. The landraces are generally softer and coarser than the modern varieties; the protein content is higher, but the protein quality is lower, and the grain size is relatively large in some landrace materials. Grain characteristics of some landrace genotypes, especially Sarı Buğday, can add genetic richness to breeding programs.It has the potential to be used in drought tolerance studies due to the earliness of the Tir genotype and the possibility of the possible long coleoptile.Including these genotypes in breeding programs to develop new varieties will contribute significantly to wheat breeding programs.

Conflict of interest

The authors have no relevant financial or non-financial interests to disclose.

Authors' contribution

All authors contributed to the study conception and design. All authors read and approved the final manuscript.

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New records for the Mycobiota of Greece

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Yunanistan Mikobiyotası için yeni kayıtlar

Abstract: Eight rare fungi, *Arachnopeziza obtusipila* Grelet, *Chaetothiersia cupressicola* Valencia, Van Vooren & M. Vega, *Chondrogaster pachysporus* Maire, *Ciboria brunneorufa* Bres., *Kallistoskypha incarnata* (Duvernoy & Maire) Pfister, Agnello, Lantieri & LoBuglio, *Lambertella palmeri* Raitv. & R. Galán, *Perilachnea fallax* M. Carbone, Valencia, Tello & Van Vooren and *Perilachnea humarioides* Valencia, M. Vega & Van Vooren, are reported for the first time from Greece. This paper provides the descriptions of the recorded collections, accompanied by images of their macroscopical and microspical features.

Key words: *Ascomycota, Basidiomycota,* mycodiversity, new record

Özet: Sekiz nadir mantar, *Arachnopeziza obtusipila* Grelet, *Chaetothiersia cupressicola* Valencia, Van Vooren & M. Vega, *Chondrogaster pachysporus* Maire, *Ciboria brunneorufa* Bres., *Kallistoskypha incarnata* (Duvernoy & Maire) Pfister, Agnello, Lantieri & LoBuglio, *Lambertella palmeri* Raitv. & R. Galán, *Perilachnea fallax* M. Carbone, Valencia, Tello & Van Vooren ve *Perilachnea humarioides* Valencia, M. Vega & Van Vooren, Yunanistan'dan ilk kez rapor edilmiştir. Bu makale, yeni kaydedilen örneklerin betimlemelerini, makroskobik ve mikroskobik görüntüleri eşliğinde, sunmaktadır.

Anahtar Kelimeler: *Ascomycota, Basidiomycota,* mikoçeşitlilik, yeni kayıt

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1. Introduction

The diversity of ascomycetes in typical Mediterranean ecosystems in Greece is poorly studied, probably due to their limited distribution. Especially for the species included in this study, their small size plays a crucial role in their difficult identification. On the contrary, the study of hypogeous asco and basidiomycetes in Greece has brought great results, and several new species from Greece have been published (Paz et. al., 2017; Vidal et. al., 2023). Still, *Chondrogaster pachysporus* Maire is an easily overlooked species, because it is completely surrounded by a mass of roots, together with plant debris and soil.

The genus *Arachnopeziza* Fuckel was created by Fuckel (1870). In his monograph of *Arachnopezizeae* Korf (1951), *Arachnopeziza* was delimited by apothecia seated on subiculum, with hyaline excipulum, straight hairs, 1−7-septate ascospores and saprotrophic mode of nutrition. A key to the twelve species known up to date is included in this work. In the world this species is recorded mainly from coniferous wood (Morozova, 2014). Due to its very small size it is not easily distinguishable.

The genus *Lambertella* Höhn. was created by Höhnel (1918). Until Whetzel (1943) extended it to eight species, his work has served as a basis for further studies and new articles. Thus, after a few years, Dumont (1971) produced a monograph in which he included keys to identify a total of twenty nine species. Korf and Zhuang (1985) created new keys to incorporate all these taxa together. The species was first described from Baja California - Mexico (Galan et al., 1994). It was first found in Europe in Colmenarejo - Madrid (Galan and Prieto, 2004). *Lambertella palmeri* Raitv. & R. Galán is an ascomycete ephemeral with a small size. It needs high humidity levels for its growth. It is dark-coloured, it does not contrast on dark leaves, so it is not easily noticed. Galan and Prieto (2004) had hypothesized that it occurs in other Mediterranean countries on hardwood species of the genus *Quercus* L. spp. as shown in the present work. In the work of Martinez et al. (2013) the species is reported as the second Spanish and European record.

Ciboria brunneorufa Bres. is a rare species that until 2007 was known only from the Iberian Peninsula (Ormad and Garcia, 2007). Pancorbo and Ribes (2010) provided additional information on its morphology and ecology, including descriptions of its microscopic features. This species was recorded in the Balkan Peninsula, Bosnia and Herzegovina, for the first time by Jukić (2016), who reports that many of the previous authors did not report the existence of two different types of paraphyses. Due to its small dimensions it is not easily distinguishable.

The study of *Caloscypha incarnata* Duvernoy & Maire from North Africa and Italy by Pfister et al. (2013), using SSU, LSU rDNA, and morphology allowed this species to be placed in a new genus, *Kallistoskypha* Pfister, Agnello, Lantieri & LoBuglio. This ascomycete is found in association with eucalypt species. It was also found side by side with *Plectania rhytidia* (Berk.) Nannf. & Korf, just as in Italy, in the collection dated 13-02-2010. In the above mentioned paper, the authors demonstrated that the recent new species *Marcelleina parvispora* Rubio, Tabarés & Martinez from Spain, (Rubio et al., 2010) is conspecific.

Chaetothiersia cupressicola Valencia was first described from collections made at two different sites in Spain and appears to be clearly associated with woody debris of *Cupressus* L. spp. (Van Vooren et al., 2021). Although this ascomycete shows a bright yellow hymenium, it appears that mycologist had not previously discovered this species.

It was found for the second time in Europe - Bulgaria and it had been hypothesized that the species might also be present in Greece (Slavova et al., 2021). This collection from Greece seems to be the third in Europe.

The genus *Perilachnea* Van Vooren was recently created to include species that, apart from the different genetic profile, differs from *Trichophaea* Boud. s. str. by deeply cupulate apothecia (at least in young state), mainly with a *Humaria*-like appearance, bi- or pluriguttulate ascospores, paraphyses containing small lipid bodies, and saprobic status (Van Vooren et al., 2021). *Perilachnea fallax* M. Carbone, Valencia, Tello & Van Vooren was first described recently (Van Vooren et al., 2022) and was given that name because of the deception, since it is morphologically very similar to *flavobrunnea*. *Perilachnea humarioides* Valencia, M.Vega & Van Vooren was also described in the above paper and given this name because of its close macroscopic similarity to *Humaria hemisphaerica* (F.H. Wigg.) Fuckel.

The genus *Chondrogaster* Maire is closely related to *Hysterangium* Vittad., from which it was segregated and differs in the lack of a distinct columella and the presence of a mycelial mass covering the whole basidioma (Giachini et al., 2000). Both the currently known species *C. angustisporus* and *C. pachysporus* are associated with *Eucalyptus* L'Hér. spp. and are probably native to Australia, but have spread to many areas of the world where *Eucalyptus* plantations have been established for forestry purposes. The external morphology of basidiomata, completely surrounded by a mass of roots, together with plant debris and soil, makes it difficult to identify in the field.

According to the existing check-lists of Greek ascomycetous (Zervakis et al., 1999), basidiomycetous (Zervakis et. al., 1998) and hypogeous macrofungi (Diamandis and Perlerou, 2008), these eight species have not been previously reported in Greece. This study aims to make a contribution to the mycobiota of Greece.

2. Materials and Method

Ascomata of *Arachnopeziza obtusipila* were collected from Rafina district of Attica province and Distrato district of Ioannina province, *Chaetothiersia cupressicola* were collected from Spata district of Attica province and the *Ciboria brunneorufa, Kallistoskypha incarnata, Lambertella palmeri*, *Perilachnea fallax* and *Perilachnea humarioides* were collected from Artemida district of Attica province. Basidiomata of *Chondrogaster pachysporus* were collected from Artemida district of Attica province and Kalloni district of Lesvos province. Examination of macro- and microscopic features is based on fresh material. Microscopic studies were performed on dried and fresh specimens under two microscopes. A binocular Olympus ECEBi and AmScope T120C-E5-3PL trinocular light microscope. The specimens were submerged in water and Melzer reagent. Cotton blue was used to highlight spore ornamentations and Congo Red was employed to stain cell walls of different elements. Spore dimensions were obtained from measurement of 30 random, mature spores using Piximetre 5.10 software. The specimens were identified with the help of Montecchi and Sarasini (2000), Pfister et al. (2013), Van Vooren et al. (2021, 2022), Ormad and Garcia (2007), Jukić (2016) and Morozova (2014). The nomenclature follows mainly "Index Fungorum" (http://www.indexfungorum.org). Where VK is the initials of the author and the collection code. The samples included in this study are kept in the author's private fungarium.

3. Results

Ascomycota Caval.-Sm.

Leotiomycetes O.E. Erikss. & Winka

Helotiales Nannf.

Arachnopezizaceae Hosoya, J.G. Han & Baral

Arachnopeziza obtusipila Grelet (Figs. 1,2)

Syn: [*Arachnopeziza zonulata* var. *obtusipila* (Grelet) Malençon & Bertault]

Macroscopic and microscopic features: Apothecia gregarious, sessile, microscopic, 0.1-0.3 µm in diameter, with whitish hymenium, regular hairy girth and waxy flesh. Ascospores smooth, hyaline, asymmetrical, elongate, with one pole slightly conical, measuring 25-27.5 × 3-4.5 µm, with 1-3 -often indistinct- septa at maturity, (seen distinctly

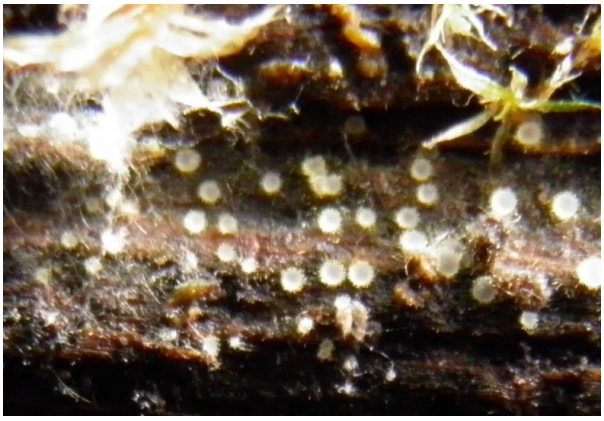

Figure 1. Apothecia of *Arachnopeziza obtusipila* on rotten wood of *Pinus halepensis* Mill.

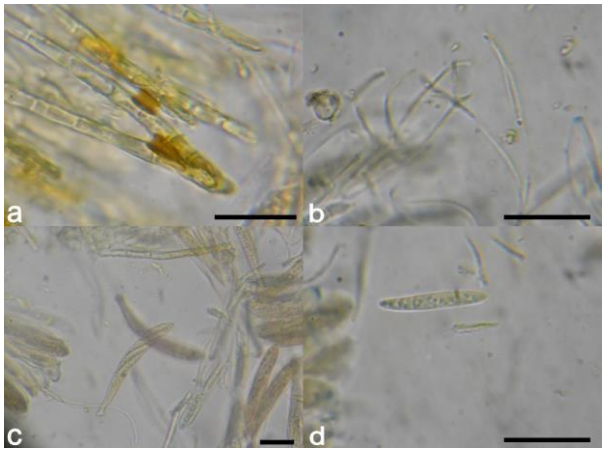

Figure 2. Hairs (a), paraphyses (b), asci (c), ascospore (d) (bars: 20 µm)

with Melzer's) and many small droplets. Asci cylindrical, 8-spored 70 -75 × 8-9.5 µm, with conical, starchy apex. Hairs yellowish, smooth, almost hyaline, rather thick-walled, septate, blunt, 90-105 × 3.5-4.5 µm long, with clumps of yellow or hyaline resinous material. Paraphyses hyaline, capitate, thin-walled, septate, sometimes bifid, 1-1.5 µm thick. Fruiting herbaceously, usually in dense

formations, on moist, decaying wood of conifers, especially pines.

Specimen examined: Greece, Attica, Rafina, on a fallen branch of *Pinus halepensis* Mill., 05.02.2015, Leg: and Det: Kaounas V, VK4009. Greece, Ioannina, Distrato, in rotten broadleaf wood, 21.05.2022, Leg: and Det: Konstantinides G, GK13932.

Rutstroemiaceae Holst-Jensen, L.M. Kohn & T. Schumach.

Lambertella palmeri Raitv. & R. Galán (Figs. 3,4)

Macroscopic and microscopic features: Apothecia cup-shaped to discoid, up to 1.5 mm high and up to 1 mm in diameter. White outer surface, yellowish in young specimens and more brown in mature specimens. Marginal is always paler and outer surface is covered with whitish hairs. Hymenium is yellowish and as it matures a blackish colour becomes visible, which takes reason of the maturation of the spores emerging from the asci. Paraphyses are cylindrical, septate, sometimes branched, as long as the asci and between 1-1.5 µm wide. Asci are 8spored, in a row arranged the spores but sometimes in two, cylindrical, inamyloid, 99-132 × 11-16 µm. Ascospores have an unusual shape, with a horn-like appendage at each end, in some cases different, but generally resembling the shape of a 'croissant' or a Napoleon's hat Baral and Marson (2005) or a garlic clove. Initially they are hyaline, then they take on an olive green to dark brown colour. With the hollow region lighter in colour, with lipid droplets internally and smooth external appearance, (28.1) 29 - 35.7 (39.3) × (8.3) 9 - 10.3 (11) µm, X = 32.6 × 9.6 µm, Q = (2.9) 3 - 3.7 (3.9), Qm = 3.4. Ectal excipulum is formed by cylindrical cells, while in the middle layer these cells are more elongated and compressed and become almost spherical at the top. The hairs are cylindrical, yellowish to brownish and thin-walled, 4-5 µm thick. Marginal hairs of the hymenium are colourless, hyaline, similar to paraphyses, except for the thickness, which is 1-2 µm.

Figure 3. *Lambertella palmeri*, fresh ascomata on rotten leaves debris of *Quercus coccifera* L.

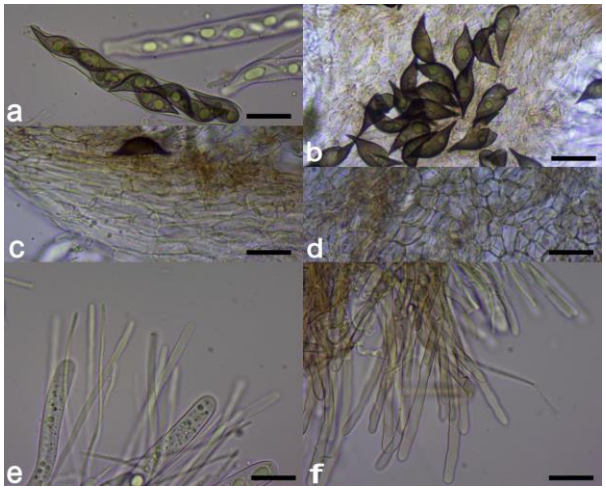

Figure 4. Asci (a), ascospores (b), ectal excipulum (lower-middle zone) (c), ectal excipulum (d), asci, paraphyses and marginal hairs (e) and external hairs (f) of *L. palmeri* (bars: 20 µm)

Specimen examined: Greece, Attica, Artemida, in fallen leaf of *Quercus coccifera* in forest with *Pinus halepensis*, 17.01.2022, Leg: and Det: Kaounas V, VK6632. There is a known, earlier collection of the species, from Heraklion, Crete, 25.03.2020, Leg: Gavalas J. and Det: Wergen B.

Sclerotiniaceae Whetzel

Ciboria brunneorufa Bres. (Figs. 5,6)

Macroscopic and microscopic features: Apothecia cup-shaped, to nearly flat, with small indistinct stipe. Diameter 2-4 mm and 2-3 mm high. Hymenium smooth, beige to brown, with pink or rust tint. Margin conspicuous in mature apothecia, usually slightly darker than hymenium. Outer side of apothecia more shiny than hymenium, sometimes with almost hairy surface across stipe. Asci cylindrical, 8-spored, usually with ascospores arranged in two rows, rarely in one row, 91.9 - 106 × 7.8 - 11.1 µm. Ascospores smooth and vitreous, elliptic to spindle-shaped, aseptate, often slightly unequal, with 1-4 larger lipid droplets 0.7-1.5 µm in diameter and several smaller ones at each pole, (11.8) 12.1 - 14.4 (14.5) × (3.9) 4.1 - 4.8 (5) µm, X = 13.3 × 4.5 µm, Q 2.6 - 3.5, Qm = 3. Paraphyses cylindrical, septate, up to 130 µm long, usually as long as asci. Two types were observed: one rather broad, 3.5-5.5 µm at apex, septate, containing pinkish-reddish pigment; the other narrower, 2.2-3.7 µm, septate, without pigment and hyaline, rarely bifid. Medullary excipulum consisting of cylindrical elongate, subhyaline to brownish, slightly convex cells with rounded edges, 5.5-8.5 µm wide and 50-110 µm long. Ectal ecipulum consisting of irregular spherical cells, 7-25 µm in diameter. There are small scattered hyphoid hairs formed by two or three cylindrical cells, the latter larger than the others, up to 22 µm long. The last cell is usually 5.5-6.5 µm thick and can be up to 13 µm thick.

Figure 5. *Ciboria brunneorufa*, fresh ascomata growing on fallen leaves of *Pistacia lentiscus* L.

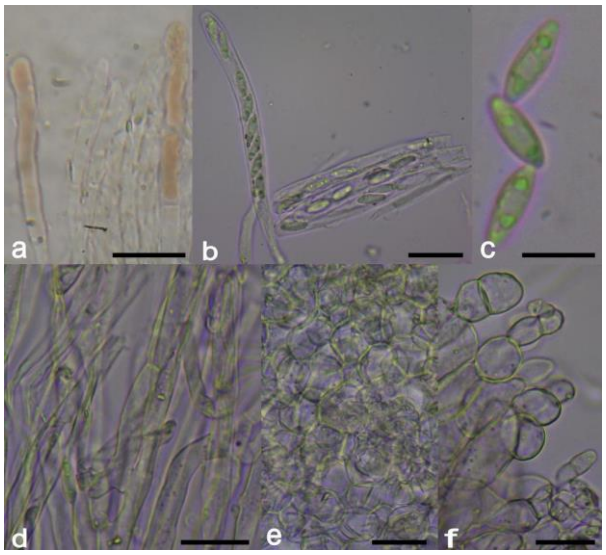

Figure 6. Pigmented paraphyses with refractive vacuoles (a), asci (b), ascospores in water (bar: 10 µm) (c), medullary excipulum (d), ectal excipulum (e), short hyphoid hairs of ectal excipulum (f) of *C. brunneorufa* (bars: 20 µm)

Specimen examined: Greece, Attica, Artemida, in fallen leaf of *Pistacia lentiscus* in forest with *Pinus halepensis*, 29.12.2021, Leg: and Det: Kaounas V, VK6521.

Pezizomycetes O.E. Erikss. & Winka

Pezizales J. Schröt.

Incertae sedis

Kallistoskyphaceae Ekanayaka, K.D. Hyde, Q. Zhao & E.B.G. Jones

Kallistoskypha incarnata (Duvernoy & Maire) Pfister, Agnello, Lantieri & LoBuglio (Figs. 7,8)

Syn: *Barlaeina incarnata* (Duvernoy & Maire) Sacc., *Caloscypha incarnata* Duvernoy & Maire, *Marcelleina parvispora* E. Rubio, Tabarés & Alej. Martínez.

Macroscopic and microscopic features: Apothecia deeply cupulate to cup-shaped, often compressed on one side, never completely flat, even at maturity, up to 15- 16 mm in diameter. Hymenium smooth, coral pink to cherry red in young specimens, changing with age to pale pink, fleshy pink, yellowish-cream, yellowish, with pink spots. External surface white to whitish-yellow to uniform color with hymenium at maturity, finely granulose, often with mycelial strands attached to the substrate, leaves or twigs. These hyaline hairs are visible with the hand lens, especially at the margin. Stipe sometimes clearly visible, 3-4 mm long, with mycelial tufts present and firmly attached to soil debris. Flesh waxy, very brittle, thin and unlayered visible to the naked eye, without the appearance of milk in the section. Odour and taste are not distinct.

These hyaline hairs are visible with the hand lens, especially at the margin. Stipe sometimes clearly visible, 3-4 mm long, with mycelial tufts present and firmly attached to soil debris. Flesh waxy, very brittle, thin and unlayered visible to the naked eye, without the appearance of milk in the section. Odour and taste are not distinct. Ascospores spherical, 8.1-9.8 µm in diameter, smooth, with thick walls, with many small oil droplets, rarely with one large droplet. Asci 145-180 × 9- 11.5 µm, cylindrical, 8spored, uniseriate,

Figure 7. *Kallistoskypha incarnata,* fresh ascomata on rotten leaves debris

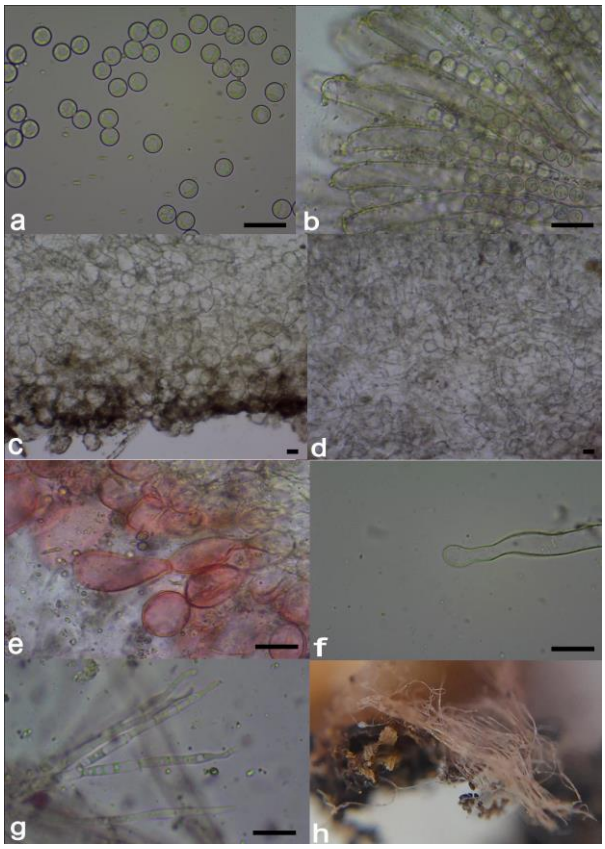

Figure 8. Ascospores (a), asci (b), ectal excipulum (c), medullary excipulum (d), outer cells of the ectal excipulum (with congo red) (e), base of the asci (f), paraphyses (g), mycelial tufts (firmly attached to soil remnants) (h) of *K. incarnata* (bars: 20 µm)

inamyloid. Paraphyses as long as asci, cylindrical, with septa and branched, simple and slightly enlarged at the top or more or less pointed, 2-3(-3.5) µm in diameter. Subhymenium consisting of cells 8-15 µm in diameter. Medullary excipulum in the upper part consisting of elements 20-35(-40) µm, below this area more elongated club-shaped cells, up to 80×40 µm mixed with other smaller and narrower cells having parallel orientation, below this there is a layer of hyphae measuring, 35-70 × 10-15 µm. Ectal excipulum thick, about 90-120 µm, consisting of a chain of 3-5(-6) cells, with the terminal cell extended, subspherical to branchial, thick-walled, coated and with granules of refractive granular/gelatinous material, up to 30 µm wide. Habitat and ecology. In rich soil mixed with

decaying wood debris; a few stocks found in small pieces of wood or dried leaves. Reserves generally in soil under leaves of *Eucalyptus* species.

Specimen examined: Greece, Attica, Artemida, under leaves of *Eucalyptus* sp. in forest with *Pinus halepensis*, 22.02.2024, Leg: and Det: Kaounas V, VK7892.

Pyronemataceae Corda

Chaetothiersia cupressicola Valencia, Van Vooren & M. Vega (Figs. 9,10)

Macroscopic and microscopic features: Apothecia 8 mm in diameter, sessile, at first slightly obconical, then cupulate or discoid, slightly depressed in the centre. Hymenium yellow to glossy yellowish. External surface pale yellow or paler, with brownish hairs at the margin and numerous anchoring hyphae at base. Subhymenium composed of narrow hyphae mixed with subspherical elements. Medullary excipulum thick, with hyaline hyphae, 4-8.5 µm wide. Ectal excipulum thin, with hyaline cells, 15-22 × 10-16 µm, with a yellowish wall in the outer part. Marginal hairs dense, pale brown, sometimes subhyaline at the top, straight or sometimes curved, (200-) 310-1000 × 8-12 µm, septate, thickly walled 0.8-1.7 µm, sharp at the top, with simple and often narrowly elongate base, sometimes showing hyaline amorphous material in lower part. Excipular hairs similar but shorter, 40-450 × 8-12 µm, pale brown, rarely subhyaline, sharp at the top, but shorter ones are clavate. Anchoring hyphae present, up to 470 µm long, 5-10 µm wide, flexible, arising from a bulbous base, with yellowish wall. Ascospores uniseriate, ellipsoid, (14.8-) 16.6-17.4 (-19.2) × (9.7-) 10.9-11.5 (-12.6) µm, x =17 × 11.2 µm, Q = 1.4-1.5-1.6, Qm = 1.5, hyaline, rather thick walled, smooth, containing two large lipid droplets, 5-7 µm in diameter, accompanied by smaller droplets. Asci cylindrical, 242-310 × 11-14 µm, 8spored. Paraphyses straight, thin, hyaline, septate, sometimes with slightly enlarged at the top, 3-4 µm diam, with yellowish interior and with sporadic tiny granular dark yellow pigments.

Specimen examined: Greece, Attica, Spata, in rotting remains of *Cupressus sempervirens*, 10.03.2024, Leg: and Det: Kaounas V, VK7971.

Perilachnea fallax M. Carbone, Valencia, Tello & Van Vooren (Figs. 11,12)

Figure 9. *Chaetothiersia cupressicola* in rotting remains of *Cupressus sempervirens* L.

Macroscopic and microscopic features: Apothecia solitary or gregarius, 5-7 mm in diameter, sessile, cupuliform, spreading at maturity. Hymenium whitish to grey, with outer surface whitish to pale yellowish, covered with short brownish hairs. Margin densely covered with dark brown hairs. Subhymenium very thin, consisting of small subspherical hyaline cells. Medullary excipulum about 90-115 µm thick, consisting of hyaline hyphae, 3.5-8.5 µm wide, mixed with some subspherical or clavate cells, 8-23 × 7-15 µm. Ectal excipulum about 200-250 µm thick, consisting of hyaline cells, 19-36 × 8-28 µm, with thick walls. Marginal cells consisting of spherical or subspherical cells, 10-21 × 10-15 µm, clavate in outer part. Excipular hairs 50-600 × 5-9 µm, superficial, brown, septate, thick-walled 1-1.5 µm, obtuse or slightly pointed at the top, with enlarged base. Marginal hairs similar but longer and denser, 150-1200 × 5-10 µm, superficial,

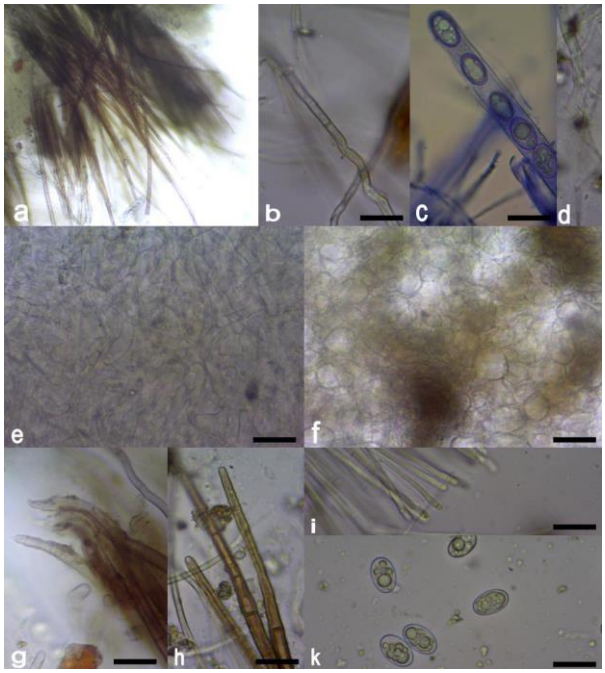

Figure 10. Marginal hairs (a), anchoring hyphae (b), asci and ascospores in cotton blue (c), base of the asci (d), medullary excipulum (e), ectal excipulum (f), excipulum hairs base (g), excipulum hairs (g), paraphyses (i) spores (k) of *C. cupressicola* (bars: 20 µm)

Figure 11. *Perilachnea fallax,* fresh ascomata on rotten wood debris of *Pinus halepensis*

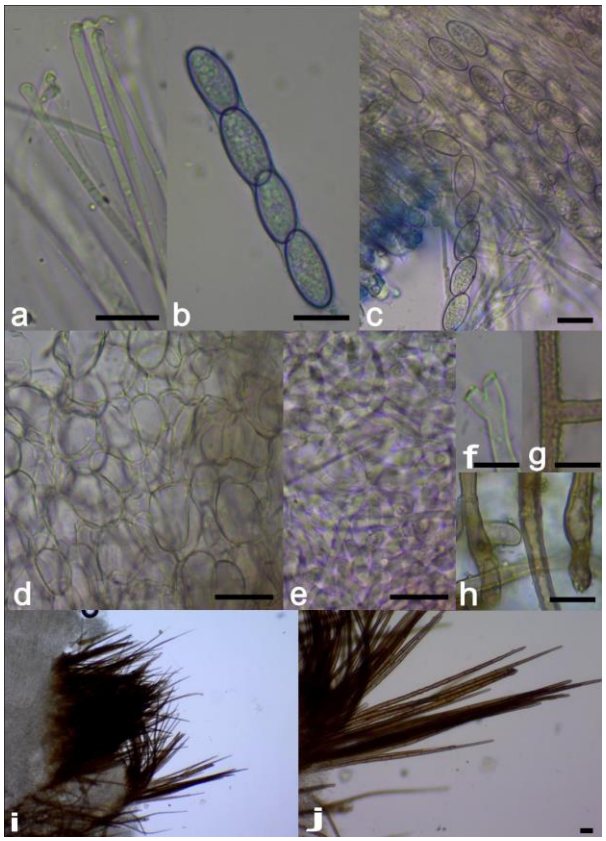

Figure 12. Paraphyses (a), ascospores (in cotton blue) (b), asci, ascospores and paraphyses (c), ectal excipulum (d), medullary excipulum (e), base of the asci (f), vertical hair bifurcation (g), base of the hairs (h) and hairs (i-j) of *P. fallax*, (a, b, c, d, e, j, bars: 20 µm), (f, g, h, bars: 10 µm)

septate, straight or slightly curved, with simple base, pointed at the top, 1.5-2 µm thick walled. Anchoring hyphae present, hyaline, 4-7 µm wide. Ascospores uniseriate, ellipsoid to elongate with tapered ends, (18.2) 20 - 20.8 (22.6) × (8.8) 9.6 - 9.9 (10.7) µm, X = 20.4 × 9.8 µm, Q 1.8 - 2.3, Qm = 2.1, hyaline, smooth, thick-walled (0.5-0.7 µm), containing several small lipid droplets in living state. Asci 8spored, cylindrical 260-300 × 9-11 µm. Paraphyses filamentous, hyaline, septate, straight, 3-4.5 µm in diameter, or slightly enlarged at the top.

Specimen examined: Greece, Attica, Artemida, on the ground, on rotten branches of *Pinus halepensis*, 08.02.2024, Leg: and Det: Kaounas V, VK7837.

Perilachnea humarioides Valencia, M. Vega & Van Vooren (Figs. 13,14)

Macroscopic and microscopic features: Apothecia solitary or gregarius, 6-10 mm in diameter, up to 8 mm high, sessile, deeply cupuliform, spreading at maturity. Hymenium whitish, to greyish, yellowish cream at the end. External surface yellowish cream, covered with short brownish to ochre hairs. Margin hairy, with brown to dark brown hairs, curved, organized in small pyramidal tufts. Subhymenium and medullary excipulum indistinguishable, slender, about 110-120 µm thick, composed of hyaline

hyphae, 3.5-7.5 µm wide, intermixed with some swollen or clavate cells, 11-28 × 7.5-12.5 µm. Ectal excipulum about 250-300 µm thick, with hyaline cells, (6.5) 8-35 µm diam, thick walled. External cells, hyaline, with terminal cell spherical, 11.5-37 × 8.5-26.5 µm. Marginal hairs

Figure 13. *Perilachnea humarioides*, fresh ascomata on rotten wood debris *Prunus dulcis* (Mill.) Rchb.

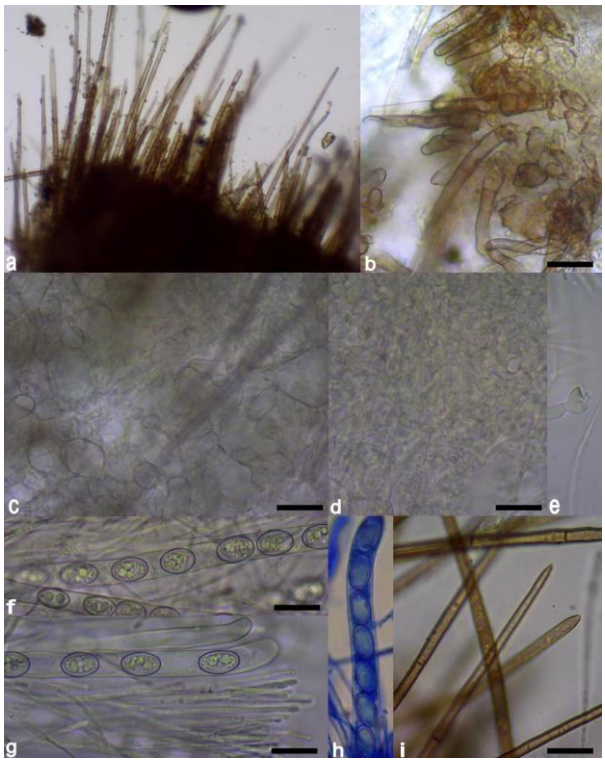

Figure 14. Marginal hairs (a-b), ectal excipulum (c), medullary excipulum (d), base of the asci (e), ascospores (f), asci, ascospores and paraphyses (g) asci and ascospores (in cotton blue) (h) and excipulum hairs (i) of *P. humarioides* (bars: 20 µm)

superficilal, of two types: first, short, 64-220 × 8-17 µm, pale brown, straight, with simple base, septate, blunt at the top, often mixed with clavate cells; second, long, 260-1030 (1300) × 8-12 (16) µm, brown, straight or slightly flexible, with a simple base, enlarged or bulbous to 27 µm, septate, acute at the top or sometimes rounded, 1-1.2 (2.6) µm thick walled. Excipular hairs superficial, similar to short hairs, not bulbous, 17.5-650 × 5-12 µm. Anchoring hyphae present, hyaline, 4-7 µm wide. Ascospores uniseriate, ellipsoid, (15.7) 16.7-17.4 (18.4) × (9.9) 10.6-11 (11.7) µm, X = 17.1 × 10.8 µm, Q 1.5-1.7, Qm = 1.6, hyaline, smooth, thick-walled, containing several lipid droplets, with 2-3 drops larger than others, up to 5 µm in diameter. Asci 8spored, cylindrical, 280-320 × 10-15 µm. Paraphyses filamentous, hyaline, septate, straight, 3-3.5 µm in diameter, not or slightly enlarged at the top.

Specimen examined: Greece, Attica, Rafina, on a fallen branch of an unknown broad-leaved tree, fallen from pruning debris, in a forest with *Pinus halepensis*, 02.02.2024, Leg: and Det: Kaounas V, VK7801. Greece, Attica, Artemida, on a rotten branch from *Prunus dulcis*, 07.03.2024, Leg: and Det: Kaounas V, VK7952.

Basidiomycota R.T. Moore

Agaricomycetes Doweld

Hysterangiales K. Hosaka & Castellano

Mesophelliaceae Jülich

Chondrogaster pachysporus Maire (Figs. 15,16)

Macroscopic and microscopic features: Basidiomata 0.5-1.5 cm in diameter, spherical or distorted by close contact with other specimens, as they almost always occur in small groups of 2-3-4 specimens, which in turn are clustered in nests of several specimens, interconnected by a matrix of accumulated masses of hyphae and rhizomorphs protruding from peridium, small roots, soil and other plant debris. This is particularly distinct at the base of the basidiomata, where the whole appears to be enveloped in a kind of dense and compact shell, a few millimetres thick, which is not separated until the gleba is detached from the peridium, which remains attached to this shell like a thin membrane. Peridium initially 0,5-1 mm thick (in young specimens), whitish in section and on the surface, with a cottony structure, but then tapering to a thin, almost imperceptible and greyish membrane, closely attached to the outer shell; hyphal structure with regular-length elements, 3-8 µm in diameter, as well as thicker elements, ellipsoidal-macroconical. Gleba compact, elastic when young, with a structure formed by rounded or elongated small cells, 0.5-2 mm wide. Which are separated by cotton white plates with a hyphal structure, continuous with the peridium. Filled with spores in a rather thick, pale white brownish matrix. Eventually, the plates become thinner, grayish, while the color of the gleba becomes darker, ending in a chocolate or dark tobacco brown. Odor light, noticeable only after short storage in a small box, with a phenol or fruit smell, no garlic smell. Basidiospores ochre-coloured at maturity, ellipsoid to broad ellipsoid, sometimes slightly ovate or with a hint of papilla, completely enveloped in a thick, very irregularly wavy or slit-like perisporium from completely amorphous to nodular or reticulate, very loose or even 4-5 µm thick, making the basidiospores appear larger and thicker, whereas under this perisporium the basidiospores are smooth and thin-walled in profile, 13.1-16 × 6.7-9 µm, Q = 1.6-2.1, X = 14.6 × 7.8 µm, Qm = 1.9, with a wide and short residual support. Habitat: Hypogeous or semihypogeous under leaves, in loose and sandy soils, in *Eucalyptus* sp. stands, from late autumn to spring.

Figure 15. Fresh basidiomata of *Chondrogaster pachysporus*

Specimen examined: Greece, Attica, Rafina, hypogeous, under of *Eucalyptus sp.* in a forest with *Pinus halepensis*, 22.02.2024, Leg: and Det: Kaounas V, VK7893.

4. Discussions

Species which are similar to *Arachnopeziza obtusipila* are *A. aurata* and *A. delicatula* have narrower and much longer spores (43-80 × 1.4-3.4 µm and 24-48 × 2-3.4 µm respectively). *Arachnopeziza aranea* has much shorter spores (5.5-9.6 × 2-2.7 µm). Also it is obviously closely related to *A. cornuta*, but differs particularly in the spores (8.9-17.7 × 2-3.4 µm) and paraphyses (Korf, 1951). *Arachnopeziza engelii* has cream to pink apothecia, and narrower ascospores (20-24 × 3.5-4.0 µm) (Engel, 1993), *A. ochracea* has beige apothecia, shorter asci and smaller ascospores (16.8 -21.3 × 2.6-3.7 µm) (Iturriaga and Korf, 1988). *Arachnopeziza hiemalis* has wider ellipsoidal ascospores (20-28 × 4.5-5.5 µm) (Wang, 2009). *Arachnopeziza trabinelloides* is easily identified because it is completely yellow. It is closely related to another taxon, *A. leonina* ((12)13,8-16,4(19,5) × 3,4-4 µm) and *A. variepilosa* is supported as a separate distinct lineage, (Kosonen et al., 2021).

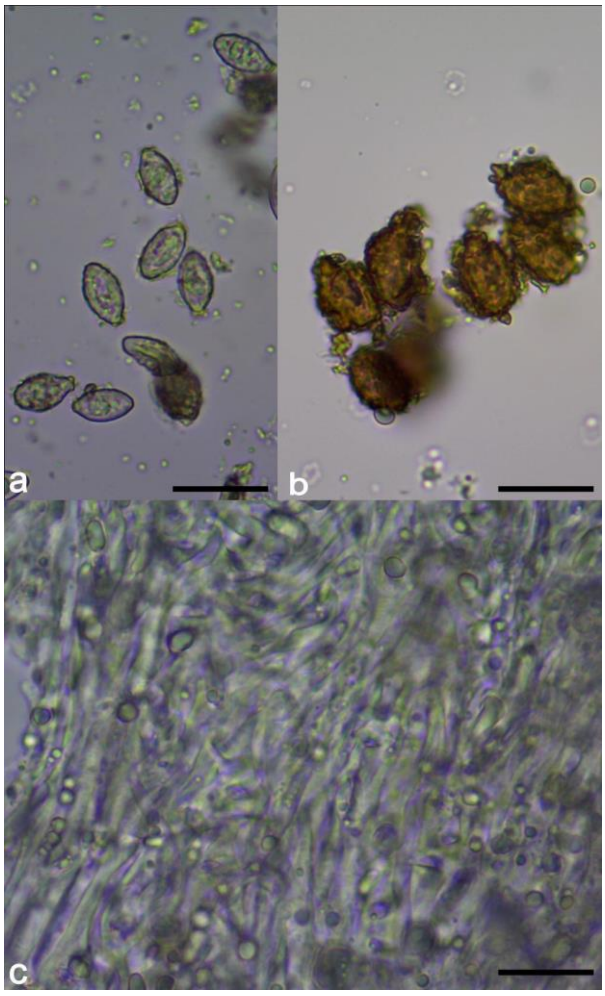

Figure 16. Immature basidiospores (a), mature basidiospores (b) and detail of the trama (c) of *C. pachysporus* (bars: 20 µm)

Lambertella palmeri has similar spores to *Bicornispora seditiosa* and *Bicornispora exophiala* but is a completely different species macroscopically. Phylogenetic analyses of the D1 and D2 domains of the nuc 28S rDNA region of the types of *B. exophiala* and *B. seditiosa* not only confirmed a close relationship between those taxa but surprisingly also with species of *Lambertella* (*Rutstroemiaceae*), particularly with *L. palmeri* (Gala´n et al., 1994). *Lambertella berberidis*, living on dead *Berberis* L. leaves, has spores with different tips and somewhat smaller 20-30 x 8-12 µm (Dumont, 1976). *Lambertella pruni*, growing on stratified *Prunus* L. fruits, has amyloid asci and even smaller ascospores (13-19 × 7-9 µm) (Dumont, 1971). These two species, except for *L. palmeri*, are of spring occurrence, which is not common in the genus (Galan and Prieto, 2004). But the collection from Heraklion, Crete, is from the spring (March).

No other species is known to have similar morphological and microscopic characteristics to *Ciboria bruneorrufa* and the same host, *Pistacia lentiscus*.

Just as for our specimen, *Kallistoskypha incarnata*, there is no other known species with macro- and micromorphological characters matching the literature, as well as the presence of the same *Eucalyptus* host.

Chaetothiersia cupressicola differs from *C. eguttulata* by its guttulate ascospores, longer marginal hairs, and its growth on woody debris and dead branches of *Cupressus* (Van Vooren et al., 2021), while *C. eguttulata* by its grows on debris of *Abies* Mill. Moreover it could be confused with another species growing on dead twigs of *Cupressus*, *Strobiloscypha cupressina* B. Perić & Pfister, which usually has apothecia with a greyish to glaucous hymenium but some collections are yellowish coloured (Perić et al., 2014). Microscopically, *S. cupressina* has ascospores with a different shape and content, and its hairs arise from an enlarged to bulbous base and have rounded apices.

Perilachnea fallax differs mainly from the *P. flavobrunnea* by its spore shape, often more elongated or oblong. The ascospore content is also slightly different, with larger lipid bodies present in *P. flavobrunnea*. To *P. fallax* occurs in decaying litter *Cupressus sempervirens* and *Pinus halepensis*, while the *P. flavobrunnea* in decaying litter *Juniperus* or *Cupressus*. For this reason a careful examination of fresh material and of naturally-ejected mature ascospores is required to separate these two species, especially when both collections are growing on *Cupressus* (Van Vooren et al., 2022). *Perilachnea ochraceoflava* is well distinguished from *P. fallax* by the definitely larger ascospores.

Perilachnea humarioides differs from other *Perilachnea* species by its growth in association with woody debris of deciduous trees, and microscopically by smaller ascospores and mean Q ratio than those of *P. flavobrunnea* and *P. fallax* (Van Vooren et al., 2022). In addition, it differs from *Trichophaea* Boud. s. str. by deeply cupulate apothecia (at least in young state), mainly with a *Humaria*-like appearance, bi- or pluriguttulate ascospores, paraphyses containing small lipid bodies, a saprobic status, and genetic profile (Van Vooren et al., 2022). Macroscopically, this species resembles *Humaria hemisphaerica* in having deeply cup-shaped apothecia and long marginal hairs. The examination of microscopical characters contradicted this resemblance, revealing smooth pluriguttulate ascospores vs. warted biguttulate ascospores in *H. hemisphaerica*. The molecular data confirmed its originality and positioned it in *Perilachnea*, a result in conformity with the characters of this genus. Ecologically, *P. humarioides* appears to be the first species of the genus associated with woody debris of deciduous trees, with the exception of *P. hemisphaerioides* which is carbonicolous and can possibly be found on various types of burnt wood (Van Vooren et al., 2022).

Chondrogaster pachysporus is easily identified because its basidiomata are surrounded by a nest or a cover of roots, plant debris and soil, resembling a shell, like *C. angustisporus*, but the gleba of the first at maturity is completely black while the second is olive black. Basidia are also a good differentiating feature if available in young specimens, as they are mostly bisporic in *C. angustisporus* and monosporic in *C. pachysporus* (Vidal, 1994; Sulzbacher et al., 2010; Giachini et al., 2000). In our sample, due to maturity, we could not observe basidia, as in Montecchi and Sarasini (2000) is not mentioned. However, there is a report of 3-spored or 4-spored basidia, (Moreno et al., 2005). *Chondrogaster pachysporus* is easily distinguished by the morphology and size of the basidiospores, since they are 6-9 µm wide, compared to *C. angustisporus* which reach 4-5 µm and in the first the basidiospores are completely surrounded by a very loose and wrinkled perisporium.

The macro and micromorphological characters of our samples fit in with the literature. Therefore *Arachnopeziza obtusipila*, *Chaetothiersia cupressicola*, *Ciboria brunneorufa*, *Kallistoskypha incarnata*, *Lambertella palmeri*, *Perilachnea fallax*, *Perilachnea humarioides* and *Chondrogaster pachysporus* are new records for Greek mycobiota.

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Effects of fertilizer type on phenolic compounds, essential oil content, and biological activities of *Coriandrum sativum* L.

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Gübre tipinin *Coriandrum sativum* L.'un fenolik bileşikleri, uçucu yağ içeriği ve biyolojik aktiviteleri üzerine etkileri

Abstract: Organic and inorganic fertilizers play an important role in improving the nutritional quality of coriander plant (*Coriandrum sativum* L.). This study consists of 3 different fertilizer applications to coriander: Control-T_0 (no fertilizer); organic fertilizer- T_1 (300-600 mL/da); chemical fertilizer-T_2 (2-3 L/da); vermicompost-T_3 (1.5 L/da). It was conducted in three replicates in a randomized block design to evaluate the effect of different fertilizer applications on the morphological, biochemical and antioxidant potential of coriander plants. It has been observed that fertilizer applications have a significant effect on the morphological, biochemical and antioxidant properties of the plant, and especially in the coriander of seeds organic fertilizer and vermicompost applications have higher phenolic and flavonoid contents (1.82, 2.14 mg GAE/g DW and 2.57, 2.46 mg QE/g DW, respectively). In the GC-MS analysis, linalool was determined as the main compound and the highest concentration of 76.44% was obtained as a result of organic fertilizer application. Antioxidant potential was evaluated by DPPH radical-scavenging assay and the most effective antioxidant activity was determined from organic origin fertilizer (organic-IC_{50}: 27.35±2.52 µg/mL, vermicompost-IC_{50}: 29.42±2.41 µg/mL) applications.

Key words: *Coriandrum sativum*, fertilizer, essential oil, antioxidant activity

Özet: Organik ve inorganik gübreler kişniş bitkisinin (*Coriandrum sativum* L.) besin kalitesinin iyileştirilmesinde önemli bir rol oynamaktadır. Bu çalışma kişnişe 3 farklı gübre uygulamasından oluşmaktadır: Kontrol-T_0 (gübresiz); organik gübre- T_1 (300-600 mL/da); kimyasal gübre-T_2 (2-3 L/da); vermikompost-T_3 (1.5 L/da). Farklı gübre uygulamalarının kişniş bitkisinin morfolojik, biyokimyasal ve antioksidan potansiyeli üzerindeki etkisini değerlendirmek için tesadüfi blok tasarımında üç tekrarlı olarak yürütülmüştür. Gübre uygulamalarının bitkinin morfolojik, biyokimyasal ve antioksidan özellikleri üzerinde önemli bir etkiye sahip olduğu ve özellikle kişniş tohumlarında organik gübre ve vermikompost uygulamalarının daha yüksek fenolik ve flavonoid içeriğine sahip olduğu görülmüştür (sırasıyla 1.82, 2.14 mg GAE/g DW ve 2.57, 2.46 mg QE/g DW). GC-MS analizinde linalool ana bileşik olarak belirlenmiş ve organik gübre uygulaması sonucunda %76.44 ile en yüksek konsantrasyon elde edilmiştir. Antioksidan potansiyel DPPH radikal giderme testi ile değerlendirilmiş ve en etkili antioksidan aktivite organik kökenli gübre (organik-IC_{50}: 27.35±2.52 µg/mL, vermikompost-IC_{50}: 29.42±2.41 µg/mL) uygulamalarından elde edilmiştir.

Anahtar Kelimeler: *Coriandrum sativum*, gübre, uçucu yağ, antioksidan aktivite

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1. Introduction

Environmental and agricultural sustainability relies on the delicate interplay between climatic factors, soil characteristics, and the accessibility of necessary mineral nutrients for crop production. In recent years, extensive use of chemical fertilizers in conventional agricultural systems has caused various ecological issues, such as soil and water pollution, reduced nutritional quality of harvested crops, and disturbance of soil microbial ecosystems (Melero et al., 2008). The approach taken towards promoting a sustainable agricultural framework has undergone significant evolution due to the adoption of innovative management techniques. This change in paradigm emphasises the need to concentrate on biological and integrated systems, with a particular focus on applying organic fertilizers. The intentional incorporation of organic fertilizers into agriculture partly fulfils plants nutrient needs and diminishes reliance on chemical fertilizers (Siddique et al., 2014). The most basic principle of sustainable agriculture is the use of organic fertilizers (animal manure, humic acid, plant residues, etc.). Forming a reservoir rich in macronutrients, micronutrients, enzymes, vitamins and hormones, these organic fertilizers are not only economically viable but also ecologically sustainable. This comprehensive nutrient profile is crucial in maintaining soil fertility and having a positive impact on crop or medicinal plant production by increasing both yield and quality (Saha et al., 2019).

Coriandrum sativum L., known as coriander, of the Apiaceae family, is an aromatic, annual medicinal plant. This plant species originates from the Mediterranean region, North Africa and Southwest Asia, and its fresh leaves and seeds are generally used in the food industry for food preservation (Rasouli et al., 2022). The essential oil obtained from its seeds has been proven to have antioxidant and antimicrobial properties as a result of many studies (Kačániová et al., 2020; Neffati et al., 2011). In addition, the principal components found in coriander essential oil,

namely linalool, 2-decenal, caryophyllene oxide, 2-dodecanal, and caprolactone, possess notable pharmacological properties. These constituents have been identified to exhibit anti-inflammatory and analgesic effects, making them potentially valuable in pain management and inflammation control. Additionally, their anticonvulsant properties suggest a role in neurological health, while their capacity to lower blood pressure and cholesterol levels aligns with their potential utility in cardiovascular health (Yildiz, 2016; Yuan et al., 2020). Similar to the essential oil effect, valuable pharmacological effects were determined by evaluating different extracts (methanol, ethanol, water, etc.) obtained from coriander in different biological activities (antioxidant, acute and sub-chronic toxicity, antimicrobial) (Farah et al., 2015; Patel et al., 2012). The phenolic composition of coriander has been identified as 11 phenolic acids and 10 flavonoids, and these phytochemicals are identified with extremely important pharmacological properties (Msaada et al., 2017).

A substantial amount of scientific research indicates that adopting organic fertilizers has a favourable influence on diverse agronomic features of medicinal plants. These include, but are not restricted to, plant height, fresh and dry matter production, absorption of micronutrients, branch complexity, and essential oil content. These effects were particularly pronounced in medicinal plant species such as *Mentha piperita* L., *Mentha arvensis* L., *Nigella damascena* L. and the data obtained underline the potential benefits of organic fertilisation in improving the growth and biochemical composition of these valuable plant species (Asadi et al., 2018; Chaturvedi and Pandey, 2021; Ulusu and Şahin, 2021, 2022).

The main idea adopted in medicinal plant cultivation is the goal of achieving high quality crop production by organic means. Therefore, the importance of organic fertilizers in meeting the nutritional requirements of farmland is of great importance. In this context, this study is an evaluation and comparative analysis of organic and chemical fertilizer regimes in coriander cultivation. In addition to the determination of growth responses and phenolic compounds in the context of organic and chemical fertilizer application, it was also evaluated in terms of biological activities. In this context, in this study, the effects of organic and chemical fertilizer regimes applied on coriander cultivation to growth responses and phenolic compounds were evaluated and comparative analyzes were carried out. In addition, the contributions of these fertilizer applications to coriander in terms of biological activities were also evaluated. The results may provide additional information on applying the right type and amount of fertilizer to synthesize adequate levels of phytochemicals in *C. sativum* cultivation.

2. Materials and Method

The research was carried out in a controlled greenhouse environment that included a temperature range of 25-30°C, suitable lighting conditions and appropriate humidity level to ensure optimum growth conditions. The research was carried out following a randomised plot design with three replications to obtain reliable results and comprehensive information on the physicochemical properties of the soil samples (0-30 cm) used in the study is shown in Table 1. Contents of fertilizers used in the application; chemical fertilizer [N: P: K (7: 7: 7%)]; organic fertilizer (45% total organic matter, 19.5% C, 3% N, 7% K_2O); vermicompost (5% total organic matter, 1% N, 10% Humic+fulvic acid). Experimental factors included liquid organic fertilizer, chemical fertilizer and vermicompost types: (T_0) no fertilizer (control), (T_1) organic fertilizer before flowering (300-600 mL/da), (T_2) chemical fertilizer before flowering (2-3 L/da), (T_3) vermicompost before flowering (1.5 L/da).

Table 1. The physicochemical properties of the experimental soils

Physiochemical properties	Fertilized soil			
	T_0	**T_1**	**T_2**	**T_3**
Sand (%)	50.76	50.83	51.32	49.65
Silt (%)	25.52	26.22	25.22	25.63
Clay (%)	19.24	19.17	19.63	19.45
Field capacity (%)	25.12	26.26	26.41	26.52
pH	7.34	7.53	7.18	7.47
E.C (mhos/cm)	0.39	0.38	0.37	0.34
CaCO3 (%)	18.08	22.46	20.38	17.64
Organic matter (%)	4.33	5.53	4.66	5.28
N (%)	1.11	1.25	1.68	1.42
P (%)	8.47	9.33	12.68	9.21
K (%)	70.07	75.03	95.67	80.36
Mg (%)	6.13	6.22	6.52	5.84
Ca (%)	14.36	19.85	17.29	13.55
Cu (ppm)	2.59	3.41	1.30	1.76
Fe (ppm)	3.60	3.06	3.76	3.21
Mn (ppm)	16.25	19.17	18.38	15.74
Zn (ppm)	1.43	2.15	2.74	2.18

T_0: Control-no fertilizer; **T_1**: Organic fertilizer-300-600 mL/da; **T_2**: Chemical fertilizer-2-3 L/da; **T_3**: Vermicompost-1.5 L/da

2.2. Morphological analysis

After the plants matured (105-127 days after sowing), all plants samples were harvested separately and the impacts of the fertilizer treatments on the morphological traits of the plants were documented. Morphological characters: plant height (cm), plant dry weight (g), lateral branch number, biological yield (g/m^2), 1000 seeds weight (g), grain yield (g/m^2) and root length (cm).

2.3. Mineral content analysis

The levels of macro and micronutrients in coriander seeds and soil are influenced by fertilizer applications. Therefore, in the study, a comprehensive quantitative elemental analysis covering eight different elements was carried out according to the method specified by Ulusu and Şahin (2021). Kjeldahl method was utilized for N analysis, while spectrophotometric analysis was employed for P_2O_5 analysis. Atomic absorption spectroscopy was utilized to determine the levels of K_2O, Mg, Fe, Zn, Cu, Mn, and Ca in the samples.

2.4. Polyphenol extraction

The extraction was carried out with minor modifications to the method described by Mau et al. (2001). After harvesting, air-dried coriander seeds were ground in a grinder. Seed samples (5g) were extracted separately with 10 mL of pure methanol for 24 h in a magnetic stirrer. Then, the mixture underwent filtration utilizing a sterile filter

featuring a pore size of 0.22 µm. Afterward, the filtrate was evaporated to dryness using a rotary evaporator maintained at 40°C. The resulting residue was then stored at +4°C until additional analysis could be conducted.

2.5. Total phenolics content (TPC) analysis

For the quantification of TPC, 0.1 mL of each extract was introduced into a 96 well microplate. Subsequently, 0.1 mL of Folin–Ciocalteu reagent and 1.6 mL of distilled water were added to each well. Following 3-min incubation, 0.2 mL of a saturated solution of Na_2CO_3 was introduced and the microplate was incubated at dark room temperature for 1 h. The absorbance measurements were conducted using a multi-plate reader at 725 nm. The findings were quantified as milligrams of gallic acid equivalents (GAE) per gram, determined through a standard curve ranging from 0 to 100 mg/mL (de Lima et al., 2024).

2.6. Total flavonoids content (TFC) analysis

75 µL $NaNO_2$ (5%) was added to 250 µL methanol extract solution and mixed. Following a 6-min incubation period, 10% $AlCl_3$ (150 µL) and NaOH (1 M) (500 µL) were introduced into the mixture. Subsequently, the volume was brought to 2.5 mL using distilled water. Subsequently, the absorbance was measured at 510 nm against a prepared blank. TFC of samples (triplicate per treatment) were quantified as mg quercetin equivalents (QE)/g, determined using a standard curve (50-500 mg/mL) (Dewanto et al., 2002).

2.7. Essential oil distillation

100 g of dried coriander seeds were subjected to hydrodistillation for 4 h in a Clevenger apparatus. The extract obtained was dried over Na_2SO_4 anhydrous and stored at 4°C until GC-MS analysis (Ulusu and Şahin, 2021).

2.8. GC-MS analysis

The Gas Chromatography/Mass Spectrometry analyses were conducted using an Agilent Technologies 7890A Network GC System, which was outfitted with an HP-5MS capillary column measuring 30 m × 0.25 mm × 0.25 µm, and an Agilent G4513A series auto-sampler. The temperature was programmed from 60 to 250 °C at 3°C/min and the split ratio was 1:10. the injector and interface temperature were 260 and 270 °C, respectively; scan range 40-340 amu; ionisation energy 70 eV; carrier gas was helium at 1.5 mL/min.

The determination of retention indices for all volatile constituents was conducted utilizing a homologous series of n-alkanes (C7–C25). The identification of oil components followed Adams' method, wherein the matching of retention indices (RI) and mass spectra was employed. The constituents of the essential oil were further characterized by GC-MS spectroscopy.

2.9. DPPH radical-scavenging assay

0.5 mL of DPPH methanolic solution (0.2 mM) was added to 1 mL of methanol seed extract of different concentrations (10-200 µg/mL). Following agitation of the mixture, it was stored in darkness at room temperature for 30 minutes, after which the absorbance value was recorded at 517 nm. DPPH and sample mixed solutions were used as sample, while only DPPH solution was used as negative control and ascorbic acid was used as a positive control. A mixture of DPPH and methanol extract was used as a sample, while only a DPPH solution served as the negative control and ascorbic acid functioned as the positive control (Msaada et al., 2017). Experiments were carried out in triplicate.

Radical scavenging activity was calculated using the following formula:

$$DPPH\ scavenging\ effect(\%) = \left[\frac{ODcontrol - OD\ sample}{OD\ control}\right] x100$$

2.10. Statistical analysis

The experimental methodology encompassed triplicate replicates for each treatment group to ensure robustness and reliability of the results. The collected data, encompassing variables related to fertilizer application, underwent statistical analysis through a two-way analysis of variance (ANOVA). Subsequent to ANOVA, post-hoc analysis was executed employing Duncan's test to discern specific variations between treatment groups. The entire statistical analysis was performed utilizing SPSS software, specifically version 24.0 developed by IBM Corp., headquartered in Armonk, NY, USA. A predetermined level of statistical significance was established at $p < 0.05$ to ascertain the validity and significance of observed differences.

3. Results and Discussion

3.1. Morphological characteristics

The results showed that plant height was positively affected by fertilizer treatments (Table 2). The highest plant height was obtained in vermicompost and chemical fertilizer treatment (63.11 and 59.45 cm, respectively). Thus, an increase of 47.06% and 43.80% was recorded in the vermicompost and chemical fertilizer groups, respectively, compared to the control group (33.41 cm) with the lowest height. Scientific research has shown that the use of fertilizers of organic origin improves soil fertility and modulates the structure of the microbial flora (Suman et al., 2017). Vermicompost, as a fertilizer of organic origin, represents an extremely rich source of nutrients containing essential elements (N, P, K, Mg). Vermicompost

Table 2. Morphological characteristics of *C. sativum* plants under the applications of different fertilizer

Treatments	Plant height (cm)	Plant dry weight (g/pot)	Lateral branch number	Biological yield (g/m^2)	1000 seeds weight (g)	Grain yield (g/m^2)
T_0	33.41±0.20^d	7.25±0.15^d	4.42±0.02^d	328.21±11.10^c	5.88±0.03^d	164.33±4.20^c
T_1	51.53±0.70^c	12.47±0.53^b	6.58±0.04^b	796.44±13.42^b	7.65±0.05^b	310.40±6.52^a
T_2	59.45±0.43^b	11.34±0.50^c	5.36±0.03^c	785.18±12.20^b	7.42±0.04^c	265.12±6.88^b
T_3	63.11±0.44^a	14.56±0.22^a	8.76±0.04^a	834.52±14.21^a	7.86±0.03^a	280.50±8.53^b

Values are represented as mean ± standard deviation of triplicates. The same letters in the same column were not differed statistically (Duncan) ($p < 0.05$)

application promotes the increase of nutrient absorption, photosynthetic activity and metabolic processes of numerous enzymes by influencing plant cell metabolism (Zuo et al., 2018). Consequently, these effects have a significant impact on plant growth and height. The findings of our study are in agreement with those of a previous parallel study on *N. damascena*, as documented in the reference (Ulusu and Şahin, 2021).

Various fertilizer inputs had a notable impact on plant dry weight (DW), as detailed in Table 2. The application of vermicompost fertilization resulted in the maximum plant DW, reaching 14.56 g. This represented a substantial increase of 50.20% compared to the control, where plant DW measured 7.25 g. The elevated numerical values observed for lateral branch number in the current study may be attributed to the beneficial impact of vermicompost such as the plant root system's metabolism and photosynthetic rate increase (Zuo et al., 2018). These cumulative effects contribute to an improvement in DW.

Lateral branch number was significantly affected by different fertilization treatments. Vermicompost application to coriander resulted in the highest number of lateral stems (8.76), which was 49.54% higher than the control (4.42). In addition, it was observed that organic fertilizer application was the most effective treatment on lateral branch number after vermicompost. Numerous scientific investigations have proposed that the application of organic fertilizers (vermicompost, manure etc.) enhances the availability of nutrients and facilitates improved mineral access for roots. Consequently, these fertilizers indirectly elevate the photosynthetic rate by fostering the development of an extensive root system. This augmentation in root functionality contributes to an increased assimilation of photo-assimilates, which are subsequently stored in the stem and thus culminates in the heightened production of lateral branches. Consistent with our findings, a study focusing on coriander corroborated that the utilization of vermicompost led to the highest count of lateral stems (Rasouli et al., 2022).

The biological yield (BY) of *C. sativum* exhibited significant variations based on the different fertilizer sources, as indicated in Table 2. The highest BY was recorded at 834.52 g/m^2, resulting from the vermicompost application. This represented a notable increase of 60.67% compared to the control, where the BY measured 328.21 g/m^2. The application of organic and chemical fertilizers resulted in a 58.79% and 58.19% increase in biological yield, respectively, compared to the control group. Vermicompost contributes to improved nutrient availability, plant quality and yield, especially by enhancing the adsorption of essential elements such as iron (Fe) and zinc (Zn). This is in agreement with the findings of Zaller (2007) who reported a significant increase in biomass yield (BM) of tomato associated with vermicompost application and supports our results.

The effects of various fertilizer sources exhibited statistical significance in terms of coriander 1000 seed weight as shown in Table 2. In particular, vermicompost application resulted in a maximum 1000 seed weight recorded at 7.86 g. This value represents a significant increase of 29% compared to the control group with a 1000 seed weight of 5.58 g. Moreover, the diverse fertilizer sources exerted a pronounced influence on grain yield, as evidenced by the statistical findings presented in Table 2. Organic fertilizer application yielded the highest grain yield, reaching 310.40 g/m^2 and demonstrated a significant distinction from the outcomes associated with alternative treatments. In contrast, the control group exhibited the lowest grain yield at 164.33 g/m^2, marking a substantial decrement of 88.88% when compared to the superior treatment. The application of fertilizers, whether chemical or organic, characterized by high nitrogen content, contributes to the development of photosynthetic organs, thereby augmenting the synthesis and storage of photo-assimilates. Nitrogen (N) availability proves indispensable for pivotal stages such as flowering, pollination, assimilate transfer, and seed filling, underscoring the critical role played by nitrogen-containing fertilizers in determining seed number and yield. Our results indicate a positive correlation between 1000 seed weight and N availability during the growth stage. Consistent with our current study, previous research indicates that the application of organic fertilizers can increase the N, P and K content in the soil, thereby promoting plant growth and increasing total yield (Adekiya et al., 2020; Gao et al., 2020).

3.2. Macro and micro-nutrients content

The results show that there were significant changes in macro and micronutrient contents of coriander as influenced by various fertilizer sources (Table 3). The application of vermicompost had the highest N (3.4%), K (0.55%), Zn (47.2 ppm), Fe (67.4 ppm) concentrations. In contrast, the highest levels of P (3.1%), Mg (1.9%) and Mn (41.2 ppm) were obtained with the use of chemical fertilizer. The control group had the lowest levels of both macro and micronutrient concentrations compared to all other treatment groups. Various fertilizer sources enhance the soil's cation exchange capacity, support the gradual release of nutrients, and influence the biological activities and physicochemical characteristics of the soil (Ostadi et al., 2020). As a result, fertilizer application contributes to an increase in the content of macro and micro-elements of the crop grown in the soil. Consistent with the findings, sweet basil plants treated with vermicompost showed a significant increase in both macro and micro-nutrients (Rezaei-Chiyaneh et al., 2021).

Table 3. Nutrient concentrations in C. sativum seeds under the applications of different fertilizer

Treatments	N(%)	P(%)	K(%)	Ca(%)	Mg(%)	Zn(ppm)	Fe(ppm)	Mn(ppm)
T_0	1.3±0.3^c	2.5±0.2^b	0.28±0.1^d	2.4±0.6^c	0.8±0.2^c	35.9±2.5^c	46.8±3.1^c	32.4±1.8^b
T_1	2.7±0.2^b	2.7±0.3^b	0.42±0.0^c	4.6±0.5^a	1.5±0.1^b	41.7±3.6^b	52.4±2.4^b	36.7±2.4^{ab}
T_2	3.1±0.3^a	3.1±0.4^a	0.45±0.1^b	4.2±0.7^a	1.9±0.1^a	43.8±1.5^b	58.6±5.4^{ab}	41.2±2.3^a
T_3	3.4±0.1^a	2.9±0.2^a	0.55±0.1^a	3.6±1.1^b	1.3±0.2^b	47.2±2.8^a	67.4±4.7^a	35.6±2.2^{ab}

Values are represented as mean ± standard deviation of triplicates. The same letters in the same column were not differed statistically (Duncan) ($p < 0.05$).

3.3. TPC and TFC

The concentration of TPC and TFC in methanol extracts of coriander grown with various fertilizer application is presented in Table 4. TPC differed significantly among the treatments studied (p<0.05). The TPC in coriander seed treated with vermicompost (2.14 mg GAE/g DW) was higher than the other treatments. However, TPC determined in organic (1.82 mg GAE/g DW) and chemical (1.79 mg GAE/g DW) fertilizer treatment groups were not statistically different. The control group had the lowest TPC content compared to the other treatment groups. Similar to our findings, the TPC determined as a result of organic and chemical fertilizer treatments applied to *Guadua angustifolia* Kunth plants was significantly higher compared to the control groups (Villamarin-Raad et al., 2023). In another study, it was stated that vermicompost had an improving effect on the amount of TPC in *Berberis integerrima* Bunge plants exposed to cadmium stress (Khosropour et al., 2021).

The highest TFC in coriander was determined in organic fertilizer (2.57 mg QE/g DW) application. This was followed by vermicompost (2.46 mg QE/g DW) application. In addition, the TFC determined in the control group lagged behind all fertilizer treatments (Table 4). There were statistical differences between all groups (p<0.05). Flavonoids and phenolic acids are recognized for their pivotal role in plant defence mechanisms. Flavonoids, phenolic compounds, exhibit a remarkable propensity for oxidation to quinones and thus contribute to the protection of ascorbic acid and unsaturated fatty acids in cellular membranes against oxidative damage (Zhang et al., 2021). This oxidation process may involve a ring-opening reaction that is facilitated under ultraviolet light conditions, especially in the presence of heavy metal ions (Havsteen, 2002). Recent research has extensively documented the therapeutic potential of flavonoids in the treatment of various diseases including autoimmune diseases, cardiovascular diseases and cancer (Abotaleb et al., 2018; Mozaffarian and Wu, 2018; Rengasamy et al., 2019). In this respect, the development of applications to induce flavonoid synthesis in plants is of utmost importance.

Table 4. TPC and TFC of the *C. sativum* seeds under the applications of different fertilizer

Treatment	TPC (mgGAE/g DW)	TFC (mgQE/g DW)	DPPH (IC_{50}, µg/mL)
T_0	1.36±0.01^c	2.05±0.02^d	48.69±3.46^c
T_1	1.82±0.05^b	2.57±0.04^a	27.35±2.52^a
T_2	1.79±0.02^b	2.22±0.02^c	34.74±1.23^b
T_3	2.14±0.04^a	2.46±0.03^b	29.42±2.41^a

DW: Dry weight; **GAE**: Gallic acid equivalents; **QE:** Quercetin equivalents; **IC_{50}:** Half maximal inhibitory concentration. Values are represented as mean ± standard deviation of triplicates. The same letters in the same column were not differed statistically (Duncan) (p < 0.05).

3.4. Essential oil constituents

13 distinct components were identified, comprising 88-99% of the total composition of coriander seed essential oil (EO). The main component was defined as linalool (monoterpenoid), which represents the majority with a range of 68.56-76.44%. In addition, γ-terpinene (4.88-5.76%), menthol (2.87-3.64%), p-cymene (1.95-2.17%) and geraniol (1.47-2.33%) were considered as other dominant components as indicated in Table 5. The highest monoterpene concentrations were observed especially in the organic fertilizer application. However, chemical and vermicompost applications caused similar effects on EO synthesis. Monoterpenoid concentrations were lower in the control group compared to all treatment groups. Essential oils, constituting a prominent class of plant secondary metabolites, fall within the category of terpenoids. The synthesis of terpene precursors, specifically isopentenyl pyrophosphate (IPP) and dimethylallyl pyrophosphate (DMAPP), necessitates adenosine triphosphate (ATP) and nicotinamide adenine dinucleotide phosphate (NADPH) derived from photosynthesis products. As such, the potential for photosynthesis directly influences the biosynthesis of EO (Rasouli et al., 2022). Various fertilizer applications have been documented to increase both essential oil content (EOC) and specific EO components in several plants such as *N. damascena* L. (Ulusu and Şahin, 2021), *Salvia officinalis* L. (Greco et al., 2021), *M. piperita*

Table 5. Composition of the *C. sativum* seeds essential oil influenced by different fertilizer applications

*RT (min)	Component Names	T0	T1	T2	T3
13.25	α-pinene	0.52±0.06	0.83±0.03	0.68±0.02	0.61±0.05
14.49	dl-limonene	1.08±0.03	1.32±0.13	1.58±0.17	1.12±0.16
15.34	p-Cymene	2.17±0.02	1.95±0.22	1.87±0.33	2.02±0.04
16.42	γ-Terpinene	4.89±0.03	5.54±0.26	5.76±0.20	4.88±0.42
17.53	o-Cymene	1.65±0.05	1.78±0.06	1.62±0.10	1.14±0.02
26.21	1-decyl aldehyde	1.22±0.01	2.41±0.05	1.08±0.15	1.45±0.08
26.78	n-Octanol	0.30±0.00	0.24±0.01	0.27±0.03	0.22±0.00
27.63	Linalool	68.56±0.55	76.44±1.20	70.25±0.55	72.37±1.54
29.32	Camphor	1.55±0.15	2.47±0.12	2.09±0.22	1.84±0.18
31.24	Menthol	2.87±0.21	3.64±0.24	3.51±0.67	2.96±0.32
32.67	a-Terpineol	1.23±0.14	1.01±0.10	1.00±0.04	0.84±0.17
34.44	Trans-2-dodecenil-ol	0.45±0.02	0.21±0.01	0.22±0.01	0.37±0.02
35.62	Geraniol	2.33±0.26	1.47±0.15	1.86±0.42	1.74±0.03
	Total indentified compounds (%)	**88.82**	**88.82**	**88.82**	**88.82**

*Retention time.

L. (Ostadi et al., 2020) and *Satureja hortensis* L. (Alizadeh et al., 2010) are in agreement with the findings of this study.

3.5. DPPH radical-scavenging activity

The assessment of antioxidant efficacy was conducted through the application of the 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay, and the corresponding results are presented in Table 4. The DPPH method utilizes the stable organic radical 1,1-diphenyl-2-picrylhydrazyl to measure the antioxidant's capacity for scavenging free radicals. The evaluation of coriander extracts inhibitory efficacy was determined through the comparative analysis with the benchmark pharmaceutical agent, ascorbic acid, to ascertain the extent of inhibition percentages. Within the treatment groups, the application of organic fertilizer proved to be the most potent inhibitor at the highest concentration (200 µg/mL), demonstrating an inhibition percentage of approximately 96.32% (p<0.05). In addition, the other fertilizer treatment groups also exhibited concentration-dependent DPPH activity and successfully scavenged DPPH radical ions at the highest concentration with respective inhibition percentages of 93.23% (vermicompost) and 88.62% (chemical) (Figure 1). Although the control group showed concentration-dependent DPPH activity, it caused the lowest inhibition (3.58%) among the treatment groups. The resultant IC_{50} value signifies the quantity of antioxidant required to reduce the initial concentration of DPPH by 50%, with lower values a indicative of heightened antioxidant activity, as elucidated by Molyneux (2004). Furthermore, the obtained IC_{50} values were 27.35 ± 3.46 µg/mL, 29.42 ± 2.41 µg/mL and 34.74 ± 1.23 µg/mL in organic, vermicompost and chemical fertilizer applications, respectively. Furthermore, the application of fertilizers significantly influenced the DPPH radical scavenging activity compared to the control (p<0.05). Similar to the data of this study, organic fertilization applied to coriander resulted in higher DPPH activity compared to chemical fertilizer application (Machado et al., 2021). The antiradical activity observed in coriander methanol extracts is attributed to the presence of phenolic compounds in the plants (Msaada et al., 2017). In particular, studies has been found that secondary metabolites such as phenols, flavonoids, tannins have the capacity to reduce DPPH and change its color thanks to their hydrogen-donation capacity (Mokrani and Madani, 2016). The accumulation of secondary metabolites in plants is strongly dependent on various environmental factors. Therefore, more yielding and pharmacologically more valuable plant cultivation is possible with improved environmental conditions.

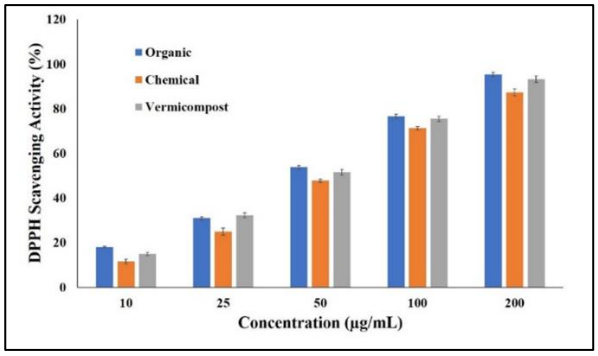

Figure 1. Effect of different fertilizer applications on DPPH scavenging activity

4. Conclusion

The results of this study revealed that *C. sativum* seeds grown with various fertilizer applications caused different effects on the morphological characters and contributed to the macro and micro nutrient element contents. It has been shown that it provides high polyphenol yield. However, fertilizer applications resulted in high polyphenol and flavonoid content in coriander, and these data were supported by GC-MS analysis. Fertilizer applications resulted in high polyphenol and flavonoid content in coriander, and these data were supported by GC-MS analysis. Moreover, in particular, organic fertilizer contributed to coriander seed exhibiting higher antioxidant activity than other applications. In this respect, considering the increasing use of synthetic antioxidants in the food industry, it is possible that phenolic compounds obtained from *C. sativum* extracts grown with the right environmental interventions can be used as natural antioxidant compounds.

Conflict of Interest

Author have declared no conflict of interest.

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New additions to the list of fungi of Türkiye-3

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Türkiye Mantarları Listesi'ne yeni ilaveler-3

Abstract: The book titled "List of Fungi of Türkiye", which is an important document for researchers working mycology, was published in 2020 and contains a checklist of all micro and macrofungus species recorded from Turkey. In addition, all fungal species are given Turkish scientific names in this book. In 2022 and 2024, two additional articles were prepared and the records after the publication of the book were included in these articles. With these studies, it is tried to keep the book and the checklist up to date. The present study is a continuation of these articles, and a total of 92 taxa (1 division, 3 families, 6 genera and 82 species) recorded from Türkiye by various researchers because of the literature searches have been added to the checklist. As a result of three update articles published after the publication of the book, the number of fungal species recorded in Turkey reached 6126 and the total number of taxa reached 7902. In this study, the method followed in the writing of the book was followed and Turkish scientific names were given to the 92 taxa identified as new records from Türkiye.

Key words: Fungi, Turkish Scientific Fungal Names, Türkiye

Özet: Mikoloji alanında çalışan bilim insanlarına önemli bir kaynak niteliği taşıyan "Türkiye Mantarları Listesi" isimli kitap 2020 yılında basılmış olup, Türkiye'den kaydı verilmiş olan tüm mikro ve makrofungus türlerini bir kontrol listesi halinde içermektedir. Ayrıca bu kitapta tüm fungal türlere Türkçe bilimsel isimler de verilmiştir. 2022 ve 2024 yıllarında ise ilave iki makale hazırlanarak, kitabın basımından sonraki kayıtlara yer verilmiştir. Bu çalışmalar ile eserin ve kontrol listesinin güncel tutulması sağlanmaya çalışılmaktadır. Mevcut çalışma da bu makalelerin devamı niteliğinde olup, yapılmış olan literatür taramaları sonucunda çeşitli araştırıcılar tarafından Türkiye'den kaydı verilen toplam 92 takson (1 bölüm, 3 familya, 6 cins ve 82 tür) kontrol listesine ilave edilmiştir. Kitabın basımından sonra yapılan üç güncelleme makalesi sonunda Türkiye'de kaydı verilen fungal tür sayısı 6126'ya, toplam takson sayısı ise 7902'ye ulaşmıştır. Çalışmada kitabın yazımında uyulan metod takip edilmiş olup, ülkemizden yeni kayıt olarak tespit edilen 92 taksona Türkçe bilimsel isimler de verilmiştir.

Anahtar Kelimeler: Mantarlar, Türkçe Bilimsel İsimler, Türkiye

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1. Introduction

Estimates of the diversity of fungi, the second largest group of eukaryotic organisms, suggest that they are represented by millions of species and only about 150,000 species have been identified as heterogeneous based on morphological, anatomical, physiological, or molecular criteria (Hawksworth, 1991; Tedersoo et al., 2018). There are 8 divisions, 341 families, 1417 genera and 6044 species reported to date through mycological studies on macro and microfungi in Türkiye (Asan et al., 2024). The Checklist of the Fungi of Turkey (Sesli et al., 2020) was published in 2020. In fact, some fungal checklists were published in Türkiye before 2020. Examples: Sesli and Baydar, 1995; Asan, 2004, 2015, 2011; Sesli and Denchev, 2005, 2008, 2014; Sesli, 2007; Asan et al., 2016; Giray et al., 2022. However, this monumental book (Sesli et al., 2020) was a first as it included all macro and microfungi recorded from Türkiye until 2020. This book includes information such as the names and synonyms of fungal taxa reported from Türkiye and the region where the record was made. In addition to this information, new Turkish scientific names are included in addition to the Latin names for all recorded fungal taxa. This book was created as a result of review all studies conducted in the field of mycology in Türkiye until 2020. Of course, it is possible that there are studies that could not be reached or were overlooked during this literature review. In addition, as mycological research continues in Türkiye, new fungal taxa will continue to be published and with the widespread use of molecular identification methods, the number of new fungal taxa for Turkey is expected to increase. It is necessary to add the fungal taxa recorded in Turkey after 2020 to the mentioned book, to continue to make scientific nomenclature in Turkish, to include overlooked species in the book and to keep the book up to date in this way, additional articles should be made. After 2020, 2 additional articles were made (Asan et al., 2022, 2024) and 179 fungal species that were not included in the book or newly recorded were added to the mycobiota of Turkey, together with their Turkish scientific names. The present article is the third update article and includes the records obtained as a result of literature review.

2. Materials and Method

In all update articles (Asan et al., 2022, 2024) following the "The Checklist of the Fungi of Turkey " book (Sesli et al., 2020), which contains the fungal taxa recorded from Türkiye, care has been taken to use the method followed in

the book without changing too much when giving records. Records given in MSc, PhD and dissertation theses and in congress/symposium abstracts are not included in the checklist. Taxa in the section categories are listed in alphabetical order, from primitive to advanced, and taxa in the family-interspecific categories are listed in alphabetical order. In this article, Turkish scientific names were given to the fungal taxa recorded for the first time, and these taxa were indicated with the (*) symbol in the text. After the Latin name of the newly recorded species from Türkiye is written, added taxon information and then the Turkish scientific name is given in bold font. If the higher taxa of the new species records were previously given Turkish scientific names, these names have been preserved. The synonyms of fungal species are given in chronological order from old year to new. The websites indexfungorum.org and mycobank.org have been utilized for the iinformation of the fungi. Macrofungi recorded after the publication date of the book are not included in this article. The book entitled "The Checklist of the Fungi of Turkey", all subsequent update articles, and the Turkish names proposed for fungal taxa in the present article are "Turkish Scientific Names" according to Menemen et al. (2021).

3. Results

This article compiles 92 fungal taxa that were not included in previously published fungal checklists. The taxa contents of previous checklists can be summarized as follows:

- Sesli et al. (2020): 6 sections 314 families, 1361 genera, 5865 species / total 7546 taxa.
- Asan et al. (2022): 1 section, 21 families, 44 genera and 111 species / total 177 taxa.
- Asan et al. (2024): 1 section, 6 families, 12 genera and 68 species / 87 taxa in total.

The current review adds a new section, 3 new families, 6 new genera and new 82 species / 92 taxa in total to the overall list. As a result, the current list is updated as 9 sections, 344 families, 1423 genera and 6126 species / a total of 7902 taxa.

List

Oomycota Arx, Pilzkunde, 16 (1967) / **Su Küfleri**.

Peronosporaceae De Bary, Annls Sci. Nat., Bot., Sér. 4 20: 102 (1863) / **Havlimildiyögiller**.

****Plasmopara*** J.Schröt., In Cohn, Krypt.-Fl. Schlesien 3.1(9–16): 236 (1886) / **Bağal.**
Type species: *Plasmopara nivea* (Unger) J. Schröt., 1886.
Syn.: *Peronospora* sect. *zoosporiparae* de Bary, Annls Sci. Nat., Bot., sér. 4 20: 104 (1863), *Rhysotheca* G.W.Wilson, Bull. Torrey Bot. Club 34: 398 (1907), *Pseudoplasmopara* Sawada, Rep. Dept Agric., Govern. Res. Inst. Formosa, Spec. Bull. Agr. Exp. Station Formosa 2: 40 (1922).

****Plasmopara viticola*** (Berk. & M.A.Curtis) Berl. & De Toni, in Berlese, De Toni & Fischer, Syll. Fung. 7(1): 239 (1888) / **Ölü bağal.**
Syn.: *Botrytis viticola* Berk. & M.A.Curtis, J. Hort. Soc., London 6: 289 (1851), *Peronospora viticola* (Berk. & M.A.Curtis) Casp., Ber. Bekanntm. Verhandl. Königlich Preuss. Akad. Wissensch. Berlin 3: 331 (1855), *Rhysotheca viticola* (Berk. & M.A.Curtis) G.W.Wilson, Bull. Torrey Bot. Club 34: 407 (1907), *Plasmopara viticola* var. *americana* N.P. Golovina, Notul. Syst. Sect. Cryptog. Inst. Bot. Acad. Sci. U.S.S.R. 10: 141 (1955), *P. viticola* var. *amurensis* N.P. Golovina, Notul. Syst. Sect. Cryptog. Inst. Bot. Acad. Sci. U.S.S.R. 10: 141 (1955), *P. viticola* var. *parthica* N.P. Golovina, Notul. Syst. Sect. Cryptog. Inst. Bot. Acad. Sci. U.S.S.R. 10: 141 (1955).
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

****Blastocladiomycota*** T.Y.James, Mycologia 98(6): 867 (2007) / **Tortul Mantarlar.**

Physodermataceae Sparrow, Mycologia 44(6): 768 (1952) / **Düdükpasigiller**.

Physoderma Wallr., Fl. Crypt. Germ. (Norimbergae) 2: 192 (1833) / **Düdükpası**.
Type species: *Physoderma maculare* Wallr. 1833.
Syn.: *Urophlyctis* J.Schröt., in Cohn, Krypt.-Fl. Schlesien (Breslau) 3.1(9–16): 196 (1886), *Oedomyces* Sacc. ex Trab., Rev. Gén. Bot. 6: 410 (1894), *Physopella* G.Poirault, Bull. Assoc. Franç. Avanc. Sci.: 325 (1905).

****Physoderma menthae*** J.Schröt., in Cohn, Krypt.-Fl. Schlesien (Breslau) 3.1(9–16): 195 (1886) / **Kokulu düdükpası**.
Syn.: *Ustilago menthae* J.Schröt., Jber. Schles. Ges. Vaterl. Kultur 48: 92 (1870), *Cladochytrium menthae* (J.Schröt.) A.Fisch., in Winter, Rabenh. Krypt.-Fl., Edn 2 (Leipzig) 1(4): 141 (1892).
Host: *Mentha longifolia (L.)* subsp. *typhoides* (Briq.) Harley
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Ascomycota Caval.-Sm., Biol. Rev. 73: 247 (1998) / **Keseli Mantarlar**.

Didymosphaeriaceae Munk, *Dansk bot. Ark.* **15** (no. 2): 128 (1953) / **Karataburgiller.**

****Dictyoarthrinium*** S.Hughes, Mycol. Pap. 48: 29 (1952) / **Yosunal.**
Type species: *Dictyoarthrinium quadratum* S.Hughes, 1952.

****Dictyoarthrinium sacchari*** (J.A.Stev.) Damon, Bull. Torrey Bot. Club 80: 164 (1953) / **Şeker yosunal.**
Syn.: *Tetracoccosporium sacchari* J.A.Stev., In Johnston & Stevenson, J. Dept. Agr. Porto Rico 1(4): 225 (1917).
Host: *Anchusa azurea* Mill. var. *azurea*
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Aspergillaceae Link, Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin 1824: 165 (1826) / **Küfgiller**.

Aspergillus P.Micheli ex Haller, Hist. Stirp. Helv. (Bernae) 3: 113 (1768) / **Asper**.
Type species: *Aspergillus glaucus* (L.) Link, 1809.
Syn.: *Aspergillus* P.Micheli, Nov. Pl. Gen. (Florentiae): 212, tab. 92 (1729), *Eurotium* Link, Mag.Gesell. Naturf. Freunde, Berlin 3(1-2): 31 (1809), *Cladaspergillus* Ritgen, Schr. Marb. Ges. 2: 89 (1831), *Sceptromyces* Corda, In Sturm, Deutschl. Fl., 3 Abt. (Pilze Deutschl.) 3(11): 7 (1831), *Rhodocephalus* Corda, Icon. Fung. (Prague) 1: 21 (1837), *Acmosporium* Corda, Icon. Fung. (Prague) 3: 11 (1839), *Emericella* Berk., Intr. Crypt. Bot. (London): 340 (1857), *Sterigmatocystis* C.E.Cramer, Vierteljahrsschr. Naturf. Ges. Zürich 4: 336 (1859), *Gutturomyces* Rivolta, Dei Parassiti Vegetali: 579 (1873), *Otomyces* Wreden,

(1874), *Basidiella* Cooke, Grevillea 6(no. 39): 118 (1878), *Alliospora* Pim,J. Bot., Lond. 21: 235 (1883), *Cleistosoma* Harkn., Bull. Calif. Acad. Sci. 1(no. 1): 41 (1884), *Theclospora* Harkn., Bull. Calif. Acad. Sci. 1(no. 1): 41 (1884), *Inzengaea* Borzí,Jb. Wiss. Bot. 16: 450 (1885), *Pyrobolus* Kuntze,Revis. Gen. Pl. (Leipzig) 2: 868 (1891), *Euaspergillus* F.Ludw., Lehrb. Niederen Kryptog. (Stuttgart): 258 (1892), *Stilbothamnium* Henn., Bot. Jb. 23(3): 542 (1897), *Aspergillopsis* Speg., Anal. Mus. Nac. B. Aires, ser. 3 13: 434 (1910) [1911], *Rhopalocystis* Grove, J.Econ. Biol. 6: 40 (1911), *Diplostephanus* Langeron, C.R. Hebd. Séanc. Mém. Soc. Biol. 87: 344 (1922), *Sartorya* Vuill., C.R. Hebd. Séanc. Acad. Sci., Paris 184: 136 (1927), *Redaellia* Cif., Arch. Protistenk. 71: 428 (1930), *Clistosoma* Clem. & Shear, Gen. Fung., Edn 2 (Minneapolis): 76 (1931), *Cladosarum* E.Yuill & J.L.Yuill, Trans. Br. Mycol. Soc. 22(1-2): 199 (1938), *Dichotomomyces* Saito,J. Ferment. Technol., Osaka 27(6): 120-122 (1949), *Royella* R.S.Dwivedi, Proc. Indian Sci. Cong. 47.3(6): 320 (1960), *Polypaecilum* G.Sm., Trans. Br. Mycol. Soc. 44(3): 437 (1961), *Dichotomomyces* Saito Ex D.B. Scott, Trans. Br. Mycol. Soc. 55(2): 313 (1970), *Chaetosartorya* Subram., Curr. Sci. 41(21): 761 (1972), *Edyuillia* Subram., Curr. Sci. 41(21): 756 (1972), *Gymnoeurotium* Malloch & Cain, Can. J. Bot. 50(12): 2619 (1973) [1972], *Harpezomyces* Malloch & Cain, Can. J. Bot. 50: 2619 (1973) [1972], *Petromyces* Malloch & Cain, Can. J. Bot. 50(12): 2623 (1973) [1972], *Sporophormis* Malloch & Cain, Can. J. Bot. 50: 2624 (1973) [1972], *Syncleistostroma* Subram., Curr. Sci. 41(21): 756 (1972), *Warcupiella* Subram., Curr. Sci. 41(21): 757 (1972), *Fennellia* B.J.Wiley & E.G.Simmons, Mycologia 65(4): 936 (1973), *Neosartorya* Malloch & Cain, Can. J. Bot. 50(12): 2620 (1973), *Hemisartorya* J.N.Rai & H.J.Chowdhery, Kavaka 3: 73 (1976) [1975], *Raperia* Subram&Rajendran, Kavaka 3: 133 (1976) [1975], *Saitoa* Rajendran & Muthappa, Proc. Indian Acad. Sci., Sect. B 89: 185 (1980), *Cristaspora* Fort & Guarro, Mycologia 76(6): 1115 (1984), *Phialosimplex* Sigler, Deanna A.Sutton, Gibas, Summerb. & Iwen, Medical Mycol. 48(2): 338 (2010).

Aspergillus fructus Jurjevic, S.W.Peterson & B.W.Horn, IMA Fungus 3(1): 70 (2012) / **Semere asper.**
Record: Özcan Ateş et al. (2023), (grape; Çanakkale).

Penicillium Link, Mag. Gesell. Naturf. Freunde, 3(1): 16 (1809) / **Penisilyum**.
Type species: *Penicillium expansum* Link 1809.
Syn.: *Coremium* Link, Mag. Gesell. Naturf. Freunde, Berlin 3(1-2): 19 (1809), *Floccaria* Grev.,Scott. Crypt. Fl. (Edinburgh) 6: 301 (1827), *Walzia* Sorokīn, Trudy Obshchestva Ispytateleĭ Prirody Pri Imperatorskom Khar'kovskom Universitê 3(3): 47 (1871), *Eupenicillium* F.Ludw., Lehrb. Niederen Kryptog. (Stuttgart): 256, 257, 263 (1892), *Citromyces* Wehmer, Ber. Dt. Bot. Ges. 11: 338 (1893), *Aspergilloides* Dierckx, (1901), *Pritzeliella* Henn., Hedwigia 42(Beibl.): (88) (1903), *Carpenteles* Langeron, C.R.Hebd. Séanc. Mém. Soc. Biol. 87: 344 (1922), *Torulomyces* Delitsch, In Lembke & Delitsch, Systematik Der Schimmelpilze, Neudamm: 91 (1943), *Eladia* G.Sm., Trans. Br. Mycol. Soc. 44(1): 47 (1961), *Thysanophora* W.B.Kendr., Can. J. Bot. 39: 820 (1961), *Hemicarpenteles* A.K.Sarbhoy & Elphick, Trans. Br. Mycol. Soc. 51(1): 155 (1968), *Chromocleista* Yaguchi & Udagawa, Trans. Mycol. Soc. Japan 34(1): 101 (1993), *Paratalaromyces* Matsush., Matsush. Mycol. Mem. 10: 111 (2003) [2001].

Penicillium fructuariae-cellae M.Lorenzini, G.Zapparoli & G.Perrone, in Lorenzini, Cappello, Perrone, Logrieco & Zapparoli, Phytopathol. Mediterr. 58(3): 713 (2019) / **Semer penisilyum.**
Record: Akgül and Kara (2022), (plant; Gaziantep).

Botryosphaeriaceae Theiss. & Syd. [as 'Botryosphaeriacae'], Annls Mycol. 16(1/2): 16 (1918) / **Meşesiğiligiller**.

Botryosphaeria Ces. & De Not., Comm. Soc. Crittog. Ital. 1(4): 211 (1863) / **Meşesiğili**.
Type species: *B. dothidea* (Moug.) Ces. & De Not.
Syn.: *Cryptosphaeria* Grev., Scott. Crypt. Fl. (Edinburgh) 1: 13 (1822), *Fusicoccum* Corda, In Sturm, Deutschl. Fl., 3 Abt. (Pilze Deutschl.) 2: 111 (1829), Gyratylium Preuss, Linnaea 26: 722 (1855) [1853], Macroplodia Westend., Bull. Acad. R. Sci. Belg., Cl. Sci., sér. 2 2(7): 562 (1857), *Stigmea* Bonord., Abh. Naturforsch. Ges. Halle 8: 79 (1864), *Thuemenia* Rehm,in Thümen, Mycoth. Univ., Cent. 10: no. 971 (in sched.) (1878), *Gibberidea* Fuckel,Jb. Nassau. Ver. Naturk. 23-24: 168 (1870) [1869-70], *Melanops* Nitschke ex Fuckel, Jb. Nassau. Ver. Naturk. 23-24: 225 (1870) [1869-70], *Diplodia* a Eudiplodia Sacc., Michelia 2(no. 6): 7 (1880), *Diplodia* b Botryodiplodia Sacc., Michelia 2(no. 6): 7 (1880), *Plowrightia* Sacc., Syll. Fung. (Abellini) 2: 635 (1883), *Phoma* subgen. *botryophoma* P.Karst., Hedwigia 23(4): 62 (1884), *P.* subgen. *macrophoma* Sacc., Syll. Fung. (Abellini) 3: 66 (1884), *Rosenscheldia* Speg., Anal. Soc. Cient. Argent. 19(6): 250 (1885), *Macrophoma* (Sacc.) Berl. & Voglino, Atti Soc. Veneto-Trent. Sci. Nat. 10(1): 172 (1886), *Dothiora* subgen. *metadothis* Sacc., Syll. Fung. (Abellini) 8: 766 (1889), *Metadothis* (Sacc.) Sacc., Syll. Fung. (Abellini) 10: 857 (1892), *Ophioceras* sect. *acerbia* Sacc., Syll. Fung. (Abellini) 11: 353 (1895), *Gibberinula* Kuntze, Revis.Gen. Pl. (Leipzig) 3(3): 481 (1898), *Acerbia* (Sacc.) Sacc. & P.Syd., Syll. Fung. (Abellini) 14(1): 619 (1899), *Coutinia* J.V.Almeida & Sousa Da Câmara, Revta Agron., Lisb. 1: 392 (1903), *Holcomyces* Lindau, Verh. Bot. Ver. Prov. Brandenb. 45: 155 (1904) [1905], *Phaeobotryosphaeria* Speg., Anal. Mus. Nac. B. Aires, ser. 3 17(10): 120 (1908), *Sclerodothiorella* Died., Krypt.-Fl. Brandenburg (Leipzig) 9(2): 299 (1912), *Elmerococcum* Theiss. & Syd., Annls Mycol. 13(3/4): 282 (1915), *Botryophoma* (P.Karst.) Höhn., Sber. Akad. Wiss. Wien, Math.-Naturw. Kl., Abt. 1 125(1-2): 72 (1916), *Epiphyma* Theiss., Verh. Kaiserl.-Königl. Zool.-Bot. Ges. Wien 66: 306 (1916), *Pyreniella* Theiss., Verh. Kaiserl.-Königl. Zool.-Bot. Ges. Wien 66: 371 (1916), *Leptodothiora* Höhn., Ber. Dt. Bot. Ges. 36(7): 311 (1918), *Desmotascus* F.Stevens, Bot. Gaz. 68(6): 476 (1919), *Keisslerina* Petr., Annls Mycol. 17(2/6): 74 (1920) [1919], *Creomelanops* Höhn., Sber. Akad. Wiss. Wien, Math.-Naturw. Kl., Abt. 1 129: 146 (1920), *Neosphaeropsis* Petr., Annls Mycol. 19(1/2): 67 (1921), Coleonaema Höhn., in Weese, Mitt. Bot. Inst. Tech. Hochsch. Wien 1(3): 95 (1924), *Macrophomopsis* Petr., Annls Mycol. 22(1/2): 108 (1924), *Botryosphaerostroma* Petr. & Syd., Beih. Reprium Nov. Spec. Regni Veg. 42(1): 126 (1927) [1926], *Naumovia* Dobrozr., Bolêz. Rast. 16(3-4): 197 (1928) [1927], *Rostrosphaeria* Tehon & E.Y. Daniels, Mycologia 19(3): 112 (1927), *Botrysphaeris* Clem. & Shear, Gen. Fung., Edn 2 (Minneapolis): 361 (1931), *Apomella* Syd., Annls Mycol. 35(1): 47 (1937), *Jaapia* Kirschst., Krypt. Fl. Brandenburg (Leipzig) 7(3): 444 (1938), *Catosphaeropsis* Tehon, Mycologia 31(5): 542 (1939), *Phomatosphaeropsis*

Ribaldi, Annali Sper. Agr., N.S. 7(3): 847 (1953), *Granulodiplodia* Zambett., Bull. Trimest. Soc. Mycol. Fr. 70(3): 330 (1955) [1954], *Caumadothis* Petr., Sydowia 24(1-6): 276 (1971) [1970], *Cylindroseptoria* Quaedvl., Verkley & Crous, Stud. Mycol. 75: 358 (2013), *Neocylindroseptoria* Thambug. & K.D.Hyde, in Thambugala, Ariyawansa, Li, Boonmee, Hongsanan, Tian, Singtripop, Bhat, *Camporesi*, Jayawardena, Liu, Xu, Chukeatirote & Hyde, Fungal Diversity 68: 125 (2014), *Neophaeocryptopus* Wanas., Camporesi, E.B.G.Jones & K.D. Hyde, in Li et al., Fungal Diversity 78, 21 (2016).

**** Botryosphaeria sarmentorum*** A.J.L.Phillips, A.Alves & J.Luque, Mycologia 97(2): 522 (2005) / **Kol meşesiğili.**
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Diplodia Fr., in Montagne, Annls Sci. Nat., Bot., sér. 2 1: 302 (1834) / **Kulakkızı**.
Type species: *Diplodia mutila* (Fr.) Mont.

****Diplodia bacchi*** Pass. & Thüm., Hedwigia 18: 121 (1879) / **Neşeli kulakkızı.**
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Lasiodiplodia Ellis & Everh., in Clendenin, Bot. Gaz. 21: 92 (1896) / **Muzkarası**.
Type species: *Lasiodiplodia tubericola* Ellis & Everh. 1896.
Syn.: *Combodia* Fr., Summa Veg. Scand., Sectio Post. 422 (1849), *Traversoa* Sacc., Syd. & P. Syd., Ann. Mycol. 11(4): 317 (1913), *Macrophomella* Died., Ann. Mycol. 14(1/2): 63 (1916), *Macrophomopsis* N.E.Stevens & Baechler, in Weedon, Mycologia 18(5): 222 (1926), *Lasiodiplodiella* Zambett., Bull. Trimest. Soc. Mycol. Fr. 70(3): 229 (1955), *Nemadiplodia* Zambett., Bull. Trimest. Soc. Mycol. Fr. 70(3): 227 (1955), *Striodiplodia* Zambett., Bull. Trimest. Soc. Mycol. Fr. 70(3): 334 (1955).

****Lasiodiplodia pseudotheobromae*** A.J.L.Phillips, A.Alves & Crous, Fungal Div. 28: 8 (2008) / **Boz muzkarası.**
Record: Akgül and Kara (2022), (plant; Gaziantep).

Microdiplodia Allesch., Rabenh. Krypt.-Fl., Edn 2, 1(7): 78 (1901) / **Odunçili**.
Type species: *Microdiplodia conigena* Allesch.
Syn.: *Syndiplodia* Peyronel, Mém. R. Accad. Sci. Torino, ser. 2 66(no. 10): 35 (1916), *Microbotryodiplodia* Sousa da Câmara, Agron. lusit. 13: 206 (1951).

****Microdiplodia uvicola*** (Speschnew) Tassi, Bulletin Labor. Orto Bot. de R. Univ. Siena 5: 38 (1902) / **Dip odunçili.**
Syn.: *Diplodia uvicola* Speschnew, Fungi Paras. Transcuic 5: 8 (1901).
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

****Camarosporiaceae*** Wanas., Wijayaw., K.D.Hyde & Crous, in Wanasinghe, Hyde, Crous, Wijayawardene, Jeewon, Jones, Bhat, Phillips, Groenewald, Dayarathne, Phukhamsakda, Thambugala, Bulgakov, Camporesi, Gafforov, Mortimer & Karunarathna, Stud. Mycol. 87: 212 (2017) / **Kabakıtıkgiller.**

Camarosporium Schulzer, Verh. Kaiserl.-Königl. Zool.-Bot. Ges. Wien 20: 649 (1870) / **Kabakıtık**.
Type species: *Camarosproim quaternatum* (Hazsl.) Schulzer
Syn.: *Piringa* Speg., Anal. Mus. Nac. B. Aires, ser. 3 13: 378 (1910), *Sclerotheca* Bubák & Vleugel, Svensk Bot. Tidskr. 11: 314 (1917).

****Camarosporium ambiens*** (Cooke) Grove, British Stem- and Leaf-Fungi (Coelomycetes) (Cambridge) 2: 90 (1937) / **Şık kabakıtık.**
Syn.: *Hendersonia ambiens* Cooke, Grevillea 14(69): 5 (1885).
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Chaetomiaceae G.Winter, Rabenh. Krypt.-Fl., 2(1): 153 (1885) / **Günokugiller**.

Botryotrichum Sacc. & Marchal, in Marchal, Bull. Soc. R. Bot. Belg. 24(1): 66 (1885) / **Günoku**.
Type species: *Botryotrichum piluliferum* Sacc. & Marchal 1885.

****Botryotrichum atrogriseum*** J.F.H.Beyma, Verh. K. Akad. Wet., eerste sectie 26(2): 14 (1928) / **Al günoku.**
Host: *Rumex conglomeratus* Murray
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Cladosporiaceae Chalm. & R.G.Archibald, Yearbook of Tropical Medicine and Hygiene: 25 (1915) / **Havaküfügiller**.

Cladosporium Link, Mag. Gesell. Naturf. Freunde, Berlin 7: 37 (1816) **/ Havaküfü.**
Type species: *Cladosporium herbarum* (Pers.) Link 1816.
Syn.: *Sporocladium* Chevall., Fl. Gén. Env. Paris (Paris) 1: 647 (1826), *Azosma* Corda, in Sturm, Deutschl. Fl., 3 Abt. (Pilze Deutschl.) 3(12): 35 (1831), *Mydonosporium* Corda, in Sturm, Deutschl. Fl., 3 Abt. (Pilze Deutschl.) 3(13): 95 (1833), *Myxocladium* Corda, Icon. Fung. (Prague) 1: 12 (1837), *Didymotrichum* Bonord., Handb. Allgem. Mykol. (Stuttgart): 89 (1851), *Hormodendrum* Bonord., Handb. Allgem. Mykol. (Stuttgart): 76 (1851), *Heterosporium* Klotzsch Ex Cooke, Grevillea 5(no. 35): 122 (1877), *Polyrhizium* Giard, Bull. Sci. France Belgique 20: 217 (1889), *Acrosporella* Riedl&Ershad, Sydowia 29(1-6): 166 (1977) [1976-1977], *Spadicesporium* V.N.Boriss. & Dvoïnos, Nov. Sist. Niz. Rast. 19: 35 (1982).

****Cladosporium fasciculare*** Fr., Syst. Mycol. (Lundae) 3(2): 370 (1832) / **Şerit havaküfü.**
Host: *Sanguisorba officinalis* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

****Coniosporiaceae*** Nann., Repert. Mic. Uomo: 475 (1934) / **Bozrozetgiller.**

Coniosporium Link, Mag. Gesell. Naturf. Freunde, Berlin 3(1-2): 8 (1809) / **Bozrozet**.
Type species: *Coniosporium olivaceum* Link 1809.
Syn.: *Sirodesmium* De Not., Mém. R. Accad. Sci. Torino, Ser. 2 10: 348 (1849), *Bonordeniella* Penz & Sacc., Malpighia 15(7-9): 259 (1902).

****Coniosporium triticinum*** Gaja, Monogr. Calic.: 26 (1911) / **Üçlü bozrozet.**
Host: *Lysimachia vulgaris* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Coniothyriaceae W.B.Cooke, Revta Biol. 12: 289 (1983) / **Kolbenigiller**.

Coniothyrium Corda, Icon. Fung. 4: 38 (1840) / **Kolbeni**.
Type species: *Coniothyrium palmarum* Corda 1840.
Syn.: *Clisosporium* Fr., Novit. Fl. Svec. 5(cont.): 80 (1819), *Cyclobium* C.Agardh, Aphor. Bot. 81 (1821), *Monoplodia* Westend., Bull. Acad. R. Sci. Belg., Cl. Sci., sér. 2 7(5): 94 (1859), *Coniothyrinula* Petr., Ann. Mycol. 21(1/2): 2 (1923), *Dactuliochaeta* G.L.Hartm. & J.B.Sinclair, Mycologia 80(5): 697 (1988).

****Coniothyrium ferrarisianum*** Biga, Cif. & Bestagno, Sydowia 12(1-6): 297 (1959) / **Demir kolbeni.**
Syn.: *Coniothyrium olivaceum* var. *aceris* Ferraris, Malpighia 16: 24 (1902).
Record: Akgül and Kara (2022), (plant; Gaziantep).

Didymosphaeriaceae Munk, Dansk Bot. Ark. 15(2): 128 (1953) / **Karataburgiller.**

****Kalmusia*** Niessl, Verh. Nat. Ver. Brünn 10: 204 (1872) / **Karaçember.**
Type species: *Kalmusia ebuli* Niessl 1872.
Syn.: *Diapleella* Munk, Dansk Bot. Ark. 15(2): 74 (1953), *Dendrothyrium* Verkley, Göker & Stielow, in Verkley, Dukik, Renfurm, Göker & Stielow, Persoonia 32: 34 (2014).

****Kalmusia variispora*** (Verkley, Göker & Stielow) Ariyaw. & K.D.Hyde, in Ariyawansa, Tanaka, Thambugala, Phookamsak, Tian & Campo, Fungal Div. 68: 85 (2014). / **Ayrık karaçember.**
Syn.: *Dendrothyrium variisporum* Verkley, Göker & Stielow, in Verkley, Dukik, Renfurm, Göker & Stielow, Persoonia 32: 36 (2014).
Record: Akgül and Kara (2022), (plant; Gaziantep).

Didymosphaeria Fuckel, Jb. Nassau. Ver. Nat. 23-24: 140 (1870) / **Karatabur**.
Type species: *Didymosphaeria epidermidis* (Fr.) Fuckel.
Syn.: *Didymosphaerella* Cooke, Grevillea 18(no. 86): 29 (1889), *Didymascina* Höhn., Annls Mycol. 3(4): 331 (1905), *Didymosphaeria* subgen. *Cryptodidymosphaeria* Rehm, Annls Mycol. 4(3): 265 (1906), *Cryptodidymosphaeria* (Rehm) Höhn., Sber. Akad. Wiss. Wien, Math. -Naturw. Kl., Abt. 1 126(4-5): 360 (1917), *Haplovalsaria* Höhn., Sber. Akad. Wiss. Wien, Math. -Naturw. Kl., Abt. 1 128(7-8): 582 (1919), *Massariellops* Curzi, Atti Ist. Bot. R. Univ. Pavia, 3 sér. 3(3): 162 (1927).

****Didymosphaeria vitis*** Fabre, Annls Sci. Nat., Bot., sér. 6 9: 83 (1879) / **Asma karatabur.**
Syn.: *Microthelia vitis* (Fabre) Kuntze, Revis. Gen. Ll. 3(3): 498 (1898).
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Dothideaceae Chevall. [as 'Dothideae'], Fl. Gén. Env. Paris, 1: 446 (1826) / **Karagözegiller**.

Hadrotrichum Fuckel, Fungi Rhenani Exsic., Suppl., Fasc. 1 (1522) (1865). ***Scirrhia*** Nitschke ex Fuckel, Jb. Nassau. Ver. Naturk. 23-24: 220 (1870) / **Şirya**.
Type species: *S. rimosa* (Alb. & Schwein.) Fuckel 1870.
Syn.: *Hadrotrichum* Fuckel, Fungi Rhenani Exsic., Suppl., Fasc. 1: no. 1522 (1865), *Phyllachora* Nitschke ex Fuckel, Fungi Rhenani Exsic., Suppl., Fasc. 6(nos 2001-2100): no. 2056 (1867), *Monographos* Fuckel, Jb. Nassau. Ver. Naturk. 29-30: 24 (1875) [1877-78], *Microbasidium* Bubák & Ranoj., in Ranojević, Annls Mycol. 12(4): 415 (1914), *Phragmodothidea* Dearn & Barthol., Mycologia 18(5): 250 (1926), *Monographus* Clem & Shear, Gen. Fung., Edn 2 (Minneapolis): 295 (1931).

****Hadrotrichum sorghi*** (Pass.) Ferraris & Massa, in Ferraris & Massa, Ann. Mycol. 10(3): 297 (1912) / **Darı şirya.**
Syn.: *Fusicladium sorghi* Pass., in Rabenhorst, Fungi Europ. Exsicc.: no. 2264 (1876), *Microbasidium sorghi* (Pass.) Bubák & Ranoj. ex Ranoj., Annls Mycol. 12(4): 415 (1914).
Host: *Sorghum halepense* (L.) Pers. var. *halepense*
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Drepanopezizaceae Baral, IMA Fungus 1(1): 16 (2019) / **Orakcilgiller**.

Diplocarpon F.A.Wolf, Bot. Gaz. 54: 231 (1912) / **Muşmulakarası**.
Type species: *Diplocarpon rosae* F.A.Wolf 1912.
Syn.: *Gloeosporium* Desm & Mont., Annls Sci. Nat., Bot., sér. 3 12: 295 (1849), *Gloeosporium* subgen. *gloeosporium* Desm & Mont., Annls Sci. Nat., Bot., sér. 3 12: 295 (1849), *Entomosporium* Lév., Bull. Soc. Bot. Fr. 3(1): 31 (1857) [1856], *Marssonia* J.C.Fisch., in Rabenhorst, Fungi Europ. Exsicc.: no. 1857 (1872), *Bostrichonema* Ces., Erb. Critt. Ital., ser. 1, Fasc. 2: no. 149 (1867), *Morthiera* Fuckel, Jb. Nassau. Ver. Naturk. 23-24: 382 (1870) [1869-70], *Marssonina* Magnus, Hedwigia 45: 89 (1906), *Entomopeziza* Kleb., Vortr. GesGeb. Bot., ser. 1 1: 33 (1914), *Saliastrum* Kujala, Memor. Soc. Fauna Flora Fenn. 22: 137 (1946).

****Diplocarpon alpestre*** (Ces.) Rossman, in Johnston, Seifert, Stone, Rossman & Marvanová, IMA Fungus 5(1): 99 (2014) / **Alp muşmulakarası.**
Syn.: *Bostrichonema alpestre* Ces., Erb. Critt. Ital., ser. 1, Fasc. 2 (149) (1867).
Host: *Polygonum amphibium* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Gloniaceae E.Boehm, C.L.Schoch & Spatafora, Mycol. Res. 113(4): 468 (2009) / **Mıcırgiller**.

Glonium Muhl. ex Fr., Syst. Mycol. 2(2): 595 (1823) / **Mıcır**.
Type species: *Glonium stellatum* Muhl. ex Fr.
Syn.: *Glonium* Muhl., Cat. Pl. Amer. Sept.: 101 (1813), *Solenarium* Spreng., Syst. Veg., Edn 16 4(1): 414 (1827), *Psiloglonium* Höhn., Annls Mycol. 16(1/2): 149 (1918).

****Glonium lineare*** (Fr.) De Not., G. Bot. Ital. 2(2): 27 (1847) / **Düz mıcır.**
Syn.: *Hysterium* lineare Fr., Syst. Mycol. 2(2): 583 (1823), *Solenarium* lineare (Fr.) Kuntze, Revis. Gen. Pl. (Leipzig) 3: 521 (1898), *Psiloglonium* lineare (Fr.) Petr., Annls Mycol. 21(3/4): 227 (1923).
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Gnomoniaceae G Winter [as 'Gnomonieae'], Rabenh. Krypt.-Fl., Edn 2, 1.2: 570 (1886) / **Hercaiemzikgiller**.

Plagiostoma Fuckel, Jb. Nassau. Ver. Nat. 23-24: 118 (1870) / **Ağaççökerten**.
Type species: *Plagiostoma euphorbiae* (Fuckel) Fuckel.
Syn.: *Phoma* Fr., Syst. Mycol. (Lundae) 1: lii (1821), *Diplodina* Westend., Bull. Acad. R. Sci. Belg., Cl. Sci., sér. 2 2(7): 562 (1857), *Diaporthe* sect. Chorostella Sacc., Syll. Fung. (Abellini) 1: 623 (1882), *Septomyxa* Sacc., Syll.

Fung. (Abellini) 3: 766 (1884), *Cytodiplospora* Oudem., Hedwigia 33: 19 (1894), *Fioriella* Sacc., Annls Mycol. 3(2): 168 (1905), *Chalcosphaeria* Höhn., Ber. Dt. Bot. Ges. 35(8): 636 (1917), *Plagiostomella* Höhn., Ber. Dt. Bot. Ges. 35(8): 635 (1917), *Cryptodiaporthe* Petr., Annls Mycol. 19(1/2): 118 (1921). *Diploplenodomopsis* Petr., Annls Mycol. 21(3/4): 208 (1923), *Diplosclerophoma* Petr., Annls Mycol. 21(3/4): 293 (1923), *Chorostella* (Sacc.) Clem & Shear, Gen. Fung., Edn 2 (Minneapolis): 68 (1931).

***Diplodina rosea** Brunaud, Act. Soc. Linn. Bordeaux 52: 146 (1897) / **Gül ağaççökerten.**
Syn.: *Diplodinula rosee* (Brunaud) Tassi, Bulletin Labor. Orto Bot. De R. Univ. Siena 5: 49 (1902).
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

***Graphostromataceae** M.E.Barr, J.D.Rogers & Y.M.Ju, Mycotaxon 48: 533 (1993) / **Tespihkarasıgiller.**

***Biscogniauxia** Kuntze, Revis. Gen. Pl. 2: 398 (1891) / **Tesbihkarası**.
Type species: *Biscogniauxia nummularia* (Bull.) Kuntze, 1891.
Syn.: *Nummularia* Tul & C.Tul., Select. Fung. Carpol. 2: 42 (1863), *Kommamyce* Nieuwl., Am. Midl. Nat. 4: 375 (1916), *Albocrustum* Lloyd, Mycol. Writ. (Cincinnati) 7(Letter 75): 1353 (1925), *Numulariola* House, N.Y. St. Mus. Bull. 266: 49 (1925), *Nummulariella* Eckblad & Granmo, Norw. Jl Bot. 25(2): 9 (1978).

***Biscogniauxia mediterranea** (De Not.) Kuntze, Revis. Gen. Pl. 2: 398 (1891) / **Akdeniz tespihkarası.**
Syn.: *Sphaeria clypeus* Schwein., Schr. Naturf. Ges. Leipzig 1: 31 [5 of repr.] (1822), *S. mediterranea* Ettingsh., Micr. Ital., Dec. 6: 96 (1845), *S. sertata* Durieu & Mont., in Durieu, Expl. Sci. Alg., Fl. Algér. 1(livr. 12): 455 (1848), *S. mediterranea* De Not., Mém. R. Accad. Sci. Torino, ser. 2 13: 96 (1853), *Hypoxylon sertatum* (Durieu & Mont.) Mont., Syll. Gen. Sp. Crypt. (Paris): 214 (1856), *H. mediterraneum* (De Not.) Ces & De Not., Comm. Soc. Crittog. Ital. 1(fasc. 4): 202 (1863), *H. regium* De Not., Comm. Soc. Crittog. Ital. 1(fasc. 4): 15 (1863), *H. clypeus* (Schwein.) M.A.Curtis, Geol. Nat. Hist. Surv. N. Carol. 3: 140 (1867), *Nummularia repandoides* Fuckel, Jb. Nassau. Ver. Naturk. 23-24: 236 (1870), *Diatrype clypeus* (Schwein.) Berk., Grevillea 4(no. 31): 95 (1876), *Hypoxylon stigmateum* Cooke, Grevillea 7(no. 41): 4 (1878), *Nummularia mediterranea* (De Not.) Sacc., Syll. Fung. (Abellini) 1: 400 (1882), *N. regia* (De Not.) Sacc., Syll. Fung. (Abellini) 1: 400 (1882), *N. clypeus* (Schwein.) Cooke, Grevillea 12(no. 61): 6 (1883), *N. sertata* (Durieu & Mont.) Cooke, Grevillea 11(no. 60): 126 (1883), *Hypoxylon repandoides* (Fuckel) Bizz., Fl. Ven. Crittog. (Padova) 1: 2101 (1885), *Biscogniauxia clypeus* (Schwein.) Kuntze, Revis. Gen. Pl. (Leipzig) 2: 398 (1891), *B. regia* (De Not.) Kuntze, Revis. Gen. Pl. (Leipzig) 2: 398 (1891), *B. repandoides* (Fuckel) Kuntze [as 'repandodes'], Revis. Gen. Pl. (Leipzig) 2: 398 (1891), *Sphaerites mediterraneus* Mesch., Syll. Fung. (Abellini) 10: 761 (1892), *Engizostoma mediterraneum* (De Not.) Kuntze, Revis. Gen. Pl. (Leipzig) 3(3): 474 (1898), *Ceratostomataceae* (Florence) 1(1): 59 (1906), *Hypoxylon mediterraneum* var. *macrosporum* J.H.Mill., Monogr. World Spec. Hypoxylon: 118 (1961), *H. mediterraneum* var. *microsporum* J.H.Mill., Monogr. World Spec. Hypoxylon: 117 (1961), *Nummularia regia* var. *mediterranea* (De Not.) Traverso, Fl. Ital. Crypt., Pars 1: Fungi. Pyrenomycetae. *Xylariaceae*, Valsaceae, *Numulariola mediterranea* (De Not.) P.M.D.Martin, Jl S. Afr. Bot. 35: 312 (1969), *Biscogniauxia mediterranea* var. *macrospora* (J.H.Mill.) Y.M. Ju & J.D.Rogers, in Ju, Rogers, San Martín & Granmo, Mycotaxon 66: 42 (1998), *Biscogniauxia mediterranea* var. *microspora* (J.H.Mill.) Y.M.Ju & J.D.Rogers, in Ju, Rogers, San Martín & Granmo, Mycotaxon 66: 42 (1998).
Record: Akgül and Kara (2022), (plant; Gaziantep).

***Herpotrichiellaceae** Munk, Dansk Bot. Ark. 15(2): 131 (1953) / **Dalboğumlusugiller**.

***Rhinocladiella** Nannf., in Melin & Nannfeldt, Svensk Skogsvårdsförening Tidskr. 3-4: 461 (1934) / **Koyuküf**.
Type species: *Rhinocladiella atrovirens* Nannf.

***Rhinocladiella aquaspersa** (Borelli) Schell, McGinnis & Borelli, Mycotaxon 17: 343 (1983) / **Sucul koyuküf.**
Syn.: *Acrotheca aquaspersa* Borelli, Acta Cient. Venez. 23: 195 (1972).
Record: Acar et al. (2022), (inanimate materials-historically important artifacts; Teos Ancient City, Izmir).

***Leptosphaeriaceae** M.E.Barr, Mycotaxon 29: 503 (1987) / **Terskadehgiller**.

***Leptosphaeria** Ces. & De Not., Comm. Soc. Crittog. Ital. 1(4): 234 (1863) / **Terskadeh**.
Type species: *Leptosphaeria doliolum* (Pers.) Ces. & De Not.
Syn.: *Bilimbiospora* Auersw., in Rabenhorst, Fungi Europ., Edn 2: no. 261 (in Sched. Corr.) (1861), *Myriocarpium* Bonord., Abh. Naturforsch. Ges. Halle 8: 154 (1864), *Ampullina* Quél., Mém. Soc. Émul. Montbéliard, sér. 2 5: 523 (1875), *Ocellularia* sect. *phyllophthalmaria* Müll. Arg., Flora, Regensburg 66(22): 352 (1883), *Scleroderris subgen phaeoderris* Sacc., Syll. Fung. (Abellini) 8: 599 (1889), *Scoleciasis* Roum. & Fautrey, Revue Mycol., Toulouse 11(no. 44): 199 (1889), *Macrobasis* Starbäck, Bot. Notiser: 31 (1893), *Baumiella* Henn., in Warburg, Kunene-Sambesi-Exped., H. Baum, 1903 (Berlin): 165 (1903), *Phyllophthalmaria* (Müll. Arg.) Zahlbr., in Engler & Prantl, Nat. Pflanzenfam., Teil. I (Leipzig) 1(1): 120 (1905), *Phaeoderris* (Sacc.) Höhn., Öst. Bot. Z. 57(9): 322 (1907), *Dothideopsella* Höhn., Sber. Akad. Wiss. Wien, Math.-Naturw. Kl., Abt. 1 124: 70 (1915), *Sclerodothis* Höhn., Annls Mycol. 16(1/2): 69 (1918), *Leptosporopsis* Höhn., Sber. Akad. Wiss. Wien, Math.-Naturw. Kl., Abt. 1 129: 174 (1920), *Exilispora* Tehon & E.Y.Daniels, Mycologia 19(3): 112 (1927), *Dendroleptosphaeria* Sousa da Câmara, Revta Agron., Lisb. 20: 24 (1932), *Humboldtina* Chardón&Toro, Monograph Univ. Puerto Rico, Series B 2: 182 (1934), *Mycotodea* Kirschst., Annls Mycol. 34(3): 201 (1936), *Bricookea* M.E.Barr, Mycotaxon 15: 346 (1982).

***Leptosphaeria viticola** Fautrey & Roum., Revue Mycol. 14(53): 6 (1892) / **Asma terskadeh.**
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

***Leptosphaeria vitigena** Sacc., Syll. Fung. 2: 29 (1883) / **Sapan terskadeh.**
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

***Lophiostomataceae** Luerss., Handbuch der Syst. Bot. Mit

Besonderer Berücksichtigung der Arzneipflanzen 1: 154 (1879) / **Karakümbetgiller**.

Lophiotrema Sacc., Michelia 1(3): 338 (1878). / **Lofotrem.** (Güncel isim: ***Lophiostoma*** Ces. & De Not., Comm. Soc. Crittog. Ital. 1(4): 219 (1863). / **Karakümbet**.
Type species: *Lophiotrema nucula* (Fr.) Sacc.

****Lophiotrema rubi*** (Fuckel) Y.Zhang ter, C.L.Schoch & K.D.Hyde, in Zhang, Schoch, Fournier, Crous, Gruyter, Woudenberg, Hirayama, Tanaka, Pointing, Spatafora & Hyde, Stud. Mycol. 64: 97 (2009). / **Dal karakümbet.**
Syn.: *Massaria rubi* Fuckel, Jb. Nassau. Ver. Naturk. 25-26: 303 (1871), *Lophiotrema emergens* P. Karst., Hedwigia 22: 42 (1883), *Massarina rubi* (Fuckel) Sacc., Syll. Fung. (Abellini) 2: 155 (1883), *Didymellina rhaphithamni* Keissl., in Skottsberg, Nat. Hist. Juan Fernandez Easter Isl. 2: 480 (1927), *Mycosphaerella rhaphithamni* (Keissl.) Petr., Annls Mycol. 38(2/4): 221 (1940), *Massarina emergens* (P. Karst.) L. Holm, Les Pleosporaceae: 149 (1957), *Lophiostoma rubi* (Fuckel) E.C.Y. Liew, Aptroot & K.D. Hyde, Mycologia 94(5): 812 (2002).
Record: Acar et al. (2022), (inanimate materials-historically important artifacts; Teos Ancient City, Izmir).

Sigarispora Thambug. & K.D.Hyde, in Thambugala et al., Fungal Div. 74: 238 (2015) / **Katıspor.**
Type species: *Sigarisproa ravennica* (Tibpromma, Camporesi & K.D.Hyde) Thambugala & K.D.Hyde.

Sigarispora arundinis (Pers.) Thambug., Qing Tian, Kaz. Tanaka & K.D.Hyde, in Thambugala et al., Fungal Div. 74: 240 (2015) / **Al katıspor.**
Syn.: *Sphaeria cristata* ß arundinis Pers., Syn. Meth. Fung. (Göttingen) 1: 54 (1801), *Lophium arundinis* (Pers.) Fr., K. Svenska Vetensk-Akad. Handl., Ser. 3 40: 115 (1819), *Sphaeria arundinis* (Pers.) Fr., in Kunze & Schmidt, Mykologische Hefte (Leipzig) 2: 55 (1823), *Lophiostoma arundinis* (Pers.) Ces&De Not., Comm. Soc. Crittog. Ital. 1(fasc. 4): 220 (1863), *Platysphaera arundinis* (Pers.) Trevis., Bull. Soc. R. Bot. Belg. 16: 17 (1877), *Navicella arundinis* (Pers.) Kuntze, Revis. Gen. Pl. (Leipzig) 3(3): 500 (1898).
Record: Acar et al. (2022), (inanimate materials-historically important artifacts; Teos Ancient City, Izmir).

Sigarispora caulium (Fr.) Thambug., Wanas., Kaz. Tanaka & K.D.Hyde, Fungal Div. 74: 238 (2015) / **File katıspor.**
Syn.: *Lophium herbarum* Fr., K.Svenska Vetensk-Akad. Handl., ser. 3 40: 114 (1819), *Sphaeria caulium* Fr., Syst. Mycol. (Lundae) 2(2): 509 (1823), *S. insidiosa* Desm., Annls Sci. Nat., Bot., sér. 2 15: 144 (1841), *Hendersonia insidiosa* Desm., Annls Sci. Nat., Bot., sér. 3 20: 223 (1853), *Lophiostoma caulium* (Fr.) Ces&De Not., Comm. Soc. Crittog. Ital. 1(4): 219 (1863), *L. insidiosum* (Desm.) Ces&De Not., Comm. Soc. Crittog. Ital. 1(fasc. 4): 220 (1863), *Lophium caulium* (Fr.) P. Crouan&H. Crouan, Florule Finistère (Paris): 29 (1867), *Leptosphaeria sambuci* Sacc., Atti Soc. Veneto-Trent. Sci. Nat. 2(1): 104 (1873), *Lophiostoma bicuspidatum subsp. simillimum* P. Karst., Bidr. Känn. Finl. Nat. Folk 23: 84 (1873), *Ampullina caulium* (Fr.) Quél., Mém. Soc. Émul. Montbéliard, sér. 2 5: 525 (1875), *Lophiostoma niesslianum* Sacc. [as 'niessleanum'], Hedwigia 14: 71 (1875), *L. simillimum* (P. Karst.) Sacc., Hedwigia 14: 72 (1875), *Platysphaera caulium* (Fr.) Trevis., Bull. Soc. R. Bot. Belg. 16: 17 (1877), *Mytilostoma simillimum* (P. Karst.) P. Karst., Meddn Soc. Fauna Flora Fenn. 5: 50 (1879), *Lophiostoma insidiosum subsp. gramineum* Sacc., Michelia 1(no. 5): 543 (1879), *L. appendiculatum* sensu Niessl; Fide Saccardo (Syll. fung. 2: 703. 1883), *L. gramineum* (Sacc.) Sacc., Syll. Fung. (Abellini) 2: 704 (1883), *Stagonospora insidiosa* (Desm.) Sacc., Syll. Fung. (Abellini) 3: 452 (1884), *Lophiostoma congregatum* Harkn., Bull. Calif. Acad. Sci. 1(no. 1): 47 (1884), *Navicella caulium* (Fr.) Kuntze, Revis. Gen. Pl. (Leipzig) 3(3): 500 (1898), *N. insidiosa* (Desm.) Kuntze, Revis. Gen. Pl. (Leipzig) 3(3): 500 (1898), *N. simillima* (P. Karst.) Kuntze, Revis. Gen. Pl. (Leipzig) 3(3): 500 (1898), *N. niessliana* (Sacc.) Kuntze, Revis. Gen. Pl. (Leipzig) 3(3): 500 (1898), *N. graminea* (Sacc.) Kuntze, Revis. Gen. Pl. (Leipzig) 3(3): 500 (1898), *N. congregata* (Harkn.) Kuntze, Revis. Gen. Pl. (Leipzig) 3(3): 500 (1898), *Lophiostoma insidiosum* var. *sessile* Rehm, Hedwigia 40(Beibl.): (104) (1901), *L. insidiosum* var. *artemisiae* Rehm, in Sydow, Mycotheca Germanica 8-9: no. 387 (1905), *L. caulium* var. *alpincola* Rehm, Annls Mycol. 9(1): 108 (1911), *L. insidiosum* var. *prodanii* M.Bechet, Contr. Bot., Univ. Cluj-Napoca, Grăd. Bot.: 85 (1961), *L. caulium* var. *congregatum* (Harkn.) Chesters & A.E. Bell, Mycol. Pap. 120: 43 (1970), *Nodulosphaeria asteris-alpini* (Gonz. Frag.) Checa, Mycotaxon 63: 485 (1997), *Sigarispora caulium* (Fr.) Thambug.,Qing Tian, Kaz.Tanaka&K.D.Hyde, in Thambugala et al., Fungal Diver, 74: 238 (2015).
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Melanommataceae G.Winter [as 'Melanommeae'], Rabenh. Krypt.-Fl., Edn 2 (Leipzig) 1.2: 220 (1885). / **Melanobagiller**.

Aposphaeria Sacc., Michelia 2(6): 4 (1880). / **Dalçıbanı**.
Type species: *Aposphaeria pulviscula* (Sacc.) Sacc. 1880.

Aposphaeria minutula (Peck) Sacc., Syll. Fung. 3: 176 (1884) / **Küçük dalçıbanı**.
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Mycocaliciaceae A.F.W.Schmidt, Mitt. Staatsinst. Allg. Bot. 13: 127 (1970) / **Yakatutangiller**.

Mycocalicium Vain., Acta Soc. Fauna Flora Fenn. 7(2): 182 (1890) / **Yakatutan**.
Type species: *Mycocalicium parietinum* (Ach.) Vain.
Syn.: *Sphinctrinella* Nádv., Annls Mycol. 40(1/2): 138 (1942).

Mycocalicium victoriae (C.Knight ex F.Wilson) Nádv., Annls Mycol. 40(1/2): 138 (1942) / **Al yakatutan.**
Record: Acar et al. (2022), (inanimate materials-historically important artifacts; Teos Ancient City, Izmir).

Mycosphaerellaceae Lindau, Nat. Pflanzenfam. Teil. I, 1(1): 421 (1897) / **Yaprakdamgasigiller**.

Cercospora Fresen. ex Fuckel, Hedwigia 2(15): 133 (1863) / **Noktayaprak**.
Type species: *Cercospora apii* Fresen. 1863. (www.mycobank.org). (There is no information about the type species in www.indexfungorum.org).
Syn.: *Virgasporium* Cooke, Grevillea 3(28): 182 (1875), *Cercosporina* Speg., Anal. Mus. Nac. B. Aires, Ser. 3 13: 424 (1910).

Cercospora medicaginis Ellis & Everh., Proc. Acad. Nat. Sci. Philad. 43(1): 91 (1891) / **Kar noktayaprak.**
Host: *Medicago sativa* L. subsp. *sativa*
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Ramularia Unger, Exanth. Pflanzen (Wien): 119 (1832) / **Artan**.
Type species: *Ramularia pusilla* Unger 1833.
Syn.: *Ascospora* Fr., Syst. Orb. Veg. (Lundae): 112 (1825), *Didymaria* Corda, Icon. Fung. (Prague) 5: 9 (1842), *Sphaeria d Sphaerella* Fr., Summa Veg. Scand., Sectio Post. (Stockholm): 395 (1849), *Gomphinaria* Preuss, Linnaea 24: 130 (1851), *Tapeinosporium* Bonord., Bot. Ztg. 11: 285 (1853), *Sphaerella* (Fr.) Rabenh., Klotzschii Herb. Viv. Mycol., Edn Nov, Ser. Sec., Cent. 3: no. 264 (in sched.) (1856), *Acrotheca* Fuckel,Jb.Nassau. Ver. Naturk. 15: 42 (1860), *Phacellium* Bonord., in Rabenhorst, Fungi Europ. Exsicc. Klotzschii Herbarii Vivi Mycologici Continuatio, Edn nova. Series Secunda, Cent. 3: No. 288 (1860), *Isariopsis* Fresen., Beitr. Mykol. 3: 87 (1863), *Sphaerella* Ces. & De Not., Comm. Soc. Crittog. Ital. 1(fasc. 4): 236 (1863), *Ovularia* Sacc., Michelia 2(no. 6): 17 (1880), *Ramularia* Sacc., Michelia 2(no. 6): 20 (1880), *Septocylindrium* Bonord. Ex Sacc., Michelia 2(no. 6): 15 (1880), *Ophiocladium* Cavara, Z. PflKrankh. 3: 26 (1893), *Hypomycopsis* Henn., Hedwigia 43(2): 86 (1904), *Haplodothis* Höhn., Sber. Akad. Wiss. Wien, Math. -Naturw. Kl., Abt. 1 120: 423 (1911), *Pseudovularia* Speg., Anal. Mus. Nac. B. Aires, Ser. 3 13: 418 (1910) [1911], *Cyclodothis* Syd. & P. Syd., in Sydow & Sydow, Annls Mycol. 11(3): 266 (1913), *Oligostroma* Syd. & P. Syd., Annls Mycol. 12(3): 265 (1914), *Oligostroma* Syd. & P. Syd., Annls Mycol. 12(3): 265 (1914), *Scirrhiachora* Theiss. & Syd., Annls Mycol. 13(5/6): 626 (1915), *Cercosphaerella* Kleb., Haupt- und Nebenfruchtformen der Ascomyzeten (Leipzig) 1: 132 (1918), *Didymellina* Höhn., Annls Mycol. 16(1/2): 66 (1918), *Ramularisphaerella* Kleb., Haupt- und Nebenfruchtformen der Ascomyzeten (Leipzig) 1: 131 (1918), *Septorisphaerella* Kleb., Haupt- und Nebenfruchtformen der Ascomyzeten (Leipzig) 1: 131 (1918), *Septosphaerella* Laib., Centbl. Bakt. ParasitKde, Abt. II 53(22/24): 559 (1921), *Ramosphaerella* Laib., Centbl. Bakt. ParasitKde, Abt. II 53(22/24): 559 (1921), *Isariopsella* Höhn., in Weese, Mitt. Bot. Inst. Tech. Hochsch. Wien 6(2): 68 (1929), *Plectosphaerella* Kirschst., Krypt. -Fl. Brandenburg (Leipzig) 7(3): 310 (1938), *Plectosphaerina* Kirschst., Annls Mycol. 36(5/6): 368 (1938), *Phragmogloeum* Petr., Sydowia 8(1-6): 158 (1954), *Eruptio* M.E.Barr, Mycotaxon 60: 437 (1996).

Ramularia armoraciae Fuckel, Jb. Nassau. Ver. Naturk. 23-24: 361 (1870) / **Zırh artan.**
Syn.: *Ovularia armoraciae* (Fuckel) Massee, Brit. Fung. -Fl. (London) 3: 321 (1893), *Cylindrosporium armoraciae* (Fuckel) J. Schröt. [as 'Cylindrospora'], in Cohn, Krypt. -Fl. Schlesien (Breslau) 3.2(4): 485 (1897), *Entylomella armoraciae* (Fuckel) Cif., Annls Mycol. 26(1/2): 17 (1928).
Host: *Raphanus raphanistrum* subsp. *raphanistrum* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Ramularia menthicola Sacc., Syll. Fung. 4: 213 (1886) / **Kokulu artan.**
Syn.: *Ramularia menthae* Sacc., Fungi Italica Autogr. Del. 17-28: tab. 991 (1881).
Host: *Mentha longifolia* (L.) L. subsp. *typhoides* (Briq.) Harley
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Ramularia ovata Fuckel, Jb. nassau. Ver. Naturk. 23-24: 362 (1870) / **Yuvarlak artan.**
Syn.: *Ovularia ovata* (Fuckel) Sacc., Fungi Iital. Autogr. Del. 17-28: tab. 980 (1881), *Neoovularia ovata* (Fuckel) U.Braun, Nova Hedwigia 54(3-4): 474 (1992).
Host: *Tanacetum balsamitoides* Sch. Bip.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Ramularia rubella (Bonord.) Nannf., in Lundell & Nannfeldt, Fungi Exsiccati Suecici, Fascicle XXIX-XL 39-40: 33 (1950) / **Kırmızı artan.**
Syn.: *Crocysporium rubellum* Bonord., Bot. Ztg. 19: 201 (1861), *Ramularia obovata* Fuckel, Jb. Nassau. Ver. Naturk. 23-24: 103 (1870), *Oidium rubellum* (Bonord.) Sacc. & Voglino, Syll. Fung. 4: 46 (1886), *Ovularia rubella* (Bonord.) Sacc., Syll. Fung. 4: 145 (1886), *O. obovata* (Fuckel) Sacc., Michelia 2(6): 17 (1880).
Host: *Falcaria vulgaris Bernh.*
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Mytilinidiaceae Kirschst. [as 'Mytilidiaceae'], Verh. Bot. Ver. Prov. Brandenb. 66: 28 (1924) / **Karaçıkangiller**.

Taeniolella S.Hughes, Can. J. Bot. 36: 816 (1958) / **Karaçıkan**.
Type species: *Taeniolella exilis* (P.Karst.) S.Hughes 1958.

Taeniolella plantaginis (Corda) S.Hughes, Can. J. Bot. 36: 817 (1958) / **Ot karaçıkan.**
Syn.: *Gyrocerus plantaginis* (Corda) Sacc., Syll. Fung. 4: 267 (1886), *Torula plantaginis* Corda, Icon. Fung. 3: 5 (1839), *Helicoceras plantaginis* (Corda) Linder, Ann. Mo. Bot. Gdn 18: 5 (1931).
Host: *Bellevalia paradoxa* (Fisch. & C.A. Mey.) Boiss., Anchusa azurea Mill. var. *azurea*
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Phyllostictaceae Fr. [as 'Phyllostictei'], Summa Veg. Scand., Sectio Post. 420 (1849) / **Yaprakkörügiller**.

Phyllosticta Pers., Traité Champ. Comest. 55, 147 (1818) / **Yaprakkörü**.
Type species: *Phyllosticta convallariae* Pers.
Syn.: *Phyllosphaera* Dumort., Comment. Bot. (Tournay): 86 (1822), *Myriocarpa* Fuckel, Jb. Nassau. Ver. Naturk. 23-24: 116 (1870), *Greeneria* Scribn & Viala, C. r. Hebd. Séanc. Acad. Sci., Paris 105: 473 (1887), *Guignardia* Viala & Ravaz, Bull. Soc. Mycol. Fr. 8(2): 63 (1892), *Frankiella* Speschnew, Arb. Tiflis Bot. Gard. 5: 11 (1900), *Pampolysporium* Magnus, Verh. Kaiserl. -Königl. Zool.-Bot. Ges. Wien 50: 444 (1900), *Polysporidium* Syd&P. Syd., Annls Mycol. 6(6): 528 (1908), *Montagnellina* Höhn., Sber. Akad. Wiss. Wien, Math. -Naturw. Kl., Abt. 1 121: 387 (1912), *Phyllostictina* Syd & P.Syd., in Sydow, Sydow & Butler, Annls Mycol. 14(3/4): 185 (1916), *Sarcophoma* Höhn., Sber. Akad. Wiss. Wien, Math. -Naturw. Kl., Abt. 1 125(1-2): 75 (1916), *Discochora* Höhn., Ber. Dt. Bot. Ges. 36(7): 315 (1918), *Laestadiella* Höhn., Annls Mycol. 16(1/2): 50 (1918), *Leptophacidium* Höhn., Sber. Akad. Wiss. Wien, Math. -Naturw. Kl., Abt. 1 127(4-5): 331 (1918), *Mesonella* Petr&Syd., Annls Mycol. 22(3/6): 367 (1924), *Macrophyllosticta* Sousa da Câmara, Anais Inst. Sup. Agron. Univ. Téc. Lisboa 3: 36 (1929), *Columnosphaeria* Munk, Dansk Bot. Ark. 15(no. 2): 103 (1953), *Caudophoma* B.V.Patil & Thirum., Sydowia 20: 36 (1968).

Phyllosticta viticola Thüm., Die Pilze des Weinstockes, 188 (1878) / **Asma yaprakörü.**
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Pleosporaceae Nitschke, Verh. Naturh. Ver. Preuss. Rheinl. 26: 74 (1869) / **Gömükömürgiller**.

Alternaria Nees, Syst. Pilze (Würzburg): 72 (1816) / **Arıküfü.**
Type species: *Alternaria tenuis* Nees 1816.
Syn.: *Elosia* Pers., Mycol. Eur. (Erlanga) 1: 12 (1822), *Macrosporium* Fr., Syst. Mycol. (Lundae) 3(2): 340, 373 (1832), *Rhopalidium* Mont., Annls Sci. Nat., Bot., sér. 2 6: 30 (1836), *Brachycladium* Corda, Icon. Fung. (Prague) 2: 14 (1838), *Ulocladium* Preuss, Linnaea 24: 111 (1851), *Stemphylium subgen pseudostemphylium* Wiltshire, Trans. Br. Mycol. Soc. 21(3-4): 223 (1938) [1937], *Prathoda* Subram., J. Indian Bot. Soc. 35: 73 (1956), *Pseudostemphylium* (Wiltshire) Subram., Curr. Sci. 30: 423 (1961), *Chmelia* Svob. -Pol., Biológia, Bratislava 21: 82 (1966), *Embellisia* E.G.Simmons, Mycologia 63(2): 380 (1971), *Trichoconiella* B.L. Jain, Kavaka 3: 39 (1976) [1975], *Botryomyces* de Hoog & C. Rubio, Sabouraudia 20: 19 (1982), *Lewia* M.E. Barr & E.G. Simmons, in Simmons, Mycotaxon 25(1): 289 (1986), *Ybotromyces* Rulamort, Bull. Soc. Bot. Centre-Ouest, Nouv. Sér. 17(2): 192 (1986), *Nimbya* E.G.Simmons, Sydowia 41: 316 (1989), *Allewia* E.G.Simmons, Mycotaxon 38: 260 (1990), *Crivellia* Shoemaker & Inderb., in Inderbitzin, Shoemaker, O'Neill, Turgeon & Berbee, Can. J. Bot. 84(8): 1308 (2006), *Undifilum* B.M.Pryor, Creamer, Shoemaker, McLain-Romero & Hambl., Botany 87(2): 190 (2009), *Pseudoalternaria* D.P.Lawr., Gannibal, Dugan & B.M.Pryor, Mycol. Progr. 13(2): 272 (2013).

Alternaria chartarum Preuss, Linnaea 24: 107 (1851) / **Toz arıküfü.**
Syn.: *Sporidesmium polymorphum* var. *chartarum* (Preuss) Cooke, Fungi Brit. Exs., ser. 2: no. 329 (1875), *Alternaria stemphylioides* Bliss, Mycologia 36(5): 538 (1944), *Ulocladium chartarum* (Preuss) E.G. Simmons, Mycologia 59(1): 88 (1967).
Host: *Equisetum arvense* L., *Calamagrostis epigeios* (L.) Roth
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Alternaria consortialis (Thüm.) J.W.Groves & S.Hughes [as 'consortiale'], in Hughes, Can. J. Bot. 31: 636 (1953) / **Koca arıküfü.**
Syn.: *Macrosporium consortiale* Thüm., Herb. Myc. Oeconom., Fasc. 9: no. 450 (1876), *Stemphylium ilicis* Tengwall, Meded. Phytopath. Labor. Willie Commelin Scholten Baarn 6: 44 (1924), *S. congestum* var. *minor* Ruehle, Mycologia 22(6): 308 (1930), *S. consortiale* (Thüm.) J.W.Groves & Skolko, Canadian Journal of Research, Section C: 196 (1944), *S. consortiale* var. *minor* (Ruehle) Neerg., Danish species of Alternaria & Stemphylium: 323 (1945), *S. ilicis* var. *minor* (Ruehle) Neerg., Danish species of Alternaria & Stemphylium: 323 (1945)*Pseudostemphylium consortiale* (Thüm.) Subram., Curr. Sci. 30: 423 (1961), *Alternaria consortialis* var. *levis* Gambogi, Ann. Ist. Super. Forest. Naz. Firenze 18: 834 (1966), *Ulocladium consortiale* (Thüm.) E.G.Simmons, Mycologia 59(1): 84 (1967).
Host: *Tanacetum balsamitoides* Sch. Bip., *Dactylis glomerata* L. subsp. *glomerata, Ranunculus flammula* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Alternaria herbiphorbicola E.G.Simmons, CBS Diversity Ser. 6: 608 (2007) / **İkiz arıküfü.**
Host: *Cirsium haussknechtii* Boiss., *Dipsacus laciniatu* L., *Silene vulgaris* (Moench) Garcke var. *vulgaris, Nepeta nuda* subsp. *albiflora* (Boiss.) Gams
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Alternaria hispidula Ellis, Bull. Torrey Bot. Club 10(5): 52 (1883) / **Diken arıküfü.**
Host: *Artemisia absinthium* L., *Euphorbia cheiradenia* Boiss. & Hohen., *Medicago sativa* L. subsp. *sativa, Hypericum perforatum* L. subsp. *veronense* (Schrank) H.Linb., *Rumex crispus* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Alternaria lanuginosa (Harz) Sacc., Syll. Fung. 4: 546 (1886) / **Tüylü arıküfü.**
Syn.: *Stemphylium lanuginosum* Harz, Bull. Soc. Imp. Nat. Moscou 44(1): 132 (1871), *Pseudostemphylium lanuginosum* (Harz) Subram., Curr. Sci. 30: 423 (1961), *Ulocladium lanuginosum* (Harz) E.G.Simmons, Mycologia 59(1): 80 (1967).
Host: *Eryngium campestre* L. var. *virens* Link, *Cichorium intybus* L., *Scorzonera veratrifolia* Fenzl, *Plantago lanceolata* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Alternaria loliicola Meng Zhang, Mycosystema 25(4): [521] (2006) / **Kal arıküfü.**
Host: *Lolium perenne* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Alternaria microspora (Moub & Abdel-Hafez) Gannibal & D.P.Lawr., Mycotaxon 133(2): 295 (2018) / **Küçük arıküfü.**
Syn.: *Ulocladium microsporum* Moub&Abdel-Hafez, Trans. Br. Mycol. Soc. 69(1): 164 (1977).
Host: *Inula britannica* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Alternaria multiformis (E.G.Simmons) Woudenb. & Crous, Stud. Mycol. 75(1): 204 (2013). / **Çoklu arıküfü.**
Syn.: *Ulocladium multiforme* E.G.Simmons, Can. J. Bot. 76(9): 1537 (1999).
Host: *Inula britannica* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Alternaria obovoidea (E.G.Simmons) Woudenb. & Crous, Stud. Mycol. 75(1): 204 (2013) / **Yan arıküfü.**
Syn.: *Ulocladium obovoideum* E.G.Simmons, Mycotaxon 37: 104 (1990).
Host: *Rumex conglomeratus* Murray
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Alternaria oudemansii (E.G.Simmons) Woudenb. & Crous, Stud. Mycol. 75(1): 206 (2013) / **Sıkı arıküfü.**
Syn.: *Ulocladium oudemansii* E.G.Simmons, Mycologia 59(1): 86 (1967).
Host: *Carex distans* L. subsp. *distans*
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Alternaria septospora (Preuss) Woudenb. & Crous, Stud. Mycol. 75(1): 201 (2013) / **Bölmeli arıküfü.**
Syn.: *Helminthosporium septosporum* Preuss, Linnaea 24: 117 (1851), *Macrosporium septosporum* (Preuss) Rabenh., Bot. Ztg. 9(25): 454 (1851), *Ulocladium septosporum* (Preuss) E.G.Simmons, Mycologia 59(1): 87 (1967).

Host: *Chenopodium album* L. subsp. *album* var. *album*, *Anchusa azurea* Mill. var. *azurea*, *Nepeta nuda* subsp. *albiflora* (Boiss.) Gams. *Alcea striata* (DC.) Alef. subsp. *striata*.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Macrosporium malvae Thüm., Ber. Bot. Ver. Landshut 7: 178 (1879) / **Ebe arıküfü.** (*Macrosporium* is the synonym of *Alternaria*).
Host: *Alcea striata* (DC.) Alef. subsp. *striata*
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Curvularia Boedijn, Bull. Jard. Bot. Buitenz, 3 Sér. 13(1): 123 (1933) / **Eğikspor**.
Type species: *C. lunata* (Wakker) (1933).

Curvularia trifolii (Kauffman) Boedijn, Bull. Jard. bot. Buitenz, 3 Sér. 13(1): 128 (1933) / **Tez eğikspor.**
Syn.: *Brachysporium trifolii* Kauffman, in Bonar, Phytopathol. 10: 441 (1920).
Host: *Sanguisorba officinalis* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Stemphylium Wallr., Fl. Crypt. Germ. 2: 300 (1833) / **Durusefil**.
Type species: *S. botryosum* Wallr. (1833).
Syn.: *Scutisporium* Preuss, Linnaea 24: 112 (1851), *Epochniella* Sacc., Michelia 2(no. 6): 127 (1880), *Fusicladiopsis* Maire, Bull. Soc. Bot. Fr. 53: CLXXXVI (1907) [1906], *Thyrodochium* Werderm., in Sydow&Werdermann, Annls Mycol. 22(1/2): 188 (1924), *Thyrospora* Tehon & E.Y. Daniels, Phytopathology 15: 718 (1925), *Soreymatosporium* Sousa da Câmara, Proposta Stemphylium: 18 (1930).

Stemphylium pyriforme Bonord. [as 'piriforme'], Handb. Allgem. Mykol. 83 (1851) / **Armut durusefil.**
Host: *Echinops spinosissimus* Turra subsp. *bithynicus* (Boiss.) Greuter., *Inula britannica* L., *Epilobium hirsutum* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Rhytismataceae Chevall. [as 'Rhytismaceae'], Fl. Gén. Env. 1: 439 (1826) / **Akçadövmegiller**.

Leptostroma Fr., Observ. Mycol. 1: 196 (1815) / **Karaiz.**
Type species: *Leptostroma scirpinum* Fr.

Hypohelion P.R.Johnst., Mycotaxon 39: 221 (1990) / **Karaiz**.
Type species: *Hypohelion scirpinum* (DC.) P.R.Johnst.
Syn.: *Leptostroma* Fr., Observ. Mycol. (Havniae) 1: 196 (1815), *Schizoderma* Ehrenb., Sylv. Mycol. Berol. (Berlin): 27 (1818), *Thyriostroma* Died., Ann. Mycol. 11(2): 176 (1913).

Leptostroma sphaeroides Fr., Observ. Mycol. 1: 196 (1815) / **Düz karaiz.**
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Sporocadaceae Corda [as 'Sporocadeae'], Icon. Fung. 5: 34 (1842) / **Kuyucukgiller**.

Seimatosporium Corda, in Sturm, Deutschl. Fl., 3 Abt. (Pilze Deutschl.) 3(13): 79 (1833) / **Karalık**.
Type species: *Seimatosporium rosae* Corda.
Syn.: *Cryptostictis* Fuckel, Fungi Rhenani Exsic., Suppl., Fasc. 4: no. 1838 (1866), *Dochmolopha* Cooke, Nuovo G. Bot. Ital. 10(1): 25 (1878), *Fenestella* subgen. *clethridium* Sacc., Syll. Fung. (Abellini) 2: 332 (1883), *Hyaloceras* subgen. *diploceras* Sacc., Syll. Fung. (Abellini) 10: 484 (1892), *Clethridium* (Sacc.) Sacc. [as 'Clathridium'], Syll. Fung. (Abellini) 11: 350 (in clave), 729 (1895), *Curreya* sect. *curreyella* Sacc., Syll. fung. (Abellini) 11: 379 (1895), *Curreyella* (Sacc.) Lindau, in Engler & Prantl, Nat. Pflanzenfam., Teil. I (Leipzig) 1(1): 379 (1897), *Labridium* Vestergr., Öfvers. Finska Vetensk. -Soc. Förh. 54(no. 1): 43 (1897), *Amphichaeta* McAlpine, Proc. Linn. Soc. N.S.W. 29: 118 (1904), *Discostroma* Clem., Gen. Fung. (Minneapolis): 50 (1909), *Phragmodothella* Theiss&Syd., Annls Mycol. 13(3/4): 343 (1915), *Griphosphaeria* Höhn., Annls Mycol. 16(1/2): 87 (1918), *Diploceras* (Sacc.) Höhn., in Falck, Mykol. Untersuch. Ber. 1(3): 342 (1923), *Leptocoryneum* Petr., Hedwigia 65: 278 (1925), *Paradidymella* Petr., Annls Mycol. 25(3/4): 237 (1927), *Seiridina* Höhn., Mitt. Bot. Inst. Tech. Hochsch. Wien 7(1): 31 (1930), *Coryneopsis* Grove, J. Bot., Lond. 70: 33 (1933) [1932], *Neobroomella* Petr., Sydowia 1(1-3): 5 (1947), *Basipilus* Subram., Proc. Natl. Inst. Sci. India, B 27: 243 (1961), *Monoceras* Guba, Monograph of Monochaetia and Pestalotia: 290 (1961), *Monochaetina* Subram., Proc. Natl. Inst. Sci. India, B 27: 241 (1961), *Discostromopsis* H.J. Swart, Trans. Br. Mycol. Soc. 73(2): 217 (1979), *Vermisporium* H.J.Swart & M.A.Will., Trans. Br. Mycol. Soc. 81(3): 491 (1983).

Seimatosporium macrospermum (Berk. & Broome) B.Sutton, Mycol. Pap. 138: 130 (1975) / **Büyük karalık.**
Syn.: *Coryneum macrospermum* Berk&Broome, Ann. Mag. Nat. Hist., Ser. 3 7: 381 (1861), *Stilbospora ulmi* Grove, British Stem- and Leaf-Fungi (*Coelomycetes*) (Cambridge) 2: 326 (1937), *Sporocadus macrospermus* (Berk&Broome) M. Morelet [as 'macrospermum'], Ann. Soc. Sci. Nat. Arch. Toulon et du Var 37(4): 234 (1985).
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Seimatosporium vitifusiforme D.P.Lawr. & Travadon, in Lawrence, Travadon & Baumgartner, Pl. Dis. 102(6): 1086 (2018) / **Hile karalık.**
Record: Akgül and Kara (2022), (plant; Gaziantep).

Seimatosporium vitis Y.P.Xiao, Camporesi & K.D.Hyde, in Senanayake et al., Fungal Div. 73: 103 (2015) / **Üzüm karalık.**
Record: Akgül and Kara (2022), (plant; Gaziantep).

Trichosphaeriaceae G.Winter [as 'Trichosphaerieae'], Rabenh. Krypt.-Fl., Edn 2 (Leipzig) 1.2: 191 (1885) / **Kayindingiligiller**.

Brachysporium Sacc., Syll. Fung. 4: 423 (1886) / **Kayindingili**.
Type species: *B. obovatum* (Berk.) Sacc. 1886.
Syn.: *Cryptadelphia* Réblová&Seifert, Mycologia 96(2): 348 (2004).

Brachysporium flexuosum (Corda) Sacc., Syll. Fung. 4: 429 (1886) / **Gevşek kayındingili.**
Host: *Pulicaria dysenterica* (L.) Bernh. subsp. *dysenterica*
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Xylariaceae Tul. & C.Tul. [as 'Xylariei'], Select. Fung. Carpol. 2: 3 (1863) / **Ölüparmağıgiller**.

Rosellinia De Not., G. Bot. Ital. 1(1): 334 (1844) / **Karameme**.
Type species: *Rosellinia aquila* (Fr.) Ces. & De Not.

Syn.: *Byssitheca* Bonord., Abh. Naturforsch. Ges. Halle 8: 82, 156 (1864), *Amphisphaerella* Henn., Hedwigia 41: 13 (1902), *Vrikshopama* D.Rao & P.Rag. Rao, Mycopath. Mycol. Appl. 23: 289 (1964).

Rosellinia amblystoma Berl. & F.Sacc., Revue Mycol. 11(43): 118 (1889) / **Şık karameme.**
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Valsaceae Tul. & C.Tul. [as 'Valsarum'], Select. Fung. Carpol. 1: 180 (1861) / **Valsagiller**.

Cytospora Ehrenb., Sylv. Mycol. Berol. 28 (1818) / **Bademgözü**.
Type species: *Cytospora chrysosperma* (Pers.) Fr.
Syn.: *Bostrychia* Fr., K. Svenska Vetensk-Akad. Handl., ser. 3 40: 117 (1819), *Circinostoma* Gray, Nat. Arr. Brit. Pl. (London) 1: 520 (1821), *Engizostoma* Gray, Nat. Arr. Brit. Pl. (London) 1: 519 (1821), *Lamyella* Fr., Summa Veg. Scand., Sectio Post. (Stockholm): 410 (1849), *Psecadia* Fr., Summa Veg. Scand., Sectio Post. (Stockholm): 414 (1849), *Torsellia* Fr., Summa Veg. Scand., Sectio Post. (Stockholm): 412 (1849), *Valsa* Fr., Summa Veg. Scand., Sectio Post. (Stockholm): 410 (1849), *Circinaria* Bonord., Handb. Allgem. Mykol. (Stuttgart): 270, 305 (1851), *Hypoplasta* Preuss, Linnaea 26: 712 (1855) [1853], *Microstoma* Auersw., in Rabenhorst, Fungi Europ. Exsicc.: no. 253 (in sched.) (1860), *Cylindrotheca* Bonord., Abh. Naturforsch. Ges. Halle 8: 81, 150 (1864), *Valsa* subgen. *leucostoma* Nitschke, Pyrenomyc. Germ. 2: 221 (1870), *Valsella* Fuckel, Jb. Nassau. Ver. Naturk. 23-24: 203 (1870), *Neocytispora* Ellis & Everh. ex Sacc. & D. Sacc., Syll. Fung. (Abellini) 18: 301 (1906), *Cytophoma* Höhn., Sber. Akad. Wiss. Wien, Math. -Naturw. Kl., Abt. 1 123: 133 (1914), *Monopycnis* Naumov, Zap. Ural'sk. Obšč. Ljubit. Estestv. 35(11-12, Champ. Oural.): 36 (1916), *Leucocytospora* Höhn., Ber. Dt. Bot. Ges. 35(4): 352 (1917), *Leucostoma* (Nitschke) Höhn., Ber. Dt. Bot. Ges. 35(8): 637 (1917), *Pleuronaema* Höhn., Hedwigia 59(5): 257 (1917), *Cytospora* subgen. *leucocytospora* Höhn., Annls Mycol. 16(1/2): 130 (1918), *Cytosporopsis* Höhn., Annls Mycol. 16(1/2): 124 (1918), *Griphosphaerioma* Höhn., Ber. Dt. Bot. Ges. 36(7): 312 (1918), *Valseutypella* Höhn., Annls mycol. 16(3/6): 224 (1919), *Leucocytospora* (Höhn.) Höhn., in Weese, Mitt. Bot. Inst. Tech. Hochsch. Wien 4(2): 73 (1927), *Cyclocytospora* Höhn., in Weese, Mitt. bot. Inst. Tech. Hochsch. Wien 5: 17 (1928).

Cytospora parasitica Norph., Bulgakov & K.D.Hyde, in Ariyawansa et al., Fungal Div. 75: 172 (2015) / **Asalak bademgözü.**
Record: Eken and Sevindik (2023), (plant; Isparta).

Cytospora ribis Ehrenb., Sylv. Mycol. Berol. 28 (1818) / **Işgın bademgözü.**
Record: Akgül and Kara (2022), (plant; Gaziantep).

Cytospora sorbicola Norph., Bulgakov, T.C.Wen & K.D.Hyde, in Norphanphoun, Doilom, Daranagama, Phookamsak, Wen, Bulgakov & Hyde, Mycosphere 8(1): 83 (2017) / **Ekşi bademgözü.**
Record: Eken and Sevindik (2023), (plant; Isparta).

Cytospora vitis Mont., Syll. Gen. sp. Crypt. 260 (1856) / **Asma bademgözü.**
Syn.: *Cytospora vitis* var. *macrospora* Sacc. & Roum., Reliq. Libert 4: no. 104 (1884).
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Incertae Sedis (*Ascomycota*) / Unknown family

Annellophorella Subram., Proc. Ind. Acad. Sci., Sect. B 55: 6 (1962) / **Yiliğan**.
Type species: *A. densa* (Syd. & P.Syd.) Subram. 1962.

Annellophorella faureae (Henn.) M.B.Ellis, Mycol. Pap. 87: 13 (1963) / **Düz yılığan.**
Syn.: *Brachysporium faureae* Henn., Kunene-Sambesi-Exped., H.Baum, 169 (1903).
Host: *Inula britannica* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Coniothecium Corda, in Sturm, Deutschl. Fl., 3 Abt. (Pilze Deutschl.) 3(13): 71 (1833) / **Konitezyum**.
Type species: *Cohiokpeciul atrum* Corda 1833.
Syn.: *Didymosporium* Nees, Syst. Pilze (Würzburg): 33 (1816), *Coniotheciella* Speg., Physis, Rev. Soc. Arg. Cienc. Nat. 4(17): 295 (1918).

Coniothecium seriale Durieu & Mont., in Durieu, Expl. Sci. Alg., Fl. Algér. 1(livr. 9): 328 (1848) / **Sarma konitezyum.**
Host: *Falcaria vulgari* Bernh., *Equisetum arvense* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Dicoccum Corda, in Sturm, Deutschl. Fl., 3 Abt. (Pilze Deutschl.) / **İkiliküre.**
Type species: *D. minutissimum* Corda 1829.

Dicoccum asperum (Corda) Sacc., Syll. Fung. (Abellini) / **Ot ikiliküre.**
Syn.: *Sporidesmium asperum* Corda, Icon. Fung. (Prague) 2: 6 (1838), *Monodictys aspera* (Corda) S.Hughes, Can. J. Bot. 36: 785 (1958), *Piricauda aspera* (Corda) R.T.Moore, Rhodora 61: 96 (1959).
Host: *Lactuca scarioloides* Boiss.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Ilyonectria P.Chaverri & Salgado, in Chaverri, Salgado, Hirooka, Rossman & Samuels, Stud. Mycol. 68: 69 (2011) / **İlyon**.
Type species*: Ilyonectria radicicola* (Gerlach & L.Nilsson) P.Chaverri & Salgado 2011.

Ilyonectri liriodendri (Halleen, Rego & Crous) P.Chaverri & Salgado, in Chaverri, Salgado, Hirooka, Rossman & Samuels, Stud. Mycol. 68: 71 (2011) / **Lale ilyon.**
Syn.: *Neonectria liriodendri* Halleen, Rego & Crous, in Halleen, Schroers, Groenewald, Rego, Oliveira & Crous, Stud. Mycol. 55: 232 (2006).
Record: Göngör Savaş (2023), (bitki-(*Vitis vinifera*); Manisa).

Knufia L.J.Hutchison & Unter., in Hutchison, Untereiner & Hiratsuka, Mycologia 87(6): 903 (1996) / **Serilen**.
Type species: *Knufia cryptophialidica* L.J.Hutchison & Unter.

Knufia chersonesos (Bogom. & Minter) Tsuneda, Hambl. & Currah, Botany 89(12): 887 (2011) / **Ada serilen.**
Syn.: *Phaeococcomyces chersonesos* Bogom. & Minter, Mycotaxon 86: 203 (2003), *Knufia chersonesos* (Bogom. & Minter) Tsuneda, Hambl. & Currah, Bot. 89(8): 535 (2011).
Record: Acar et al. (2022), (inanimate materials-historically important artifacts; Teos Ancient City, Izmir).

Knufia petricola (Wollenz. & de Hoog) Gorbushina & Gueidan, Fungal Genetics Biol. 56: 58 (2013) / **Koku serilen.**
Syn.: *Sarcinomyces petricola* Wollenz. & De Hoog, in Wollenzien, Hoog, Krumbein & Uijthof, Antonie van Leeuwenhoek 71(3): 283 (1997).
Record: Acar et al. (2022), (inanimate materials-historically important artifacts; Teos Ancient City, Izmir).

Monodictys S.Hughes, Can. J. Bot. 36: 785 (1958) / **Tektokmak**.
Type species: *Monodictys putredinis* (Wallr.) S.Hughes.

Monodictys abuensis (Chouhan & Panwar) V.Rao & de Hoog, Stud. Mycol. 28: 26 (1986) / **Nine tektokmak.**
Syn.: *Berkleasmium abuense* Chouhan & Panwar, Indian Phytopathol. 33(2): 287 (1981).
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Periconia Tode, Fung. Mecklenb. Sel. 2: 2 (1791) / **Püskürten**.
Type species: *Periconia lichenoides* Tode 1791.
Syn.: *Dematium* Pers., Tent. Disp. Meth. Fung. (Lipsiae): 41 (1797), *Chromatium* Link, Abh. K. Akad. Wiss. Berlin: 180 (1824), *Sporocybe* Fr., Syst. Orb. Veg. (Lundae): 170 (1825), *Sporodum* Corda, Icon. Fung. (Prague) 1: 18 (1837), *Cephalotrichum* Berk. ex Sacc., Syll. Fung. (Abellini) 4: 275 (1886), *Harpocephalum* G.F. Atk., Bulletin of Cornell University 3(no. 1): 41 (1897), *Berkeleyna* Kuntze, Revis. Gen. Pl. (Leipzig) 3(3): 447 (1898), *Trichocephalum* Costantin, Mucéd. Simpl. (Paris): 106 (1888), *Trichurus* Clem., in Pound & Clements, Bot. Surv. Nebraska 4: 7 (1896), *Pachytrichum* Syd., Annls Mycol. 23(3/6): 420 (1925), *Blepharia* (Pers.) Ainsw. & Bisby, Ainsworth & Bisby's Dictionary of the Fungi: [1] (1943), *Noosia* Crous, R.G. Shivas & McTaggart, in Crous, Groenewald, Shivas, Edwards, Seifert, Alfenas, Alfenas, Burgess, Carnegie, Hardy, Hiscock & Hübe, Persoonia 26: 139 (2011), *Bambusistroma* D.Q.Dai & K.D.Hyde, Index Fungorum 225: 1 (2015), *Bambusistroma* D.Q.Dai & K.D.Hyde, Cryptog. Mycol. 36(2): 123 (2015).

Periconia funerea (Ces.) E.W. Mason & M.B. Ellis, Mycol. Pap. 56: 117 (1953) / **Kol püskürten.**
Syn.: *Torula funerea* Ces., in Rabenhorst, Klotzschii Herb. Viv. Mycol., Edn Nov, Ser. Sec., 1 (79) (1855).
Host: *Hordeum bulbosum* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Pyrenochaeta De Not., Mém. R. Accad. Sci. Ser. 2 10: 347 (1849) / **Kökçürüten**.
Type species: *Pyrenochaeta nobilis* De Not. 1849.
Syn.: *Herpotrichiopsis* Höhn., Sber. Akad. Wiss. Wien, Math.-Naturw. Kl., Abt. 1 123: 115 (1914), *Lasiophoma* Naumov, Zap. Ural'sk. Obšč. Ljubit. Estestv. 35(11-12): 30 (1916).

Pyrenochaeta vitis Viala & Sauv., J. Bot. 5: 357 (1891) / **Asma kökçürüten.**
Host: *Vitis vinifera* L.
Record: Arslan and Erdoğdu (2022), (plant; Kırşehir).

Scolicotrichum Kunze, in Kunze & Schmidt, Mykologische Hefte (Leipzig) 1: 10 (1817) / **Kapraşık.**
Type species: *Scolicotrichum virescens* Kunze 1817.

Scolicotrichum bonordenii Sacc., Syll. Fung. 4: 348 (1886) / **Bön kapraşık.**
Host: *Lepidium draba* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Sporidesmium Link, Mag. Gesell. Naturf. Freunde, Berlin 3(1-2): 41 (1809) / **Ekligelen**.
Type species: *Sporidesmium atrum* Link, 1809.
Syn.: *Podoconis* Boedijn, Bull. Jard. Bot. Buitenz, 3 sér. 13(1): 133 (1933), *Imicles* Shoemaker & Hambl., Can. J. Bot. 79(5): 598 (2001).

Sporidesmium cladosporii Corda, Icon. Fung. 1: 7 (1837) / **Yan ekligelen.**
Syn.: *Caeoma cladosporii* (Corda) Bonord., Handb. Allgem. Mykol. 48 (1851).
Host: *Acanthus dioscoridis* L. var. *dioscoridis*, *Cirsium arvense* (L.) Scop., *Xanthium strumarium* L. subsp. *strumarium.*
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Sporidesmium microscopicum Schulzer, Flora, Regensburg 59(3): 47 (1876) / **Küçük ekligelen.**
Host: *Lysimachia vulgaris* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Basidiomycota R.T.Moore, Bot. Mar. 23(6): 371 (1980) / **Topuzlu Mantarlar**.

Pucciniaceae Chevall, Fl. Gén. Env. Paris, 1: 413 (1826). / **Pasgiller.**

Aecidium Pers. ex J.F.Gmel., Syst. Nat., Edn 13 2(2): 1472 (1792). / **Ezdimpası.** (Güncel isim: ***Puccinia*** Pers., Neues Mag. Bot. 1: 118 (1794). / **Pas**.
Type species: *Puccinia graminis* Pers. 1794 (www.mycobank.org).
Syn.: *Aecidium* Pers. ex J.F.Gmel., Syst. Nat., Edn 13 2(2): 1472 (1792), *Aecidium* Pers., Observ. Mycol. 1: 97 (1796), *Bullaria* DC., in Lamarck & De Candolle, Fl. Franç., Edn 3 (Paris) 2: 226 (1805), *Caeoma* Link, Mag. Gesell. Naturf. Freunde, 3(1-2): 5 (1809), *Hypodermium* Link, Mag. Gesell. Naturf. Freunde, 8: 26 (1816) [1815]. *Sphaerotheca* Desv., Mém. Soc. Imp. Nat. 5: 68 (1817), *Dicaeoma* Gray [as 'Diceoma'], Nat. Arr. Brit. Pl. 1: 541 (1821), *Eriosporangium* Bertero ex Ruschenb., Amer. J. Sci. Arts 20: 259 (1831), *Symperidium* Klotzsch, Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur., Suppl. 1 19: 245 (1843), *Solenodonta* Castagne, Cat. Pl. Mars.: 202 (1845), *Cutomyces* Thüm., J. Sci. Math. Phys. Nat. Lisboa, 1 Ser. 6(21-24): 239 (1878), *Leptinia* Juel, Bih. K. Svenska Vetensk Akad. Handl., Afd. 3 23(10): 15 (1897), *Puccinia* subgen. *leptopuccinia* G. Winter, Rabenh. Krypt.-Fl., Edn 2 (Leipzig) 1.1: 164 (1881), *Rostrupia* Lagerh., J. Bot., Paris 3: 188 (1889), *Puccinidia* Mayr, Die Waldungen Von Nordamerika: 337 (1890), *Sphenospora* Dietel, Ber. Dt. Bot. Ges. 10: 63 (1892), *Jackya* Bubák, Öst. Bot. Z. 52(2): 42 (1902), *Leptopuccinia* (G.Winter) Rostr., Plantepatologi: 268 (1902), *Micropuccinia* Rostr., Plantepatologi: 266 (1902), *Allodus* Arthur, Résult. Sci. Congr. Bot. Wien 1905: 345 (1906), *Argotelium* Arthur, Résult. Sci. Congr. Bot. Wien 1905: 343 (1906), *Lysospora* Arthur, Résult. Sci. Congr. Bot. Wien 1905: 340 (1906), *Argomyces* Arthur, N. Amer. Fl. (New York) 7(3): 217 (1912), *Coronotelium* Syd., Annls Mycol. 19(3-4): 174 (1921), *Linkiella* Syd., Annls Mycol. 19(3-4): 173 (1921), *Pleomeris* Syd., Annls Mycol. 19(3-4): 171 (1921), *Sclerotelium* Syd., Annls Mycol. 19(3-4): 172 (1921), *Lindrothia* Syd., Annls Mycol. 20(3/4): 119 (1922), *Poliomella* Syd., Annls Mycol. 20(3/4): 122 (1922),

Persooniella Syd., Annls Mycol. 20(3/4): 118 (1922), *Schroeterella* Syd., Annls Mycol. 20(3/4): 119 (1922), *Trailia* Syd., Annls Mycol. 20(3/4): 121 (1922), *Diorchidiella* J.C.Lindq., Darwiniana 11: 416 (1957).

Aecidium eremostachydis Petr., Sydowia 20(1-6): 287 (1968) / **Korkan pas.**
Host:*Phlomoides laciniata* (L.) Kamelin & Makhm.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Aecidium polygoni-cuspidati Dietel, Bot. Jb. 32: 629 (1903) / **Çoklu pas.**
Host: *Polygonum aviculare* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Puccinia ganeschinii Tranzschel & Erem. [as 'ganeschini'], in Tranzschel, Conspectus Uredinalium URSS: 402 (1939) / **Sarmal pas.**
Host: *Rhaponticum repens* (L.) Hidalgo
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Puccinia pozzii Semadeni, in Fischer, Ured. der Schweiz: 111 (1904) / **Lav pası.**
Host: *Chaerophyllum crinitum* Boiss.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Puccinia praegracilis Arthur, Bull. Torrey Bot. Club 34: 585 (1907) / **Tahta pas.**
Host: *Dactylorhiza umbrosa* (Karelin & Kirilow) Nevski var. *umbrosa*
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Puccinia tiflisensis Petr., Annls Mycol. 38(2/4): 237 (1940) / **Tiflis pası.**
Host: *Cirsium arvense* (L.) Scop.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Puccinia vagans (Lam. & DC.) Arthur, Man. Rusts in the US & Canada: 313 (1934) / **Atak pası.**
Syn.: *Uredo vagans* Lam. & DC., Syn. Plant. Fl. Gall. Descript. (Parisiis): 47 (1808), *Uromyces vagans* (Lam. & DC.) Lév., Annls Sci. Nat., Bot., sér. 3 8: 371 (1847).
Host: *Epilobium hirsutum* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Uromyces (Link) Unger, Exanth. Pflanzen (Wien), 277 (1833) / **Zerpas.**
Type species: *Uromyces appendiculatus* F.Strauss.

Uromyces coronillae Vienn.-Bourg., Revue de Pathol. Végetale et d'Entom. Agr. de France 29: 164 (1950) / **Kor zerpas.**
Record: Akdeniz and Sert (2022), (plant; Antalya).

Uromyces epilobii (DC.) Lév., Annls Sci. Nat., Bot., sér. 3 8: 371 (1847) / **Üst zerpas.**
Host: *Epilobium hirsutum* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

Uromyces turcomanicus Katajev [as 'turcomanicum'], Notul. Syst. Sect. Cryptog. Inst. Bot. Acad. Sci. U.S.S.R. 8: 111 (1952) / **Ortapas.**
Host: *Hordeum bulbosum* L.
Record: Sırrı and Özaslan (2023), (plant; Hakkari).

4. Discussions

Fungal checklists have been published in many countries (Examples: Lastra et al., 2022; Tamayo-Cevallos and Alvarez-Montero, 2022; Giray et al., 2022; Yanez-Ayabaca et al., 2023; Wijayawardene et al., 2023; Voglmayr et al., 2023). Since these studies contain data up to the date of publication, updating is also required. Therefore, Sesli et al. (2020) 3 update articles were prepared after the publication of his book, and this article is the third of them. The checklist in this article includes 92 new taxa (1 section, 3 families, 6 genera and 82 species) for Türkiye. In this article, taxa were included in 3 division categories (*Oomycota*, *Blastocladiomycota Ascomycota*) and one of them, *Blastocladiomycota* (Tortul Mantarlar), was given a Turkish scientific name. *Physoderma menthae* (kokulu düdükpası) species in this section is a newly registered species from Türkiye. The genus *Pysoderma* was previously classified in the *Physodermataceae* family and the *Chytridiomycota* section. However, according to the new classification, it was transferred to the *Blastocladiomycota* section and its taxonomic status was updated in this article.

In this article, 92 taxa were given Turkish scientific names and thus, Turkish names were added to the Latin names of all fungal taxa isolated from Türkiye. While making these nomenclatures; if Turkish names were previously given for the upper categories, these names were preserved, and in the naming of new records from sub-taxa, care was taken to ensure that the names in the upper categories are integrated with the names in the upper categories and comply with the naming rules. The update articles both ensure that the book of Sesli et al. (2020) is continued as a living book and that the purpose of naming the newly recorded taxa in Turkish is realized. With such an application, it is also aimed to popularize the awareness and use of Turkish names of fungi. Therefore, as long as mycological research continues in Türkiye, additional update articles are planned to be prepared.

Conflict of interest

Authors have declared no conflict of interest.

Authors' contributions

The authors contributed equally.

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Macromycetes determined in Yıldız Mountain (Sivas)

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Yıldız Dağı (Sivas)'nda belirlenen makromantarlar

Abstract: In this study macrofungi determined at Yıldız Mount (Sivas-Türkiye), through the identification on the samples collected between 2019-2020, are presented. As a result of field and laboratory studies, 62 species within 26 families were identified. Four of them belong to the division *Ascomycota* and 58 to *Basidiomycota.* The determined species are listed together with their collection localities, habitats, edibility status and voucher numbers.

Key words: Biodiversity, macrofungi, mycota, Türkiye

Özet: Bu çalışmada, 2019-2020 yılları arasında toplanan örneklerin teşhisiyle Yıldız Dağı (Sivas-Türkiye)'nda belirlenen makromantarlar verilmektedir. Arazi ve laboratuar çalışmaları sonucunda, 26 familya içerisinde yer alan 62 tür tespit edilmiştir. Bunlardan dört tanesi *Ascomycota,* 58 tanesi ise *Basidiomycota* bölümüne aittir. Belirlenen türler, lokaliteleri, habitatları, yenilebilirlik durumları ve toplayıcı numaraları ile birlikte listelenmiştir.

Anahtar Kelimeler: Biyoçeşitlilik, makromantarlar, mikota, Türkiye

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1. Introduction

Yıldız Mountain is located within the boundaries of Sivas province, and situated between 37°40′-38°12′ northern latitudes and 35°06′-35°37′ eastern longitudes (Figure 1). The mounth is a natural habitat for a number of trees such as *Pinus sylvestris* L., *Juniperus oxcycedrus* L., *Salix alba* L., *Populus tremula* L. and *Quercus* L. species.

As a result of numerous studies conducted within the boundaries of Türkiye, about 2600 macrofungi species have been recorded for Turkish mycota (Sesli et al., 2020; Solak and Türkoğlu, 2023). New contributions have also been made by some recent studies (Çetinkaya and Uzun, 2021; Polat and Keleş, 2022; Şengül Demirak et al., 2022; Acar, 2023; Akçay, 2023; Çelik and Alma, 2023; Kaygusuz et al., 2023; Kuru and Allı, 2023; Şahin, et al., 2023; Sesli, 2023a,b,c; Uzun, 2023; Uzun and Kaya, 2023; Yeşilyurt et al., 2023).

Some studies have also been carried out on the macrofungi of the Sivas region (Hüseyinov et al. 2001; Kırış et al. 2012), but they don't cover the province as a whole. The study aims to determine the macrofungal composition of Yıldız Mountain, and to make a contribution to the mycobiota of Türkiye.

2. Materials and Method

Macrofungi samples were collected from Yıldız Mountain within the boundaries of Sivas province during field studies performed between 2019 and 2020. Fruit bodies were photographed at their natural habitats and notes were taken about their morphology, ecology and geographic position. Then the fruit bodies were collected and put in paper boxes. Then they were transferred to the fungarium, and dried in an air conditioned room. Micromorphological investigations were based on dry materials. The specimens were identified with the help of the relevant literature (Phillips, 1981; Moser, 1983; Breitenbach and Kränzlin, 1984, 1986, 1991, 1995, 2000; Buczacki, 1989; Bresinsky and Besl, 1990; Jordan, 1995). The specimens are kept in the fungarium of Biology Department, Science and Arts Faculty, Tokat Gaziosmanpaşa University.

3. Results

The determined macrofungi species are listed together with their collection locality, habitat, geographical position, collection date, voucher numbers and edibility status. Index Fungorum (accessed on 20 August 2022) were followed for the systematics of the taxa.

Fungi R.T. Moore

Ascomycota Whittaker

Pezizales J. Schröt**.**

Morchellaceae Rchb

1. *Morchella esculenta* (L.) Pers.

Sivas, Yıldızeli, Demirözü Village, forest area, 40°11'30.0"N-36°51'18.3"E, 1505 m, 06.06.2020, YILDIZ 35. Edible.

Pezizaceae Dumort**.**

2. *Legaliana badia* (Pers.) Van Vooren

Sivas, Yıldızeli, Yusufoğlan Village, forest area, 40°07'57.5"K-36°54'57.5"D, 2033 m, 27.06.2020, YILDIZ 56. Poisonous when eaten raw, edible when cooked.

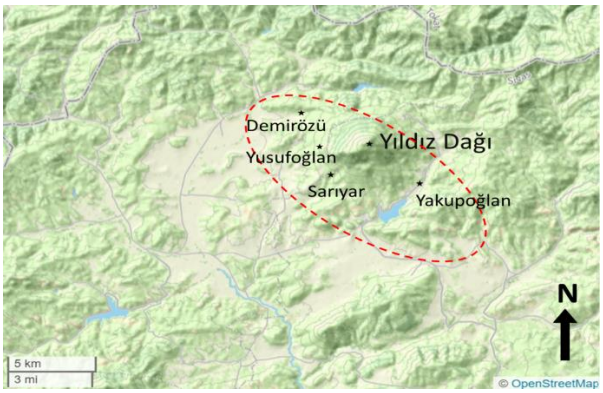


Figure 1. Map of the research area (modified from Google Earth)

3. *Peziza cerea* Sowerby

Sivas, Yıldızeli, Yusufoğlan Village, forest area, 40°07'58.5"N-36°55'30.1"E, 1966 m, 02.06.2019, YILDIZ 13. Poisonous.

4. *Sarcosphaera coronaria* (Jacq.) J. Schröt.

Sivas, Yıldızeli, Demirözü Village, forest area, 40°11'30.9"N-36°51'17.6"E, 1500 m, 06.06.2020, YILDIZ 27. Poisonous.

Basidiomycota R.T. Moore

Agaricales Underw.

Agaricaceae Chevall**.**

5. *Agaricus bernardii* Quél.

Sivas, Central district, Yakupoğlan Village, among grass in forest, 40°09'08.1"N-36°53'48.2"E, 1421 m, 06.06.2020, YILDIZ 25. Edible.

6. *Agaricus bisporus* (J.E. Lange) Imbach

Sivas, Central district, Yıldız Town, among grass, 40°03'53.2"N-36°54'38.6"E, 1.454 m, 05.05.2019, YILDIZ 2, Edible. Sivas-Central-Yıldızdağı ski facilities, green area, 40°08'04.2"N-36°56'25.2"E, 1736 m, 10.05.2019, YILDIZ 7. Edible.

7. *Agaricus campestris* L.

Sivas, Yıldızeli, Sarıyar Village, green area, 40°07'45.8"N-36°53'28.9"E, 1819 m, 05.05.2019, YILDIZ 1; Sivas-Central-Yıldızdağı, ski facilities, grass land, 40°08'20.6"N-36°56'29.7"E, 1701 m, 24.06.2020, YILDIZ 47. Edible.

8. *Agaricus xanthodermus* Genev.

Sivas, Yıldızdağı ski facilities, among grass in forest, 40°08'10.9"N-36°56'43.3"E, 1674 m, 06.06.2020, YILDIZ 26. Poisonous.

9. *Coprinus comatus* (O.F. Müll.) Pers.

Sivas, Central district, Yakupoğlan Village, grass land, 40°06'24.5"N-36°57'18.0"E, 1527 m, 10.05.2020, YILDIZ 21, Edible. Sivas-Yıldızeli-Sarıyar Village, green area, 40°07'37.3"N-36°53'27.4"E, 1801 m, 31.05.2020, YILDIZ 23. Edible.

10. *Cyathus olla* (Batsch) Pers.

Sivas, Yıldızeli, Demirözü, forest area, 40°11'31.8"N-36°51'17.1"E, 1496 m, 06.06.2020, YILDIZ 28. Inedible.

Amanitaceae E.-J. Gilbert

11. *Amanita ceciliae* (Berk. & Broome) Bas

Sivas, Yıldızeli, Yusufoğlan Village, forest area, 40°08'50.8"K-36°54'40.8"D, 1753 m, 27.06.2020, YILDIZ 57. Poisonous.

12. *Amanita nivalis* Grev.

Sivas, Yıldızeli, Yusufoğlan Village, among grass, 4040°09'09.5"K-36°54'02.3"D, 1433 m, 27.06.2020, YILDIZ 61. Inedible.

13. *Amanita vaginata* (Bull.) Lam.

Sivas, Yıldızeli, Yusufoğlan Village, forest area, 40°09'07.7"K-36°53'53.2"D, 1432 m, 27.06.2020, YILDIZ 58. Edible

Inocybaceae Jülich

14. *Inocybe inodora* Velen.

Sivas, Yıldızeli, Sarıyar Village, grass land, 40°07'37.3"N-36°53'27.4"E, 1.801 m, 31.05.2020, YILDIZ 22. Poisonous.

Hygrophoraceae **Lotsy**

15. *Hygrocybe acutoconica* (Clem.) Singer

Sivas, Central district, Yıldızdağı, ski facilities, grassland, 40°08'04.7"N-36°56'25.3"E, 1734 m, 24.06.2020, YILDIZ 45, Inedible.

16. ***Hygrophorus eburneus*** (Bull.) Fr.

Sivas, Central district, Demirözü Village, forest area, 40°11'29.6"K-36°51'26.6"D, 1548 m, 27.06.2020, YILDIZ 59, Edible.

Lycoperdaceae Chevall.

17. *Bovista plumbea* Pers.

Sivas, Central district, Yıldızdağı, ski facilities, grass land, 40°08'20.6"N-36°56'29.7"E, 1701 m, 24.06.2020, YILDIZ 46, Edible.

18. *Bovistella utriformis* (Bull.) Demoulin & Rebriev

Sivas, Yıldızeli, Yusufoğlan Village, forest area, 40°08'01.6"N-36°55'23.6"E, 1974 m, 26.10.2019, YILDIZ 18, Edible.

19. *Lycoperdon perlatum* Pers.

Sivas, Yıldızeli, Demirözü Village, forest area, 40°11'30.9"N-36°51'16.1"E, 1493 m, 24.06.2020, YILDIZ 44, Edible.

Marasmiaceae Roze ex Kühner

20. *Marasmius oreades* (Bolton) Fr.

Sivas, Yıldızeli, Demirözü Village, forest area, 40°11'32.4"N-36°51'20.7"E, 1509 m, 06.06.2020, YILDIZ 34, Edible.

Mycenaceae Overeem

21. *Mycena crocata* (Schrad.) P. Kumm.

Sivas, Yıldızeli, Demirözü Village, forest area, 40°11'30.9"N-36°51'16.1"E, 1493 m, 26.10.2019, YILDIZ 20, Edible.

22. ***Mycena leptocephala*** (Pers.) Gillet

Sivas, Yıldızeli, Demirözü Village, forest area, 40°11'30.0"N-36°51'18.3"E, 1505 m, 06.06.2020, YILDIZ 19, Inedible.

23. ***Mycena pura*** (Pers.) P. Kumm.

Sivas, Yıldızeli, Demirözü Village, forest area, 40°11'32.7"N-36°51'16.3"E, 1490 m, 06.06.2020, YILDIZ 29, Poisonous.

24. ***Mycena renati*** Quél.

Sivas, Yıldızeli, Demirözü Village, forest area, 40°11'32.7"N-36°51'16.3"E, 1490 m. 06.06.2020, YILDIZ 31, Inedible.

25. ***Mycena rosea*** Gramberg

Sivas, Yıldızeli, Demirözü Village, forest area, 40°11'30.0"N-36°51'18.3"E, 1505 m, 06.06.2020, YILDIZ 30. Inedible.

Pleurotaceae Kühner

26. ***Pleurotus eryngii*** (DC.) Quél.

Sivas, Yıldızeli, Yusufoğlan Village, forest area, 40°08'09.0"K-36°55'29.7"D, 1885 m, 27.06.2020, YILDIZ 62. Edible.

Physalacriaceae Corner

27. ***Hymenopellis radicata*** (Relhan) R.H. Petersen

Sivas, Yıldızeli, Yusufoğlan Village, forest area, 40°08'03.5"K-36°55'14.1"D, 1980 m, 27.06.2020, YILDIZ 60. Edible.

Psathyrellaceae Vilgalys, Moncalvo & Redhead

28. ***Coprinellus micaceus*** (Bull.) Vilgalys, Hopple & Jacq. Johnson

Sivas, Central district, Yakupoğlan, around decaying stump, 40°08'10.2"N-36°56'56.8"E, 1653 m, 02.06.2019, YILDIZ 9. Inedible.

29. ***Coprinopsis atramentaria*** (Bull.) Redhead, Vilgalys & Moncalvo

Sivas, Central district, Yıldız Town, around decaying stump, 40°05'10.8"N 36°55'27.2"E, 1502 m, 27.06.2020, YILDIZ 65. Poisonous.

30. ***Coprinopsis nivea*** (Pers.) Redhead, Vilgalys & Moncalvo

Sivas, Central district, Yıldız Town, on cow dung, 40°04'56.9"N-36°54'44.6"E, 1.532 m, 02.06.2019, YILDIZ 8. Inedible.

31. ***Candolleomyces candolleanus*** (Fr.) D. Wächt. & A. Melzer

Sivas, Central district, Yakupoğlan Village, among grass, 40°08'08.5"N-36°57'02.3"E, 1661 m, 26.10.2019, YILDIZ 17. Inedible.

Schizophyllaceae Quél.

32. ***Schizophyllum commune*** Fr.

Sivas, Merkez, Demirözü Village, forest area, 40°11'39.2"K-36°51'12.5"D, 1453 m, 27.06.2020, YILDIZ 63. Inedible.

Galeropsidaceae Singer

33. ***Panaeolus papilionaceus*** (Bull.) Quél.

Sivas, Yıldızeli, Yusufoğlan Village, among grass, 40°07'59.7"N-36°55'32.6"E, 1947 m, 02.06.2019, YILDIZ 12. Poisonous.

Strophariaceae Singer & A.H. Sm.

34. ***Protostropharia semiglobata*** (Batsch) Redhead

Sivas, Central district, Yakupoğlan Village, among grass, 40°08'04.4"N-36°57'08.2"E, 1649 m, 06.06.2020, YILDIZ 24. Inedible.

Hymenogastraceae Vittad.

35. ***Psilocybe coronilla*** (Bull.) Noordel.

Sivas, Yıldızeli, Yusufoğlan Village, among grass, 40°08'02.7"N-36°55'20.4"E, 1971 m, 24.06.2020, YILDIZ 41. Inedible.

Tricholomataceae R. Heim ex Pouzar

36. ***Atractosporocybe inornata*** (Sowerby) P. Alvarado, G. Moreno & Vizzini

Sivas, Yıldızeli, Yusufoğlan Village, forest area, 40°08'04.0"N-36°55'16.8"E, 1965 m, 24.06.2020, YILDIZ 43. Inedible.

Omphalotaceae Bresinsky

37. ***Gymnopus dryophilus*** (Bull.) Murrill

Sivas, Yıldızeli, Yusufoğlan Village, in mixed forest, 40°08'04.7"N-36°55'14.8"E, 1963 m, 24.06.2020, YILDIZ 42. Edible.

38. ***Infundibulicybe gibba*** (Pers.) Harmaja

Sivas, Yıldızeli, Sarıyar Village, among grass in forest, 40°07'37.6"K-36°52'28.7"D, 1506 m, 27.06.2020, YILDIZ 55. Edible.

39. ***Lepista irina*** (Fr.) H.E. Bigelow

Sivas, Central district, Yakupoğlan Village, among grass, 40°08'10.4"N-36°56'42.2"E, 1679 m, 05.05.2019, YILDIZ 3. Edible.

40. ***Lepista nuda*** (Bull.) Cooke

Sivas, Yıldızeli, Yusufoğlan Village, forest area, 40°08'04.0"N-36°55'13.8"E, 1974 m, 24.06.2020, YILDIZ 40. Edible.

41. ***Melanoleuca polioleuca*** (Fr.) Kühner & Maire

Sivas, Yıldızeli, Sarıyar Village, green area, 40°07'43.5"N-36°53'28.0"E, 1816 m, 06.06.2020, YILDIZ 38. Edible.

Physalacriaceae Corner

42. ***Strobilurus tenacellus*** (Pers.) Singer

Sivas, Yıldızeli, Demirözü Village, forest area, 40°11'32.4"N-36°51'20.7"E, 1509 m, 06.06.2020, YILDIZ 36. Inedible.

Boletales E.-J. Gilbert

Boletaceae Chevall.

43. *Leccinum versipelle* (Fr. & Hök) Snell

Sivas, Central district, Yakupğlan Village, wooded area, 40°08'10.3"N-36°57'03.6"E, 1649 m, 24.06.2020, YILDIZ 49. Edible.

44. *Xerocomellus chrysenteron* (Bull.) Šutara

Sivas, Central district, Yakupoğlan Village, grassland, 40°08'13.9"N-36°56'45.8"E, 1662 m, 24.06.2020, YILDIZ 48. Edible.

Gomphidiaceae Maire ex Jülich

45. *Chroogomphus rutilus* (Schaeff.) O.K. Mill.

Sivas, Central district, Yakupoğlan Village, green area, 40°08' 15.2"N-36°56'52.3"E, 1634 m, 26.10.2019, YILDIZ 15. Edible.

Paxillaceae Lotsy

46. *Paxillus involutus* (Batsch) Fr.

Sivas, Yıldızeli, Sarıyar Village, grass land, 40°07'45.8"N-36°53'28.9"E, 1815 m, 24.06.2020, YILDIZ 39. Poisonous.

Rhizopogonaceae Gäum. & C.W. Dodge

47. *Rhizopogon luteolus* Fr.

Sivas, Central district, Yıldızdağı ski facilities, grassland, 40°08'21.7"N-36°56'27.3"E, 1705 m, 29.06.2019, YILDIZ 14. Edible.

Suillaceae (Singer) Besl & Bresinsky

48. *Suillus granulatus* (L.) Roussel

Sivas, Yıldız Mountain ski resort facilities, forest area, 40°08'04.2"N-36°56'25.2"E, 1736 m, 10.05.2019, YILDIZ 5. Edible.

49. *Suillus luteus* (L.) Roussel

Sivas, Yıldız Mountain ski resort facilities, grassland, 40°08'07.8"N-36°56'30.8"E, 1715 m, 10.05.2019, YILDIZ 4, Edible.

Geastrales K. Hosaka & Castellano

Geastraceae Corda

50. *Geastrum coronatum* Pers.

Sivas, Yıldız Mountain ski resort facilities, forest area, 40°08'20.2"N-36°56'26.9"E, 1713 m, 10.05.2019, YILDIZ 6. Inedible.

***Polyporales* Gäum.**

Panaceae Miettinen, Justo & Hibbett

51. *Panus conchatus* (Bull.) Fr.

Sivas, Yıldızeli, Yusufoğlan Village, around decaying stump, 40°07'59.7"N-36°55'32.6"E, 1947 m, 02.06.2019, YILDIZ 11. Inedible.

Polyporaceae Fr. ex Corda

52. *Fomes fomentarius* (L.) Fr.

Sivas, Yıldızeli, Yusufoğlan, forest area, 40°08'00.3"N-36°55'31.9"E, 1945 m, 02.06.2019, YILDIZ 10. Inedible.

53. *Polyporus brumalis* (Pers.) Fr.

Sivas, Yıldızeli, Demirözü, forest area, 40°11'31.6"N-36°51'15.8"E, 1494 m, 06.06.2020, YILDIZ 32. Inedible.

54. *Polyporus dictyopus* Mont.

Sivas, Yıldızeli, Demirözü Village, forest area, 40°11'31.7"N-36°51'16.7"E, 1497 m, 06.06.2020, YILDIZ 33. Inedible.

55. *Trametes versicolor* (L.) Lloyd

Sivas, Yıldızeli, Demirözü Village, forest area, 40°11'31.3"N-36°51'15.6"E, 1493 m, 06.06.2020, YILDIZ 37. Inedible.

Auriscalpiaceae Maas Geest.

56. *Auriscalpium vulgare* Gray

Sivas, Central district, Yakupoğlan Village, grassland, 40°08'11.0"K-36°56'51.5"D, 1661 m, 26.10.2019, YILDIZ 16. Inedible.

Russulales Kreisel ex P.M. Kirk, P.F. Cannon & J.C. David

Russulaceae Lotsy

57. *Lactarius acerrimus* Britzelm.

Sivas-Merkez-Yakupoğlan Village, among leaf litter in forest, 40°08'10.7"N 36°57'03.5"E, 1643 m, 27.06.2020, YILDIZ 54. Inedible.

58. *Lactarius blennius* (Fr.) Fr.

Sivas, Central district, Yakupoğlan Village, forest area, 40°08'13.5"K-36°57'01.5"D, 1622 m, 27.06.2020, YILDIZ 64. Inedible.

59. *Russula aurea* Pers.

Sivas, Central district, Yıldız Village, forest area, 40°03'50.3"K-36°54'35.7"D, 1452 m, 24.06.2020, YILDIZ 52. Edible.

60. *Russula brunneoviolacea* Crawshay

Sivas, Merkez, Demirözü Village, forest area, 40°11'34.5"K- 36°51'18.8"D, 1498 m, 27.06.2020, YILDIZ 68. Edible.

61. *Russula roseipes* Secr. ex Bres.

Sivas, Central district, Yakupoğlan Village, forest area, 40°08'08.4"K-36°57'02.0"D, 1661 m, 24.06.2020, YILDIZ 50. Inedible.

Stereaceae Pilát

62. *Stereum hirsutum* (Willd.) Pers.

Sivas, Central district, Yakupoğlan Village, forest area, 40°08'07.4"K-36°57'04.2"D, 1661 m, 24.06.2020, YILDIZ 51. Inedible

4. Discussions

As a result of the field and laboratory studies, 62 taxa belonging to 2 divisions, 26 families and 46 genera were identified. 4 (6%) taxa belonged to Ascomycota, and the remaining 58 (94%) taxa belonged to *Basidiomycota* divisions (Figure 2). Of the 62 taxa determined in the study

area, 28 (45.16%) were edible, 26 were inedible (41.94%), and 8 were poisonous (12.90%).

The most represented families are the *Tricholomataceae* family 7 species, *Agaricaceae* family 6 species, *Mycenaceae*, *Psathyrellaceae* and *Russulaceae* families 5 species, *Polyporaceae* family 4 species, *Pezizaceae*, *Amanitaceae* and *Lycoperdaceae* families 3 species and *Suillaceae, Boletaceae Strophariaceae, Pezizaceae* families with 2 species. The distribution of macrofungus taxa detected in the research region according to families is given in Figure 3.

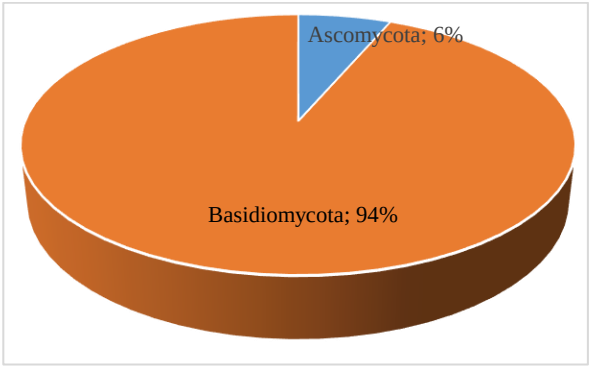
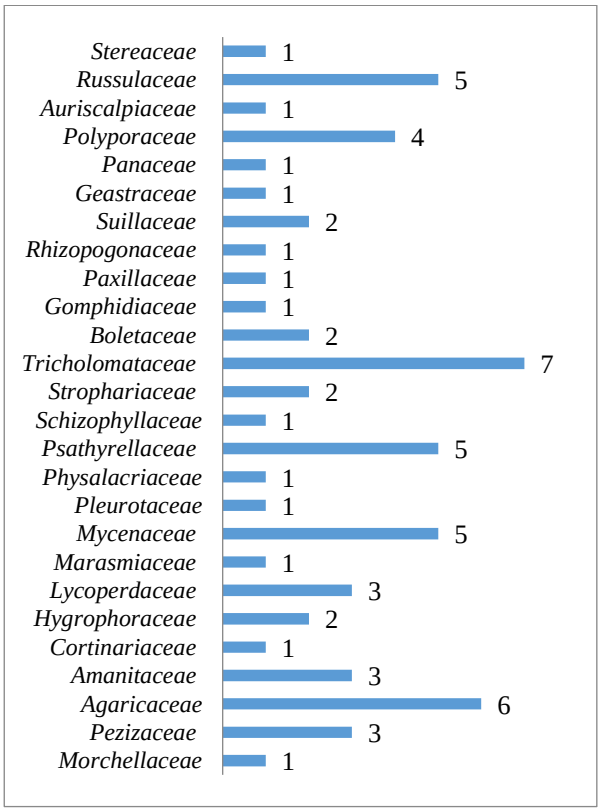


Figure 2. Distribution of identified taxa according to sections



The results obtained in this study are showed similarities when compared with studies conducted in neighboring regions. These studies and the similarity percentages are given in Table 1. According to this, the highest similarity percentage was found 33.3% in the study conducted by Türkekul and Zülfikaroğlu (2010) in Çamlıbel (Tokat) district. Also the lowest similarity percentage was found 7.35% in the study conducted by Hüseyinov et al. (2001) (Sivas) district. The similarity percentages with other studies in neighboring regions were 26.8% (Kırış et al., 2012) Gemerek (Sivas), 28.8% (Türkekul, 2003) Tokat respectively.

Conflict of Interest

Authors have declared no conflict of interest.

Authors' Contributions

The authors contributed equally.

Table 1. Comparison of studies carried out in Yıldız mountain and nearby areas

Neighbouring study	Working area	# of identical taxa	Total taxa	Similarity percentae (%)
Hüseyinov (2001)	Sivas	5	68	7.35
Türkekul (2003)	Tokat	17	59	28.81
Türkekul and Zülfikaroğlu (2010)	Çamlıbel (Tokat)	17	51	33.33
Kırış et al. (2012)	Gemerek (Sivas)	11	41	26.82

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Use of humic substance and GA3 in *Agaricus bisporus* cultivation

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Agaricus bisporus yetiştiriciliğinde humik madde ve GA3 kullanımı

Abstract: In this study, the effects of commercially used gibberellic acid and humic acid, known as plant growth regulators, on mushroom yield were investigated. At the end, the positive effect of both humic substance and gibberellic acid (GA3) which were added to the irrigation water was determined. The highest efficiency was obtained from the trials in which 0.75% and 1% solutions of both substances were used, on average. According to these results, humic substance or gibberellic acid addition to the post-harvest maintenance water in *Agaricus bisporus* cultivation positively affects the harvest amount.

Key words: *Agaricus bisporus*, cultivated mushrooms, humic, GA3

Özet: Bu çalışmada bitki gelişim düzenleyicisi olarak bilinen ve ticari olarak kullanılan Giberelik asit(GA3) ve humik asitin mantar verimine etkisi araştırılmıştır. Çalışma sonunda sulama suyuna ilave edilen hem humik madde hem de giberelik asit ilavelerinin olumlu etkisi tespit edilmiştir. En yüksek verim her iki maddenin %0.75 ve %1'lik çözeltilerinin kullanıldığı denemelerden elde edilmiştir. Bu sonuçlara göre *Agaricus bisporus* yetiştiriciliğinde hasat sonrası bakım suyuna humik madde veya giberelik asit ilave edilmesi hasat miktarını olumlu yönde etkilemektedir.

Anahtar Kelimeler: *Agaricus bisporus*, kültür mantarları, humik, GA3

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1. Introduction

Mushroom cultivation around the world has developed very rapidly with the use of advanced technologies. Especially *Agaricus bisporus* (J.E. Lange) Imbach, and among *Pleurotus* species *P. ostreatus* (Jacq.) P. Kumm., and including the other mushroom species production rates have increased significantly. As humanity's nutritional needs increase, it is expected result that cultivated mushroom species will also increase due to the search for various foods due to the increase in population. From this perspective, serious progress has been made in the production studies of many macrofungi around the world. It has recently been known that more than 20 macrofungi have been cultured at different levels. Today, the most produced mushroom in the world is the *Agaricus bisporus* species, known as the button mushroom. Parallel to this, the situation is in the same direction in our country. Therefore, some studies have been carried out on champion mushrooms in terms of different substrates, earliness, and yield. Some of these have been reduced to the application field by manufacturers, while others remain in the article lines.

Significant developments have been observed in cultivated mushroom production in Türkiye in recent years, and the production amount reached 65.000 tons as of the end of 2018 (Eren and Pekşen, 2019). There are regional development differences in terms of cultivated mushrooms in Türkiye. This difference is evident between some regions. The Mediterranean Region leads in production (61.5%) and the Marmara Region leads in consumption (40%) (Eren and Pekşen, 2016). However, it is also known that natural mushrooms are used for export rather than cultivated mushrooms in economic terms and are an important source of foreign exchange income (Öztürk et al., 2019).

Different studies have been carried out related to the compost structure (Kaşık and Öztürk, 2000; Baysal, 2004) and the cover material in the cultivation of *Agaricus bisporus* species (Duran et al. 2023; Eren and Boztok, 2013; Çetin and Eren, 2017; Gülser and Pekşen, 2003; Pekşen and Günay, 2009).

The effects of plant growth regulators on plants are evident. Both humic substances and gibberellic acid are used in different periods in plant production and are reported to be effective (Shunkla et al., 1987; Chen and Aviad, 1990; Madrap et al., 1992; Bohme and Thi Lua, 1997; Adani et al., 1998; Nardi et al., 1998; Sharif et al. 2002; Eyheraguibel et al., 2008; Aşık et al., 2009; Saruhan et al., 2011; Engin and Cöcen, 2013).

No study has been found in the literature regarding the administration of plant growth regulators with irrigation water in the cultivation of *Agaricus bisporus*, also known as Champion Mushroom (Sesli et al. 2020). The effects of applying these substances to the cover soil with irrigation water in different solution rates on mushroom culture were examined.

2. Materials and Method

In this study ready-planted compost, purchased from Mega Tesnim company, was used as material. Compost packages were placed in the incubation chamber and incubated at 22-

24 °C and 70-80% humidity to allow mycelia to develop in the compost. Mycelial development was monitored. Following the completion of wrapping the mycelia in compost, the disinfected cover soil prepared using peat was covered on the bags with a thickness of 3-4 cm, and the bags were placed in the production rooms.

The climatic conditions of the production rooms were adjusted to 16-18 °C and 80-90% humidity.

Plant growth regulators were applied in pulverized form to the mycelia that developed in the cover soil and reached the soil surface. Trial solutions were used to maintain soil moisture during primordium development (Fig. 1).

Figure 1. Developing primordiums and young basidiocarps

Gibberellic acid (GA3), known under the trade name Berelex, and humic acid, known under the trade name Humat 75, were used as plant growth regulators. A solution of 0.5, 0.75, and 1 g of plant growth regulators was prepared in 10 L of water. The prepared solution was applied to the mycelia visible on the soil surface and on the bag to prevent soil moisture loss. This solution was used as maintenance water during the harvest period. The amount of solution used was 5lt for each bag. The study was carried out with three replications and four bags were used in each trial. Conditions other than irrigation water were prepared in accordance with the methods applied within the scope of the standard mushroom cultivation process. Temperature, ambient humidity, and ventilation were controlled by automatic systems. The amount of product obtained from each bag during the harvest period was determined separately, and the total amount of product obtained from a bag during the harvest period was determined. The average values of each application were obtained by evaluating the amount of product obtained from the bags followed in each application. The harvest period was determined as 30 days in the trials.

The results obtained were evaluated statistically.

3. Results

In this study, the effects of humic acid and GA3, two plant growth regulators, were investigated and their effects on the harvest amount were examined by giving them as a solution in certain proportions to the maintenance water and cover soil in mushroom cultivation, and the results given in Table 1 were obtained. The results obtained from the experiments were evaluated statistically.

One-way ANOVA was performed to determine the statistical significance of the difference between the groups' averages. Since the p-value of the analysis was 0.859>0.05, the difference between the groups was found to be statistically insignificant. Large measurement variances and small sample sizes reduce the power of the ANOVA test. Considering this situation, the fact that the difference is statistically insignificant does not mean that there is no difference in efficiency. For example, the difference between the average yield of the control group and the average yield of humic acid and gibberellic acid at 0.75 and 1% rates is noteworthy. Although it was not statistically significant, it was observed that there was an increase in efficiency compared to the control group in all trial averages.

The change graphs of the yield amount obtained per bag in the control group and trials in the study are given in Figure 2.

4. Discussions

In this study, the effect of aqueous solutions of humic acid and gibberellic acid, two plant regulators, applied during mycelium development and primordium formation after soil cover, on the yield in the culture of *Agaricus bisporus* species, was examined. During the first appearence of the fungal hypha on the surface of the cover soil, pulverized irrigation was applied according to the moisture of the soil in the bags. Five liters of aqueous solution prepared with plant regulators was used for each bag. After the mushrooms reached to harvest size, the mushrooms were harvested from the bags and weighed. The data obtained data of the trials were evaluated and the yield amounts per bag were determined.

Table 1. Yield averages (g) and standard deviation values obtained in the study

Bags in trials	Control	Humic acid			Giberellic acid		
		0.5	0.75	1	0.5	0.75	1
1	4633.33	5221.25	5191.25	4607.50	4151.25	4928.75	5480.00
2	2586.66	2896.25	3661.25	3317.50	3236.25	3840.00	3365.00
3	3490.50	3612.50	3857.50	3851.25	2570.00	3642.50	3866.50
4	1815.55	2670.00	2718.75	3601.25	4306.25	3687.50	3103.25
General Average	3131.51	3600.00	3857.50	3844.38	3565.94	4024.69	3953.69
Standard deviation	1212.84	1153.07	1018.84	553.50	814.70	608.60	1065.68
Standard error	606.42	576.53	509.42	276.75	407.35	304.30	532.84

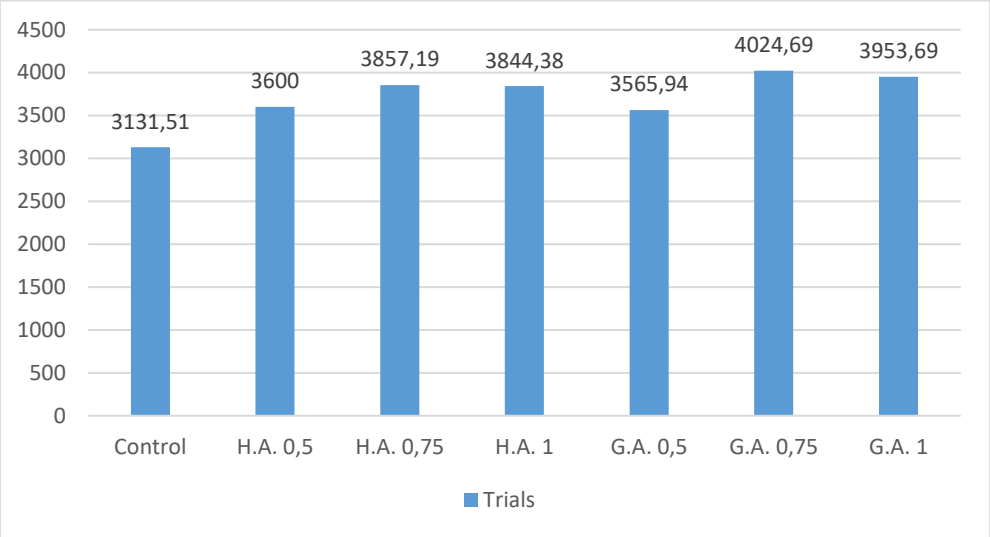

Figure 2. Yield averages (gr.) obtained in the trials

There is no data in the literature regarding the use of humic acid and gibberellic acid as irrigation water in mushroom cultivation. However, there are some studies on additives added to compost. In the study conducted by Kaşık and Öztürk (2000), the effects of some nutrients added to wheat straw synthetic compost on mycelial development, yield, and earliness of *Agaricus bisporus* were investigated. Corn meal, wheat feed meal, soybean meal, sunflower seed meal, and laying hen feed were used as additional nutrients. The highest yield was determined as 2900-2715 grams in the bags to which 250 grams and 350 grams of laying hen feed were added. As a result of the experiments, they stated that not only earliness was achieved in terms of mycelial development, but also an increase in yield was detected. In the study by Padem et al. (2003) on humic acid in *Agaricus bisporus* culture conducted, it was reported that the addition of humic acid to the cover soil consisting of organic wastes had a negative effect on the yield. The reason was shown to be the presence of humic substance as a natural decomposition material in organic wastes, which were investigated for the possibility of being used as cover soil and kept for about a year, and they concluded that no additional humic substance was required. It has been understood that the presence of a humic substance, which increases with the addition of humic acid, has a negative effect on fungal growth. In the study reported by Özdemir (2007), it was reported that the highest yield was obtained in the experiment in which *Agaricus bisporus* culture was added to the compost at the rate of 0.72 liters/ton, and low yield was observed at higher doses (Önay et al., 2018). Taş et al. (2021) stated in their cultural study that as a result of the processing of pistachios (*Pistacia vera* L.) grown in the Southeastern Anatolia region of our country, approximately 20.000 tons of outer shell (exocarp) emerge as agricultural industrial waste every year and that these wastes are an important source of environmental pollution. Since these wastes have various organic compounds, cultivated mushroom compost can be obtained by fermenting the waste shells, and they produce cultivated mushrooms by mixing different proportions of peanut shells into the compost. As a result of the study, the mushrooms grown were analyzed and evaluated. As a result of the evaluation, they determined that the application containing 25% fermented pistachio shells could be used in mushroom cultivation.

The evaluation of the findings of addition of HA and GA3 to irrigation water revealed that that the highest efficiency averages were obtained from the trials in which 0.75% and 1% aqueous solutions of both substances were applied. It can be concluded that the addition of humic matter and GA3 to irrigation water at certain rates during the primordium formation stage in the cover soil give positive results in terms of productivity in *Agaricus bisporus* cultivation. When applying humic acid and GA3, it should be taken into consideration that the structural composition of the cover soil may be important.

Conflict of Interest

Authors have declared no conflict of interest.

Authors' Contributions

The authors contributed equally.

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A new record of vibrisseaceous fungus from Hakkari (Türkiye)

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Hakkâri (Türkiye)'den yeni bir vibrisseaceous mantar kaydı

Abstract: This study involved specimens of the genus *Vibrissea* Fr. growing on submerged wood, rubbish or other submerged organic matter in freshwater habitats collected in Şemdinli (Hakkâri) on 01.05.2015. The *Vibrissea* specimens, characterised by small and delicate fructification organs in the form of cups or bowls, were identified based on morphological data. In this text, *Vibrissea decolorans* (Saut.) A. Sánchez & Korf is described and illustrated to be a new record for the *Ascomycota* of Türkiye. The text provides a brief description of the newly recorded genus including collection date, geographical coordinates, macro- and micromorphological characteristics.

Key words: *Ascomycota*, new record, *Vibrisseaceae*, Türkiye

Özet: Bu çalışma 01.05.2015 yılında Şemdinli'de (Hakkâri) toplanan tatlı su habitatlarında batık odun, çöp veya diğer batık organik maddeler üzerinde yetişen *Vibrissea* Fr. cinsinin örneklerini kapsamaktadır. Fincan veya çanak şeklinde küçük ve narin fruktifikasyon organları ile karakterize edilen *Vibrissea* örneği morfolojik verilere dayanılarak teşhis edilmiştir. Bu metinde, *Vibrissea decolorans* (Saut.) A. Sánchez & Korf'un Türkiye'deki *Ascomycota* üyeleri için yeni bir kayıt olduğu belirtilmiş ve gösterilmiştir. Metin yeni kaydedilen taksonun toplanma tarihi, coğrafi koordinatları, makro ve mikromorfolojik özelliklerini içeren kısa bir betimini sunmaktadır.

Anahtar Kelimeler: *Ascomycota*, yeni kayıt, *Vibrisseaceae*, Türkiye

Citation: Acar İ, Uzun Y (2024). A new record of vibrisseaceous fungus from Hakkari (Türkiye). Anatolian Journal of Botany 8(2): 138-141.

1. Introduction

Leotiomycetes (*Pezizomycotina*), formed by the division of the superclass *Leotiomyceta* into seven classes, is a very diverse class (Eriksson and Winka, 1997). Although *Leotiomycetes* consists of 13 orders, eight of which are monotypic, more than 200 genera are represented by a single species (Baral, 2016; Wijayawardene et al., 2018; Ekanayaka et al., 2019; Johnston et al., 2019; Karunarathna et al., 2020). *Helotiales*, which is among the orders of *Leotiomycetes*, contains the highest number of genera many of which are not assigned in a family (approximately 90-151) (Quijada et al., 2018; Wijayawardene et al., 2018; Karunarathna et al., 2020). *Helotiales*, a polyphyletic order, is estimated to have more than 70,000 species and is currently represented by only 2.334 species belonging to 423 genera in 25 families, accounting for half of all known species in *Leotiomycetes* (Ekanayaka et al., 2019; Karunarathna et al., 2020). The family *Vibrisseaceae* within the *Helotiales* was organised by Korf in 1990 to include the genera *Vibrissea* Fr., *Chlorovibrissea* L.M. Kohn and *Leucovibrissea* (A. Sánchez) Korf.

Species belonging to the family *Vibrisseaceae* are usually aquatic or wet soil dwellers, with sessile or long-stalked apothecia which are disc-shaped, and whitish, yellowish, brownish, olive or blackish-green in colour. Also they have an ectal excipulum of textura globosa, textura angularis to textura prismatica and characteristic filiform ascospores. The three genera *Vibrissea*, *Chlorovibrissea* and *Leucovibrissea*, can be distinguished by the colour of the apothecia, the structure of the ectal excipulum and the apparatus of the ascal apex. Besides these three genera, *Acephala* Grünig & T.N. Sieber and *Phialocephala* W.B. Kendr. have also been included in this family in recent studies. Currently, the family contains 78 species, of which 2 are classified in *Acephala*, 6 in *Chlorovibrissea* 1 in *Leucovibrissea*, 33 in *Phialocephala* and 36 in *Vibrissea* (Korf, 1990; Sandoval-Leiva et al., 2014; Zheng and Zhuang 2017).

Previously published studies related to macrofungi of Türkiye (Akata et al., 2016; Uzun et al., 2017; Sesli et al., 2020; Acar 2023; Acar and Dizkırıcı, 2023; Akçay et al., 2023; Şahin et al., 2023; Uzun and Kaya, 2023a,b) indicates that only two members of vibrisseaceous fungi have been reported. In this study, *Vibrissea decolorans* (Saut.) A. Sánchez & Korf, is reported as a new record for Türkiye based on morphological data, as the third member of the vibrisseaceous species,.

2. Materials and Method

In 2015, fresh samples of *Vibrissea* were collected from the Şemdinli district of Hakkâri province. The specimens underwent meticulous examination. First they were photographed at their natural habitats, then transported to the laboratory, where they were subjected to macroscopic analysis following the methodologies outlined by Sánchez

and Korf (1966), Sanchez (1967), and Korf (1990). Morphological characteristics were meticulously documented, with specimens deposited in both the Fungarium of Van Yüzüncü Yıl University (VANF) and the author's collection for future reference. Micromorphological investigations were conducted on dried specimens, by rehydrating with distilled water, and carried out under a Leica DM500 (Germany) research microscope, equipped with an oil immersion lense. Thin sections from various parts of the basidiomata were manually prepared for further examination. A minimum of 20 measurements were performed for both basidiospores and basidia using the Leica Application Suite (version 3.4.0). Illustrations accompanying the manuscript were crafted using CorelDRAW (64-bit) (Canada), ensuring accuracy and clarity in depicting the observed characteristics of *Vibrissea*.

3. Results

Ascomycota Caval.-Sm.

Leotiomycetes O.E. Erikss. & Winka

Helotiales Nannf.

Vibrisseaceae Korf

Vibrissea Fr.

Vibrissea decolorans (Saut.) A. Sánchez & Korf . (Figure 1-3).

Syn: [*Apostemidium decolorans* Boud., *Belonopsis decolorans* (Saut.) Rehm, *Gorgoniceps decolorans* (Saut.) Sacc., *Helotium decolorans* Saut., *Peziza decolorans* Saut.].

Ascocarp 1-3.5 mm in diameter and sessile. **Disc** bluish grey or yellow, rarely dark or orange, the lower part brown or dark brown. **Asci** 270-370 × 7-9 µm and ascus stalk 10-25 µm long. **Ascospores** (180)250-350 × 1-2.3 µm, seems to be combined in the ascus if not looked at on closer inspection. **Paraphyses** identical, rarely one or two branched, clavate or slightly enlarged at apex.

Vibrissea decolorans is reported to grows on decaying branches of *Carpinus* L., *Rubus* L., *Prunus* L. spp., and similar trees (Sanchez, 1967).

Figure 1. Ascomata of *Vibrissea decolorans*

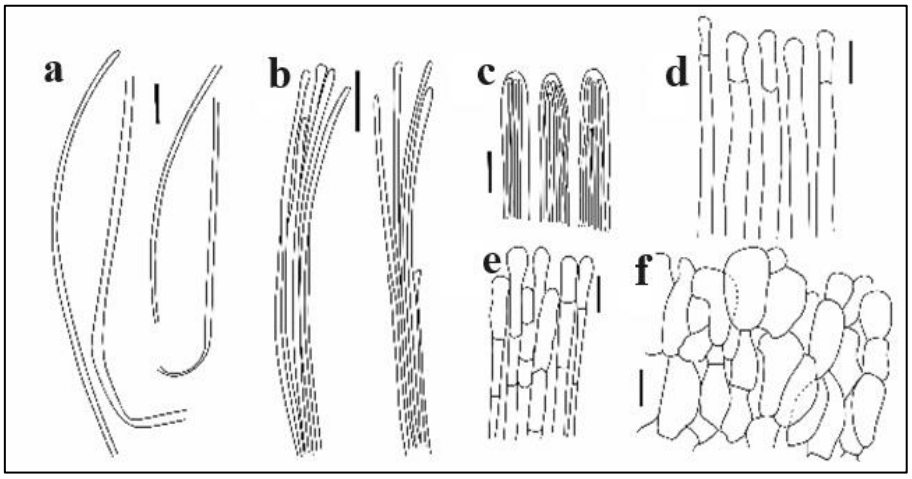

Figure 2. Ascospores particles (a), shattered asci (b), asci apex (c), asci base (d), paraphyses (e) and ectal excipulum of *Vibressea decolorans* (Scale bars: 10 µm)

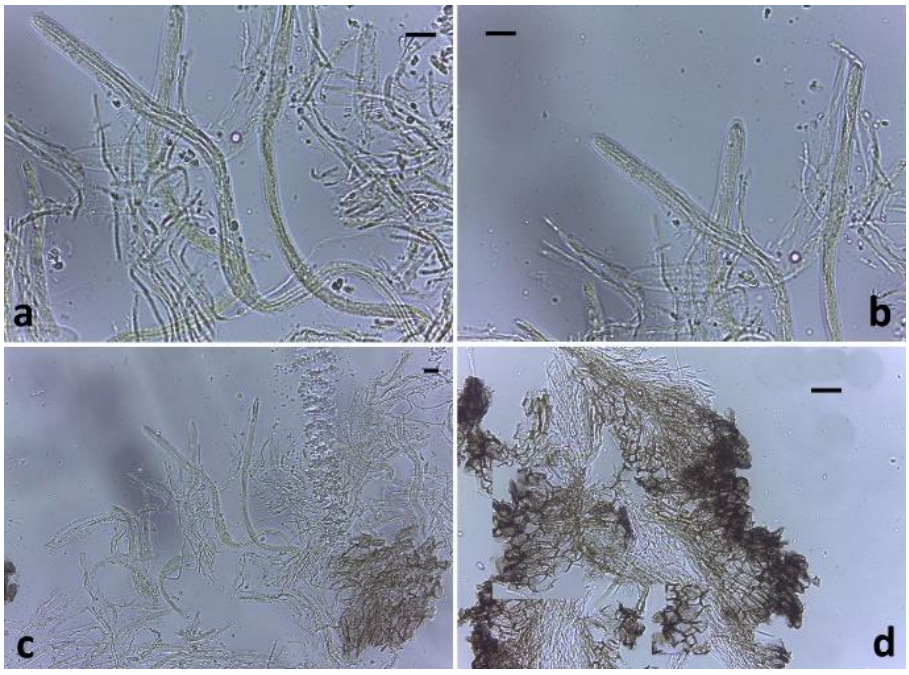

Figure 3. Asci, parphyses and ascospores (a-c) and ectal excipulum of *Vibressea decolorans* (Scale bars: 10 µm)

Specimen examined: Şemdinli, near Şabatan Passage, on decayingbrances of *Salix* L. sp., 37°21'687"N-44°32'461"E, 1723 m, 01.05.2015, Acar 927.

Suggested Turkish name for the presented species is "Renk değiştiren titreşimli mantar".

4. Discussions

The main distinguishing fueatures between the three genera of the family *Vibrisseaceae* are the colour of the apothecia and the structure of the ectal excipulum (Sandoval-Leiva et al., 2014; Zheng and Zhuang, 2017). The excipular cells of *Vibrissea*, the subject of our study, are more or less spherical and angular. They ayer mostly rectangular in the genera *Chlorovibrissea* and *Leucovibrissea* (Zheng and Zhuang, 2017).

Vibrissea decolorans is morphologically similar to *V. pezizoides*. However, *V. pezizoides* differs from *V. decolorans* in that the apothecia having a stalk-like base, the asci having long sterile stalks 50 to 70 µm, not bluished ascal acpical pore in iodine and the ascospores that are flat and dispersed in the ascus (Sanchez, 1967).

The most important noticeable difference between our sample and *Vibrissea flavovirens*, which has been previously published in Türkiye, is that *V. flavovirens* has a stalk (0.2-0.3 mm) and the length of ascospores is smaller (160-180 × 1.5-2 µm) (Akata et al., 2016). Another published species, *Vibrissea filisporia*, differs from our species in having shorter apothecium (0.4–1.5 mm), ascus (185–200 × 6–7 µm) and ascospores (150–185 × 1–1.5 µm) (Uzun et al., 2017).

In conclusion, *Vibressea decolorans* has been added as new record for to the mycobiota of Türkiye, as the third member vibrisseous fungi.

Conflict of interest

Authors have declared no conflict of interest.

Authors' contributions

The authors contributed equally.

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The pomological characteristics and values for public health of *Crataegus tanacetifolia*

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*Crataegus tanacetifolia'*nın pomolojik özellikleri ve halk sağlığı açısından önemi

Abstract: This study aimed to determine the pomological characteristics and allometric relationships of *Crataegus tanacetifolia*, an endemic plant species in Türkiye, as well as to assess its significance for public health. Fruit samples collected from its natural habitat were subjected (Mihalıççık district of Eskişehir province, 1330-1350m) to pomological measurements. Subsequently, pomological characteristics were correlated with allometric relationships. The following pomological parameters were observed for *Crataegus tanacetifolia*: fruit length was 15.30±1.70mm, width was 19.51±2.30mm, thickness was 18.85±2.30mm, weight was 3.34±0.99g, flesh weight was 2.73±0.901g, arithmetic mean diameter was 17.89±2.04mm, geometric mean diameter was 17.78±2.02mm, sphericity index was 116.26±4.79%, surface area was 1005.55±223.28mm^2, appearance ratio was 0.79±0.05, seed ratio was 0.19±0.04, peduncle length was 3.26±0.24mm, flesh hardness was 14.02±1.61kg/cm^2, and fruit color (L*a*b) was 71.54±0.92*9.34±1.82*60.62±3.11. The fruit color ranged from light yellow to light pink, with green being the dominant color in unripe fruits. The seed length was 7.20±0.51 mm, width was 4.14±0.37mm, thickness was 5.42±0.43mm, weight was 0.12±0.02g, volume was 53.73±8.48mm^3, and surface area was 80.09±9.29. There was a high relationship between fruit surface area and allometric relationships, with R^2=0.9603 and R^2=0.8729 confidence interval. The allometric relationships between seed ratio and fruit sizes were in the range of R^2=0.3984 and R^2=0.5045. In this study, it was determined that *Crataegus tanacetifolia* is important for public health, its fruits are used as food.

Key words: *Crataegus tanacetifolia*, public health, pomology, hawthorn, biological diversity

Özet: Bu çalışma ile Türkiye'nin endemik bitkilerinden olan *Crataegus tanacetifolia*'nın pomolojik özellikleri ile allometrik ilişkileri ve bu türün halk sağlığı açısından öneminin belirlemesi amaçlanmıştır. Çalışmada *Crataegus tanacetifolia* 'nın doğal yayılış alanından toplanan meyve örnekleri üzerinde pomolojik ölçümler yapılmıştır. Daha sonra meyve pomolojik özellikler ile allometrik ilişkiler belirlenmeye çalışılmıştır. *Crataegus tanacetifolia*'nın; meyve uzunluğu 15,3±1,70 mm, genişliği19,5±2,30mm, kalınlığı 18,85±2,30mm, ağırlığı 3,34±0,99g, meyve etli kısım ağırlığı 2,73±0,901g, meyve aritmetik ortalama çapı 17,89±2,04mm, meyve geometrik ortalama çapı 17,78±2,02mm, meyve küresellik indeksi 116,26±4,79%, meyve yüzey alanı 1005,55±223,28mm^2, meyve görünüş oranı 0,79±0,05, meyve çekirdek oranı 0,19±0,04, meyve sapı 3,26±0,24mm, meyve eti sertliği 14,02±1,61 kg/cm^2 ve meyve rengi (L*a*b) 71,54±0,92*9,34±1,82*60,62±3,11 olduğu bulunmuştur. Meyve rengi açık sarıdan açık pembeye kadar değişim göstermekte ve olgunlaşmamış meyvelerde baskın renk yeşildir. Çekirdek uzunluğu 7,20±0,51mm, genişliği 4,14±0,37mm, kalınlığı 5,42±0,43mm, ağırlığı 0,12±0,02g, hacmi 53,73±8,48mm^3 ve çekirdek yüzey alanı 80,09±9,29 bulunmuştur. Meyve yüzey alanı ile meyve allometrik ilişkileri R^2=0,9603 ve R^2=0,8729 güven aralığında tanımlanan yüksek bir ilişki vardır. Meyve çekirdek oranı ve meyve boyutları arasındaki allometrik ilişkiler R^2=0,3984 ve R^2=0,5045 aralığındadır. Bu çalışmada *Crataegus* tanacetifolia'nın halk sağlığı açısından önemli olduğu, meyvelerinin gıda olarak tüketildiği belirlenmiştir.

Anahtar Kelimeler: *Crataegus tanacetifolia,* halk sağlığı, pomoloji, alıç, biyolojik çeşitlilik

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1. Introduction

The public health approach is perceived as the "science and art of disease prevention" rather than just treating diseases. Efforts that facilitate life and the prolong lifespan, enhancing the overall quality of life through the collaborative efforts of various organizations, communities, and individuals can all be considered within the scope of public health. The use of plants in solving humanity's fundamental problem of health is as ancient as human history itself. The World Health Organization defines health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." Services aiming to protect individuals before diseases occur can be divided into two main categories: environmental and individual preventive health services (Tözün and Sözmen, 2015). Public health not only protects individuals from potential illnesses but also covers the

protection of the environment in its entirety. In an environment where biological diversity is disrupted, it is not possible for humans to remain healthy. In this context, *Crataegus tanacetifolia* (Lam.) Pers., an endemic species, is not only characterized by its food and ethnobotanical properties but also serves as a significant element in biological diversity.

Various species of the genus *Crataegus* L. are sold in pharmacies, herbal shops, and markets as herbal products, food, and herbal medicine. A significant portion of these products is collected from nature. In many countries, species of the *Crataegus* genus, including their flowers, leaves, and fruits, are used as antispasmodic, cardiotonic, hypotensive, and antiatherosclerotic agents within complementary medicine (Edwards et al., 2012). In Türkiye, various species of *Crataegus* spp. are primarily used by local communities for conditions such as cardiovascular diseases, hypertension, sedation, shortness of breath, asthma, and insomnia; its fruits are consumed as food, and the juice prepared from the fruit is also considered as an analgesic (Yücel and Yücel, 2020). Flavonoids and proanthocyanidins are the main components responsible for observed biological activities (Çalişkan et al., 2012). Extracts obtained from genotypes of this genus increase the activation of cardiac muscle cells, regulate blood flow, and have a positive inotropic effect (Yusuf and Meriçli, 2016).

The genus *Crateagus* L. is represented by a total of 27 taxa in Türkiye, including 16 species, 3 subspecies, 6 varieties, and 6 hybrid species, with an endemism rate of 37% (Özkan et al. 2014). Polymorphism and hybridization are very high in the *Crataegus* section, and genetic diversity extends from Türkiye to Iran (Dönmez, 2007), which increases the possibility of Türkiye being the genetic center of the *Crataegus* spp. genus. Widespread hybridization results in the formation of numerous intermediate forms.

Most studies related to *Crataegus* species are taxonomically examined at the genus level as *Crataegus* spp. without specifying the species. According to a study conducted on 18 genotypes grown in Malatya, it was stated that *Crataegus* spp. fruits, which contain substances beneficial to human health, could be used in the development of functional foods due to their high phenolic content, anthocyanin content, and antioxidant properties (Ercisli et al., 2015). In a study conducted on 52 samples taken from 17 taxa of *Crataegus* spp., it was found that their leaves and flowers had significantly high antioxidant capacities (Özyürek et al., 2012). The fruits of *Crataegus* spp. are used as food and have high levels of flavonoids, vitamin C, glycosides, anthocyanidins, saponins, tannins, and antioxidants (Serçe et al., 2011). In another study conducted on 7 hawthorn taxa in Western Anatolia, a total of 81 volatile components were determined in leaves and flowers, with the highest proportion of volatile oil component being benzaldehyde (82.54%) along with the highest of 10 fatty acids was linoleic acid (64.23%) in seeds (Özderin et al., 2016). A study conducted on 15 genotypes of *Crataegus* spp. in Uşak province reported that the region had valuable potential in terms of hawthorn genetic resources (Oktan et al., 2017). Some physical properties of fruits collected from 51 genotypes of *Crataegus* spp. naturally growing in Çorum province were determined (Balta et al., 2015). In research focusing on *Crataegus* spp. fruits, drying time, color value, and drying curves of the product were modeled, and it was determined that the mathematical model that best predicted the drying curves of the fruit among thin-layer drying models was the Midilli-Küçük model (Polatçı and Taşova, 2017). *Crataegus aronia* (L.) Bosc var. *aronia*; *C. aronia* var. *dentata* Browicz; *C. aronia* var. *minuta* Browicz; *Crataegus orientalis* (Mill.) Bosc var. *orientalis* and *Crataegus monogyna* Jacq. subsp. *azarella* (Griseb.) Franco species sampled from Türkiye's Eastern Mediterranean region were found to have antioxidant activity in their fruits (Çalişkan et al., 2012).

Crataegus tanacetifolia (Yunus Emre Hawthorn) is a deciduous shrub or small tree with a height of up to 3 meters, short thorns, and a scattered top. The leaves are deeply lobed with 5-7 lobes, having serrated margins, the tips of the teeth are glandular, and light green in color; flowers are arranged in groups of 4-8, compound corymb, white in color; the fruit is a false fruit, fleshy, usually with shiny yellow color, sometimes reddish; and the fruit contains five seeds (Yücel, 2012). It prefers sunny and mild climates as well as well-drained, slightly acidic, neutral, and basic (slightly alkaline-alkaline) sandy-loamy soils. *Crataegus tanacetifolia* is an endemic plant species of Türkiye and grows naturally in regions such as Eskişehir, as well as Bolu, Karabük, Kastamonu, Ankara, Erzincan, Malatya, Samsun, and Sivas (Tübives, 2019).

There are numerous studies worldwide on the genus *Crataegus* and these studies generally focus on its natural distribution, systematic characteristics, phytochemical properties of fruits, leaves, and flowers, and their use in traditional medicine. However, there are very few studies directly elucidating the pomological characteristics of *Crataegus tanacetifolia* in a comprehensive manner.

This study aims to determine the pomological characteristics and assess the importance of *Crataegus tanacetifolia*, an endemic plant species in Türkiye, from a public health perspective.

2. Materials and Method

In this study, the natural distribution area of *Crataegus tanacetifolia*, where it is densely found, in the Mihalıççık district of Eskişehir province (1335m-1345m), was chosen as the research area, and the fruits were selected as the research material. Ten different trees were identified in each of the five selected sample areas. Required measurements were conducted on 25 randomly selected samples from among 100 ripe fruits collected in equal proportions from each tree in October.

Fruit and seed weight were measured using a digital scale sensitive to 0.01 g, while the dimensional properties of the fruit and seed (length, width, thickness), and fruit peduncle were measured using a digital caliper sensitive to 0.01 mm. Fruit hardness was measured using a penetrometer (kg/cm^2), and fruit color (L*a*b*) was measured using a color spectrophotometer. Juiciness, taste, aroma, attractiveness, and fruit quality were evaluated on a scale of 1-10 (1: worst, 10: best). The yield was determined by dividing the total yield values per tree by the number of trees (kg/tree) (Cemeroğlu, 1992; Acar, 2016). 1000 Seed weight (g) was determined according to ISTA standards (Aveling, 2014).

To determine the pomological characteristics of the fruit, the following measurements were taken: Fruit length (L) mm, fruit width (W) mm, fruit thickness (T) mm. The following formulas were used to calculate various fruit characteristics:

Arithmetic mean diameter (Da) mm (Mohsenin, 2020): $Da = (L+W+T)/3$

Geometric mean diameter (Dg), mm (Mohsenin, 2020): $Dg = (L*W*T)^{1/3}$

Sphericity index (Sp), % (Mohsenin, 2020): $Sp = (Dg/L)100$

Surface area (S), mm^2 (Sacilik et al., 2003): $S = \pi(Dg^2)$

Appearance ratio (Ra) (Owolarafe et al., 2007): $Ra = W/L$

Fruit/Seed ratio: FS = Seed weight/Fruit weight

The maximum and minimum values of the measured characters and their relationships were examined. For statistical analysis, Microsoft Excel and SPSS 21.0 software packages were used. The results were considered statistically significant at the $p \leq 0.05$ level.

3. Results

According to the objectives of the study, the pomological characteristics and allometric relationships of *Crataegus tanacetifolia* genotypes were investigated, and the findings are summarized in Table 1.

Among the examined genotypes, the average fruit length ranged from 12.21 to 18.09 mm, with a mean fruit length of 15.30 mm. The fruit width ranged from 15.03 to 24.25 mm, with an average fruit width of 19.51 mm; fruit thickness ranged from 14.79 to 23.92 mm, with an average value of 18.85 mm; and the fruit peduncle length was measured with an average of 3.26 mm (ranging from 2.83 to 3.76 mm). The fruit weight varied between 2.018 and 5.787 g, with an average of 3.34 g. The weight of the fleshy part of the fruit ranged from 1.541 to 4.918 g, with an average of 2.73 g.

The fruit-to-seed ratio ranged from 0.13 to 0.27, with an average ratio of 0.19. The geometric mean diameter of the fruit ranged from 14.37 to 21.89 mm, with a mean of 17.78 mm; the sphericity index ranged from 107.61% to 127.20%, with an average sphericity index of 116.26%; the fruit surface area ranged from 648.44 to 1505.00 mm^2, with a mean surface area of 1005.55 mm^2; the fruit appearance ratio ranged from 0.68 to 0.89, with a mean appearance ratio of 0.79. The color of the fruit surface in the L*a*b* coordinates ranged from 70.41*11.79*55.26 to 72.96*8.04*62.49. The fruits are generally yellow, sometimes with a slight pinkish hue on one side. Fruit juiciness was determined to be within the range of >3-6<. The fruit aroma was found to be quite intense (>2-5<). Fruit hardness was measured between 12 and 16 kg/cm^2. Yield values per tree in the research area were determined to be in the range of 12 to 25 kg/tree.

Table 1. Some physical and pomological characteristics of *Crataegus tanacetifolia* ($p \leq 0.05$)

Parameters	Minimum	Maximum	Mean ± Standard deviation
Fruit length (L), mm	12.21	18.09	15.30±1.70
Fruit width (W), mm	15.03	24.25	19.51±2.30
Fruit thickness (T), mm	14.79	23.92	18.85±2.30
Fruit average weight, g	2.018	5.787	3.34±0.99
Fleshy part weight, g	1.541	4.918	2.73±0.901
Fruit arithmetic mean diameter (Da), mm	14.39	22.09	17.89±2.04
Fruit geometric mean diameter (Dg), mm	14.37	21.89	17.78±2.02
Fruit sphericity index (Sp) %	107.61	127.2	116.26±4.79
Fruit surface area (S), mm^2	648.44	1505	1005.55±223.28
Fruit appearance ratio (Ra)	0.68	0.89	0.79±0.05
Fruit/Seed ratio	0.13	0.27	0.19±0.04
Fruit peduncle length, mm	2.83	3.76	3.26±0.24
Fruit juiciness ratio	>3	6<	>3-6<
Taste	>3	7<	>3-7<
Aroma	>4	8<	>4-8<
Fruit flesh hardness	12	16	14.02±1.61
Color (L*a*b)			
L	70.41	72.96	71.54±0.92
a	7.17	11.79	9.34±1.82
b	55.26	62.99	60.62±3.11
Attractiveness	>3	7<	>3-7<
Fruit quality	>4	7<	>4-7<
Yield (kg/tree)	>12	25<	>12-25<
Seed length, mm	6.18	8.17	7.20±0.51
Seed width, mm	3.16	4.77	4.14±0.37
Seed thickness, mm	4.21	6.2	5.42±0.43
Seed weight, g	0.09	0.16	0.12±0.02
Seed volume, mm^3	36.59	69.97	53.73±8.48
Seed surface area, mm^2	60.97	97.12	80.09±9.29

In the examined genotypes, the number of seeds was determined to be 5. Seed length ranged from 6.18 to 8.17 mm, with an average length of 7.20 mm. Seed width ranged from 3.16 to 4.77 mm, with an average width of 4.14 mm; seed thickness ranged from 4.21 to 6.20 mm, with an average thickness of 5.42 mm. Individual seed weight ranged from 0.0863 to 0.7103 g, with an average weight of 0.1459 g. The fruit-to-seed ratio among genotypes varied from 0.13 to 0.27, with an average ratio of 0.19. The thousand-seed weight was determined to be 121.80 g.

3.1. The allometric relationship between fruit length and dimensions

Since fruit length can be easily measured with a caliper, other pomological characteristics of the fruit can be estimated. Equations defining the allometric relationships with fruit length have been found with confidence intervals of $R^2 = 0.8777$ and $R^2 = 0.7493$ (Table 2). These equations represent other allometric relationships to a high degree based on the fruit length. However, the representation rate of the equations obtained for seed dimensions in relation to fruit length is lower ($R^2 = 0.051$ and $R^2 = 0.495$) (Table 2).

3.2. The allometric relationship between fruit surface area and dimensions

Fruit surface area and its allometric relationships are represented within confidence intervals of $R^2 = 0.9603$ and $R^2 = 0.8729$, indicating a close relationship (Table 3). Particularly, a better allometric relationship was found between fruit surface area and fruit thickness.

3.3. The allometric relationships between the fruit/seed ratio and fruit dimensions

The allometric relationships between the fruit-seed ratio and fruit dimensions can be expressed by first-degree equations with confidence intervals of $R^2 = 0.3984$ and $R^2 = 0.5045$, respectively (Table 5). However, it is observed that the allometric relationships between the fruit/seed ratio and fruit dimensions are low.

4. Discussions

In the understanding of public health, the fundamental principle is that humans are an integral part of their physical, biological, and social environments, and all elements of this whole should be considered together. In real terms, public health prioritizes preventing illness and promoting wellness rather than solely managing sickness in individuals (Büyüksoy, 2019). As biological components of the environment, humans are constantly interacting with other elements of the environment. Therefore, it is not possible for humans to remain healthy in an environment where biological diversity is disrupted. *Crataegus tanacetifolia* is one of Türkiye's endemic plants and is an important component of biological diversity, along with its food and ethnobotanical properties (Yücel, 2008). In complementary medicine, it is used against cardiovascular and neurological diseases (Yücel, 2014).

Due to the increasing demand for Hawthorn products in Türkiye, cultivation has begun in agricultural areas. However, harvesting from nature continues to be predominant.

Table 2. Allometric relationships between fruit length and dimensions

Variables (x)	Fruit length (L)	R^2
Fruit length (L), mm	y = 1.1736x + 1.55	$R^2 = 0.7529$
Fruit width (W), mm	y = 1.1749x + 0.874	$R^2 = 0.7493$
Fruit thickness (T), mm	y = 0.5347x - 4.8442	$R^2 = 0.8451$
Fruit average weight, g	y = 0.4877x - 4.7345	$R^2 = 0.8449$
Fleshy part weight, g	y = 1.1161x + 0.808	$R^2 = 0.8613$
Fruit arithmetic mean diameter (Da), mm	y = 1.1145x + 0.7255	$R^2 = 0.8777$
Fruit geometric mean diameter (Dg), mm	y = -0.3491x + 121.6	$R^2 = 0.0153$
Fruit sphericity index (Sp) %	y = 122.84x - 874.23	$R^2 = 0.8729$
Fruit surface area (S), mm2	y = 0.0038x + 0.7279	$R^2 = 0.0180$
Fruit appearance ratio (Ra)	y = -0.017x + 0.4511	$R^2 = 0.4950$
Seed length, mm	y = 0.1545x + 4.8405	$R^2 = 0.2659$
Seed width, mm	y = 0.0494x + 3.3865	$R^2 = 0.0510$
Seed thickness, mm	y = 0.0669x + 4.3976	$R^2 = 0.0708$
Seed weight, g	y = 0.047x - 0.1096	$R^2 = 0.3985$

Table 3. Allometric relationships between fruit surface area and dimensions

Variables (x)	Fruit surface area (S)	R^2
Fruit length (L), mm	y = 122.84x – 874.23	$R^2 = 0.8729$
Fruit width (W), mm	y = 95.608x – 859.68	$R^2 = 0.9673$
Fruit thickness (T), mm	y = 95.432x – 793.67	$R^2 = 0.9706$
Fruit average weight, g	y = 221.54x + 266.11	$R^2 = 0.9603$

The resemblance of certain species within the *Crataegus* spp. genus makes it difficult for the public and herbalists to distinguish them. As a result, all species with partially similar fruits are consumed and marketed under the name "Hawthorn." For example, in Eskişehir territory, *Crataegus orientalis*, *Crataegus tanacetifolia*, and *Crataegus* x *bornmüellerii* are sold and consumed under the name Hawthorn. The majority of scientific studies conducted on Hawthorn have been done under the title "*Crataegus* spp. genotypes" without specifying the species. It is known that the *Crataegus* L. genus is represented by 27 taxa in Türkiye and approximately 200 hawthorn taxa worldwide. Therefore, research results conducted under the title "*Crataegus* spp. genotypes" contain uncertainty at the species level as it is not clear which species or taxa are included.

Studies on this species are quite limited. Studies conducted cover topics such as phytochemical properties, antimicrobial properties or use in complementary medicine. These studies are important in terms of showing the importance of the species in terms of public health and economy. For example; *Crataegus tanacetifolia* leaf extracts have been found to have hypotensive effects on rats (Birman et al., 2001). The aqueous leaf extract of *Crataegus tanacetifolia* (100 mg/kg) administered intragastrically has been observed to prevent N$^{\omega}$nitro-L-arginine methyl ester-induced hypertension in rats, particularly the hyperoside fraction, and to have beneficial effects on the cardiovascular system (Koçyıldız et al., 2006). Studies conducted with the aqueous leaf extract of *Crataegus tanacetifolia* in rats have reported that the extract induces changes in rheological parameters, suggesting potential clinical applications in diseases characterized by rheological abnormalities such as hypertension (Tamer, 2001). Extracts from the fruit, leaves, and flowers of this species have been reported to be effective on the cardiovascular system (Tamer et al., 2000; Yücel and Yücel, 2020).

The methanol leaf extract of *Crataegus tanacetifolia* has been found to exhibit bactericidal activity against *Bacillus subtilis*, *Shigella*, *Staphylococcus aureus*, and *Listeria monocytogenes* (Benli et al., 2008). The fruit extract of *Crataegus tanacetifolia* has been found to exhibit antimicrobial activity against bacteria and yeasts to some extent. Additionally, *Penicillium notatum* is the only fungal species inhibited by *Crataegus tanacetifolia* extract as well as the yeast isolate *Rhodotorola rubra* is inhibited by the plant extract (Güven et al., 2006).

The prominent volatile aroma compounds of *Crataegus tanacetifolia* vinegar have been identified as acetic acid, phenylacetic acid, acetoin, pentanoic acid, benzoic acid, (E)-isoeugenol, 2-cyclohexenone, propanoic acid, chavicol, and diethyl succinate, with gallic acid being the predominant phenolic compound in both wine and vinegar, followed by chlorogenic acid (Özdemir et al., 2022). *Crataegus tanacetifolia* vinegar has been shown to possess significant antioxidant and enzyme inhibitory effects which could be an indicator of antidiabetic activity (Akgün, et al., 2023). *Crataegus tanacetifolia* vinegar has been found to be rich in phenolic and mineral content and exhibits high antioxidant capacity (Tomar, et al., 2020).

In this study, Eskişehir surroundings were determined as the research area for the pomological characteristics of the species. Since the region chosen as the research area is in the triangle of Central Anatolia Region, Marmara Region and Black Sea Region, it can be considered as a transition zone region. Some characters of the species are genotypic and do not change under the influence of ecological factors, while some characters may change. This issue may be the subject of a separate study. However, there is a need for studies to cover the entire natural distribution area of the species.

It has been determined that characteristics such as fruit pomology and seed weight of *Crataegus tanacetifolia* are higher compared to *Crataegus monogyna*. Furthermore, citric acid has been identified as the predominant organic acid in the genotypes of both species, followed by malic and succinic acids. A study conducted in the Bolu region reported certain pomological characteristics related to fruit volume, weight, width, height, seed weight, fruit peduncle length, and thickness of *Crataegus tanacetifolia* fruits (Gürlen et.al., 2020).

In this study, it was found that *Crataegus tanacetifolia* has the following characteristics: fruit length (L) of 15.30±1.70 mm, width (W) of 19.51±2.30 mm, thickness (T) of 18.85±2.30 mm, weight of 3.34±0.99 g, flesh weight of 2.73±0.901 g, arithmetic mean diameter (Da) of 17.89±2.04 mm, geometric mean diameter (Dg) of 17.78±2.02 mm, sphericity index (Sp) of 116.26±4.79%, surface area (S) of 1005.55±223.28 mm^2, appearance ratio (Ra) of 0.79±0.05, seed/fruit ratio of 0.19±0.04, peduncle length of 3.26±0.24 mm, flesh hardness of 14.02±1.61, and fruit color (L*a*b) of 71.54±0.92*9.34±1.82*60.62±3.11. The fruit displays a spectrum of colors, ranging from light yellow to pale pink. In unripe fruits, green is the predominant color observed. Additionally, the seed measurements are as follows: seed length of 7.20±0.51 mm, width of 4.14±0.37 mm, thickness of 5.42±0.43 mm, weight of 0.12±0.02 g, volume of 53.73±8.48 mm^3, and surface area is 80.09±9.29.

When examining the fruit length and allometric relationships, it is observed that fruit length represents allometric relationships to a high degree with R^2 values of 0.8777 and 0.7493 within the confidence interval. However, the representation of allometric relationships between fruit length and seed sizes, as indicated by the obtained equations, is lower with R^2 values of 0.051 and 0.495 (Table 2). This suggests that it may be necessary to develop different calculation methods that cover various dimensions to find better allometric relationships between fruit length and seed size.

There is a high relationship between fruit surface area and fruit allometric relationships with $R^2 = 0.9603$ and $R^2 = 0.8729$ confidence intervals. Particularly, a strong allometric relationship was observed between fruit surface area and fruit thickness (Table 3). However, since fruit width is one of the main components of fruit shape, its verification is required for new populations. Additionally, there is a need for calculation methods that consider multiple dimensions to find a better relationship between fruit surface area and allometric dimensions.

The allometric relationships between seed weight and fruit sizes were found to be within the confidence intervals of $R^2 = 0.3985$ and $R^2 = 0.5781$ (Table 4). There was a strong correlation between seed weight and fruit thickness, while the weakest correlation was found between fruit length and

Table 4. The allometric relationships between seed weight and fruit dimensions

Variables (x)	Seed weight (g)	R^2
Fruit length (L), mm	y = 0.047x – 0.1096	R^2 = 0.3985
Fruit width (W), mm	y = 0.0413x – 0.1962	R^2 = 0.5632
Fruit thickness (T), mm	y = 0.0417x – 0.1766	R^2 = 0.5781
Fruit average weight, g	y = 0.092x + 0.3018	R^2 = 0.5179

Table 5. The allometric relationships between the fruit/seed ratio and fruit dimensions

Variables (x)	Fruit/seed ratio)	R^2
Fruit length (L), mm	y = -0.017x + 0,4511	R^2 = 0.495
Fruit width (W), mm	y = -0.0116x + 0,4168	R^2 = 0.4198
Fruit thickness (T), mm	y = -0.0112x + 0,4028	R^2 = 0.3984
Fruit average weight, g	y = -0.0295x + 0,2895	R^2 = 0.5045
Fleshy part weight, g	y = 0.0909x + 0,3608	R^2 = 0.4207

seed weight. This indicates that genetic and physiological factors affecting seed weight may develop somewhat independently of fruit allometric dimensions.

The allometric relationships between seed ratio and fruit sizes range between R^2 = 0.3984 and R^2 = 0.5045 (Table 5). This clearly indicates the low representation of seed sizes in relation to fruit allometric relationships. Therefore, there is a need to develop new methods involving multiple parameters to calculate seed and fruit allometric relationships in *Crataegus tanacetifolia*. Simple allometric relationships between fruit surface area and pomological characteristics which can be done without damaging the fruit, can enable reliable estimation of fruit surface area and other attributes. The results regarding the pomological characteristics of the genotypes examined in this study are parallel to the findings of other studies (Gürlen et.al., 2020). However, some differences may have arisen from ecological factors.

Conclusion

In conclusion, this study sheds light on the pomological characteristics and allometric relationships of *Crataegus tanacetifolia*, an endemic plant species in Türkiye, from the perspective of public health. The findings highlight the importance of understanding and preserving the natural diversity of plants like *Crataegus tanacetifolia*, which have been utilized for centuries in traditional medicine and are increasingly recognized for their potential health benefits. The examination of pomological characteristics and the establishment of allometric relationships provide insights into the physical attributes and potential yield of *Crataegus tanacetifolia* fruits. These findings can inform cultivation practices, conservation efforts, and the development of functional foods or herbal medicines derived from *Crataegus tanacetifolia*. Despite strong correlations between certain dimensions identified in this study, the need for enhanced methodologies to have a deeper understanding of the connections among various attributes still remains. Further detailed studies are necessary for the conservation of its natural habitats and for its cultivation and widespread adoption.

Conflict of Interest

Authors have declared no conflict of interest.

Authors' Contributions

All authors contributed to all processes. All authors have read and agreed to the published version of manuscript.

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The effects of the magnetic field on germination and seedling growth of chickpea (*Cicer arietinum* L.) and sunflower (*Helianthus annuus* L.)

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Manyetik alanın nohut (*Cicer arietinum* L.) ve ayçiçeği (*Helianthus annuus* L.) çimlenmesi ve fide büyümesine etkileri

Abstract: Organisms interact with their environment and effects of environmental factors vary depending on ecology and tolerance levels. However magnetic field is an inevitable factor for all organisms. The aim of the study was to investigate the effects of different magnetic field (MF) applications on germination percentage, pigment content and antioxidant capacity of two important agricultural plant (Sunflower and Chickpea) species. Initially, seeds were exposed to 5 mT, 10 mT and 20 mT magnetic field generated by Helmholtz coil for detection of germination effects. Then seedling test was survived at the same conditions. MF was applied 20 minutes for every day at the same time period. According to germination results, MF application to sunflower and chickpea seeds was resulted with increase in germination percentage compared to control. 20 mT application caused decrease in shoot length of sunflower seedlings. On the contrary, 20 mT MF application resulted with increase in shoot length of chickpea seedlings. All magnetic field strengths increased carotenoid levels in chickpea seedlings. Also, MF application affected the phenolic and flavonoid contents of sunflower and chickpea seedlings. Depending on the increase in secondary metabolites, DPPH and FRAP activities varied. As a conclusion, MF application contributed to effect on plant metabolism and it has the potential to be used in agricultural applications.

Key words: Magnetic field, Helmholtz coil, germination, magnetic field response

Özet: Organizmalar çevreleriyle etkileşim halindedir ve çevresel faktörlerin etkileri ekoloji ve tolerans düzeylerine bağlı olarak değişmektedir. Ancak manyetik alan tüm organizmalar için kaçınılmaz bir faktördür. Çalışmanın amacı, farklı manyetik alan (MF) uygulamalarının iki önemli tarım bitkisi (Ayçiçeği ve Nohut) türünün çimlenme yüzdesi, pigment içeriği ve antioksidan kapasitesi üzerine etkilerinin araştırılmasıdır. Çimlenme etkilerinin tespiti için ilk olarak tohumlar Helmholtz bobini tarafından oluşturulan 5 mT, 10 mT ve 20 mT manyetik alana maruz bırakılmıştır. Daha sonra fide testi için de aynı şartlarda hazırlanmıştır. MF her gün aynı saat diliminde 20 dakika uygulanmıştır. Çimlenme sonuçlarına göre ayçiçeği ve nohut tohumlarına MF uygulamasının kontrole göre çimlenme yüzdesinde artışa neden olduğu görülmüştür. 20 mT uygulaması ayçiçeği fidelerinde sürgün boyunda azalmaya neden olmuştur. Buna karşılık 20 mT MF uygulaması nohut fidelerinde sürgün uzunluğunun artmasına neden olmuştur. Tüm manyetik alan kuvvetleri nohut fidelerinde karotenoid düzeylerini arttırmıştır. Ayrıca uygulama ayçiçeği ve nohut fidelerinin fenolik ve flavonoid içeriklerini de etkilemiştir. Sekonder metabolitlerdeki artışa bağlı olarak DPPH ve FRAP aktiviteleri farklılık göstermiştir. Sonuç olarak MF uygulamasının bitki metabolizması üzerine etkisi olduğu ve tarımsal uygulamalarda kullanılma potansiyeline sahip olduğu sonucuna varılmıştır.

Anahtar Kelimeler: Manyetik alan, Helmholtz bobini, çimlenme, manyetik alan tepkisi

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1. Introduction

The nutritional needs in the World are increasing due to the continuous increase in the population. For this reason, natural and alternative methods or applications are being researched to increase food quality and yield. Static magnetic field, one of the methods used in recent years, is used to improve plant development (Pentoś et al., 2022).

Paleogeographic records revelated that the geomagnetic field has been effective on Earth for at least 4.2 billion years (Tarduno et al., 2015). Plant genome, exposure time, energy level and target distance to energy source affect the biological effects of MF (Baghel et al., 2018). Plants are not completely resistant to all kinds of environmental changes due to their physiological, molecular and genetic structures, and they must modify depending on their genetic potential under changing conditions. Recently, some researchers have focused on the use of MF to improve agronomical characters (Shabrangy et al., 2021), and also MF affects phytochemical content of plants (Nasiri et al., 2022). However, our knowledge is limited about how MF effect on metabolism.

An important question is the MF has any distinctive effects on biological systems. In literature studies, it has been stated that MF affects various plant functions, such as growth, development, protein biosynthesis and enzyme activity. In addition, MF has positive effects on plant characteristics; such as shoot development, seed germination, fresh weight and plant height, fruit yield per plant and average fruit weight, increasing photosynthetic pigment content; and intensifying cell division, as well as water and nutrient uptake (De Souza et al., 2006; Sarraf et

al., 2020; Tirono et al., 2021). On the contrary, in some cases, application of magnetic field caused a decrease in germination parameters. It has been found that weak electromagnetic fields suppress the growth of plants and reduce cell division (Belyavskaya, 2004; Kornarzyński et al., 2020). MF can change the antioxidant enzyme activities (Sahebjamei et al., 2007; Alikamanoğlu and Sen, 2011). Exposure of seeds with MF caused the increase in amylolytic enzymes activity in seeds and seedlings of pea (Podleśny et al., 2021).

MF has been shown to significantly improve plant development in various species, including sunflower (*Helianthus annuus* L.) (Vashisth and Nagarajan, 2010), rice (*Oryza sativa* L.) (Fl'orez et al., 2007), and chickpea (*Cicer arietinum* L.) (Vashisth and Nagarajan, 2008). Improving germination and growth rates is crucial for sustainable horticulture, particularly in the Mediterranean region.

The aim of this study was to investigate the how different static magnetic intensities (0 mT, 5 mT, 10 mT and 20 mT) affect to germination rate, shoot and root length, pigment content and antioxidant capacity of two important commercial plants chickpea (*Cicer arietinum*) and sunflower (*Helianthus annuus*). Also i) to create a constant and controllable magnetic effect, unlike the variable intensity in magnetic field studies with different magnets, ii) to reveal the state of the magnetic field in different vegetables and to determine their comparative responses. iii) to determine their effects on germination and development physiology and to determine their agricultural application potential.

2. Materials and Method

2.1. Plant materials and growth conditions

Helianthus annuus L. (TD0005 AA) and *Cicer arietinum* L. (3660 OC) seeds were used for MF applications. Uniform and undamaged seeds were selected and sterilized with 3 % sodium hypochlorite for 10 min. Seeds were sowed in sterile glass jars (8 x 5 x 5.5 cm) with bi-layered sterile filter paper on the bottom of each sterile glass jar. Filter papers were watered with 5 mL of Hoagland's solution. 10 seeds were placed into each jar with five replicate. Jars were incubated in controlled plant growth room (25±1 °C, 16/8 photoperiod, 2500 lux light intensity and 70% humidity).

2.2. Magnetic field treatment for germination and seedling growth

Seeds were exposed to different MF intensities (0 mT, 5 mT, 10 mT and 20 mT) for 20 minutes after planting for every day. Power supply (DC: direct current) and Helmholtz Coil were used for generation of magnetic field of 5 mT (22.4 V), 10 mT (34 V) and 20 mT (41.8 V). Generated MF was measured regularly by a Teslameter during the exposure period (Fig. 1). At the end of the 5th day of application, germination percentage was calculated for each group.

After five days, seeds were considered as germinated and calculations (germination percentage) were made, for seedling applications seeds were exposed to same strength and duration magnetic field for ten days. At the end of the period, samples were harvested by liquid nitrogen and stored in ultra-freezer (-80 °C) for further analysis.

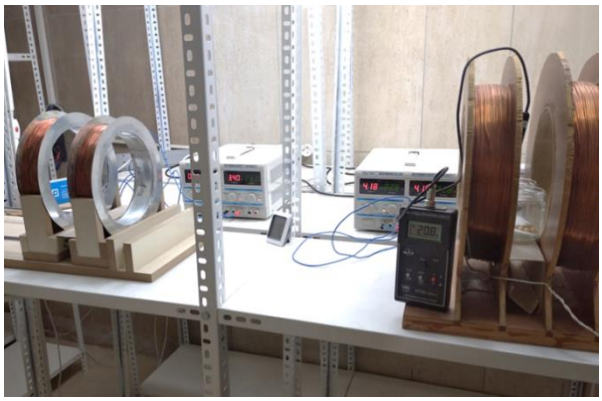

Figure1. Magnetic field apparatus and application methodology

2.3. Physiological parameters

Fresh weight, dry weight, turgid weight, length of soot and root tissues were measured at the end of the 10th day. The relative water content of the seedlings was calculated according to equation based on the three measured values (dry, fresh and turgor weight) (Hu et al., 2010).

Relative Water Content (%) = [(Fresh Weight-Dry Weight)/ (Turgid Weight-Dry Weight)] x 100

2.4. Pigment content

Chlorophyll a, b and carotenoids were determined by using spectrophotometer. For chlorophyll content, leaf sample (0.1 g) was homogenized by using 10 ml (80 %) acetone. Chlorophyll and carotenoid contents were assessed by determining absorbance at 480, 645 and 663 nm (Arnon, 1949). The amounts of photosynthetic pigments were calculated according to the equations below and expressed in mg/g.

Chlorophyll-a = [ΔA663 x 12.70 - Δ A645 x 2.69] [(V/1000)*W]

Chlorophyll-b = [ΔA645 x 22.90 - Δ A663 x 4.68] [(V/1000)*W]

Total chlorophyll = [ΔA645 x 20.2 + Δ A663 x 8.02] [V/1000)*W]

Carotenoids = [ΔA480 + Δ A663 x 0.114 - Δ A645 x 0.638/112.50] [(V/1000)*W]

{ΔA: The absorbance value at the specified wavelengths, V: the final extraction volume in ml, W: the amount of plant taken for analysis in g}.

2.5. Total Phenolic and Total Flavonoid Content Analysis

Folin-Ciocalteu assay was performed to determine the total phenolic content (TPC) at 600 nm. TPC of samples was expressed as mg of gallic acid equivalent per gram dry weight (mg GAE/g DW) (Dalar and Konczak, 2013).

The total flavonoid content (TFC) assay was performed at 510 nm. Results of TFC were presented as mg of rutin equivalent per gram of dry weight (mg RE/g DW) (Dalar and Konczak, 2013).

2.6. Antioxidant activities

2,2-diphenyl-1-picrylhydrazyl (DPPH) activity was performed according to Konczak-Islam et al. (2003). 75 µL of the sample solution used for extraction and 75 µL of 0.4

mM DPPH solution were mixed and left at room temperature for 2 min. The decrease in absorbance of the prepared mixture at 517 nm was measured using a microplate reader. Measurements were made three times. DPPH inhibitions were calculated using the following equation (Moraes-De-Souza et al., 2008).

DPPH activity (%) = [(absorbance control − absorbance of samples) / absorbance of control] × 100

Fluorescence recovery after photobleaching (FRAP) activity was performed according to Sudha et al. (2012). 10 µL of the prepared plant extracts were placed in a 96-well microplate and 3 mL of FRAP reagent (300 mM acetate buffer, 20 mM $FeCl_3$ and 10 mM 2,4,6-tri-s-triazine (TPTZ) solution) was added. After 4 min of incubation, absorbance was measured at 593 nm using a microplate reader. The total reducing capacities of the extracts were expressed as µ mol of iron (Fe^{2+}) per gram of dry weight (µmol Fe^{2+}/g DW) based on an iron sulphate standard (Fe_2SO_4) curve against a blank control.

2.7. Statistical analysis

Samples were presented as mean value and standard error. Samples were compared using one-way analysis of variance (GraphPad Prism 8.0 One Way Anova). Statistical difference was accepted as $p \leq 0.05$.

3. Results

The seeds began to germinate five days after starting the application. The number of germinated seeds were monitored daily for five days, and changes were observed. At the end of the fifth day, germination rates of sunflower and chickpea seeds were evaluated compared to the control group. Figure 2a demonstrates the germination percentage of sunflower seeds either control or magnetic field exposed conditions. Germination of the control seeds was 68%, which increased to 97, 98 and 98 % by applications of 5/10/20 mT magnetic field, respectively. However, germination rate of chickpea for were calculated as 54 % for control and 85, 80, and 89% for 5/10/20 mT magnetic field treatments, respectively (Fig. 2b).

The longest shoot length was measured in 5 mT treated sunflower seedlings (7.64±0.40). On the other hand, the shortest and significant shoot length was measured in 20 mT treated sunflower seedlings (5.66±0.16). The length of shoot of the sunflower seedlings in 5 and 10 mT treatments were measured as 7.64±0.40 and 7.21±0.28, respectively. The root length was measured as 10.21±0.93, 10.11±1.44, 7.15±0.68 and 9.30±0.53 in control and different MF applications 5, 10 and 20 mT, respectively (Fig. 3a).

According to Figure 3b, the longest shoot length of chickpea seedlings was found in 20 mT application as 2.00±0.04. Control seedlings had the shortest shoot length (1.35±0.24). Shoot length of other MF applications, 5 and 10 mT, was found as 1.70±0.04 and 1.80±0.17, respectively. Chickpea seedlings had different root lengths. While the longest root legth (2.75±0.67) was in 20 mT application, the shortest root length (1.88±0.22) was measured in control seedlings (Fig. 3b).

Pigment concentrations of samples was determined as µg/g (Table 1). According to findings, the highest pigment content of sunflower plant was found in 20 mT MF application. On the other hand, the lowest pigment content was determined in 10 mT MF application.

According to chickpea pigment content results, the highest pigment content except carotenoids was found in 20 mT MF application. The lowest pigment content was determined in control chickpea samples. (Table 1) Data about total phenolic, flavonoid and antioxidant activities were presented in Table 2. According to results, 20 mT MF applied sunflower plant had the highest total phenolic content and FRAP activity. The highest total phenolic content was determined in 10 mT MF application. The highest DPPH activity was measured in control sunflower seedlings.

According to findings, 20 mT MF applied chickpea plant had the highest total phenolic content and FRAP activity. The highest total phenolic content and DPPH activity were determined in 10 mT MF application (Table 2).

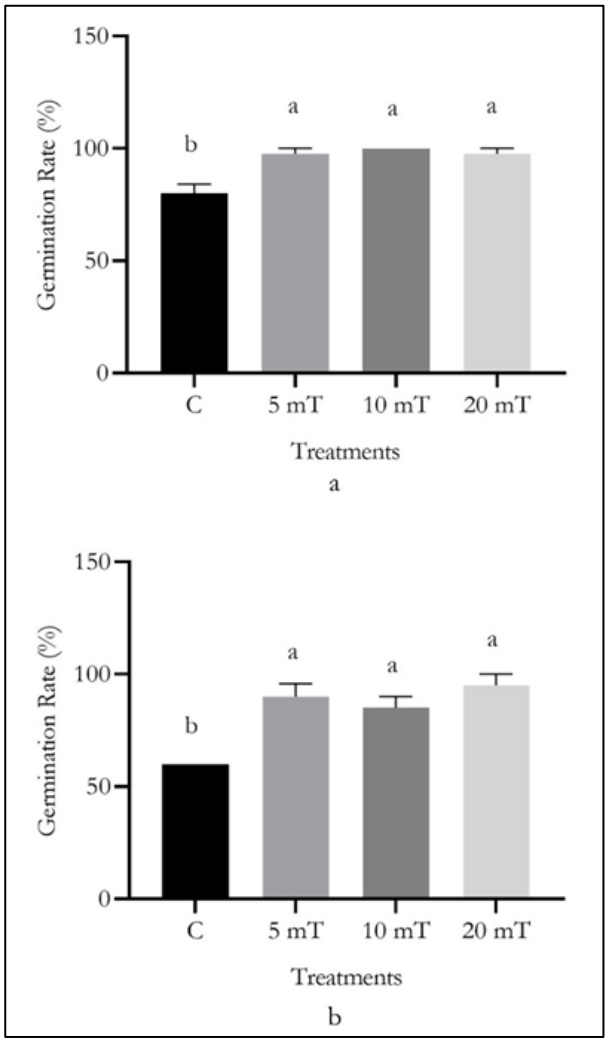

Figure 2. Effects of magnetic fields on germination rate (%). a: *H. annuus*, b: *C. arietinum*. Different letters on the same column exhibited statistically significant different between groups (P=0.0007).

4. Discussions

MF has been demonstrated to increase a range of plant physiological responses, including germination, blooming time, photosynthesis, biomass, cryptochrome activation, and shoot growth (Maffei, 2014). Magnetic field caused

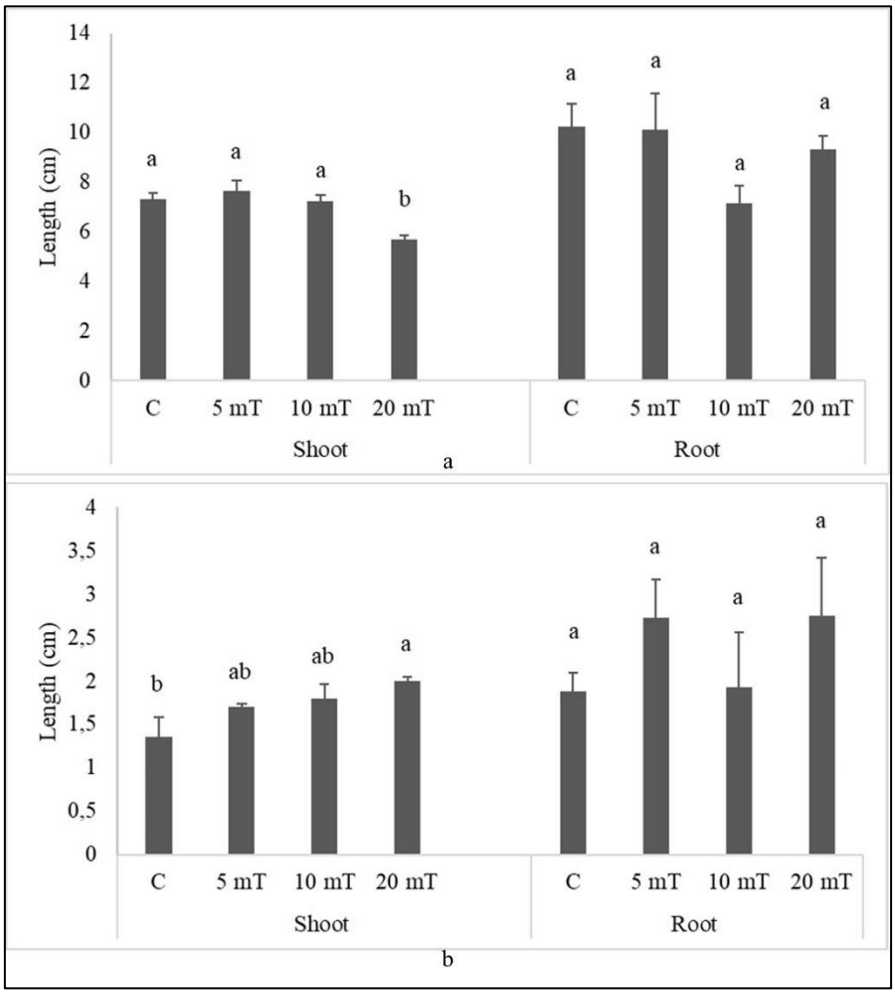

Figure 3. Effects of magnetic fields on shoot and root length (cm). a: *H. annuus*, P=0.0001 for shoot, b: *C. arietinum*, C vs. 20mT for shoot: P=0.0393 Different letters on the same column exhibited statistically significant difference between groups.

significantly increase in the germination rate of sunflower and chickpea seedlings in different rates. This revealed that MF strength is a critical factor affecting the seed germination especially in chickpea. Furthermore, exogenous MF can impact plant transcriptome, proteome, and metabolome profiles based on its strength and frequency (Herranz et al., 2013; Jin et al., 2019; Islam et al., 2020). The effective MF strength that stimulates growth and germination varies depending on the plant type employed, as well as the MF strength, frequency, and exposure period (Ercan et al., 2022). Among the evaluated MFs, this study discovered that 20 mT is the most effective, increasing germination by 33%. External MF stimulates the maximum activity of proteolytic enzymes, including α-amylase (Ramakrishna and Rao 2005). It is possible that MF treatment may improve germination and speed of germination by increasing the activity of proteolytic enzymes (Vashisth and Nagarajan 2010). The study indicated that the magnetic field had a statistically significant influence on germination in chickpea seeds rather than sunflower seeds.

Table 1. Effects of magnetic fields on pigments concentrations (µg/g).

		Chlorophyll a	Chlorophyll b	Total Chlorophyll	Carotenoid
	Control	222.33 ± 13.85^{a}	236.16 ± 51.39^{a}	458.34 ± 65.16^{a}	6.34 ± 0.12^{a}
	5 mT	241.78 ± 26.54^{a}	236.50 ± 44.73^{a}	478.13 ± 70.84^{a}	6.55 ± 0.38^{a}
H. annuus	**10 mT**	217.70 ± 12.56^{a}	206.69 ± 15.39^{a}	424.27 ± 27.47^{a}	5.34 ± 0.35^{a}
	20 mT	242.07 ± 13.15^{a}	236.80 ± 12.85^{a}	478.72 ± 25.96^{a}	7.00 ± 0.34^{a}
	P value	0.672	0.910	0.863	0.108
	Control	84.90 ± 1.09^{a}	108.78 ± 2.10^{a}	193.62 ± 2.97^{a}	2.48 ± 0.05^{b}
	5 mT	110.35 ± 6.58^{a}	135.51 ±7.42^{a}	245.78 ± 13.95^{a}	3.22 ± 0.19^{a}
C. arietinum	**10 mT**	111.64 ± 12.09^{a}	129.08 ± 13.09^{a}	240.64 ± 25.17^{a}	3.33 ± 0.13^{a}
	20 mT	113.54 ± 4.00^{a}	141.60 ± 4.17^{a}	255.05 ± 8.17^{a}	3.31 ± 0.10^{a}
	P value	0.068	0.080	0.077	0.004

Table 2. Effects of magnetic fields on total phenolic, flavonoid content and antioxidant activities.

		Total Phenolic (mg/g)	Total Flavonoid (mg/g)	DPPH (%)	FRAP (μ mol Fe^{2+}/g)
	Control	3.82 ± 0.09^{b}	3.39 ± 0^{b}	84.57 ± 0.18^{a}	1.89 ± 0.02^{b}
	5 mT	3.92 ± 0.03^{b}	3.35 ± 0.09^{b}	81.56 ± 0.88^{b}	2.21 ± 0.03^{a}
H. annuus	**10 mT**	3.95 ± 0.03^{ab}	4.41 ± 0.27^{a}	83.19 ± 0.50^{ab}	2.27 ± 0.02^{a}
	20 mT	4.24 ± 0.11^{a}	3.45 ± 0.03^{b}	83.38 ± 0.44^{ab}	2.33 ± 0.07^{a}
	P value	0.005	<0.0001	0.010	0.038
	Control	9.01 ± 0.03^{c}	1.79 ± 0.06^{b}	65.29 ± 0.29^{b}	2.77 ± 0.04^{b}
	5 mT	9.24 ± 0.04^{b}	1.40 ± 0.03^{b}	66.07 ± 0.49^{b}	2.85 ± 0.02^{ab}
C. arietinum	**10 mT**	10.01 ± 0.04^{a}	2.41 ± 0.27^{a}	75.65 ± 0.35^{a}	2.97 ± 0.04^{a}
	20 mT	10.02 ± 0.01^{a}	2.02 ± 0.13^{ab}	60.59 ± 0.71^{c}	2.98 ± 0.05^{a}
	P value	<0.0001	0.017	<0.0001	0.004

In agricultural use, it can be used to accelerate germination, speed up growth, and increase yield of chickpea seeds. Different MF intensities and durations increase the germination rate (Suarez et al., 2017; Shabrangy et al., 2021; Sharma et al., 2021). The reason for this is that exposure of seeds to MF improves seed membrane integrity, reduces cellular leakage and electrical conductivity. In germinating seeds, enzyme activities of α-amylase, dehydrogenase and protease were significantly higher in MF treated seeds compared to control group. Higher enzyme activity in MF treated sunflower seeds could trigger rapid germination and early viability of seedlings (Vashisth and Nagarajan, 2010). Florez et al. (2007) stated that there was a significant increase in germination of chickpea seeds exposed to static MF. The researchers connected their findings to amylolytic enzymes (α-β amylase) or hydrolysis or the expression of hormones (indole, gibberellins, or zeatin). Variable magnetic fields can affect variations in hormone concentrations, enzyme activity, ion transport across the cell membrane, DNA synthesis, or transmission (Strasak et al. 2002).

Shoot and root length are important parameters for physiological development under different growth conditions. According to findings obtained from this study, MF application caused significantly decrease in shoot length of *H. annuus* according to control, 5 mT and 10 mT applications (Fig. 3). On the other hand, MF application caused significantly increase in shoot length of *C. arietinum* compared to control group. There was no difference between root lengths of seedlings. It was reported that applied MF intensities increased the growth parameters and plant development in the early stages of growth in the sunflower plant, and this could be due to the changes in the Ca^{+2} level induced by MF (Florez et al., 2007). In another study conducted with *H. annuus* L., the effect of constant MF in systems with and without iron nanoparticles (Fe-NPs) was investigated, and it was reported that Fe-NPs and MF caused a decrease in germination parameters of seeds in most cases (Kornarzyński et al., 2020). In addition, Belyavskaya (2004) determined that weak electromagnetic fields suppressed the growth of plants, reduced cell division, and concentrated the protein.

As in our study, it was emphasized that MF applications increased shoot length in most of the MF studies on chickpea (Bhattacharya and Barman, 2011; Mridha and Nagarajan, 2014; Sharma et al., 2021). In our study, it was determined that the shoot length increased compared to the control, especially in parallel with the increasing magnetic field strength. In a similar study, Vashisth and Nagarajan (2008) reported that total root length doubled in 1-month-old plants grown from chickpea seeds treated with 100 mT for 1 h. In a study, the effects of MF on the growth parameters of *H. annuus* L. were investigated and it was stated that different MF intensities did not have a significant effect on the fresh weight of the leaves (Peyvandi et al., 2013). Similarly, in the study, it was determined that the MF did not cause any change in the root and shoot relative water content of sunflower and chickpea seedlings.

Application of MF with different intensities to sunflower and chickpea seedlings did not cause changes for pigment concentrations in the seedlings except carotenoid content. There was a significant increase in the carotenoid concentration of all MF applied seedlings compared to the control group (Table 1). MF treatment enhances photosystem II (PSII) efficiency, photosynthetic pigments (chlorophyll a and b), and the performance index, as well as leaf gas exchange performance (Yano et al., 2004; Rochalska and Orzeszko-Rywka, 2005; Baghel et al., 2018; Tirono et al., 2021). A similar study showed that magnetized seeds irrigated with magnetized water increased seed performance in terms of total photosynthetic pigments (chlorophyll a, b and carotenoids) (Abdul et al., 2010). In our study, no significant difference was detected. MF caused similar effect on pigment content (carotenoids, chlorophyll a, b, and total pigments), whereas carotenoids and chlorophyll a were more affected than chlorophyll b (Shine et al., 2012). Similarly, a significant increase was observed in carotenoid, especially in chickpeas compared to the control group in our study. The MF intensity, exposure time and plant genome are important parameters for pigment content.

In sunflower and chickpea seedlings, it was determined that the application of MF caused increase in antioxidant capacity. According to Table 2, total phenolic content of 20 mT MF applied *H. annuus* was significantly increased compared to control and 5 mT applied plants. Additionally, 10 mT treated seedlings of sunflower had statistically more total flavonoid content than control, 5 mT and 20 mT applied seedlings. On the other hand, 5 mT application of *H. annuus* caused importantly decrease in DPPH activity according to control. FRAP activity of all MF treated sunflower seedlings was determined significantly higher than control.

Total phenolic content of all MF treated *C. arietinum* seedlings was determined significantly higher than control.

Additionally, 10 mT treated seedlings of chickpea had statistically more total flavonoid content than control and 5 mT applied seedlings. Moreover, 10 mT application of chickpea caused importantly increase in DPPH activity according to other applications. FRAP activity 10 mT and 20 mT treated *C. arietinum* seedlings was determined significantly higher than control (Table 2).

There is a correlation between total phenolics and antioxidant capacity in many plant species (Rainha et al., 2011). Phenolic acids and flavonoids are known as typical phenolics with antioxidant activity. In our study, it was determined that MF application caused increase in antioxidant capacities of sunflower and chickpea seedlings according to control in the light of the results of total phenolic and flavonoid contents and DPPH and FRAP activities.

MF application caused increase in germination rate of *H. annuus* and *C. arietinum*.While MF treatment was resulted with increase in shoot length of chickpea seedlings, MF treatment caused decrease in shoot length of sunflower seedlings. MF did not affect the root length. Chlorophyll a and chlorophyll b contents were not affected from MF, however MF caused increase in carotenoid content. Additionally, MF application caused increase in antioxidant capacity of sunflower and chickpea seedlings. In the light of these findings, MF application could have been used as agricultural purposes.

Because the magnetic field affects diverse channels, its impacts on living things are assessed differently. Some view the magnetic field as an environmental stressor that hinders plant growth, while others see it as a potentially useful tool for enhancing agricultural practices.

Conflict of Interest

Authors have declared no conflict of interest.

Authors' Contributions

Concept: Ö.B., Design: Ö.B., Data Collection or Processing: S.G., Ö.B., Analysis or Interpretation: Ö.B., S.G., Literature Search: S.G., Writing: Ö.B., S.G.

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The checklist of macrofungi of Karaman province

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Karaman ili makromantarlarının kontrol listesi

Abstract: This study was based on the findings of macrofungal studies performed within the boundaries of Karaman province between 2000 and 2023. Tracing the researches carried out in the region, a list of 380 taxa belonging to 180 genera, 75 families, 20 orders and 8 classes within *Ascomycota* and *Basidiomycota* have been compiled.

Key words: Biodiversity, macrofungi, Türkiye

Özet: Bu çalışma 2000 ve 2023 yılları arasında Karaman il sınırları içinde makromantarlar üzerinde gerçekleştirilmiş çalışmaların bulgularına dayanmaktadır. Bölgede gerçekleştirilen çalışmalar taranarak *Ascomycota* ve *Basidiomycota* bölümleri içinde yer alan 8 sınıf, 20 takım, 75 familya ve 180 cinse ait 380 taksonu içeren bir liste oluşturulmuştur.

Anahtar Kelimeler: Biyoçeşitlilik, makromantarlar, Türkiye

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1. Introduction

Karaman is a province of Türkiye within Central Anatolian region and is among the studied regions of Türkiye in terms of macrofungal biodiversity. In Karaman, the first mycological study related to macrofungi was carried out by Kaşık et al. (2000). Five local list (Kaşık et al., 2000; Öztürk et al., 2001; Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021) were presented. Seventeen papers (Doğan and Işıloğlu, 2002; Kaşık et al., 2002; Öztürk, 2002; Doğan et al., 2003, 2007, 2011a,b; Intini et al., 2003; Öztürk et al., 2003; Doğan and Karadelev, 2009; Doğan and Aktaş, 2010; Türkoğlu et al., 2015; İleri et al., 2019; Çetinkaya et al., 2020; Çetinkaya and Uzun, 2021; Kaplan et al., 2021; Kaya and Uzun, 2023) had also been published to present new species, new records or new distributions. The current study was based on the findings of the above mentioned studies carried out within the boundaries of Karaman province. Some of the presented taxa were included in a country-wise checklist prepared by Sesli et al. (2020). Though 23 publication have been presented regarding the macrofungi of Karaman, none of them have clear information about total species that have so far been determined within the boundaries of Karaman province. The aim of the study is to present the marcromycetes of Karaman province as a complete list and to contribute to the mycobiota of Türkiye.

2. Materials and Method

The researches presented on macromycetes of Karaman province were traced and a list of the macromycete taxa was prepared together with their citations. Only the taxa presented in a peer reviewed article were included in the list. The taxa existing in unpublished theses and conference papers which were not presented as a full text were not considered. The authors names of fungal taxa are abbreviated according to Kirk & Ansell (1992) and Kirk et al. (2004). The systematic of the taxa follows Cannon and Kirk (2007), Kirk et al. (2008), and Index Fungorum (accessed 15 July 2024).

3. Results

The list of the taxa, reported from the region within the boundaries of Karaman province are listed in alphabetical order together with the references they were presented in.

Fungi R.T. Moore

Ascomycota Caval.-Sm.

Dothideomycetes O.E. Erikss. & Winka

Patellariales D. Hawksw. & O.E. Erikss.

Patellariaceae Corda

1. ***Patellaria atrata*** (Hedw.) Fr.: (İleri et al., 2020; Çetinkaya et al., 2021).

Leotiomycetes O.E. Erikss. & Winka

Helotiales Nannf.

Incertae Sedis

2. ***Stamnaria americana*** Massee & Morgan: (Kaplan et al., 2021).

Lachnaceae Raitv.

3. ***Brunnipila clandestina*** (Bull.) Baral: (İleri et al., 2020).

4. ***Lachnellula arida*** (W. Phillips) Dennis: (Kaşık et al., 2002).

5. ***Lachnellula subtilissima*** (Cooke) Dennis: (Doğan and Öztürk, 2006).

6. ***Lachnum sulphureum*** (Fuckel) P. Karst.: (Çetinkaya et al., 2021).

7. ***Lachnum virgineum*** (Batsch) P. Karst.: (İleri et al., 2020).

Helotiaceae Rehm

8. ***Hymenoscyphus calyculus*** (Fr.) W. Phillips: (İleri et al., 2020).

9. ***Hymenoscyphus caudatus*** (P. Karst.) Dennis: (Çetinkaya and Uzun, 2021).

10. ***Hymenoscyphus lutescens*** (Hedw.) W. Phillips: (Doğan and Aktaş, 2010).

Mollisiaceae Rehm

11. ***Mollisia hydrophila*** (P. Karst.) Sacc.: (Çetinkaya et al., 2021).

12. ***Mollisia melaleuca*** (Fr.) Brunaud: (İleri et al., 2020).

Orbiliomycetes O.E. Erikss. & Baral

Orbiliales Baral, O.E. Erikss., G. Marson & E. Weber

Orbiliaceae Nannf.

13. ***Orbilia auricolor*** (A. Bloxam) Sacc.: (Çetinkaya et al., 2021).

Pezizomycetes O.E. Erikss. & Winka

Pezizales J. Schröt.

Ascobolaceae Boud. ex Sacc.

14. ***Ascobolus behnitziensis*** Kirschst.: (İleri et al., 2020).

15. ***Ascobolus furfuraceus*** Pers.: (İleri et al., 2020).

16. ***Thecotheus lundqvistii*** Aas: (Çetinkaya et al., 2020).

Caloscyphaceae Harmaja

17. ***Caloscypha fulgens*** (Pers.) Boud.: (Doğan and Öztürk, 2006).

Discinaceae Benedix

18. ***Gyromitra esculenta*** Pers. ex Fr.: (Öztürk et al., 2001).

Helvellaceae Fr.

19. ***Dissingia leucomelaena*** (Pers.) K. Hansen & X.H. Wang: (Öztürk et al., 2001; Çetinkaya et al., 2021).

20. ***Helvella acetabulum*** (L.) Quél.: (Kaşık et al., 2000; Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

21. ***Helvella ephippium*** Lév.: (Kaşık et al., 2000).

22. ***Helvella fusca*** Gillet: (Çetinkaya et al., 2021).

23. ***Helvella lacunosa*** Afzel.: (Çetinkaya et al., 2021).

24. ***Helvella latispora*** Boud.: (İleri et al., 2020).

25. ***Helvella solitaria*** P. Karst.: (Çetinkaya et al., 2021).

26. ***Helvella spadicea*** Schaeff.: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

27. ***Paxina queletii*** (Bres.) Stangl: (Doğan and Öztürk, 2006).

Morchellaceae Rchb.

28. ***Morchella deliciosa*** Fr.: (İleri et al., 2020; Çetinkaya et al., 2021).

29. ***Morchella esculenta*** (L.) Pers.: (Kaşık et al., 2000; Öztürk et al., 2001; Doğan and Öztürk, 2006; İleri et al., 2020).

30. ***Morchella semilibera*** DC.: (Doğan and Öztürk, 2006).

Pezizaceae Dumort.

31. ***Iodophanus carneus*** (Pers.) Korf: (İleri et al., 2020).

32. ***Paragalactinia succosa*** (Berk.) Van Vooren: (Çetinkaya et al., 2021).

33. ***Peziza arvernensis*** Roze & Boud.: (Kaşık et al., 2002).

34. ***Peziza domiciliana*** Cooke: (Kaşık et al., 2002).

35. ***Peziza fimeti*** (Fuckel) E.C. Hansen: (İleri et al., 2020).

36. ***Peziza varia*** (Hedw.) Alb. & Schwein.: (Öztürk et al., 2001).

37. ***Sarcopeziza sicula*** (Inzenga) Agnello, Loizides & P.Alvarado (Kaya and Uzun, 2023).

38. ***Sarcosphaera coronaria*** (Jacq.) J. Schröt.: (Öztürk et al., 2001).

39. ***Terfezia albida*** Ant. Rodr., Muñ.-Moh. & Bordallo: (Çetinkaya et al., 2021).

40. ***Terfezia boudieri*** Chatin: (Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

41. ***Terfezia claveryi*** Chatin: (Türkoğlu et al., 2015; İleri et al., 2020; Çetinkaya et al., 2021).

Pyronemataceae Corda

42. ***Genea lobulata*** (Mor.-Arr., J. Gómez & Calonge) P. Alvarado & Mor.-Arr.: (İleri et al., 2020).

43. ***Geopora arenicola*** (Lév.) Kers: (Öztürk et al., 2001; Doğan and Öztürk, 2006; Çetinkaya et al., 2021).

44. ***Geopora sumneriana*** (Cooke ex W. Phillips) M. Torre: (Çetinkaya et al., 2021).

45. ***Humaria hemisphaerica*** (F.H. Wigg.) Fuckel: (Kaşık et al., 2000).

46. ***Inermisia gyalectoides*** (Svrček & Kubička) Dennis & Itzerott: (İleri et al., 2020).

47. ***Octospora axillaris*** (Nees) M.M. Moser: (İleri et al., 2020).

48. ***Octospora musci-muralis*** Graddon: (İleri et al., 2020).

49. ***Octospora polytrichi*** (Schumach.) Caillet & Moyne: (İleri et al., 2020).

50. ***Parascutellinia violacea*** (Velen.) Svrček: (Çetinkaya et al., 2021).

51. ***Picoa juniperi*** Vittad.: (Çetinkaya et al., 2021).

52. ***Picoa lefebvrei*** (Pat.) Maire: (İleri et al., 2020; Çetinkaya et al., 2021).

53. ***Pyronema domesticum*** (Sowerby) Sacc.: (Çetinkaya et al., 2021).

54. ***Pyronema omphalodes*** (Bull.) Fuckel: (Çetinkaya et al., 2021).

55. ***Scutellinia crinita*** (Bull.) Lambotte: (İleri et al., 2020).

56. ***Scutellinia scutellata*** (L.) Lambotte: (Doğan and Öztürk, 2006).

57. ***Trichophaeopsis bicuspis*** (Boud.) Korf & Erb: (Çetinkaya et al., 2021).

Sarcoscyphaceae Le Gal ex Eckblad

58. ***Pithya vulgaris*** Fuckel: (Doğan and Işıloğlu, 2002).

Tuberaceae F. Berchtold & J. Presl

59. ***Tuber nitidum*** Vittad.: (İleri et al., 2020).

Sordariomycetes O.E. Erikss. & Winka

Diaporthales Nannf.

Valsaceae Tul. & C. Tul.

60. ***Cytospora chrysosperma*** (Pers.) Fr.: (Çetinkaya et al., 2021).

Hypocreales Lindau

Nectriaceae Tul. & C. Tul.

61. ***Hydropisphaera peziza*** (Tode) Dumort.: (İleri et al., 2020; Çetinkaya et al., 2021).

62. ***Nectria cinnabarina*** (Tode) Fr.: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

Xylariales Nannf.

Diatrypaceae Nitschke

63. ***Diatrype stigma*** (Hoffm.) Fr.: (İleri et al., 2020; Çetinkaya et al., 2021).

Xylariaceae Tul. & C. Tul.

64. ***Kretzschmaria deusta*** (Hoffm.) P.M.D. Martin: (Çetinkaya et al., 2021).

65. ***Nemania serpens*** (Pers.) Gray: (Çetinkaya et al., 2021).

Basidiomycota R.T. Moore

Agaricomycetes Doweld

Agaricales Underw.

Incertae Sedis

66. ***Calyptella capula*** (Holmsk.) Quél.: (Çetinkaya et al., 2021).

67. ***Cyathus olla*** (Batsch) Pers.: (Çetinkaya et al., 2021).

68. ***Cyathus stercoreus*** (Schwein.) De Toni: (İleri et al., 2020).

69. ***Cystodermella ambrosii*** (Bres.) Harmaja: (Doğan et al., 2007).

70. ***Lepista nuda*** (Bull.) Cooke: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

71. ***Melanoleuca arcuata*** (Bull.) Singer: (Kaşık et al., 2000).

72. ***Melanoleuca cognata*** (Fr.) Konrad & Maubl.: (Doğan and Öztürk, 2006).

73. ***Melanoleuca exscissa*** (Fr.) Singer: (Doğan and Öztürk, 2006).

74. ***Melanoleuca humilis*** (Pers.) Pat.: (Doğan and Öztürk, 2006).

75. ***Melanoleuca luteolosperma*** (Britzelm.) Singer: (Doğan and Öztürk, 2006).

76. ***Melanoleuca melaleuca*** (Pers.) Murrill: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

77. ***Melanoleuca paedida*** (Fr.) Kühner & Maire: (Doğan and Öztürk, 2006).

78. ***Melanoleuca polioleuca*** (Fr.) Kühner & Maire: (Doğan and Öztürk, 2006).

79. ***Melanoleuca schumacheri*** (Fr.) Singer: (Doğan and Öztürk, 2006).

80. ***Melanoleuca stridula*** (Fr.) Singer: (Doğan and Öztürk, 2006).

81. ***Melanoleuca subalpina*** (Britzelm.) Bresinsky & Stangl: (Doğan and Öztürk, 2006).

82. ***Melanoleuca substrictipes*** Kühner: (Doğan and Öztürk, 2006).

83. ***Melanoleuca turrita*** (Sacc.) Singer: (Kaşık et al., 2000).

84. ***Panaeolina foenisecii*** (Pers.) Maire: (İleri et al., 2020).

Agaricaceae Chevall.

85. ***Agaricus arvensis*** Schaeff.: (Doğan and Öztürk, 2006).

86. ***Agaricus bresadolanus*** Bohus: (Doğan and Öztürk, 2006).

87. ***Agaricus campestris*** L.: (Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

88. ***Agaricus heimii*** Bon: (Öztürk et al., 2003).

89. ***Agaricus langei*** (F.H. Møller) F.H. Møller: (Doğan and Öztürk, 2006).

90. ***Agaricus luteomaculatus*** F.H. Møller: (Öztürk et al., 2003).

91. ***Agaricus sylvicola*** (Vittad.) Peck: (Kaşık et al., 2000).

92. ***Coprinus comatus*** (O.F. Müll.) Pers.: (Kaşık et al., 2000; Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

93. ***Coprinus sterquilinus*** (Fr.) Fr.: (Doğan and Öztürk, 2006).

94. ***Lepiota clypeolaria*** (Bull.) P. Kumm.: (Doğan and Öztürk, 2006).

95. ***Lepiota cristata*** (Bolton) P. Kumm.: (Doğan and Öztürk, 2006).

96. ***Lepiota erminea*** (Fr.) P. Kumm.: (Doğan and Öztürk, 2006).

97. ***Lepiota oreadiformis*** Velen.: (Doğan and Öztürk, 2006).

98. ***Lepiota subincarnata*** J.E. Lange: (Öztürk et al., 2003).

99. ***Lepiota wasseri*** Bon: (Öztürk et al., 2003).

100. ***Leucoagaricus badhamii*** (Berk. & Broome) Singer: (Doğan and Öztürk, 2006).

101. ***Leucocoprinus leucothites*** (Vittad.) Redhead: (Kaşık et al., 2000; İleri et al., 2020; Çetinkaya et al., 2021).

102. ***Macrolepiota excoriata*** (Schaeff.) Wasser: (Doğan and Öztürk, 2006; Çetinkaya et al., 2021).

103. ***Macrolepiota mastoidea*** (Fr.) Singer: (Doğan and Öztürk, 2006).

104. ***Macrolepiota procera*** (Scop.) Singer: (Doğan and Öztürk, 2006).

105. ***Mycenastrum corium*** (Guers.) Desv.: (İleri et al., 2020).

106. ***Tulostoma brumale*** Pers.: (Kaşık et al., 2000; İleri et al., 2020).

107. ***Tulostoma fimbriatum*** Fr.: (Kaşık et al., 2000; Doğan and Öztürk, 2006).

Amanitaceae E.-J. Gilbert

108. ***Amanita citrina*** Pers.: (Öztürk et al., 2001).

109. ***Amanita ovoidea*** (Bull.) Link: (Doğan and Öztürk, 2006).

Bolbitiaceae Singer

110. ***Conocybe apala*** (Fr.) Arnolds: (İleri et al., 2020; Çetinkaya et al., 2021).

111. ***Conocybe deliquescens*** Hauskn. & Krisai: (İleri et al., 2020; Çetinkaya et al., 2021).

112. ***Conocybe pygmaeoaffinis*** (Fr.) Kühner: (Doğan et al., 2003).

113. ***Conocybe rickeniana*** P.D. Orton: (Kaşık et al., 2000).

114. ***Conocybe rickenii*** (Jul. Schäff.) Kühner: (Doğan and Öztürk, 2006).

115. ***Conocybe semiglobata*** Kühner & Watling: (Doğan et al., 2003).

116. ***Conocybe siennophylla*** (Berk. & Broome) Singer ex Chiari & Papetti: (Doğan et al., 2003).

117. ***Conocybe subovalis*** Kühner & Watling: (Doğan et al., 2003).

Chromocyphellaceae Knudsen

118. ***Chromocyphella muscicola*** (Fr.) Donk: (İleri et al., 2020).

Clitocybaceae Vizzini, Consiglio & M. Marchetti

119. ***Clitocybe bresadolana*** Singer: (Doğan and Öztürk, 2006).

120. ***Clitocybe dryadicola*** (J. Favre) Harmaja: (Doğan and Öztürk, 2006).

121. ***Clitocybe phyllophila*** (Pers.) P. Kumm.: (Öztürk et al., 2001).

122. ***Collybia cookei*** (Bres.) J.D. Arnold: (Doğan and Öztürk, 2006).

Cortinariaceae Singer

123. ***Calonarius elegantior*** (Fr.) Niskanen & Liimat.: (Öztürk, 2002; Doğan and Öztürk, 2006).

124. ***Calonarius splendens*** (Rob. Henry) Niskanen & Liimat.: (Doğan and Öztürk, 2006).

125. ***Calonarius sulfurinus*** (Quél.) Niskanen & Liimat.: (Doğan and Öztürk, 2006).

126. ***Cortinarius duracinus*** Fr.: (Öztürk et al., 2001).

127. ***Cortinarius psittacinus*** M.M. Moser: (Doğan and Öztürk, 2006).

128. ***Cortinarius subvalidus*** Rob. Henry: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

Crepidotaceae (S. Imai) Singer

129. ***Crepidotus caspari*** Velen.: (Öztürk et al., 2003).

130. ***Crepidotus luteolus*** Sacc.: (Kaşık et al., 2000).

131. ***Crepidotus mollis*** (Schaeff.) Staude: (Öztürk et al., 2001; Çetinkaya et al., 2021).

132. ***Crepidotus variabilis*** (Pers.) P. Kumm.: (Çetinkaya et al., 2021).

133. ***Pleuroflammula tuberculosa*** (Schaeff.) E. Horak: (Doğan and Öztürk, 2006).

Cyphellaceae Burnett

134. ***Chondrostereum purpureum*** (Pers.) Pouzar: (Doğan and Öztürk, 2006; Çetinkaya et al., 2021).

Entolomataceae Kotl. & Pouzar

135. ***Entoloma cetratum*** (Fr.) M.M. Moser: (Doğan and Öztürk, 2006).

136. ***Entoloma niphoides*** Romagn. ex Noordel.: (Öztürk et al., 2003).

137. ***Entoloma sepium*** (Noulet & Dass.) Richon & Roze: (Doğan and Öztürk, 2006).

138. ***Entoloma sinuatum*** (Bull.) P. Kumm.: (Doğan and Öztürk, 2006).

139. ***Entoloma subradiatum*** (Kühner & Romagn.) M.M. Moser: (Öztürk et al., 2003).

Galeropsidaceae Singer

140. ***Panaeolus ater*** (J.E. Lange) Kühner & Romagn. ex Bon: (Öztürk et al., 2001; Doğan and Öztürk, 2006; İleri et al., 2020).

141. ***Panaeolus fimicola*** (Pers.) Gillet: (Öztürk et al., 2001; Doğan and Öztürk, 2006; İleri et al., 2020).

142. ***Panaeolus olivaceus*** F.H. Møller: (Doğan and Öztürk, 2006).

143. ***Panaeolus papilionaceus*** (Bull.) Quél.: (Doğan and Öztürk, 2006).

144. ***Panaeolus semiovatus*** (Sowerby) S. Lundell & Nannf.: (Doğan and Öztürk, 2006).

145. ***Panaeolus subbalteatus*** (Berk. & Broome) Sacc.: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

Hygrophoraceae Lotsy

146. ***Ampulloclitocybe clavipes*** (Pers.) Redhead, Lutzoni, Moncalvo & Vilgalys: (Doğan and Öztürk, 2006).

147. ***Arrhenia obscurata*** (D.A. Reid) Redhead, Lutzoni, Moncalvo & Vilgalys: (Doğan et al., 2007).

148. ***Hygrophorus erubescens*** (Fr.) Fr.: (Öztürk et al., 2003).

149. ***Hygrophorus marzuolus*** (Fr.) Bres.: (Doğan and Öztürk, 2006).

150. ***Galerina clavata*** (Velen.) Kühner: (Doğan and Öztürk, 2006).

151. ***Galerina marginata*** (Batsch) Kühner: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

152. ***Lichenomphalia umbellifera*** (L.) Redhead, Lutzoni, Moncalvo & Vilgalys: (Doğan and Öztürk, 2006).

Hymenogastraceae Vittad.

153. ***Hebeloma crustuliniforme*** (Bull.) Quél.: (Doğan and Öztürk, 2006).

154. ***Hebeloma mesophaeum*** (Pers.) Quél.: (Doğan and Öztürk, 2006).

155. ***Hymenogaster bulliardii*** Vittad.: (Çetinkaya et al., 2021).

156. ***Hymenogaster olivaceus*** Vittad.: (Çetinkaya et al., 2021).

157. ***Naucoria pampeana*** (Speg.) Rick: (Doğan and Öztürk, 2006).

158. ***Psilocybe coronilla*** (Bull.) Noordel.: (Doğan and Öztürk, 2006).

Inocybaceae Jülich

159. ***Inocybe abietis*** Kühner: (Doğan and Öztürk, 2006).

160. ***Inocybe dulcamara*** (Pers.) P. Kumm.: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

161. ***Inocybe fraudans*** (Britzelm.) Sacc.: (Kaşık et al., 2000).

162. ***Inocybe hirtella*** Bres.: (Öztürk et al., 2001).

163. ***Inocybe lacera*** (Fr.) P. Kumm.: (Öztürk et al., 2001; Doğan and Öztürk, 2006; İleri et al., 2020).

164. ***Inocybe muricellata*** Bres.: (Doğan and Öztürk, 2006).

165. ***Inocybe praetervisa*** Quél.: (Kaşık et al., 2000).

166. ***Inocybe queletii*** Konrad: (Doğan and Öztürk, 2006).

167. ***Mallocybe fuscomarginata*** (Kühner) Matheny & Esteve-Rav.: (Doğan and Öztürk, 2006).

168. ***Pseudosperma rimosum*** (Bull.) Matheny & Esteve-Rav.: (Kaşık et al., 2000; Doğan and Öztürk, 2006; Çetinkaya et al., 2021).

Lycoperdaceae F. Berchtold & J. Presl

169. ***Bovista plumbea*** Pers.: (Doğan and Öztürk, 2006; İleri et al., 2020).

170. ***Bovistella utriformis*** (Bull.) Demoulin & Rebriev: (Doğan and Öztürk, 2006).

171. ***Calvatia cyathiformis*** (Bosc) Morgan: (Öztürk et al., 2003; İleri et al., 2020).

172. ***Calvatia gigantea*** (Batsch) Lloyd: (Doğan and Öztürk, 2006).

173. ***Lycoperdon lividum*** Pers.: (Doğan and Öztürk, 2006).

174. ***Lycoperdon marginatum*** Vittad.: (Öztürk et al., 2003).

175. ***Lycoperdon molle*** Pers.: (İleri et al., 2020).

176. ***Lycoperdon nigrescens*** Pers.: (Doğan and Öztürk, 2006).

177. ***Lycoperdon perlatum*** Pers.: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

178. ***Lycoperdon pratense*** Pers.: (Doğan and Öztürk, 2006).

179. ***Lycoperdon umbrinum*** Pers.: (Doğan and Öztürk, 2006).

Lyophyllaceae Jülich

180. ***Calocybe gangraenosa*** (Fr.) V. Hofst., Moncalvo, Redhead & Vilgalys: (Doğan et al., 2007).

181. ***Lyophyllum infumatum*** (Bres.) Kühner: (Doğan et al., 2007).

182. ***Lyophyllum semitale*** (Fr.) Kühner: (Doğan et al., 2007).

Macrocystidiaceae Kühner

183. ***Macrocystidia cucumis*** (Pers.) Joss.: (Doğan et al., 2007).

Marasmiaceae Roze ex Kühner

184. ***Marasmius epiphyllus*** (Pers.) Fr.: (Öztürk et al., 2001).

185. ***Marasmius epodius*** Bres.: (İleri et al., 2020).

Mycenaceae Overeem

186. ***Mycena acicula*** (Schaeff.) P. Kumm.: (Çetinkaya et al., 2021).

187. ***Mycena amicta*** (Fr.) Quél.: (Doğan et al., 2007).

188. ***Mycena metata*** (Fr.) P. Kumm.: (Doğan and Öztürk, 2006).

189. ***Mycena silvae-nigrae*** Maas Geest. & Schwöbel: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

190. ***Mycena xantholeuca*** Kühner: (Doğan et al., 2007).

191. ***Xeromphalina campanella*** (Batsch) Kühner & Maire: (Kaşık et al., 2000).

192. ***Xeromphalina cauticinalis*** (Fr.) Kühner & Maire: (Doğan and Öztürk, 2006).

Niaceae Jülich

193. ***Merismodes anomala*** (Pers.) Singer: (Çetinkaya et al., 2021).

Omphalotaceae Bresinsky

194. ***Gymnopus dryophilus*** (Bull.) Murrill: (Doğan and Öztürk, 2006; İleri et al., 2020).

195. ***Gymnopus foetidus*** (Sowerby) P.M. Kirk: (Doğan and Öztürk, 2006).

196. ***Gymnopus fusipes*** (Bull.) Gray: (Doğan and Öztürk, 2006).

197. ***Gymnopus hariolorum*** (Bull.) Antonín, Halling & Noordel.: (Doğan and Öztürk, 2006).

198. ***Rhodocollybia prolixa*** (Fr.) Antonín & Noordel.: (Doğan et al., 2007).

Physalacriaceae Corner

199. ***Armillaria cepistipes*** Velen.: (Doğan et al., 2007).

200. ***Armillaria mellea*** (Vahl) P. Kumm.: (Öztürk et al., 2001; Doğan and Öztürk, 2006; Çetinkaya et al., 2021).

201. ***Flammulina velutipes*** (Curtis) Singer: (Öztürk et al., 2001).

202. ***Hymenopellis hygrophoroides*** (Singer & Clémençon) R.H. Petersen: (Doğan et al., 2007).

203. ***Oudemansiella melanotricha*** (Dörfelt) M.M. Moser: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

204. ***Strobilurus stephanocystis*** (Kühner & Romagn. ex Hora) Singer: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

205. ***Xerula pudens*** (Pers.) Singer: (Doğan and Öztürk, 2006).

Pleurotaceae Kühner

206. ***Hohenbuehelia atrocoerulea*** (Fr.) Singer: (Doğan and Öztürk, 2006).

207. ***Pleurotus dryinus*** (Pers.) P. Kumm.: (Öztürk et al., 2001; İleri et al., 2020).

208. ***Pleurotus eryngii*** (DC.) Quél.: (Öztürk et al., 2001).

209. ***Pleurotus ostreatus*** (Jacq.) P. Kumm.: (Öztürk et al., 2001; Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

210. ***Pleurotus pulmonarius*** (Fr.) Quél.: (Doğan and Öztürk, 2006).

Pluteaceae Kotl. & Pouzar

211. ***Pluteus cervinus*** (Schaeff.) P. Kumm.: (İleri et al., 2020).

212. ***Pluteus granularis*** Peck: (İleri et al., 2020).

213. ***Pluteus nanus*** (Pers.) P. Kumm.: (Öztürk et al., 2003).

214. ***Pluteus podospileus*** Sacc. & Cub.: (Öztürk et al., 2003).

215. ***Pluteus romellii*** (Britzelm.) Lapl.: (Doğan and Öztürk, 2006; Çetinkaya et al., 2021).

216. ***Pluteus satur*** Kühner & Romagn.: (Doğan and Öztürk, 2006).

217. ***Volvariella media*** (Schumach.) Singer: (Doğan and Öztürk, 2006).

218. ***Volvariella pusilla*** (Pers.) Singer: (İleri et al., 2020).

219. ***Volvopluteus gloiocephalus*** (DC.) Vizzini, Contu & Justo: (Kaşık et al., 2000).

Porotheleaceae Murrill

220. ***Phloeomana hiemalis*** (Osbeck) Redhead: (Doğan et al., 2007).

Psathyrellaceae Vilgalys, Moncalvo & Redhead

221. ***Candolleomyces candolleanus*** (Fr.) D. Wächt. & A. Melzer: (Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

222. ***Candolleomyces typhae*** (Kalchbr.) D. Wächt. & A. Melzer: (İleri et al., 2019; 2020).

223. ***Coprinellus disseminatus*** (Pers.) J.E. Lange: (Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

224. ***Coprinellus domesticus*** (Bolton) Vilgalys, Hopple & Jacq. Johnson: (Doğan and Öztürk, 2006).

225. ***Coprinellus micaceus*** (Bull.) Vilgalys, Hopple & Jacq. Johnson: (Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

226. ***Coprinellus silvaticus*** (Peck) Gminder: (İleri et al., 2020).

227. ***Coprinellus truncorum*** (Scop.) Redhead, Vilgalys & Moncalvo: (Doğan et al., 2003).

228. ***Coprinopsis atramentaria*** (Bull.) Redhead, Vilgalys & Moncalvo: (İleri et al., 2020; Çetinkaya et al., 2021).

229. ***Coprinopsis cinerea*** (Schaeff.) Redhead, Vilgalys & Moncalvo: (Doğan et al., 2003).

230. ***Coprinopsis cothurnata*** (Godey) Redhead, Vilgalys & Moncalvo: (Doğan et al., 2003).

231. ***Coprinopsis episcopalis*** (P.D. Orton) Redhead, Vilgalys & Moncalvo: (Doğan et al., 2003).

232. ***Coprinopsis lagopus*** (Fr.) Redhead, Vilgalys & Moncalvo: (İleri et al., 2020).

233. ***Coprinopsis marcescibilis*** (Britzelm.) Örstadius & E. Larss.: (Doğan et al., 2003).

234. ***Coprinopsis nivea*** (Pers.) Redhead, Vilgalys & Moncalvo: (İleri et al., 2020; Çetinkaya et al., 2021).

235. ***Coprinopsis stangliana*** (Enderle, Bender & Gröger) Redhead, Vilgalys & Moncalvo: (İleri et al., 2020).

236. ***Homophron spadiceum*** (P. Kumm.) Örstadius & E. Larss.: (Doğan and Öztürk, 2006).

237. ***Lacrymaria lacrymabunda*** (Bull.) Pat.: (Kaşık et al., 2000; İleri et al., 2020).

238. ***Narcissea patouillardii*** (Quél.) D. Wächt. & A. Melzer: (Doğan et al., 2003).

239. ***Parasola auricoma*** (Pat.) Redhead, Vilgalys & Hopple: (İleri et al., 2020).

240. ***Parasola plicatilis*** (Curtis) Redhead, Vilgalys & Hopple: (Doğan and Öztürk, 2006).

241. ***Psathyrella artemisiae*** (Pass.) Konrad & Maubl.: (Doğan and Öztürk, 2006).

242. ***Psathyrella bipellis*** (Quél.) A.H. Sm.: (Doğan et al., 2003).

243. ***Psathyrella cotonea*** (Quél.) Konrad & Maubl.: (Doğan et al., 2003).

244. ***Psathyrella fatua*** (Fr.) Konrad & Maubl.: (Öztürk et al., 2001).

245. ***Psathyrella lutensis*** (Romagn.) Bon: (Doğan et al., 2003).

246. ***Psathyrella ochracea*** (Romagn.) M.M. Moser ex Kits van Wav.: (Doğan et al., 2003).

247. ***Psathyrella pseudogracilis*** (Romagn.) M.M. Moser: (Doğan et al., 2003).

248. ***Psathyrella sphagnicola*** (Maire) J. Favre: (Doğan et al., 2003).

249. ***Psathyrella tephrophylla*** (Romagn.) Bon: (Doğan and Öztürk, 2006).

250. ***Tulosesus ephemerus*** (Bull.) D. Wächt. & A. Melzer: (Doğan et al., 2003).

Schizophyllaceae Quél.

251. ***Schizophyllum amplum*** (Lév.) Nakasone: (İleri et al., 2020; Çetinkaya et al., 2021).

252. ***Schizophyllum commune*** Fr.: (Öztürk et al., 2001; Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

Strophariaceae Singer & A.H. Sm.

253. ***Agrocybe dura*** (Bolton) Singer: (Öztürk et al., 2001; İleri et al., 2020).

254. ***Agrocybe molesta*** (Lasch) Singer: (Doğan and Öztürk, 2006; İleri et al., 2020).

255. ***Agrocybe paludosa*** (J.E. Lange) Kühner & Romagn. ex Bon: (Doğan and Öztürk, 2006; İleri et al., 2020).

256. ***Agrocybe pediades*** (Fr.) Fayod: (Doğan and Öztürk, 2006; İleri et al., 2020).

257. ***Agrocybe praecox*** (Pers.) Fayod: (Doğan and Öztürk, 2006).

258. ***Agrocybe putaminum*** (Maire) Singer: (Doğan et al., 2003).

259. ***Agrocybe vervacti*** (Fr.) Singer: (Doğan and Öztürk, 2006; İleri et al., 2020).

260. ***Deconica coprophila*** (Bull.) P. Karst.: (Çetinkaya et al., 2021).

261. ***Hypholoma fasciculare*** (Huds.) P. Kumm.: (Doğan and Öztürk, 2006).

262. ***Pholiota conissans*** (Fr.) M.M. Moser: (Doğan and Öztürk, 2006).

263. ***Pholiota gummosa*** (Lasch) Singer: (Doğan and Öztürk, 2006).

264. ***Pholiota limonella*** (Peck) Sacc.: (Çetinkaya et al., 2021)

265. ***Pholiota lucifera*** (Lasch) Quél.: (Öztürk et al., 2001).

266. ***Pholiota pudica*** (Bull.) Gillet: (Doğan and Öztürk, 2006).

267. ***Pholiota spumosa*** (Fr.) Singer: (Doğan and Öztürk, 2006).

268. ***Pholiota squarrosa*** (Vahl) P. Kumm.: (Doğan and Öztürk, 2006).

269. ***Protostropharia semiglobata*** (Batsch) Redhead, Moncalvo & Vilgalys: (Doğan and Öztürk, 2006).

270. ***Stropharia aeruginosa*** (Curtis) Quél.: (Doğan and Öztürk, 2006).

Tricholomataceae R. Heim ex Pouzar

271. ***Tricholoma album*** (Schaeff.) P. Kumm.: (Doğan and Öztürk, 2006).

272. ***Tricholoma anatolicum*** H.H. Doğan & Intini (Intini et al., 2003; Doğan and Akata, 2011).

273. ***Tricholoma apium*** Jul. Schäff.: (Doğan et al., 2007).

274. ***Tricholoma aurantium*** (Schaeff.) Ricken: (Öztürk et al., 2001).

275. ***Tricholoma caligatum*** (Viv.) Ricken: (Öztürk et al., 2001).

276. ***Tricholoma columbetta*** (Fr.) P. Kumm.: (Öztürk et al., 2001).

277. ***Tricholoma equestre*** (L.) P. Kumm.: (Doğan and Öztürk, 2006).

278. ***Tricholoma imbricatum*** (Fr.) P. Kumm.: (Doğan and Öztürk, 2006).

279. ***Tricholoma orirubens*** Quél.: (Doğan and Öztürk, 2006).

280. ***Tricholoma pardalotum*** Herink & Kotl.: (Doğan and Öztürk, 2006).

281. ***Tricholoma populinum*** J.E. Lange: (Doğan and Öztürk, 2006).

282. ***Tricholoma portentosum*** (Fr.) Quél.: (Doğan and Öztürk, 2006).

283. ***Tricholoma radotinense*** Pilát & Charvát: (Doğan et al., 2007).

284. ***Tricholoma scalpturatum*** (Fr.) Quél.: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

285. ***Tricholoma stans*** (Fr.) Sacc.: (Doğan and Öztürk, 2006).

286. ***Tricholoma virgatum*** (Fr.) P. Kumm.: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

Tubariaceae Vizzini

287. ***Tubaria furfuracea*** (Pers.) Gillet: (Öztürk et al., 2001; İleri et al., 2020).

288. ***Cyclocybe cylindracea*** (DC.) Vizzini & Angelini: (Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

Auriculariales Bromhead

Incertae Sedis

289. ***Pseudohydnum gelatinosum*** (Scop.) P. Karst.: (Öztürk et al., 2001).

Boletales E.-J. Gilbert

Boletaceae Chevall.

290. ***Cyanoboletus pulverulentus*** (Opat.) Gelardi, Vizzini & Simonini: (Doğan and Öztürk, 2006).

291. ***Hemileccinum impolitum*** (Fr.) Šutara: (Doğan and Öztürk, 2006).

292. ***Suillellus queletii*** (Schulzer) Vizzini, Simonini & Gelardi: (Doğan and Öztürk, 2006).

293. ***Xerocomellus chrysenteron*** (Bull.) Šutara: (Doğan and Öztürk, 2006).

294. ***Xerocomus subtomentosus*** (L.) Quél.: (Doğan and Öztürk, 2006).

Diplocystidiaceae Kreisel

295. ***Astraeus hygrometricus*** (Pers.) Morgan: (Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

Gomphidiaceae Maire ex Jülich

296. ***Chroogomphus rutilus*** (Schaeff.) O.K. Mill.: (Öztürk et al., 2001; Doğan and Öztürk, 2006; Çetinkaya et al., 2021).

297. ***Gomphidius glutinosus*** (Schaeff.) Fr.: (Öztürk et al., 2001).

Paxillaceae Lotsy

298. ***Paxillus involutus*** (Batsch) Fr.: (Doğan and Öztürk, 2006).

Rhizopogonaceae Gäum. & C.W. Dodge

299. ***Rhizopogon luteolus*** Fr.: (Öztürk et al., 2001; Çetinkaya et al., 2021).

300. ***Rhizopogon obtextus*** (Spreng.) R. Rauschert: (Kaşık et al., 2000).

301. ***Rhizopogon roseolus*** (Corda) Th. Fr.: (Kaşık et al., 2000; Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

Sclerodermataceae Corda

302. ***Pisolithus arhizus*** (Scop.) Rauschert: (İleri et al., 2020).

303. ***Scleroderma areolatum*** Ehrenb.: (Çetinkaya et al., 2021).

Suillaceae Besl & Bresinsky

304. ***Suillus collinitus*** (Fr.) Kuntze: (İleri et al., 2020; Çetinkaya et al., 2021).

305. ***Suillus granulatus*** (L.) Roussel: (Doğan and Öztürk, 2006).

306. ***Suillus grevillei*** (Klotzsch) Singer: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

307. ***Suillus luteus*** (L.) Roussel: (Doğan and Öztürk, 2006).

Cantharellales Gäum.

Hydnaceae Chevall.

308. ***Cantharellus cibarius*** Fr.: (Kaşık et al., 2000).

309. ***Membranomyces spurius*** (Bourdot) Jülich: (Öztürk et al., 2003).

Geastrales K. Hosaka & Castellano

Geastraceae Corda

310. ***Geastrum fimbriatum*** Fr.: (Doğan and Öztürk, 2006; İleri et al., 2020).

311. ***Geastrum pectinatum*** Pers.: (Doğan and Öztürk, 2006).

312. ***Geastrum rufescens*** Pers.: (Doğan and Öztürk, 2006).

313. ***Geastrum striatum*** DC.: (Doğan and Öztürk, 2006).

314. ***Geastrum triplex*** Jungh.: (Doğan and Öztürk, 2006).

Gloeophyllales Thorn

Gloeophyllaceae Jülich

315. ***Gloeophyllum abietinum*** (Bull.) P. Karst.: (Öztürk et al., 2001).

316. ***Gloeophyllum sepiarium*** (Wulfen) P. Karst.: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

317. ***Gloeophyllum trabeum*** (Pers.) Murrill: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

318. ***Neolentinus lepideus*** (Fr.) Redhead & Ginns: (Öztürk et al., 2001).

Gomphales Jülich

Gomphaceae Donk

319. ***Gomphus clavatus*** (Pers.) Gray: (Kaşık et al., 2000; Doğan and Öztürk, 2006).

320. ***Phaeoclavulina abietina*** (Pers.) Giachini: (Öztürk et al., 2003).

321. ***Ramaria flava*** (Schaeff.) Quél.: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

322. ***Ramaria obtusissima*** (Peck) Corner: (Öztürk et al., 2003).

Hymenochaetales Oberw.

Incertae Sedis

323. ***Trichaptum abietinum*** (Pers. ex J.F. Gmel.) Ryvarden: (Kaşık et al., 2000; Doğan and Öztürk, 2006).

324. ***Trichaptum fuscoviolaceum*** (Ehrenb.) Ryvarden: (Doğan and Öztürk, 2006).

Hymenochaetaceae Donk

325. ***Coniferiporia sulphurascens*** (Pilát) L.W. Zhou & Y.C. Dai: (Doğan and Karadelev, 2009; Doğan et al., 2011a).

326. ***Fomitiporia punctata*** (P. Karst.) Murrill: (Doğan and Öztürk, 2006).

327. ***Fomitiporia robusta*** (P. Karst.) Fiasson & Niemelä: (Doğan and Öztürk, 2006).

328. ***Inocutis rheades*** (Pers.) Fiasson & Niemelä: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

329. ***Inocutis tamaricis*** (Pat.) Fiasson & Niemelä: (Doğan and Öztürk, 2006).

330. ***Inonotus hispidus*** (Bull.) P. Karst.: (Öztürk et al., 2001; Doğan and Öztürk, 2006; İleri et al., 2020).

331. ***Phellinus hartigii*** (Allesch. & Schnabl) Pat.: (Doğan and Öztürk, 2006).

332. ***Phellinus igniarius*** (L.) Quél.: (Öztürk et al., 2001; Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

333. ***Phellinus laevigatus*** (P. Karst.) Bourdot & Galzin: (Doğan and Öztürk, 2006).

334. ***Phellinus pomaceus*** (Pers.) Maire: (Kaşık et al., 2000; Doğan and Öztürk, 2006).

335. ***Phellinus viticola*** (Schwein.) Donk: (Öztürk et al., 2001; Öztürk et al., 2003).

336. ***Phellinus vorax*** Harkn. ex Černý: (Doğan and Öztürk, 2006).

337. ***Xanthoporia radiata*** (Sowerby) Ţura, Zmitr., Wasser, Raats & Nevo: (Doğan and Öztürk, 2006).

Hyphodontiaceae R.T. Moore

338. ***Hyphodontia arguta*** (Fr.) J. Erikss.: (Doğan et al., 2011a).

Polyporales Gäum.

Incertae Sedis

339. ***Amaropostia stiptica*** (Pers.) B.K. Cui, L.L. Shen & Y.C. Dai: (Doğan and Öztürk, 2006).

340. ***Rhodonia placenta*** (Fr.) Niemelä, K.H. Larss. & Schigel: (Öztürk et al., 2003).

Cerrenaceae Miettinen, Justo & Hibbett

341. ***Cerrena unicolor*** (Bull.) Murrill: (Öztürk et al., 2001).

Dacryobolaceae Jülich

342. ***Postia tephroleuca*** (Fr.) Jülich: (Doğan and Öztürk, 2006).

Fomitopsidaceae Jülich

343. ***Brunneoporus juniperinus*** (Murrill) Zmitr.: (Doğan et al., 2011a).

344. ***Fomitopsis officinalis*** (Vill.) Bondartsev & Singer: (Doğan and Öztürk, 2006).

Laetiporaceae Jülich

345. ***Laetiporus sulphureus*** (Bull.) Murrill: (İleri et al., 2020; Çetinkaya et al., 2021).

Meruliaceae Rea

346. ***Physisporinus vitreus*** (Pers.) P. Karst.: (Öztürk et al., 2003).

Phanerochaetaceae Jülich

347. ***Bjerkandera adusta*** (Willd.) P. Karst.: (Doğan and Öztürk, 2006; Çetinkaya et al., 2021).

Polyporaceae Fr. ex Corda

348. ***Fomes fomentarius*** (L.) Fr.: (Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

349. ***Ganoderma applanatum*** (Pers.) Pat.: (Doğan and Öztürk, 2006).

350. ***Ganoderma lucidum*** (Curtis) P. Karst.: (İleri et al., 2020).

351. ***Lentinus tigrinus*** (Bull.) Fr.: (Kaşık et al., 2000; Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

352. ***Pachykytospora tuberculosa*** (Fr.) Kotl. & Pouzar: (Öztürk et al., 2003).

353. ***Perenniporia medulla-panis*** (Jacq.) Donk: (Öztürk et al., 2003).

354. ***Pyrofomes demidoffii*** (Lév.) Kotl. & Pouzar: (Öztürk et al., 2001; Doğan and Öztürk, 2006; Doğan et al., 2011a).

355. ***Trametes gibbosa*** (Pers.) Fr.: (Doğan and Öztürk, 2006).

356. ***Trametes hirsuta*** (Wulfen) Lloyd: (Çetinkaya et al., 2021).

357. ***Trametes ochracea*** (Pers.) Gilb. & Ryvarden: (Doğan and Öztürk, 2006).

358. ***Trametes suaveolens*** (L.) Fr.: (Öztürk et al., 2001).

359. ***Trametes trogii*** Berk.: (İleri et al., 2020; Çetinkaya et al., 2021).

360. ***Trametes versicolor*** (L.) Lloyd: (Doğan and Öztürk, 2006; Çetinkaya et al., 2021).

Russulales Kreisel ex P.M. Kirk, P.F. Cannon & J.C. David

Hericiaceae Donk

361. ***Hericium cirrhatum*** (Pers.) Nikol.: (Doğan and Öztürk, 2006).

Peniophoraceae Lotsy

362. ***Peniophora aurantiaca*** (Bres.) Höhn. & Litsch.: (İleri et al., 2020).

363. ***Peniophora quercina*** (Pers.) Cooke: (İleri et al., 2020).

Russulaceae Lotsy

364. ***Boidinia furfuracea*** (Bres.) Stalpers & Hjortstam: (Doğan et al., 2011b).

365. ***Lactarius acerrimus*** Britzelm.: (Doğan and Öztürk, 2006).

366. ***Lactarius deliciosus*** (L.) Gray: (Doğan and Öztürk, 2006).

367. ***Russula chloroides*** (Krombh.) Bres.: (Doğan and Öztürk, 2006).

368. ***Russula emetica*** (Schaeff.) Pers.: (Doğan and Öztürk, 2006).

369. ***Russula ochroleuca*** Fr.: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

370. ***Russula pallidospora*** J. Blum ex Romagn.: (Kaşık et al., 2000; Doğan and Öztürk, 2006).

371. ***Russula vesca*** Fr.: (Doğan and Öztürk, 2006).

Stereaceae Pilát

372. ***Stereum hirsutum*** (Willd.) Pers.: (Doğan and Öztürk, 2006; İleri et al., 2020; Çetinkaya et al., 2021).

373. ***Stereum sanguinolentum*** (Alb. & Schwein.) Fr.: (Doğan and Öztürk, 2006).

Thelephorales Corner ex Oberw.

Bankeraceae Donk

374. ***Boletopsis leucomelaena*** (Pers.) Fayod: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

375. ***Hydnellum glaucopus*** (Maas Geest. & Nannf.) E. Larss., K.H. Larss. & Kõljalg: (Doğan and Öztürk, 2006).

376. ***Sarcodon imbricatus*** (L.) P. Karst.: (Öztürk et al., 2001; Doğan and Öztürk, 2006).

Thelephoraceae Chevall.

377. ***Thelephora caryophyllea*** (Schaeff.) Pers.: (Öztürk et al., 2003).

Dacrymycetes Doweld

Dacrymycetales Henn.

Dacrymycetaceae J. Schröt.

378. ***Dacrymyces capitatus*** Schwein.: (İleri et al., 2020).

379. ***Dacrymyces variisporus*** McNabb: (Doğan and Öztürk, 2006).

Tremellomycetes Doweld

Tremellales Fr.

Tremellaceae Fr.

380. ***Tremella mesenterica*** (Schaeff.) Pers.: (Çetinkaya et al., 2021).

4. Discussions

Compiling the overall macrofungal taxa that had been presented so far, Karaman was determined to hosts a total of 380 species within *Ascomycota* and *Basidiomycota.* Sixty five (%17.11) of them belong to *Ascomycota* while 315 (%82.89) belong to *Basidiomycota*.

Table 1. Distribution of the determined taxa in classes.

Division	Class	# of taxa
Ascomycota	*Pezizomycetes*	46
	Leotiomycetes	11
	Sordariomycetes	6
	Dothideomycetes	1
	Orbiliomycetes	1
Basidiomycota	*Agaricomycetes*	312
	Dacrymycetes	2
	Tremellomycetes	1

The macrofungi species determined in Karaman were found to distribute in eight classes (Table 1) and 20 orders (Table 2). The most crowded class and the order were found to be *Agaricomcyetes* and *Agaricales* respectively.

Seventy five macromycete families were represented in Karaman. Thirty of the compiles species are currently not assigned in a family and are in Incertae Sedis position. *Psathyrellaceae, Agaricaceae, Strophariaceae, Pyronemataceae* and *Tricholomataceae* are the first 5 most crowded families in the region with 30, 23, 18, 16 and 16 species respectively. The most crowded genus is *Tricholoma* (Fr.) Staude with 16 taxa. It was followed by *Melanoleuca* Pat., *Psathyrella* (Fr.) Quél., *Conocybe* Fayod and *Coprinopsis* P. Karst. with 13, 9, 8 and 8 species respectively.

According to the presented data and the literatural data, 91 of the 380 species are edible, 258 are inedible and 31 are poisonous. Twenty four of them (*Agaricus campestris, Bovista plumbea, Chroogomphus rutilus, Gomphus clavatus, Lactarius deliciosus, Langermannia gigantea, Lepista nuda, Macrolepiota excoriata, M. procera, Melanoleuca schumacheri, Mitrophora semilibera, Morchella deliciosa, M. esculenta, Picoa juniperi, P. lefebvrei, Pleurotus ostreatus, Ramaria flava, Rhizopogon roseolus, Terfezia albida, T. boudieri, T. claveryi, Tricholoma populinum, T. terreum, Xerula melanotricha*) are collected and consumed by local public. *Terfezia* spp. are heavily collected and consumed in Central Anatolian parts of Karaman and surrounding regions (Doğan and Öztürk, 2006; Çelik et al., 2020; İleri et al., 2020; Çetinkaya et al., 2021; Çevik et al., 2021; Berber et al., 2022).

Table 2. Distribution of the determined taxa in orders.

Division	Class	# of taxa
Ascomycota	*Pezizales*	46
	Helotiales	11
	Xylariales	3
	Hypocreales	2
	Diaporthales	1
	Orbiliales	1
	Patellariales	1
Basidiomycota	*Agaricales*	223
	Polyporales	22
	Boletales	18
	Hymenochaetales	16
	Russulales	13
	Geastrales	5
	Gloeophyllales	4
	Gomphales	4
	Thelephorales	4
	Cantharellales	2
	Dacrymycetales	2
	Auriculariales	1
	Tremellales	1

Among the determined taxa, 107 are lignicolous, 16 are coprophilous, 7 are bryophilous, 7 are herbicolous, 2 are pyrophilous and the rest of the taxa are terricolous. Fifteen of them were determined as hygogeous.

Conflict of Interest

The author has declared no conflict of interest.

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Comparison of DNA isolation methods for GMO detection from biscuit samples

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Bisküvi örneklerinden GDO tespiti için DNA izolasyon metotlarının karşılaştırılması

Abstract: The global increase in genetically modified organism (GMO) content in feed and food products has necessitated the development of precise detection methods to differentiate between biotechnologically derived foods and those without GMOs. Despite the various regulations in different countries, an internationally consistent approach to labeling GMO products is needed. For this reason, there is a widespread need to develop effective GMO detection methods to provide reliable and transparent food safety to consumers. The first experimental step in creating accurate and reliable detection methods for GMOs is effective DNA isolation. Determining DNA isolation methods specific to different processing levels of foods is very important. This study was aimed to compare different DNA extraction methods in biscuit samples. For this reason, DNA from different biscuit samples was isolated using three different protocols (CTAB-PVP, modified CTAB-1, and modified CTAB-2). DNA samples extracted from biscuits, were evaluated regarding DNA concentration and purity. According to the results obtained, the CTAB-2 procedure generally showed the best performance in terms of both DNA amount and purity rates for biscuit samples.

Key words: Biscuit, CTAB, DNA extraction, GMO, food safety

Özet: Genetiği değiştirilmiş organizmaların (GDO) kullanıldığı yem ve gıda ürünlerinin dünya çapında artış göstermesi, biyoteknolojik yollarla elde edilen bu gıdalar ile, GDO içermeyen gıdalar arasında ayrım yapabilen tespit yöntemlerinin geliştirilmesine yol açmıştır. Farklı ülkelerdeki çeşitli düzenlemelere rağmen, GDO'lu ürünlerin etiketlenmesi konusunda uluslararası düzeyde tutarlı bir yaklaşıma ihtiyaç vardır. Bu sebeple tüketicilere güvenilir ve şeffaf bir gıda güvenliği sağlamak açısından etkili GDO tespit yöntemlerinin geliştirilmesine dair ihtiyaç oluşmaktadır. GDO'ya yönelik doğru ve güvenilir tespit yöntemlerinin oluşturulmasında ilk deneysel işlem basamağı etkili bir DNA izolasyonudur. Bu konuda farklı işlenmişlik seviyesindeki gıdalara özgü DNA izolasyon yöntemlerinin belirlenmesi oldukça önemlidir. Bu çalışmada, bisküvi örnekleri için farklı DNA ekstraksiyon yöntemlerinin karşılaştırılması amaçlanmıştır. Bu sebeple farklı bisküvi örneklerine ait DNA'lar, seçilen üç faklı protokol (CTAB-PVP, modifiye CTAB-1 ve modifiye CTAB-2) kullanılarak izole edilmiştir. İşlenmiş gıda ürünleri olan bisküvilerden ekstrakte edilen DNA örnekleri, DNA konsantrasyonu ve saflığı bakımından değerlendirilmiştir. Elde edilen sonuçlara göre bisküvi örnekleri için hem DNA miktarı hem de saflık oranları bakımından genel olarak en iyi performansı CTAB-2 prosedürü göstermiştir.

Anahtar Kelimeler: Bisküvi, CTAB, DNA ekstraksiyonu, GDO, gıda güvenliği

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1. Introduction

The labeling of products containing genetically modified organisms (GMOs), which have been artificially altered to obtain desired traits, is subject to varying regulations in different countries (Arvas and Kocaçalışkan, 2020). For instance, the European Union (EU), Korea, and Japan have legal frameworks that mandate necessary measures for the traceability of GMOs. According to EU law, mandatory labeling procedures are applied for GMO content exceeding a certain threshold (0.9%) (Davison, 2010). However, in most African countries, labeling is still not obligated (Gbashi et al., 2021). In Türkiye, within the scope of the Biosafety Law, the use of plant products containing GMOs in food products and production processes is prohibited (Regulation, TR). Nevertheless, certain transgenic products are allowed to enter the country with the necessary permits, particularly for animal feed, and the likelihood of imported agricultural products being genetically modified increases daily (Arvas and Yılmaz, 2019). Therefore, the development and effective use of GMO detection methods are crucial to ensure the proper implementation of labeling and regulatory standards at an international level, providing consumers with more reliable and transparent food safety.

Today, most of the corn and soybean crops grown are genetically modified. In the United States, most processed foods on the market contain GMOs (Abrams et al., 2024). Among GMOs, soybeans, corn, and canola are the most commonly grown plant sources found in many food products (Erkan and Destan, 2017; Soylu et al., 2020; Ashrafi-Dehkordi et al., 2021; Abrams et al., 2024). Genetically modified soybeans are the most widely cultivated crop globally, while corn, following soybeans, is the second most extensively produced plant product (ISAAA, 2019). The agricultural sector heavily utilizes GMO products for animal feed, and GMO components are frequently encountered in processed food products. These products include processed corn starch, soybean-based oils,

and high-fructose corn syrup (Abrams et al., 2024). Approximately 77% of global soybean production comes from genetically modified soybeans. In leading soybean-producing countries such as Brazil, the United States, and Argentina, most of these 'biotech crops' are glyphosate-tolerant varieties, with adoption rates ranging from 94% to 100% (Bøhn and Millstone, 2019).

The global increase in GMO-containing soybean feed and food products is driving the development of GMO detection methods worldwide. These methods must detect, identify, and quantify added DNA or expressed proteins. However, using processed and highly refined components can make DNA and protein detection challenging or even impossible when soybean or corn-derived components are present in low concentrations (Gryson et al., 2002; Aksoy and Ateş Sönmezoğlu, 2022).

GMO-containing foods can be identified through various biomolecules such as specific proteins, RNA, DNA, and metabolites. Among these targets, DNA is the only molecule that is stable, abundant, and easily amplifiable (Lin and Pan, 2016). Heat transfer processes, such as cooking, baking, drying, sterilizing, or freezing, are integral to almost every food processing operation (Vijayakumar et al., 2009). Therefore, the detection of specific DNA sequences using a PCR-based approach remains the most effective strategy (Lin and Pan, 2016; Singh et al., 2021). However, DNA quality in food products can deteriorate due to processing procedures. A validated extraction method is a prerequisite for obtaining detectable quantities of DNA with acceptable purity, not only for DNA-based food authentication (Ramos-Gómez et al., 2014) but also for GMO testing. In this context, an effective DNA isolation process is the first step in accurately and reliably detecting GMOs. However, specific flavors or chemical contents in processed foods can alter DNA quality and act as inhibitors for amplification (Ramos-Gómez et al., 2014; Singh et al., 2021). The presence of multiple components in processed foods, especially in the food industry, complicates the process by potentially providing insufficient quality and quantity of DNA for PCR amplification (Aksoy and Ateş Sönmezoğlu, 2022). Complex matrices, such as chocolate and biscuits, contain a range of PCR inhibitors like polysaccharides and polyphenols that can hinder DNA amplification.

Additionally, challenges in amplifying the lectin gene in contents like chocolate, biscuits, and cakes arise due to the low concentrations of soybean components found in sweetener industry products (Gryson et al., 2004). Thus, an efficient extraction procedure is crucial. To address these challenges, research in the literature has focused on using DNA extraction methods from processed foods for effective GMO analysis. Di Pinto et al. (2007) compared two different commercial kits (Wizard® Magnetic DNA Purification Kit and DNeasy® Tissue Kit) for DNA extraction from various food matrices, finding that the Wizard® Magnetic DNA Purification Kit was suitable for some vegetable matrices, while the DNeasy® Tissue Kit was more appropriate for other complex and processed matrices. Mafra et al. (2008) compared the CTAB (Cetyltrimethylammonium Bromide) method with three different commercial kit procedures, performing DNA extraction from various food products derived from soybeans. They demonstrated that the Wizard method was suitable for highly processed foods. Turkec et al. (2015) applied DNA extraction methods to corn products, including flour, starch, bread, cereal, chips, biscuits, diet breakfast cereals, canned corn seeds, and feed samples, and recommended the Wizard, Genespin, or CTAB methods for the highest DNA content. Singh et al. (2021) reported on the use of CTAB methods and modifications of the DNeasy Mericon Food Kit for a wide range of food products, from oils such as canola, cotton, mustard, and soybean to other products like apple juice, green apple, corn, potatoes, soy, and tomatoes, emphasizing that DNA extraction is a critical step in GMO detection tests for food derivatives.

Commercial kits are more expensive compared to traditional CTAB-based DNA extraction methods and are suitable for only a limited number of samples. In contrast, conventional CTAB-based DNA extraction methods are more cost-effective, with the necessary chemicals and materials often being readily available, providing researchers with affordable options for large-scale studies. These procedures can be modified according to laboratory conditions, sample types, or experimental requirements. Ateş Sönmezoğlu and Keskin (2015) compared eight different DNA extraction protocols, including two commercial kits, for 27 processed food products. They reported that extraction kits (protocols 7 and 8) did not yield high DNA outputs but provided good DNA quality regarding A260/A280 ratios (1.67 and 1.64). Among the two CTAB procedures used in the study, the protocol-4 CTAB method produced higher DNA yields than the protocol-6 CTAB method, and the Wizard methods (protocols 1 and 2) were identified as the most suitable for extracting DNA from highly processed foods such as breakfast cereals, corn chips, biscuits, and cakes. Ashrafi-Dehkordi et al. (2021) compared three different CTAB-based methods and found that the modified CTAB method yielded promising results due to higher concentrations compared to the standard CTAB and phenol/chloroform methods. Different food products may require different DNA extraction protocols because DNA purity and concentration are significantly influenced by food processing, contaminants in sample matrices such as polysaccharides, lipids, and polyphenols, and physical parameters or extraction chemicals like CTAB (Xia et al., 2019). While the CTAB method is suitable for extracting DNA from complex food matrices or more challenging samples, SDS-based methods are more appropriate for extracting DNA from less processed foods (seeds, powder, pulp) (Wang et al., 2012; Ashrafi-Dehkordi et al., 2021). PVP (Polyvinylpyrrolidone) (1–2% w/v) is used in CTAB-based extraction methods to isolate DNA from plant species by absorbing polyphenols and preventing their oxidation, thus preventing DNA degradation (Sahu et al., 2012). Further comprehensive data on such extraction methods require similar studies on different food materials.

This study compared various CTAB-based DNA extraction methods to determine GMO content in biscuit samples. DNA extraction was performed on different biscuit samples using three different protocols (CTAB-PVP, modified CTAB-1, and modified CTAB-2). The DNA samples obtained from processed food products like biscuits were analyzed spectrophotometrically for DNA concentration and purity.

2. Materials and Method

2.1 Food materials

In this study, four different brands of biscuits containing soybean ingredients were used as food materials. The biscuit samples were sourced from local markets between 2023 and 2024. The GMO-positive control, GM soy (soybean meal), was obtained from the TÜBİTAK-MAM Biotechnology Institute. The soybean meal used in the experiment is a protein-rich feed product derived from the residual part of soybean seeds after oil extraction (Ergin and Aydemir, 2018). The biscuit and soybean meal samples were ground into flour using a mortar and pestle, and the experiments were conducted in triplicate for each food product.

2.2 DNA extraction methods

2.2.1. Procedure 1 (CTAB-PVP Method)

This procedure, described by Costa et al. (2015) with some minor modifications, was used in this study. According to this protocol, 200 mg of ground biscuit sample was placed into 2 mL sterile tubes. To this, 1 mL of CTAB extraction buffer (%2 CTAB (w/v), 0.1 mol/L Tris, 1.4 mol/L NaCl, %1 PVP-40 (w/v), 0.02 mol/L EDTA, pH 8.0) (Sigma Aldrich, USA) was added. The buffer was preheated to 65 ± 0.5°C, and 20 µL of β-mercaptoethanol (Sigma Aldrich) was added. After incubation with continuous mixing (900 rpm) at 65°C for 1 hour, the mixture was centrifuged (15 minutes, 18,500 × g, 4°C). The upper phase (700 µL) was collected into a separate Eppendorf tube and centrifuged again for 5 minutes under the same conditions. The supernatant was mixed vigorously with 500 µL of chloroform (Sigma Aldrich) for 20 seconds and then centrifuged (10 minutes, 12,000 × g, 4°C). The supernatant (approximately 500 µL) was separated and transferred to a new Eppendorf tube. To this solution, CTAB precipitation solution (%0.5 CTAB (w/v), 0.04 mol/L NaCl) (Sigma Aldrich) was added in double volume (1000 µL) and incubated at room temperature for 1 hour. The mixture was centrifuged again (10 minutes, 12,000 × g, 4°C), and the supernatant was discarded. The precipitated DNA was dissolved in a 350 µL solution containing 1.2 mol/L NaCl. This solution was subjected to liquid-liquid extraction with 350 µL of chloroform and centrifuged under the same conditions. The upper phase (300 µL) was mixed with 80% isopropanol (v/v) (Sigma Aldrich) at -20°C. The mixture was centrifuged again, and the supernatant was discarded. The pellet was washed with 70% ethanol (Merck, USA) solution at -20°C and dried at 50°C for 30 minutes. DNA was dissolved overnight at 4°C in 100 µL of Tris-EDTA buffer (1 mmol/L Tris, 0.1 mmol/L EDTA).

2.2.2. Procedure 2 (Modified CTAB-1 Method)

According to the modified CTAB protocol proposed by Gryson et al. (2004), 300 µL of sterile deionized water was added to a microcentrifuge tube containing 100 mg of homogenized sample, and the mixture was homogenized with a Petri stick. Subsequently, 500 µL of CTAB buffer (20 g/L CTAB, 1.4 M NaCl, 0.1 M Tris-HCl, 20 mM Na2EDTA) (Sigma Aldrich) was added and the mixture was mixed again. Then, 20 µL of Proteinase K (20 mg/mL) (Sigma Aldrich) was added, the tube was vortexed, and incubated at 65°C for 90 minutes. Following this, 20 µL of RNase A (10 mg/mL) (Thermo Fisher Scientific) was added and incubated at 65°C for 5-10 minutes. The tube was then centrifuged at approximately 16,000 g for 10 minutes. The upper phase was transferred to a new microcentrifuge tube containing 500 µL of chloroform, and the tube was vortexed for 30 seconds. It was centrifuged at 16,000 g for 10 minutes and left until phase separation occurred. The upper phase was transferred to a new microcentrifuge tube. A double volume of CTAB precipitation solution (5 g/L CTAB, 0.04 M NaCl) was added as the precipitation solution. The solution was pipetted to mix, incubated at room temperature for 60 minutes, and then centrifuged at 16,000 g for 5 minutes. The supernatant was discarded, and the pellet in the solution was dissolved in 350 µL of 1.2 M NaCl. 350 µL of chloroform was added, vortexed for 30 seconds, and centrifuged again at 16,000 g for 10 minutes. The upper phase was transferred to a new microcentrifuge tube, and 0.6 volume of isopropanol was added. The tube was vortexed and centrifuged at 16,000 g for 10 minutes, and the supernatant was discarded. The pellet was washed in 500 µL of 70% ethanol, vortexed gently, and centrifuged at 16,000 g for 10 minutes. Finally, the supernatant was discarded, the pellet was dried, and the DNA was dissolved in 100 µL of sterile deionized water (Sisea and Pamfil, 2007; Ashrafi-Dehkordi et al., 2021).

2.2.1. Procedure 3 (Modified CTAB-2 Method)

This procedure, used in this study with minor modifications, was proposed by Lipp et al. (1999). Initially, 100 mg of the homogenized sample was transferred to a sterile reaction tube, and 500 µL of CTAB buffer (20 g/L CTAB, 1.4 M NaCl, 0.1 M Tris/HCl, 20 mM EDTA) was added to the solution. The mixture was then incubated at 65°C for 30 minutes. After centrifugation at 12,000 x g for 10 minutes, the upper phase was transferred to a tube containing 200 µL of chloroform. The mixture was vortexed for 30 seconds and then centrifuged at 11,500 x g for 10 minutes. The supernatant was transferred to a new tube. A double volume of CTAB precipitation solution (5 g/L CTAB, 0.04 M NaCl) was added. The mixture was incubated at room temperature for 60 minutes and then centrifuged at 12,000 x g for 5 minutes. The pellet was dissolved in 350 µL of NaCl (1.2 M), and 350 µL of chloroform was added and mixed. The mixture was vortexed for 30 seconds and then centrifuged at 12,000 x g for 10 minutes. The upper phase (aqueous phase) was transferred to a new reaction tube, and isopropanol (0.6 volume) was added. The mixture was then centrifuged at 11,500 x g for 10 minutes. Ethanol solution (70%; 500 µL) was added to the pellet tube and centrifuged at 11,500 x g for 10 minutes. The supernatant was discarded, the separated pellet was dried, and the DNA was dissolved in 100 µL of sterile deionized water (Lipp et al., 2001; Leão-Buchir et al., 2022).

2.3 DNA concentration and purity measurements

The quantity and purity of DNA isolated from biscuit samples were determined using spectrophotometric methods. For this purpose, the samples were quantitatively assessed at 260-280 nm wavelengths using a NanoDrop (Denovix, DS-11 Spectrophotometer) (Wilfinger et al., 2006).

2.4 Statistical analysis

To evaluate the spectrophotometric values of DNA yield and purity obtained from the extraction procedures used in this study, a one-way ANOVA test was conducted using the

SPSS software package (IBM SPSS Statistics, version 22, New York, USA). Before analysis, all data were assessed for normality and homogeneity of variances. Individual differences were compared using Tukey's test. Differences were considered statistically significant at $p < 0.05$ (Costa et al., 2015).

3. Results and Discussion

The DNA concentrations and purity of biscuit samples subjected to DNA isolation methods were examined both across different brand sample groups (Table 1) and in terms of average values according to the extraction procedure (Table 2).

The A_{260}/A_{280} ratio provides important information about the purity and quality of a DNA sample (Vahdani et al., 2024). It indicates the degree of contamination of DNA with proteins and other organic components. Ideally, values between 1.8 and 2.0 indicate that the DNA is free from unwanted proteins and has been isolated with high quality. Additionally, values of 1.7 and above are considered acceptable in the literature (Sambrook and Russell, 2001). While a ratio of 1.8 signifies high purity of DNA, values above 2 suggest RNA contamination in the sample (Ateş Sönmezoğlu and Terzi, 2018).

Previous studies, including those by Arun et al. (2013) and Li et al. (2011), have emphasized that food processing methods such as temperature and pH changes can affect nucleic acid integrity. In this study, the observation that A_{260}/A_{280} ratios in biscuit samples did not exceed 2.0 suggests that the integrity of nucleic acids may have been compromised (Table 1). Consequently, this indicates that protein contamination is likely higher than anticipated. However, for the GM soy samples used as controls, the A_{260}/A_{280} ratio was above 2.0 for both protocol-1 (2.47) and protocol-3 (2.10) (Table 1). In protocol-2, this ratio was lower (1.67). Among all extraction protocols, only protocol-2 included RNAse A (10 mg ml^{-1}). Thus, using RNAse A was observed to be effective in preventing RNA contamination.

Regarding the A_{260}/A_{280} ratio, protocols 1 and 2, with the exception of sample-1 in protocol-2, yielded ratios below 1.8. Protocol-3, on the other hand, showed ideal results with values between 1.8 and 2.0 for all samples. Protocol-3 demonstrated an ideal extraction performance in terms of being free from protein contamination (Table 1).

Among all the extraction procedures examined, the highest average DNA yield was 51.76 ng μl^{-1} in protocol-3. The lowest DNA yield was found in protocol-2, with an average of 13.95 ng μl^{-1} (Table 2). Al-Salameen et al. (2012) noted that DNA extracted from processed foods is generally of low quality, present in very low concentrations, and may even be severely damaged. Therefore, in terms of providing sufficient DNA content for molecular detection and further analysis, the modified CTAB-2 method (protocol-3) contains a higher amount of DNA compared to other procedures (Table 2).

Although proteins may denature during food processing, detectable or trace amounts of DNA fragments can remain in the products; however, ensuring DNA quality is crucial (Singh et al., 2021). Pacheco Coello et al. (2017) reported that DNA quality extracted from processed foods could be a limiting factor for GMO testing. In Table 2, the A_{260}/A_{280} ratios obtained from the extraction methods vary according to the extraction procedure ($p<0.05$). While protocol-1 yields higher DNA quantities than protocol-2, the DNA quality is significantly lower, as indicated by the A_{260}/A_{280} ratio. This suggests a high level of protein contamination in protocol-1. Residual impurities from the DNA extraction process, such as phenol or ethanol, have also been reported to lower the A_{260}/A_{280} ratio (Piskata et al., 2019). Protocol-1, unlike the other protocols, involves drying the pellet at 50°C for 30 minutes after washing with ethanol. This may suggest that ethanol was not completely removed from the pellet.

As a secondary measure of nucleic acid purity, polysaccharide contamination can also be assessed by obtaining the A_{260}/A_{230} absorbance ratio (Walker and Wilson, 2005). This ratio is used to evaluate the level of salt residues in pure DNA, and it is recommended that this ratio be greater than 1.5 and preferably close to 1.8 (Aboul-Maaty and Oraby, 2019). Although Procedure-3 exhibits the best average A_{260}/A_{230} ratio of 1.79 (Table 2), individual sample analysis (Table 1) reveals that the presence of values above or below the optimal ratio does not provide a reliable result. Additionally, the negative control, soybean meal, showed significantly lower A_{260}/A_{230} ratios across all extraction protocols compared to the biscuit samples (Table 1). Chemical reagents involved in the isolation procedure can affect the purity of the extracted DNA, potentially leading to contamination (Piskata et al., 2019). Therefore, careful attention should be given to the final steps of DNA extraction, particularly the purification and washing stages.

Analysis of the DNA quantity and quality ratios of the GM soy used as a control reveals a significant difference in DNA amount (ng/µl) (Table 1). Ateş Sönmezoğlu and Keskin (2015) demonstrated in their study of various processed

Table 1. DNA quantity and purity measurements of biscuit samples

	Procedure-1			**Procedure-2**			**Procedure-3**		
Sample name	ng μl^{-1}	$A_{260/280}$	$A_{260/230}$	ng μl^{-1}	$A_{260/280}$	$A_{260/230}$	ng μl^{-1}	$A_{260/280}$	$A_{260/230}$
Sample -1	69.38	1.38	2.05	15.22	1.91	1.18	51.0	1.90	1.93
Sample -2	22.13	0.44	1.49	14.35	1.35	1.45	56.23	1.84	1.59
Sample -3	30.17	0.60	2.69	11.72	1.31	1.09	76.82	1.89	2.06
Sample -4	20.87	0.54	1.45	14.52	1.39	1.18	23.0	1.95	1.04
PC	123.57	2.47	0.95	394.17	1.67	0.18	156.06	2.10	0.98

PC: positive control (GM soy)
ng μl^{-1}: DNA amount (yield)
260, absorbance at A_{260} nm; 280, absorbance at A_{280} nm

Table 2. Summary of DNA yield and purity for biscuit samples using DNA extraction methods

DNA extraction method	DNA yield (ng µl^{-1})±SD of medium	DNA purity (A_{260}/A_{280})	A_{260}/A_{230}
Procedure - 1	35.64±22.86ab	0.74±0.43a	1.92±0.58a
Procedure - 2	13.95±1.53a	1.49±0.28b	1.22±0.15a
Procedure - 3	51.76±22.17b	1.89±0.04b	1.79±0.65a
***P* value**	0.05	0.001	0.181

Mean ± SD: mean ± standard deviation
A_{260}, absorbance at 260 nm; A_{280}, absorbance at 280 nm
a,b Different letters in each column indicate significant differences between DNA concentration or purity values (p<0.05)

food samples, including different biscuit types, that soybean flour and soybean meal (GM soy) yielded the highest DNA content among the analyzed food samples, attributed to their lower degree of processing. In this study, GM soybean meal was chosen as a positive control for comparing DNA yields from biscuit samples, given its relatively lower processing. The results are consistent with Ateş Sönmezoğlu and Keskin (2015) findings, confirming that biscuit samples had significantly lower DNA yields compared to the GM soy control. For Procedure-2, the average DNA yield for biscuit samples was approximately 13.95 ng/µl, while the highest DNA yield of 394.17 ng/µl was obtained from GM soy. Similar results in terms of DNA quantity were observed between biscuit samples and GM soy across other extraction procedures. This difference is likely related to the physical grinding process and the high degree of food processing undergone by the biscuit samples before DNA extraction, resulting in lower DNA yields (Turkec et al., 2015; Pacheco Coello et al., 2017; Bitir et al., 2020; Leão-Buchir et al., 2022). Additionally, Ramos-Gómez et al. (2014) noted that the presence of specific components (including fats and carbohydrates) can significantly impact DNA yield and quality. Therefore, GM soy samples are expected to yield higher DNA results than biscuit samples.

The quality of DNA extracted from food samples is typically influenced by factors such as the degree of damage, the presence of PCR inhibitors in complex food matrices, and the average fragment length of the extracted DNA. These factors depend on both the samples themselves and the processes involved in food production, as well as the physical and chemical parameters of the extraction method (Peano et al., 2004; Elsanhoty et al., 2011). Abdel-Latif and Osman (2017) reported that in their study using a CTAB-based extraction method with 1% PVP added, they could not observe an absorbance peak at 260 nm when measuring with a NanoDrop device. In this study, the CTAB extraction procedure with added PVP (Procedure-1) provided spectroscopic measurements of considerably lower purity for biscuit samples compared to the other two extraction procedures. Thus, the addition of PVP to the CTAB extraction method did not result in improved DNA isolation in this study. Previous studies have confirmed that the CTAB method yielded better results for DNA extraction from raw soybeans, raw corn, animal feeds (Tung-Nguyen et al., 2009), dairy products (Pirondini et al., 2010), and chocolate and biscuits (Gryson et al., 2004; Mutlu et al., 2021). In this study, among the CTAB-based extraction procedures compared, Procedure-3 demonstrated sufficient DNA yield and quality for potential use in GMO detection analyses of biscuit samples, aligning with results from previous similar studies.

Based on the results obtained from the DNA extraction methods, it is evident that the quality and quantity of DNA significantly influence the accuracy and reliability of GMO detection in processed food samples, such as biscuits. For example, in a study by Arun et al. (2016) investigating the impact of heat treatment on GMO detection in baked, it was reported that DNA integrity in soybean samples baked at 220°C significantly decreased over time. The findings of this study suggest that the modified CTAB-2 method (Procedure-3) provides better DNA yields and purity, which are critical for subsequent GMO analysis. Given the inherent challenges posed by processed food matrices, such as the presence of PCR inhibitors and degraded DNA, the selection of the extraction method is of paramount importance.

In practical terms, this study underscores the importance of selecting the most appropriate DNA extraction protocol based on the specific characteristics of the food sample for applications in the food industry and regulatory bodies involved in GMO detection. The conventional CTAB method is a widely used technique for extracting DNA from food matrices and is manually performed using chloroform to separate DNA from contaminants (Verginelli et al., 2023). The EU Reference Laboratory for GM Food and Feed (EURL GMFF) frequently reports this method, often with potential modifications depending on the matrix (Sajali et al., 2018). Alternative methods exist that separate DNA from other cellular components using DNA-binding silica columns or magnetic beads (Ohmori et al., 2008; Krinitsina et al., 2015). While numerous articles have been published over time comparing different DNA extraction methods across various food matrices (Mafra et al., 2008; Tan and Yiap, 2009; Elsanhoty et al., 2011; Verginelli et al., 2023), the aim of this study is to validate to what extent the manually performed DNA extraction methods, commonly used in GMO detection of processed foods, meet the performance criteria for DNA quality and quantity in biscuit samples. For instance, in situations where high DNA purity is crucial, Procedure-3, which exhibited ideal A_{260}/A_{280} ratios and minimized protein contamination, would be the most appropriate choice. Conversely, if the primary concern is maximizing DNA yield, particularly from highly processed foods, Procedure-3 also appears to be the best method among the procedures tested, providing the highest average DNA yield.

Moreover, these findings emphasize the necessity of considering the impact of food processing on DNA integrity when designing GMO detection strategies.

Regulatory bodies may consider recommending specific extraction methods, such as Procedure-3, for routine analysis of processed foods to ensure reliable and consistent results. By adopting standardized and validated DNA extraction procedures, the food industry can improve the accuracy of GMO labeling, thereby enhancing consumer confidence and compliance with food safety regulations. Overall, this study provides valuable insights that can guide both the selection of extraction methods in research and their practical application in the food industry.

4. Conclusions

This study is based on a comparative analysis of DNA samples obtained from biscuit samples using different DNA extraction methods. Spectroscopic measurements were performed to obtain comparable information on the effectiveness and yield of routine DNA extraction procedures applied as an initial step for detecting GMO content. The results include an evaluation of DNA concentration and purity based on spectrophotometric measurements for DNA samples obtained using three different protocols (CTAB-PVP, modified CTAB-1, and modified CTAB-2).

The findings indicate that the yield and purity values of DNA samples extracted from processed food products, such as biscuits, varied depending on the extraction methods. The lowest DNA content was found in samples extracted using the modified CTAB-1 method. On the other hand, samples extracted with the modified CTAB-2 method exhibited the highest average DNA concentration and optimal purity in terms of the A_{260}/A_{280} ratio.

These results suggest that the modified CTAB-2 method (Procedure-3) could be preferred as an effective DNA isolation method for determining GMO content in biscuit samples. Furthermore, the study provides insights into the effects of routine chemicals and content used in DNA extraction protocols on the extraction of biscuit samples and evaluates the effectiveness of modified CTAB-based DNA extraction methods. The results from this study are expected to contribute to the development and improvement of CTAB-based methods as an alternative to commercial kits for routine analyses, addressing important food safety issues such as GMO detection and labeling. More comprehensive data on such extraction methods will require larger sampling and similar studies on different food materials with agarose gel imaging and PCR analyses. Such studies could enhance our understanding of the performance of DNA extraction methods across various food types and help achieve more reliable results.

Conflict of Interest

The authors of the articles declare that they have no conflict of interest.

Authors' Contributions

The data for this study were collected by Özlem Ateş Sönmezoğlu and Dr. Begüm Terzi Aksoy. Laboratory analyses for the study were conducted by Begüm Terzi Aksoy and Ahlem Sattuf. The text of the article was written by Begüm Terzi Aksoy.

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First record of *Hygrophoropsis flavida* (*Hygrophoropsidaceae, Agaricomycetes*) from Türkiye

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Hygrophoropsis flavida (*Hygrophoropsidaceae, Agaricomycetes*)'nın Türkiye'den ilk kaydı

Abstract: *Hygrophoropsis flavida* is reported for the first time from southern Türkiye, based on morphological and multi-molecular phylogenetic analyses, including nucleotide sequences of the nuclear ribosomal internal transcribed spacer (ITS1-5.8S-ITS2 = ITS) and large subunit (LSU) of the ribosomal RNA (rRNA) gene. In addition, the species was found on the rotten wood of relict endemic *Liquidambar orientalis* trees, which are presented here for the first time as a new substrate for this genus. A description of this species, based on macro- and micromorphological characteristics, is provided, along with colour photographs and line drawings.

Key words: *Agaricales*, multi-locus phylogeny, new record, nrITS, nrLSU, taxonomy, Türkiye

Özet: *Hygrophoropsis flavida*, morfolojik ve nükleer ribozomal iç transkripsiyonlu aralığının (ITS1-5.8S-ITS2 = ITS) ve ribozomal RNA (rRNA) geninin büyük alt biriminin (LSU) nükleotid dizilerini içeren moleküler filogenetik analizlere dayanarak Türkiye'nin güneyinden ilk kez rapor edilmiştir. Ayrıca, söz konusu tür, ilk kez bu cins için yeni bir konukçu olarak sunulan relikt endemik *Liquidambar orientalis* ağaçlarının çürümekte olan odun kalıntıları üzerinde bulunmuştur. Türün, makro ve mikromorfolojik özelliklerine dayanan tanımı, renkli fotoğrafları ve çizgi çizimleri ile birlikte verilmiştir.

Anahtar Kelimeler: *Agaricales*, çok lokuslu filogeni, yeni kayıt, nrITS, nrLSU, taksonomi, Türkiye

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1. Introduction

Hygrophoropsis (J. Schröt.) Maire ex Martin-Sans is one of the small genera in the *Boletales* E.-J. Gilbert, (*Hygrophoropsidaceae*), with its type species *H. aurantiaca* (Wulfen) Maire ex Martin-Sans, and is primarily characterised by its lamellate hymenophore; thick, narrow, often forked, dichotomously branched and decurrent lamellae; a central stipe that is often reduced and tapering; hyaline, thin- to somewhat thick-walled, dextrinoid basidiospores; and a white basidiospore print (Kuyper, 1995; Knudsen and Vesterholt, 2008; Kibby, 2012; Holec and Kolařík, 2013). The species of the genus occurs widely in areas across both the northern and southern hemispheres (Kuyper, 1995; Knudsen and Vesterholt, 2008). *Hygrophoropsis aurantiaca* is the most widely dispersed species, occurring on multiple continents (Kuyper, 1995; Roberts and Evans, 2011). In contrast, other species within the genus are less well-known and tend to have more restricted geographic distributions (Kibby, 2012).

Hygrophoropsis is closely related to *Coniophora* DC., and *Leucogyrophana* Pouzar (Binder and Hibbett, 2006; Zmitrovich et al., 2019). Unlike most *Boletales*, species of *Hygrophoropsis* are saprotrophic, causing brown rot, and are non-ectomycorrhizal (Watling, 2008). This distinguishes them from the family *Paxillaceae* Lotsy, where the genus was previously classified (Kibby, 2012).

Hygrophoropsis includes over 18 species globally (www.catalogueoflife.org/annual-checklist/, Catalogue of Life 2024). According to the Index Fungorum database (www.indexfungorum.org, accessed 7 August 2024), 42 taxa of *Hygrophoropsis* have been documented, though some of these are considered illegitimate names or synonyms. In Türkiye, two species, *Hygrophoropsis aurantiaca* and *H. macrospora* (D.A. Reid) Kuyper, have been previously reported (Sesli et al., 2020; Solak and Türkoğlu, 2022). This study, part of ongoing research to explore macrofungal biodiversity in Türkiye, presents the first record of *Hygrophoropsis flavida* Testoni & Setti in the country, supported by both morphological and phylogenetic analyses.

2. Materials and Method

2.1. Collections and morphological analyses

Hygrophoropsis specimens were gathered during field expeditions to the Burdur and Muğla Provinces in southern Türkiye in 2015 and 2017. The characteristics of fresh specimens were observed, and morphological features were documented following the methodology described by Vellinga (1988) and Kuyper (1995). For microscopic analysis, dried samples were mounted using cotton blue, 3% KOH or Melzer's reagent. A Leica DM750 microscope was used to examine microscopic features at magnifications of up to 1000×. Measurements were taken from a minimum of 30 basidiospores, and the Q value

represents the average length-to-width ratio derived from these measurements. All specimens have been stored in the fungarium at Isparta University of Applied Sciences (ISUF).

2.2. DNA analyses techniques

The ZR Fungal/Bacterial DNA MiniPrep kit was employed to extracted from small dried specimens. To amplify DNA through Polymerase Chain Reaction (PCR), two sets of barcodes and primers were utilized. ITS1F (White et al., 1990) and ITS4 (Gardes and Bruns, 1993) were used to amplify a fragment of the Internal Transcribed Spacer (ITS) region, while LR0R (Vilgalys and Hester, 1990) and LR5 (Rehner and Samuels, 1994) were specific for nuclear ribosomal Large Subunit (28S) gene.

A total of 25 µL was used to set up the PCR reaction mixture, which contained 12.5 µL of 2× PCR Master Mix, 8.5 µL of distilled water, 2 µL of DNA template, and 1 µL of each primer. A preliminary denaturation at 95°C for 7 minutes prepared the mixture for the amplification of the rDNA ITS and LSU regions. Following this, there were 35 cycles of denaturation (for one minute) at 93°C, annealing (for 45 seconds) at 55°C, and extension (for one minute) at 72°C. The final cycle involved maintaining the temperature at 72°C for ten minutes. A 1.0% agarose gel stained with ethidium bromide was used to visualize the final PCR products.

The selection of sequences for phylogenetic analyses was guided by BLAST results obtained from both GenBank (https://blast.ncbi.nlm.nih.gov/Blast.cgi) and the UNITE database (https://unite.ut.ee/analysis.php) (Nilsson et al., 2019). The combined nrITS and nrLSU dataset was aligned using the MAFFT v7 software for multiple sequence alignment (Katoh et al., 2019) and adjusted manually in BioEdit v7.0 when necessary (Hall, 2004). Phylogenetic relationships among taxa were determined through Maximum Likelihood (ML) and Bayesian Inference (BI) analyses. The ML analysis utilized RAxML v7.2.6 (Stamatakis, 2014) with 1,000 bootstrap replicates and the GTRGAMMA substitution model. For the BI analysis, MrBayes was used on the XSEDE platform via the CIPRES Science Gateway. This involved Markov Chain Monte Carlo (MCMC) sampling with six parallel chains running for 1 million generations, sampling trees every 1,000 generations. Branches with Maximum Likelihood Bootstrap (MLB) values of 80% or higher and Bayesian Posterior Probabilities (BPP) values of 0.90 or higher were indicated. The resulting phylogenetic tree was visualized using FigTree v1.4.2 (Rambaut, 2012).

3. Results

3.1. Phylogeny

Three sequences of *Hygrophoropsis* specimens were generated and deposited in GenBank (PQ148172-

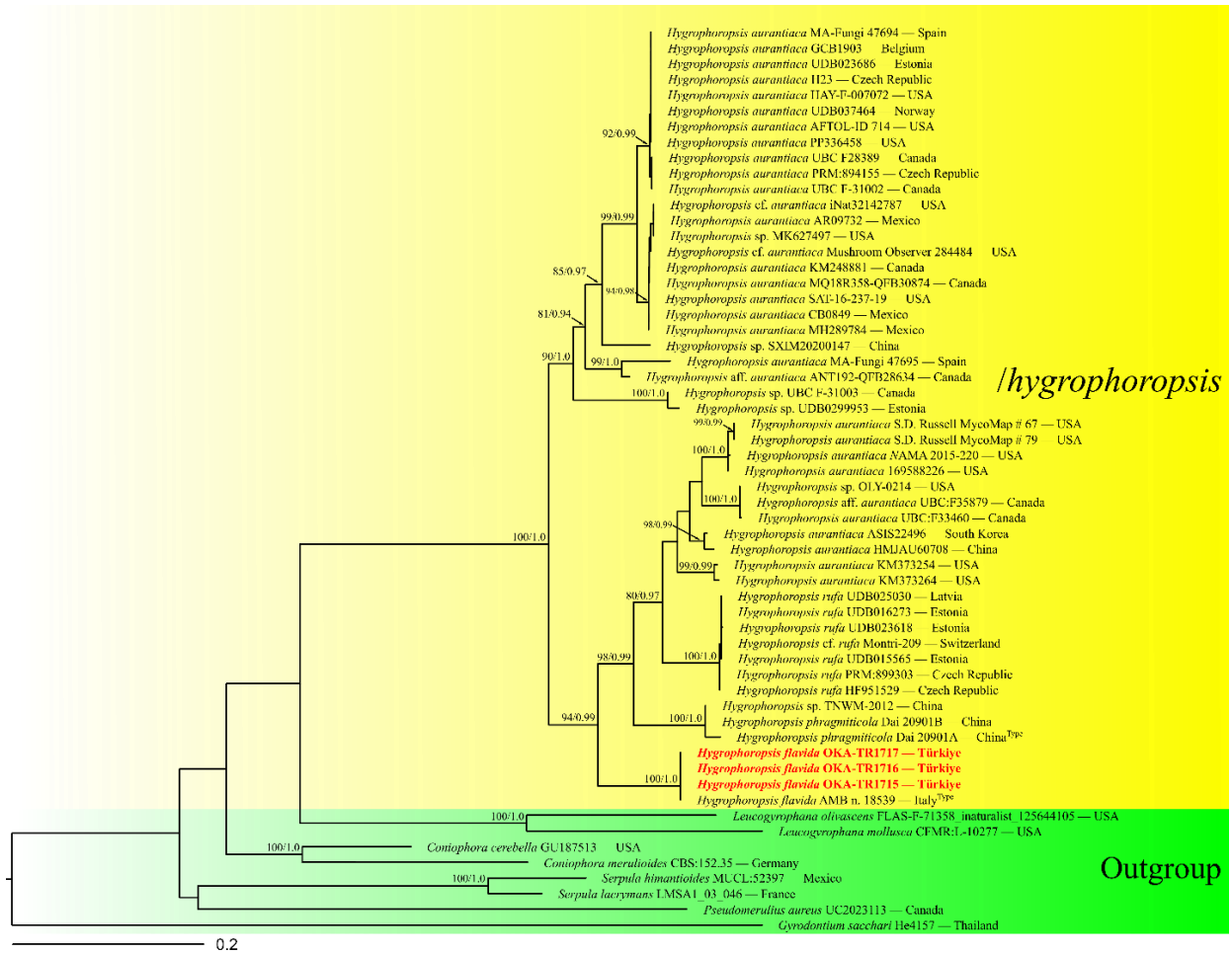

Figure 1. Phylogram generated from Maximum Likelihood (ML) analysis based on combined nrITS and nrLSU sequence data of *Hygrophoropsis*. Taxa used as outgroups in the phylogenetic analyses are highlighted in green. Newly generated sequences are shown in red.

PQ148174, PQ148178-PQ148180) as part of this study. According to the phylogenetic analyses based on rDNA ITS/LSU, the collections of *Hygrophoropsis flavida* (OKA-TR1715, OKA-TR1716, and OKA-TR1717) presented from Türkiye match the type sequence of *H. flavida* (AMB n. 18539). In addition, the collections of *Hygrophoropsis flavida* form a clade well supported by high bootstrap values (MLB = 100%, BPP = 1.0, Fig.1) and show strong statistical support for its genetic separation from other species within the genus *Hygrophoropsis.*

3.2. Taxonomy

Hygrophoropsis flavida Testoni & Setti, Riv. Micol. 64(3): 242 (2022) (Fig. 2)

Descriptions: Pileus 60–80 mm in diameter, initially convex to plano-convex, then expanding to applanate with a depressed at the centre; involute margin when young, becomes more or less inflexed, with a wavy-undulating margin when old; surface felty, creamy-whitish to yellow-cream or pale-ochraceous, slightly paler towards the margin. Lamellae crowded, decurrent to deeply decurrent, with about 10–25 mm connected to the stipe, forked and dichotomously branched, cream-coloured, then distinctly orange, with an entire, concolorous edge. Stipe 25–55 × 3.0–9.0 mm, curved and lateral, leathery or cartilaginous; surface hairy, whitish-orange, then yellowish-orange. Taste mushroom-like and odor mild. Spore print whitish to whitish-cream.

Basidiospores 5.5–6.5× 3.5–4.0 µm, Q = 1.6, ellipsoid, with a hilar appendage, smooth, thin- or slightly thick-walled, hyaline. Basidia 30–35 × 5.0–7.0 µm, clavate, 4–spored, thin-walled, hyaline. Basidioles 15–20 × 4.0–6.5 µm, narrowly clavate, thin-walled, hyaline. Pleurocystidia 35–45 × 6.0–12.0 µm, clavate to lageniform, sometimes moniliform, thin-walled, hyaline. Pileipellis a cutis of variously interwoven hyphae, branched, slightly gelatinous, 4.0–10.0 µm wide, cylindrical, hyaline; terminal hyphae 5.0–12.0 µm wide, narrowly clavate to clavate, thin-walled, hyaline. Trama of gills made up of parallel to slightly interwoven hyphae, 5.0–10.0 µm wide, cylindrical, thin-walled, hyaline. Hyphae of stipe consisting of cylindrical cells, 3.0–5.0 µm wide, thin-walled, hyaline. In all tissues, clamp connections are present.

Ecology: Saprotrophic, occurring on rotten branches or buried wood of *Liquidambar orientalis* Mill. during autumn.

Additional materials examined: Türkiye, Muğla Province, Fethiye district, in Yanıklar town, on decayed wood of *Liquidambar orientalis*, elev. 9 m a.s.l., 20 October 2015, leg. O. Kaygusuz (OKA-TR1715, GenBank nrITS: PQ148172, nrLSU: PQ148178); ibid., Köyceğiz district, in Döğuşbelen town, on *L. orientalis*, elev. 3 m a.s.l., 1 November 2016, leg. O. Kaygusuz (OKA-TR1716, GenBank nrITS: PQ148173, nrLSU: PQ148179). Burdur Province, Bucak district, close to Karacaören, in Sweetgum Forest Nature Protection Area, on wood of *L. orientalis*, elev. 255 m a.s.l., 25 October 2017, leg. O. Kaygusuz (OKA-TR1717, GenBank nrITS: PQ148174, nrLSU: PQ148180).

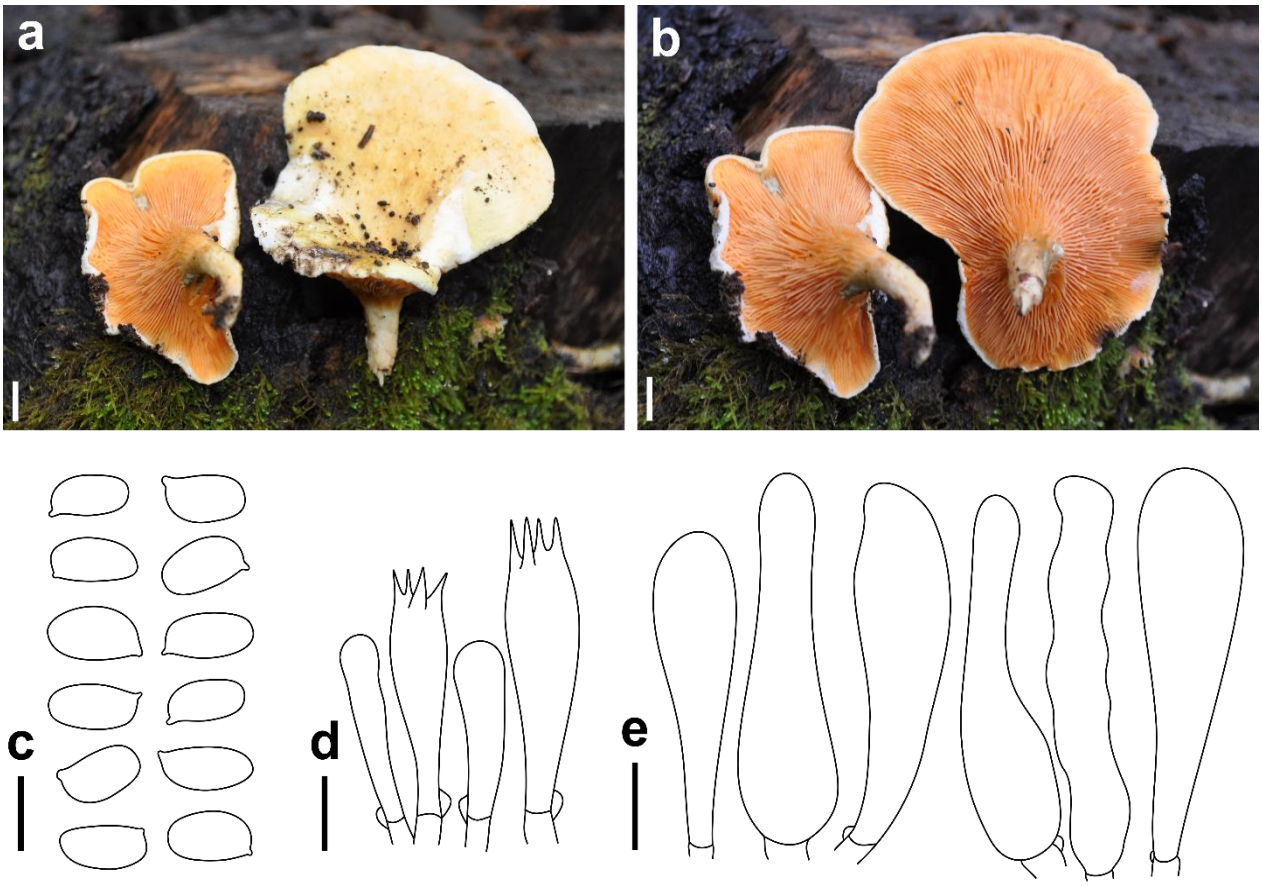

Figure 2. *Hygrophoropsis flavida*. (a-b) Basidiomata. (c) Basidiospores. (d) Basidia and basidioles. (e) Pleurocystidia. Scale bars: (a-b) = 10 mm, (c) = 5 µm, (d-e) = 10 µm.

4. Discussions

Hygrophoropsis flavida was recently described from Italy by Testoni and Setti (2022) from dead stems of *Populus* sp. Specimens of *Hygrophoropsis flavida* collected in Türkiye are reported on decaying wood of the relict endemic *Liquidambar orientalis*, representing a novel substrate for the genus *Hygrophoropsis*.

The phylogenetic results indicated that *Hygrophoropsis flavida* has a close affinity with *H. aurantiaca*, *H. phragmiticola* L.T. Ban & Meng Zhou, and *H. rufa* (D.A. Reid) Knudsen. However, morphologically, *Hygrophoropsis aurantiaca* differs from *H. flavida* by a bright to pale orange pileus with a felty-tomentose surface, a slender and darker orange stipe, and slightly longer basidiospores (5.5–7.0 × 3.0–4.0 µm) (Kuyper, 1995; Knudsen and Vesterholt, 2008; Kibby, 2012). *Hygrophoropsis phragmiticola*, originally described from China, can be distinguished by its creamy-whitish to pale-ochraceous pileus, white to cream lamellae, notably longer basidiospores (6.0–10.0 × 4.0–4.5 µm), and its growth on *Phragmites* sp. (Hongpeng et al., 2022). *Hygrophoropsis rufa* differs by having larger basidiomata (up to 100 mm in diameter), orange-brown to dark brown pileus, and usually grows on stumps or trunks of coniferous trees (Knudsen and Vesterholt, 2008; Holec and Kolařík, 2013).

Hygrophoropsis flavida also resembles some European species, such as *H. fuscosquamula* P.D. Orton and *H. macrospora*. *Hygrophoropsis fuscosquamula* differs from *H. flavida* by its dark-brownish hairs on the pileus surface, slightly longer basidiospores (6.0–8.0 × 3.5–4.5 µm), and cylindric-clavate pileipellis cells with brownish contents (Orton, 1960). *Hygrophoropsis macrospora* differs by having a pale pileus and lamellae, and distinctly longer basidiospores (up to 13 µm) (Reid, 1972; Kuyper, 1995; Krieglsteiner, 2001; Kibby, 2012; Glejdura, 2013; Gyosheva and Stoykov, 2017).

Conflict of Interest

The author has declared no conflict of interest.

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Vertical distribution of epiphytic lichens on *Quercus robur* L. in Görükle Campus Area of Bursa Uludag University (Bursa, Türkiye)

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Bursa Uludağ Üniversitesi (Bursa, Türkiye) Görükle Yerleşkesi alanında *Quercus robur* L. üzerindeki epifitik likenlerin dikey dağılımı

Abstract: In this study, the vertical change of epiphytic lichen species on *Quercus robur* was examined in Johansson zones based on frequency and cover values. A total of 20 epiphytic lichen species were determined from five trees. Total frequency and cover values of epiphytic lichen species show significant changes in Johansson regions. Beta diversity and Shannon diversity index values shows significant change with Johansson zone pairs. There is a significant difference in epiphytic lichen diversity between the Z1Z2 zone pair corresponding to the base and middle part of trunk on trees, and the Z4Z5 zone pair corresponding to the branches. *Athallia pyracea, Catillaria nigroclavata, Physcia adscendens* and *Rinodina pyrina* were positively correlated with Johansson zones, while *Phaeophyscia orbicularis* was negatively correlated with Johansson zones. *A. pyracea* is an indicator species especially for thin branches (Z5). *P. adscendens* is an indicator for Z4 and *Ph. orbicularis* is for the trunk part of the tree (Z1, Z2 and Z3).

Key words: Epiphytic lichen, vertical distribution, species diversity, species richness, *Quercus robur*

Özet: Bu çalışmada *Quercus robur* üzerindeki epifitik liken türlerinin Johansson zonlarındaki dikey değişimi frekans ve örtü değerlerine göre incelenmiştir. Beş ağaç üzerinden toplam 20 epifitik liken türü belirlendi. Epifitik liken türlerinin toplam frekans ve örtü değerleri Johansson bölgelerinde önemli değişiklikler göstermektedir. Beta çeşitliliği ve Shannon çeşitlilik indeksi değerleri Johansson bölge çiftleri ile anlamlı değişim göstermektedir. Ağaçlarda gövdenin taban ve orta kısmına karşılık gelen Z1Z2 bölge çifti ile dallara karşılık gelen Z4Z5 bölge çifti arasında epifitik liken çeşitliliği açısından önemli bir fark bulunmaktadır. *Athallia pyracea, Catillaria nigroclavata, Physcia adscendens* ve *Rinodina pyrina* Johansson zonları ile pozitif korelasyon gösterirken *Phaeophyscia orbicularis* Johansson zonları ile negatif korelasyon göstermektedir. *A. pyracea* özellikle ince dallar (Z5) için gösterge türdür. *P. adscendens* Z4 için gösterge ve *Ph. orbicularis* ağacın gövde kısmı (Z1, Z2 ve Z3) için gösterge türlerdir.

Anahtar Kelimeler: Epifitik liken, dikey dağılım, tür çeşitliliği, tür zenginliği, *Quercus robur*

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1. Introduction

The presence of corticolous lichens is associated with forest type, age, composition and structure, as well as light and moisture availability (Li et al., 2015; Güvenç and Öztürk Kula, 2021). Lichens are poikilohydric and highly sensitive to increases in light intensity. They are not very efficient at controlling water content. Therefore, they are very sensitive to changes in microclimate (Rheault et al., 2003). The main environmental factors controlling the diversity and distribution of epiphytic lichens are light intensity and humidity. Because the lower trunks of trees receive much less light than the upper trunk, epiphytic lichen diversity and biomass are generally higher in the sun-exposed upper canopy than at the trunk bases. As humidity increases, epiphytic lichen cover also increases (Cleavitt et al., 2009; Hauck, 2011). At the tree scale, the vertical distribution of epiphytic lichen diversity and community structure are affected due to their poikilohydric nature (Normann et al., 2010), leading to changes in the species structure and composition of epiphytic lichens from the base to tip of a tree (Castillo-Campos et al., 2019; Öztürk et al., 2023).

Other parameters affecting the lichen community are the pH and structure of the bark (Hauck et al., 2001; Wolseley et al., 2006) and the environment where trees of the same species grow, tree height and colonization time (tree age) (Çobanoğlu and Sevgi, 2009; Güvenç and Öztürk, 2017). For this reason, the distribution of lichens on trees is not homogeneous; some species prefer shady and moist areas, while others thrive in brighter, drier areas. Some species exhibit a wider range of microenvironmental tolerance (Öztürk et al., 2019).

The conversion of natural ecosystems to agricultural lands causes the loss, fragmentation or degradation of habitats for many species and is therefore one of the greatest threats to biodiversity worldwide. In addition to habitat loss, agricultural activities, especially fertilizer-intensive agriculture and intensive animal husbandry, also have a great impact on the atmosphere. These activities are the main anthropogenic sources of atmospheric nitrogen compounds, and their effects on terrestrial vegetation and lichens have been widely reported (Filippini et al., 2020).

The old trunk of *Quercus robur* is host a variety of lichen flora. Over time, oak bark becomes suitable for rare and

threatened species with increasing age (Johansson et al., 2010; Jonsson et al., 2011).

The aim of this study is to determine whether there is a vertical difference in epiphytic lichen diversity from base to tip on the trunk of *Q. robur*.

2. Materials and Method

2.1. Study area

This study was carried out in the oak grove next to the Faculty of Agriculture in Bursa Uludağ University Görükle campus. This pure oak grove consists of *Quercus robur*. trees. The faculty of agriculture was moved to Bursa Uludağ University Görükle Campus in 1996. There are agricultural application areas, roads and a heating center around the faculty of agriculture. The trees in the pure stemmed oak grove selected as the study area were planted in 1996. Coal was burned in the heating center until 2005. Natural gas was switched to the Görükle campus in 2005.

Q. robur, also known as pedunculate or English oak, is a broad-leaved deciduous tree. Individuals are very long-lived and can reach 3-4 meters in diameter and 40 meters in height. The main trunk of *Q. robur* tends to disappear in the crown and irregular branches with sinuous branches develop. Their bark is thick, gray and cracked. *Q. robur* is common throughout much of Europe; it extends to southern Norway and Sweden in the north, and to the northern part of the Iberian Peninsula, Southern Italy, the Balkan Peninsula and Turkey in the south. *Q. robur* is chosen for ornamental purposes due to its size and shade, and is especially preferred as a park or roadside tree (Eaton et al., 2016).

Epiphytic lichen samples were collected from 5 trees in the oak grove on 07 November 2023. The study area is located between 40°13′26-28″ north latitudes and 28°51′38-41″ east longitudes. Görükle campus area is under the influence of Mediterranean climate (Akman, 1999). The mean annual temperature is 14.4°C, and the mean annual rainfall is 691.9 mm in the Görükle campus area. The campus area has a wide variety of different plants, natural and planted and a total of 252 species, 71 subspecies and 33 varieties were recorded from here. Most of these taxa are Mediterranean element, followed by Euro-Siberian and Irano-Turanian elements, respectively (Tarımcılar and Kaynak, 1994; 1995). A total of 79 lichen species have been recorded in the studies conducted in the Görükle campus area so far (Güvenç and Aslan, 1994; John and Güvenç, 2023; Oran and Öztürk, 2011; Oran, 2019).

2.2. Collection of lichen samples

Lichen sampling was carried out on 5 *Quercus robur* trees in the study area. Each tree was sampled by dividing it into five Johansson zones defined by Gradstein et al. (2003) (Table 1). Trees close together in the same environment were selected to minimize the impact of environmental conditions on epiphytic lichen diversity. In order to minimize the effect of environmental conditions on epiphytic lichen diversity, trees close to each other in the same environment were selected. The trees in the pure-peduncle oak grove selected as the study area were planted in 1996. Therefore, the development of all trees is not at the same level. Therefore, five trees suitable for sampling were selected.

A modified form of the method used by Castillo-Campos et al. (2019) was used to collect the samples. To obtained the frequency and cover value of epiphytic lichens in each Johansson region, 10×10 cm^2 sampling templates consisting of four squares, each divided into 5×5 cm^2 squares, were placed in the north and south directions at the base, middle and upper parts of the trunk.

Samples were taken by randomly selecting 8 thick branches and placing a square with a surface area of 5x5 cm^2 on each of them. 8 branch pieces, 15 cm long, were randomly cut from the thin branches at the ends. A sampling template consisting of 4 vertically placed squares with an area of 2.5 cm^2 was used on each branch. Thus, sampling was made from an area of 5x5 cm^2 on a thin branch. In order to calculate the area (cover value) occupied by lichen species on the trunk and branches, photographs were taken of each sampling performed on each tree. According to this method, when a species is found in all frames sampled in a Johansson region on a tree, the frequency value can be maximum 8, and if the entire sampled surface is covered, the cover value can be maximum 200 cm^2.

2.3. Statistical Analyses

Total frequency and total cover values were used to analyze the vertical variation of epiphytic lichen species from the base to the thin branches at the tip of the tree. To compare epiphytic lichen diversity in five different Johansonn zones on the tree, we calculated total beta diversity (β_{cc}) and the difference in species richness between pairs of zones (β_{rich}) according to Castillo-Campos et al. (2019).

Total beta diversity

$$\beta_{cc} = \frac{b + c}{a + b + c}$$

The difference in species richness between pairs of zones

$$\beta_{rich} = \frac{|b - c|}{a + b + c}$$

Here;
a: the number of species common to both regions,
b: the number of species specific to the first region,
c: the number of species specific to the second region.

Table 1. Characteristics and average number of species of Johansson zones

Johansson zones	Location of zones on the tree trunk	Average circumference of the sampled part of trees	Average number of Lichen species
Z1	Base of tree (at ground level)	102.6±13.0	5.6±1.82
Z2	Middle part (at breast level)	85.4±11.5	5.6±1.52
Z3	Upper part (starting level of thick branches)	87.6±11.5	4.8±2.68
Z4	Thick branches (1 m above the beginning of branching)	24.3±4.2	5.8±1.48
Z5	Thin branches (at the tip)	4.5±1.1	7.8±1.92

Additionally, the difference in species diversity in different Johansson regions was analyzed according to the Shannon-Wiener Diversity Index (H') values calculated using frequency values (Nolan and Callahan, 2006). One-way analysis of variance (ANOVA) was used to analyze the changes in total frequency and cover values in the Johnsson zones. Total frequency, total cover and species richness (Shannon-Wiener Diversity Index, beta diversity) data calculated for Johansson zones and characteristic species for zones were compared using nonparametric Kruskal-Wallis tests followed by the Wilcoxon test for pairwise comparisons. Statistical analyses were performed using the IBM SPSS Statistics version 28. The significance level in the tests was evaluated as $p<0.05$.

3. Results

In this study, a total of 20 epiphytic lichen species were determined on *Quercus robur*. *Phaeophyscia orbicularis, Physcia adscendens* and *Xanthoria parietina* are the most common species. In all Johnsson regions, the cover and frequency values of *Ph. orbicularis, P. adscendens* and *X. parietina* are highest, while *Glaucomaria carpinea* and *Physcia stellaris* are low. Species found only in one zone are: *Amandinea punctata* (Z1), *Lecanora chlarotera* (Z2), *Biatora globulosa* and *Polyozosia hagenii* (Z5). While *A. punctata, Lecania cyrtella, L. chlarotera, Lecidella elaeochroma, Physconia distorta* and *Physconia grisea* were found only on the trunk part of the tree (Z1, Z2, Z3), *B. globulosa* and *Po. hagenii* were found only on the thin branches of the tree (Z5). The families with the highest species content are Lecanoraceae and Physciaceae (6 species), followed by Teloschistaceae with 4 species and Caliciaceae, Candelariaceae, Catillariaceae and Ramalinaceae with 1 species each (Table 2).

Total frequency and cover values in Johansson areas vary significantly from the base to the tip of the tree (Table 3). While the total frequency value shows a positive correlation with Johansson zones and an increase in the branches ($F: 3.461$, $p<0.05$), the total cover value shows a negative correlation and decrease in the branches part of the tree ($F: 7.166$, $p<0.01$).

Beta diversity values shows significant change with Johansson zone pairs. There is a significant difference in epiphytic lichen diversity between the Z1Z2 zone pair corresponding to the base and middle part of trunk on trees, and the Z4Z5 zone pair corresponding to the branches ($Z: -2.032$, $p<0.05$) (Fig. 1A). Similarly, in the comparison between Shannon diversity index values and Johansson zones, a significant difference ($Z: -2.023$, $p<0.05$) was found between the base (
1B).

When Johansson zone pairs are compared based on the difference in species richness, the lowest mean value is in the Z1Z2 zone pair corresponding to the base and middle part of the trunk of the tree, and the highest mean value is in the Z3Z4 zone pair, corresponding to the upper part of

Table 2. Total cover (cm^2) and frequency of epiphytic lichen species in Johansson areas on *Quercus robur*

		Z1		Z2		Z3		Z4		Z5		Total	
Average circumference of the sampled part of the tree		**102.6±13.0**		**85.4±11.5**		**87.6±11.5**		**24.3±4.2**		**4.5±1.1**			
Average number of lichen species		**5.6±1.82**		**5.6±1.52**		**4.8±2.68**		**5.8±1.48**		**7.8±1.92**			
The Shannon-Weiner Species Diversity Index		**1.44±0.34**		**1.44±0.28**		**1.27±0.46**		**1.53±0.17**		**1.83±0.29**			
Families	**Species**	**F**	**C**	**F**	**C**	**F**	**C**	**F**	**C**	**F**	**C**	**F**	**C**
Teloschistaceae	*Athallia cerinella* (Nyl.) Arup. Frödén & Søchting	4	4	1	0.5	0	0	2	0.7	12	6.8	19	12
Teloschistaceae	*Athallia pyracea* (Ach.) Arup. Frödén & Søchting	2	0.5	0	0	1	0.3	9	3	35	27	47	30.8
Ramalinaceae	*Biatora globulosa* (Flörke) Rabenh.	0	0	0	0	0	0	0	0	3	0.8	3	0.8
Teloschistaceae	*Caloplaca cerina* (Hedw.) Th. Fr.	0	0	1	0.5	0	0	0	0	4	1	5	1.5
Candelariaceae	*Candelaria concolor* (Dicks.) Arnold	0	0	0	0	1	0.3	1	0.8	0	0	2	1
Catillariaceae	*Catillaria nigroclavata* (Nyl.) J. Steiner	0	0	0	0	1	0.3	14	13.8	7	4	22	18
Lecanoraceae	*Glaucomaria carpinea* (L.) S.Y. Kondr., Lőkös & Farkas	4	1.5	3	0.8	2	0.5	3	1.3	2	0.5	14	4.5
Lecanoraceae	*Lecania cyrtella* (Ach.) Th. Fr.	0	0	1	0.3	1	0.5	0	0	0	0	2	0.8
Lecanoraceae	*Lecanora chlarotera* Nyl.	0	0	2	0.5	0	0	0	0	0	0	2	0.5
Lecanoraceae	*Lecidella elaeochroma* (Ach.) M. Choisy	2	0.8	0	0	2	2	0	0	0	0	4	2.8
Physciaceae	*Phaeophyscia orbicularis* (Neck.) Moberg	32	69.8	32	62.8	34	160.3	17	19.8	5	3	120	315.5
Physciaceae	*Physcia adscendens* H. Olivier	16	31.8	18	47.8	13	22.8	38	99	32	31.5	117	232.8
Physciaceae	*Physcia stellaris* (L.) Nyl.	2	1.8	5	5.3	6	12	1	1.3	1	0.3	15	20.5
Physciaceae	*Physconia distorta* (With.) J.R. Laundon	1	1	1	1	0	0	0	0	0	0	2	2
Physciaceae	*Physconia* grisea (Lam.) Poelt	5	20.8	2	12	0	0	0	0	0	0	7	32.8
Lecanoraceae	*Polyozosia hagenii* (Ach.) S.Y. Kondr., Lőkös & Farkas	0	0	0	0	0	0	0	0	5	1.3	5	1.3
Lecanoraceae	*Polyozosia persimilis* (Th. Fr.) S.Y. Kondr., Lőkös & Farkas	0	0	3	1	2	0.8	3	0.8	16	5	24	7.5
Physciaceae	*Rinodina pyrina* (Ach.) Arnold	3	3.5	1	0.5	1	0.5	0	0	15	5.8	20	10.3
Teloschistaceae	*Xanthoria parietina* (L.) Th. Fr.	37	343.3	40	406.3	39	347.3	40	468.8	40	245.5	196	1811
	Total	**109**	**479**	**110**	**539**	**103**	**547.3**	**128**	**609**	**177**	**332.3**	**627**	**2506.5**

Table 3. Comparison of mean ± standard deviation of total cover and frequency in Johansson areas (One-Way Anova)

Johansson zones	Total frequency	Total cover
Z1	21.8±8.2	96.2±16.3
Z2	22.0±5.2	107.8±10.1
Z3	20.6±6.1	109.6±24.1
Z4	25.6±2.9	122.2±14.0
Z5	35.4±11.2	66.4±20.4
df	4	4
F	3.461	7.166
Sig.	0.026*	0.001**

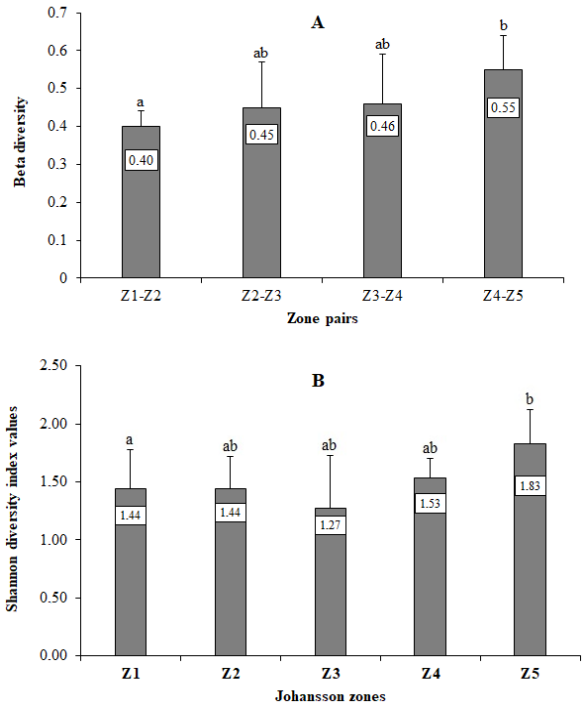

Figure 1. Comparison of Johansson zone pairs based on beta diversity (A) and Johansson zones based on Shannon diversity index values (B).

the trunk and thick branches. Z1Z2 zone pair is significantly different from both Z3Z4 (Z: -2.023, p<0.05) and Z4Z5 zone pairs (Z: -2.032, p<0.05). There is no significant difference between Z3Z4 and Z4Z5 zone pairs (Fig. 2).

Of the total 20 epiphytic lichen species detected on *Q. robur*, 6 species show significant differences when compared between the five Johansson zones. *A. pyracea*, *C. nigroclavata* and *Ph. orbicularis* show significant differences between Johansson zones in both frequency and cover values at the p<0.01 level. *P. adscendens* and *R. pyrina* have a significant difference between Johansson zones only in frequency values at the p<0.05 level. *X. parietina* has a significant difference only in cover values at the p<0.05 level. Depending on the change in frequency values, *A. pyracea*, *C. nigroclavata*, *P. adscendens* and *R. pyrina* were positively correlated with Johansson zones, while *Ph. orbicularis* was negatively correlated with Johansson zones (Table 4).

The frequency and cover values of *A. pyracea* increase significantly from the base to the thin branches of the tree. It is a characteristic species especially for thin branches

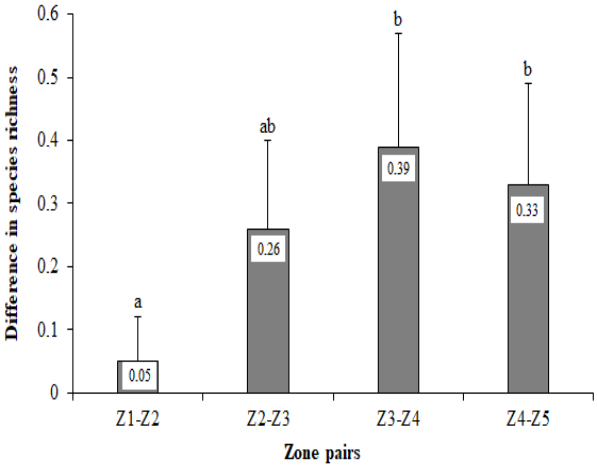

Figure 2. Comparison of Johansson zone pairs based on differences in species richness.

Table 4. Species showing significant differences in vertical change from the base to the tip of the tree (n:5)

		Mean Rank					Kruskal-Wallis H	df	Asymp. Sig.
		Z1	Z2	Z3	Z4	Z5			
A. pyracea	F	9.90	8.00	9.60	14.50	23.00	17.487	4	**0.002****
	C	9.80	8.00	9.60	14.60	23.00	17.606	4	**0.001****
C. nigroclavata	F	8.50	8.50	10.50	19.40	18.10	14.304	4	**0.006****
	C	8.50	8.50	10.20	19.70	18.10	14.913	4	**0.005****
Ph. orbicularis	F	17.40	16.90	18.80	7.80	4.10	16.517	4	**0.002****
	C	16.60	15.40	20.00	9.40	3.60	15.664	4	**0.004****
P. adscendens	F	8.80	9.90	7.70	20.70	17.90	13.105	4	**0.011***
	C	10.10	13.70	8.80	20.40	12.00	7.606	4	0.107
R. pyrina	F	12.00	11.50	11.50	9.50	20.50	10.923	4	**0.027***
	C	12.60	11.50	11.50	9.50	19.90	9.500	4	0.050
X. parietina	F	9.40	14.50	12.10	14.50	14.50	5.948	4	0.203
	C	11.40	16.10	11.80	19.90	5.80	10.444	4	**0.034***

*P<0.05 **P<0.01

(Z5). Similarly, the vertical change in the frequency and cover values of *P. adscendens* is characteristic for Z4. On the contrary, the frequency and cover values of *Ph. orbicularis* are high in the trunk part of the tree and low in the branches. It is a characteristic species for the trunk part of the tree (Z1, Z2 and Z3). While the change in frequency values of *X. parietina* in Johansson zones is not significant, the vertical change in cover values is significant for Z1, Z2 and Z4 (Table 5).

4. Discussions

The availability of light and moisture are important factors controlling the within-stand variation of epiphytic lichens. Generally, epiphytic lichen cover increases with increasing humidity. Increasing or decreasing the amount of light has an effect on the community structure of epiphytic lichens. Habitat diversity has a substantial influence on the diversity of epiphytic lichens (Hauck, 2011). Light conditions on the tree trunk are affected by the tree structure, and low light availability on the trunk can have a negative effect on lichens living on the base of the trunk (Bäcklund et al., 2016).

Bark pH, light and nutrient availability relative to water content of bark are determinants of a species' ability to colonize the bark surface (Ellis et al., 2021). The diversity of epiphytic lichens along the trunk of a tree is also significantly affected by the age of the tree and changes in microclimate (Fritz, 2009; Öztürk et al., 2019).Various studies have been conducted examining the vertical distribution of epiphytic lichen diversity on the tree trunk (Córdova-Chávez et al., 2016; Fanning et al., 2007; Li et al., 2015).

In this study, we determined that there is a significant difference in species richness between different Johansson regions. Species richness increases from the lowest parts of the tree to the highest parts. Similarly, lower regions (Z1-Z2) have lower richness than higher regions (Z4-Z5). This result is consistent with the results obtained in the study carried out by Castillo-Campos et al. (2019), in which the vertical variation of epiphytic lichen species in five Johansson zones on *Quercus laurina* was analyzed. Recently, in a study carried out in the stemmed oak grove located next to the Faculty of Agriculture in Bursa Uludağ University Görükle campus, a significant difference in epiphytic lichen diversity was found between the base and trunk of *Q. robur* (Öztürk et al., 2023). On the contrary, in their study on *Quercus laurina* in the Great Smoky Mountains National Park, Córdova-Chávez et al. (2016) found that there was no difference in species richness between different Johansson regions.

When the results of this study were compared with the results of a previous study on *Q. robur* by Öztürk et al. (2023) in the same area, nine species identified in the previous study were not found in this study. These species consist of crustose (*Scoliciosporum chlorococcum* (Graewe ex Stenh.) Vězda), foliose (*Melanelixia subaurifera* (Nyl.) O. Blanco et al., *Parmelina tiliacea* (Hoffm.) Hale, *Physcia aipolia* (Ehrh. ex Humb.) Fürnr., *Physconia enteroxantha* (Nyl.) Poelt, *P. perisidiosa* (Erichsen) Moberg, *Pleurosticta acetabulum* (Neck.) Elix & Lumbsch) and fruticose (*Evernia prunastri* (L.) Ach. and *Ramalina pollinaria* (Westr.) Ach.). Unlike the previous study, seven species (*Amandinea punctata* (Hoffm.) Coppins & Scheid., *Athallia pyracea* (Ach.) Arup, Frödén & Søchting, *Biatora globulosa* (Flörke) Rabenh., *Candelaria concolor* (Dicks.) Arnold, *Glaucomaria carpinea* (L.) S.Y. Kondr., Lőkös & Farkas, *Physconia distorta* (With.) J.R. Laundon and *Polyozosia persimilis* (Th. Fr.) S.Y. Kondr., Lőkös & Farkas) were found in this study. This difference in species

Table 5. Indicator species and their Z values for Zohansson zones.

Wilcoxon Signed Ranks Test			**Test Pairs**									
			Z2 - Z1	Z3 - Z1	Z4 - Z1	Z5 - Z1	Z3 - Z2	Z4 - Z2	Z5 - Z2	Z4 - Z3	Z5 - Z3	Z5 - Z4
A. pyracea	F	Z	-1.000[c]	-.447[c]	-1.633[b]	**-2.041[b]**	-1.000[b]	-1.604[b]	**-2.041[b]**	-1.633[b]	**-2.060[b]**	**-2.032[b]**
		Sig.	0.317	0.655	0.102	**0.041**	0.317	0.109	**0.041**	0.102	**0.039**	**0.042**
	C	Z	-1.000[c]	-.447[c]	-1.633[b]	**-2.032[b]**	-1.000[b]	-1.732[b]	**-2.023[b]**	-1.633[b]	**-2.023[b]**	**-2.023[b]**
		Sig.	0.317	0.655	0.102	**0.042**	0.317	0.083	**0.043**	0.102	**0.043**	**0.043**
Ph. orbicularis	F	Z	.000[a]	**-.707[b]**	**-2.032[c]**	**-2.023[c]**	-.577[b]	-1.890[c]	**-2.032[c]**	**-2.023[c]**	**-2.032[c]**	-1.841[c]
		Sig.	1.000	**0.480**	**0.042**	**0.043**	0.564	0.059	**0.042**	**0.043**	**0.042**	0.066
	C	Z	-.135[c]	-1.483[b]	-1.753[c]	**-2.023[c]**	**-2.023[c]**	**-2.023[c]**	**-2.023[c]**	**-2.023[c]**	**-2.023[c]**	**-2.023[c]**
		Sig.	0.893	0.138	0.080	**0.043**	**0.043**	**0.043**	**0.043**	**0.043**	**0.043**	**0.043**
P. adscendens	F	Z	-.447[b]	-.736[c]	**-2.070[b]**	**-2.041[b]**	-1.089[c]	**-2.041[b]**	-1.841[b]	**-2.032[b]**	**-2.023[b]**	-1.414[c]
		Sig.	0.655	0.461	**0.038**	**0.041**	0.276	**0.041**	0.066	**0.042**	**0.043**	0.157
	C	Z	-1.461[b]	-.135[c]	**-2.023[b]**	-.135[c]	-1.75[c]	-1.753[c]	-.674[b]	**-2.023[b]**	-.674[b]	**-2.023[c]**
		Sig.	0.144	0.893	**0.043**	0.893	0.080	0.080	0.500	**0.043**	0.500	**0.043**
X. parietina	F	Z	-1.342[b]	-1.414[b]	-1.342[b]	-1.342[b]	-1.000[c]	.000[a]	.000[a]	-1.000[b]	-1.000[b]	.000[a]
		Sig.	0.180	0.157	0.180	0.180	0.317	1.000	1.000	0.317	0.317	1.000
	C	Z	-1.483[b]	-.135[c]	-1.753[b]	**-2.023[c]**	-1.753[c]	-1.761[b]	**-2.023[c]**	-1.753[b]	-1.483[c]	**-2.023[c]**
		Sig.	0.138	0.893	0.080	**0.043**	0.080	0.078	**0.043**	0.080	0.138	**0.043**

Z values in bold are significant at p<0.05 level.
a: The sum of negative ranks equals the sum of positive ranks.
b: Based on negative ranks.
c: Based on positive ranks

diversity is due to the fact that the sampled trees are in different pa rts of the study area. The sampled trees in the previous study were located close to agricultural areas, away from the road passing in front of the Faculty of Agriculture and the heat center. The sampled trees in this study are located in the immediate vicinity of the road and the heat center.

As a result of these two studies, a total of 29 species were found on *Q. robur* trees. There are 85 species in the records given so far from the campus area (Güvenç and Aslan, 1994; John and Güvenç, 2023; Oran and Öztürk, 2011; Oran, 2019). In this study, five additional species (*Athallia pyracea*, *Biatora globulosa*, *Candelaria concolor*, *Physconia distorta* and *Polyozosia persimilis*) were recorded for the campus. As a result, the total number of species in the Görükle campus area is 90.

In our study, *Ph. orbicularis*, *P. adscendens* and *X. parietina* are the most common species on *Q. robur*. These common species are also abundant on common oak species (*Quercus robur, Q. cerris, Q. rubra* and *Q. palustris*) in three parks in London (Llewellyn et al., 2020).

In this study, we determined that there is a significant difference in species richness between different Johansson regions. Species richness increases from the lowest parts of the tree to the highest parts. There is a negative relationship between trunk diameter and species diversity in the vertical change of epiphytic lichen diversity from the base of the tree to the thin branches. Species diversity is low at the base of the tree and highest in the thin branches (Fig. 1A, Table 1). A similar relationship between tree age and species diversity was reported by Öztürk et al. (2019) on *Q. petraea*. Of the total number of lichen species, 14 (70%) were crustose and 6 (30%) foliose lichens. The number of crustose and foliose species are equal in Z1 and Z2. Crustose species are more common than foliose species in the Z3, Z4 and Z5 zones (Fig. 3).

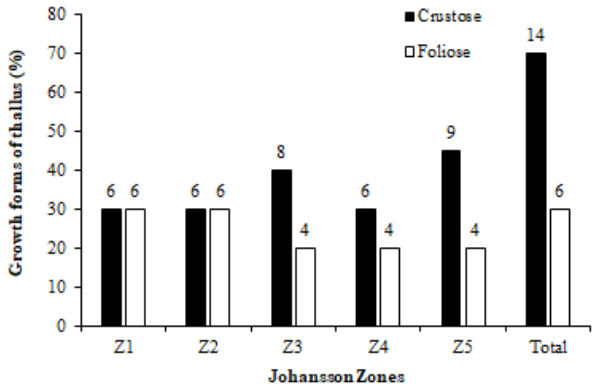

Figure 3. The number of growth forms of epiphytic lichens in Johansson regions.

The diversity of epiphytic lichens varies depending on trunk height. The greatest species diversity was found in the crown of the tree. In other parts, the diversity was quite variable (Muchnika and Blagoveschenskayab, 2022). Foliose lichens are more competitive than both crustose and fruticose species. Lichens with crustose growth forms are expected to resist drought events better due to their lower surface-to-volume ratio and consequently have a higher tolerance to desiccation. In addition, the competitive abilities of crustose species are weaker than foliose and fruticose species. Therefore, they are pioneers in colonizing young trees and thin branches of the tree (Armstrong and Bradwell, 2010; Kantelinen et al., 2022).

A. pyracea and *P. adscendens* are characteristic for the upper Johansson zones (Z4-Z5), while *Ph. orbicularis* and *X. parietina* are characteristic for the lower Johansson zones (Z1, Z2 and Z3). As a result of urbanization, epiphytic lichen richness and cover on *Q. robur* were found to be lower in urban trees than in rural trees. In addition, as the duration of urban trees being surrounded by houses increases, their richness and cover gradually decrease (Lättman et al., 2014). Epiphytic lichen diversity is affected by intensive agricultural activities. The frequency of Physciaceae tends to increase as the cultivation area increases. The increased frequency of *Physcia* species indicates a eutrophication process in that region (Filippini et al., 2020). In our study, the families with the highest species content are Lecanoraceae and Physciaceae (6 species), followed by Teloschistaceae with 4 species.

Görükle campus and its surroundings were evaluated as a semi-natural zone (low naturality) in terms of environmental quality based on lichen diversity. In the semi-natural zone, Xanthorion vegetation is dominated by nitrophytic species with high frequency. These species with high frequency were reported to be *C. vitellina, H. adglutinata, P. orbicularis, P. adscendens, P. stellaris, Ph. grisea* and *X. parietina*. In addition, Lecanorion species (*G. carpinea, L. chlarotera, L. elaeochroma* and *P. hagenii*) were shown as important species for this group. *H. adglutinata, L. elaeochroma, P. adscendens* and *X. parietina* were found abundantly in oak trees near agricultural areas and around settlements (Güvenç, 2017).

All of the annual and seasonal average $PM_{2.5}$ values measured in Bursa Uludağ University Görükle campus in 2015 are above the European Union limit value of 25 $\mu g/m^3$. In 2023, this value is slightly above the limit value only in the winter season. SO_2 and NO_2 values measured at Bursa Uludağ University Görükle campus in 2015 are below the European Union limit values of 20 and 40 $\mu g/m^3$, respectively. In 2023, these values dropped even lower. NO_x values measured at Bursa Uludağ University Görükle campus in both 2015 and 2023 are above the European Union limit value of 30 $\mu g/m^3$ (Table 6). According to the EPA Air Quality Index Classification, the air quality index at Bursa Uludağ University Görükle campus is at a "good" level for both 2015 and 2023 (UHKIA, 2015; 2023).

Nitrogen oxides (NO_x) values measured in the air of the Görükle campus are above the limit values in the autumn and winter seasons. These high nitrogen oxide values can be explained by the presence of the Istanbul-Izmir highway Görükle connection road, 500 meters away from the study area, and the road connecting the inner-city transportation to the Görükle center and the highway connection road right next to it, as well as the surrounding agricultural areas.

Because, primary sources of reactive nitrogen in the atmosphere are nitrogen oxides (NO_x) and ammonia (NH_3). While road traffic contributes the majority of atmospheric NO_x, NH_3 is largely a product of intensive agricultural activities (Wolseley et al., 2006). NO_2 concentration was found to be positively correlated with traffic density and negatively correlated with distance from the nearest highway (Frati et al., 2008).

Table 6. Annual and seasonal changes of the average values of pollutant (daily) concentrations in µg/m3 for the years 2015 and 2023 at Bursa - Uludağ University Meteorology Station (38) (UHKIA, 2015; 2023).

Years	Seasons	Pollutants						Air Quality Index Value
		$PM_{2.5}$	SO_2	NO_2	NO_x	NO	O_3	
2015	Spring	27.16	5.12	25.74	36.79	7.27	54.30	26.06
	Summer	26.35	3.62	17.64	22.14	3.02	74.23	24.50
	Autumn	31.09	4.31	23.54	51.72	19.26	40.33	28.38
	Winter	34.40	7.31	32.53	80.40	30.72	29.51	35.81
	Annual mean	**29.75**	**5.09**	**24.86**	**47.76**	**15.07**	**49.59**	**28.69**
2023	Spring	21.52	2.54	13.94	24.81	4.48	49.53	19.47
	Summer	19.30	2.27	17.42	36.44	4.11	78.38	26.32
	Autumn	18.96	3.31	19.27	48.37	13.44	55.03	26.40
	Winter	26.59	3.18	24.55	60.85	20.77	30.10	27.67
	Annual mean	**21.59**	**2.83**	**18.80**	**42.62**	**10.70**	**53.26**	**24.97**

AQI Value	AQI Category	AQI Color
0 - 50	Good	Green
51 - 100	Moderate	Yellow
101 - 150	Unhealthy for Sensitive Groups	Orange
151 - 200	Unhealthy	Red
201 - 300	Very Unhealthy	Purple

Loppi et al. (2002) reported that "semi-natural" areas were characterized by *C. concolor*, *H. adglutinata*, *P. adscendens*, *Ph. grisea* and Xanthorion elements, while "natural" areas were characterized by a high frequency of *Parmelia* species (*Flavoparmelia caperata* (L.) Hale, *M. subaurifera*, *Parmelia sulcata* Taylor and *Punctelia subrudecta* (Nyl.) Krog). The transition from Parmelion-dominated to Xanthorion-dominated lichen vegetation was generally interpreted as occurring due to increased human activities and air pollution. This suggests that under human disturbance conditions, more competitive opportunistic Xanthorion species tend to invade Parmelion communities and increase total species diversity. Therefore, synergistic effects may explain the absence or scarcity of certain sensitive lichen species, especially *Parmelia* species, from the "semi-altered" area, despite low SO_2 and NO_x levels.

Conflict of Interest

Authors have declared no conflict of interest.

Authors' Contributions

The authors contributed equally.

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