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Contribution to the earthworm fauna of Edirne province Türkiye (Clitellata, Megadrili)

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Abstract

This study was conducted between September 2019 - June 2021 to determine the earthworm fauna of Edirne province. For this purpose, 79 samples were collected from 14 localities within the borders of Edirne Province. Identification of the samples collected resulted in recording 9 species belonging to 5 genera as follows; *Aporrectodea caliginosa* (Savigny, 1826), *Aporrectodea dubiosa dubiosa* (Örley, 1881), *Aporrectodea jassyensis jassyensis* (Michaelsen, 1891), *Aporrectodea rosea* (Savigny, 1826), *Aporrectodea trapezoides* (Duges, 1828), *Eiseniella tetraedra tetraedra* (Savigny, 1826), *Lumbricus rubellus* Hoffmeister, 1843, *Octodrilus transpadanus* (Rosa, 1884), *Octolasion lacteum* (Örley, 1881). The species *Aporrectodea dubiosa dubiosa* (Örley, 1881) and *Octolasion lacteum* (Örley, 1881) were recorded for the first time from the Thracian part of the Marmara region.

Key words: Edirne, earthworms, Annelida, Clitellata, Fauna of Türkiye

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Türkiye Edirne ili topraksolucanı (Clitellata, Megadrili) faunasına katkı

Özet

Bu çalışma, Edirne İli solucan faunasını belirlemek amacıyla Eylül 2019 - Haziran 2021 tarihleri arasında yapılmıştır. Bu amaçla Edirne İli sınırları içindeki 14 lokaliteden 79 örnek toplanmıştır. Toplanan örneklerin kimliklendirilmesi sonucunda 5 cinse ait 9 tür aşağıdaki şekilde kayıt altına alınmıştır; *Aporrectodea caliginosa* (Savigny, 1826), *Aporrectodea dubiosa dubiosa* (Örley, 1881), *Aporrectodea jassyensis jassyensis* (Michaelsen, 1891), *Aporrectodea rosea* (Savigny, 1826), *Aporrectodea trapezoides* (Duges, 1828), *Eiseniella tetraedra tetraedra* (Savigny, 1826), *Lumbricus rubellus* Hoffmeister, 1843, *Octodrilus transpadanus* (Rosa, 1884), *Octolasion lacteum* (Örley, 1881). *Aporrectodea dubiosa dubios*a (Örley, 1881) ve *Octolasion lacteum* (Örley, 1881) türleri Marmara bölgesinin Trakya bölümünden ilk kez bildirilmiştir.

Anahtar kelimeler: Edirne, toprak solucanı, Annelida, Clitellata, Türkiye Faunası

1. Introduction

Earthworms (Clitellata: Megadrili) are one of the groups of animals playing an important role in nature. They significantly affect the structure, chemical composition and fertility of soils.. It is also known that they accelerate the mixing of fertilizers, lime and organic substances applied to the surface with the soil. In addition, it has been proven by laboratory studies that they support plant root development, increase soil porosity, and reduce plant root diseases.

There are 5738 earthworm species/subspecies described all over the world, of which 689 belong to the family Lumbricidae [1]. If look at our neighboring countries, 66 species are registered in Greece, 49 in Bulgaria, 21 in Cyprus, 14 in Syria, 28 in Iran, 58 in Georgia, 29 in Azerbaijan and 31 in Armenia [2]. In Türkiye 87 taxa are recorded belonging to the families Acanthodrilidae (1 genus, 2 species), Criodrilidae (1 genus, 1 species), Lumbricidae (18 genera, 80 species) and Megascolecidae (2 genera, 4 species). 32 species are endemic to Türkiye. Regarding the

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zoogeographical composition of the lumbricid species, 2 belong to the Balkan-Anatolia group, 13 to the Caucasus-Anatolia group, 3 to theCircum Mediterranean group, 3 to the East Mediterranean group, 7 to the Levant-Anatolia group, 14 to the peregrines, 6 species show Trans-Aegean distribution. All the species of the other families are peregrines and allochtonous in Türkiye [3, 4].

Edirne province located in the Thracian part of the eastern tip of the Balkan peninsula in Türkiye. Thracian earthworm fauna was evaluated by the studies carried out by Mısırlıoğlu at al. [5], Mısırlıoğlu and Stojanovic [6], Mısırlıoğlu and Stojanovic [7], Valchovski and Mısırlıoğlu [8] .

2. Materials and methods

The study was carried out between 19.09.2019-02.02.2020, and the samples were collected by digging-hand-sorting method from a depth of 0-20 cm. The samples collected were first put into 85% ethanol, then transferred to the laboratory and put the samples into the 96% ethanol. All samples were examined under an Olympos VMF-1X model stereo-microscope.. The photographs were taken using a Leica EZ 16 device.

Bouche [9], Reynolds [10], Sims and Gerard [11], Csuzdi and Zicsi [12], Csuzdi et al. [13], Mısırlıoğlu [14] and Reynolds and Mısırlıoğlu [15] were used for identification.

3. Results

In the present study 9 species were found belonging to 5 genera and two of them *Aporrectodea dubiosa dubiosa* (Örley, 1881) and *Octolasia lacteum* (Örley, 1885) are recorded for the first time from the Thracian part of the Marmara region.

3.1 List of localities and the species found

1. Edirne, center, Doyran village, forested area, grass and puddles, 27 m a.s.l., N41°29'25.7887" E26°36'27.4530", 19.09.2019.

Octolasion lacteum (Örley, 1885) 4 exemplars

2. Edirne, center, Üyüklütatar village, grassy area, 31 m a.s.l., N41°32'54.2804" E26°36'59.4754", 19.09.2019.

Aporrectodea dubiosa dubiosa (Örley, 1881) 18 exemplars

3. Edirne, center, Tayakadın village, grassy area, with a slamm stream tributary passes nearby , 46 m a.s.l., N41°34'26.1108" E26°39'59.1136", 29.01.2020.

Octodrilus transpadanus (Rosa, 1884) 1 exemple

4. Edirne, center, Tayakadın village, muddy area surrounded by grass, 44 m a.s.l., N41°33'56.3554" E26°40'5.3447", 29.01.2020.

Aporrectodea rosea (Savigny, 1826) 1 exemple

Aporrectodea trapezoides (Duges, 1828) 1 exemple

5. Edirne, **center**, Tayakadın village, grass, 47 m a.s.l., N41°34'29.4490" E26°39'51.3158", 29.01.2020.

Aporrectodea caliginosa (Savigny, 1826) 1 exemple

Octodrilus transpadanus (Rosa, 1884) 1 exemple

6. Edirne, **center**, Karakasım village, reedy area with grass, 45 m a.s.l., N41°32'35.7541" E26°39'15.7212", 29.01.2020.

Aporrectodea jassyensis jassyensis (Michaelsen, 1891) 1 exemple

Aporrectodea trapezoides (Duges, 1828) 1 exemple

Octodrilus transpadanus (Rosa, 1884) 2 exemplars

Octolasion lacteum (Örley, 1885) 4 exemplars

7. Edirne, **center**, Orhaniye village, swampy area surrounded by reeds and grass, 29 m a.s.l., N41°31'4.3860" E26°38'55.8779", 29.01.2020.

Aporrectodea dubiosa dubiosa (Örley, 1881) 4 exemplars

8. Edirne, **center**, Sazlıdere village, grassy area with a small stream and with reeds, 59 m a.s.l., N41°36'52.6660" E26°40'50.4552", 02.02.2020.

Lumbricus rubellus (Hoffmeister, 1843) 1 exemple

Octodrilus transpadanus (Rosa, 1884) 2 exemplars

Octolasion lacteum (Örley, 1885) 5 exemplars

9. Edirne, **center**, Sazlıdere village, grass and trees, 67 a.s.l., N41°36'0.4653" E26°40'25.1578", 02.02.2020.

Aporrectodea caliginosa (Savigny, 1826) 1 exemple

Aporrectodea trapezoides (Duges, 1828) 3 exemplars

Lumbricus rubellus (Hoffmeister, 1843) 3 exemplars

10. Edirne, **center**, İskender village, puddle and grass, 65 m a.s.l., N41°37'54.9075" E26°40'49.7627", 02.02.2020.

Aporrectodea caliginosa (Savigny, 1826) 2 exemplars

Octolasion lacteum (Örley, 1885) 3 exemplars

11. Edirne, **center**, İskender village, grass, 62 a.s.l., N41°37'55.4749" E26°40'48.0527", 02.02.2020.

Eiseniella tetraedra tetraedra (Savigny, 1826) 3 exemplars
Octolasion lacteum (Örley, 1885) 2 exemplars

12. Edirne, **center**, Köşençiftliği village, muddy edge of a stream and surrounded by grass, 71 m a.s.l., N41°39'11.3015" E26°41'11.1458", 02.02.2020.

Aporrectodea caliginosa (Savigny, 1826) 1 exemple
Aporrectodea jassyensis jassyensis (Michaelsen, 1891) 1 exemple
Aporrectodea trapezoides (Duges, 1828) 1 exemple
Octodrilus transpadanus (Rosa, 1884) 1 exemple

13. Edirne, **center**, Demirhanlı village, grass trees 102 m a.s.l., N41°41'42.9257" E26°43'51.1262", 02.02.2020.

Aporrectodea caliginosa (Savigny, 1826) 1 exemple
Aporrectodea trapezoides (Duges, 1828) 3 exemplars
Octolasion lacteum (Örley, 1885) 1 exemple

14. Edirne, **center**, Demirhanlı village, it was grassy area under trees, 101 m a.s.l., N41°41'44.9744" E26°43'55.2653", 02.02.2020.

Aporrectodea rosea (Savigny, 1826) 1 exemple
Lumbricus rubellus (Hoffmeister, 1843) 5 exemplars

3.2 List of species

Family Lumbricide Rafinesque-Schmaltz, 1815
Genus *Aporrectodea* Örley, 1885
Species: *Aporrectodea caliginosa* (Savigny, 1826)

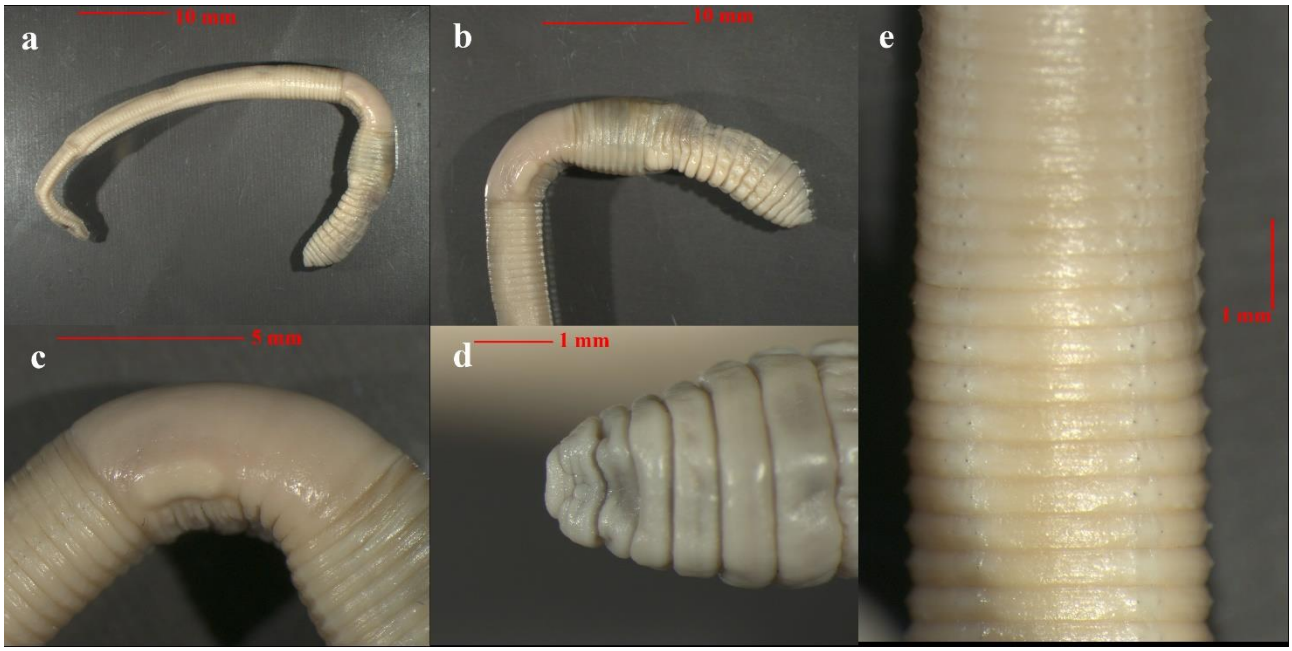

Figure 2. *Aporrectodea caliginosa*, a) general body view; b) first part of the body; c) clitellum; d) epilobic prostomium; e) closely paired setae.

Distribution in Turkey: Bolu, Bursa, Eskişehir, Kütahya,Van [13,16].

Species: *Aporrectodea dubiosa dubiosa* (Örley, 1881)

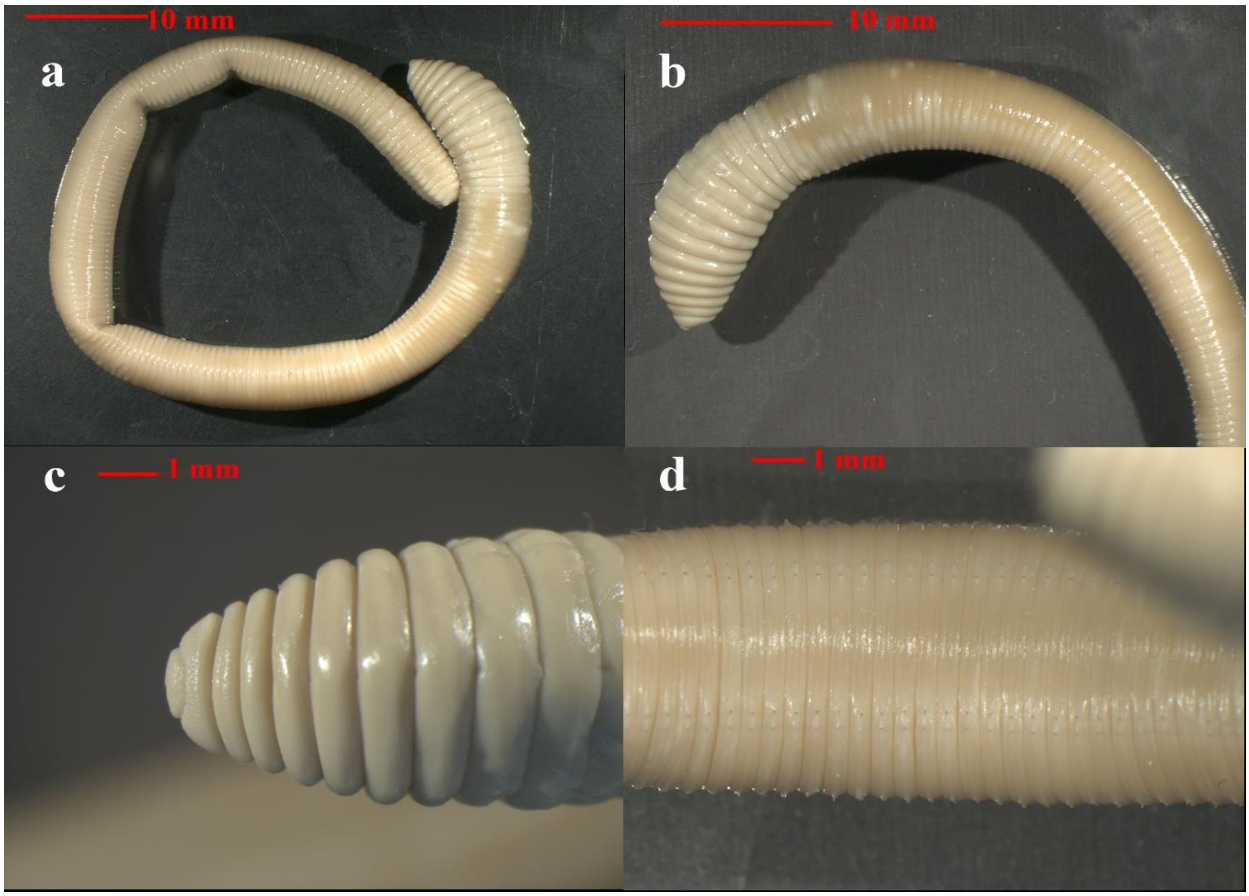

Figure 3. *Aporrectodea dubiosa dubiosa*, a) general body view; b) first part of the body and clitellum; c) epilobic prostomium; d) closely paired setae.

Distribution in Turkey: Samsun [17].

Species *Aporrectodea jassyensis jassyensis* (Michaelsen, 1891)

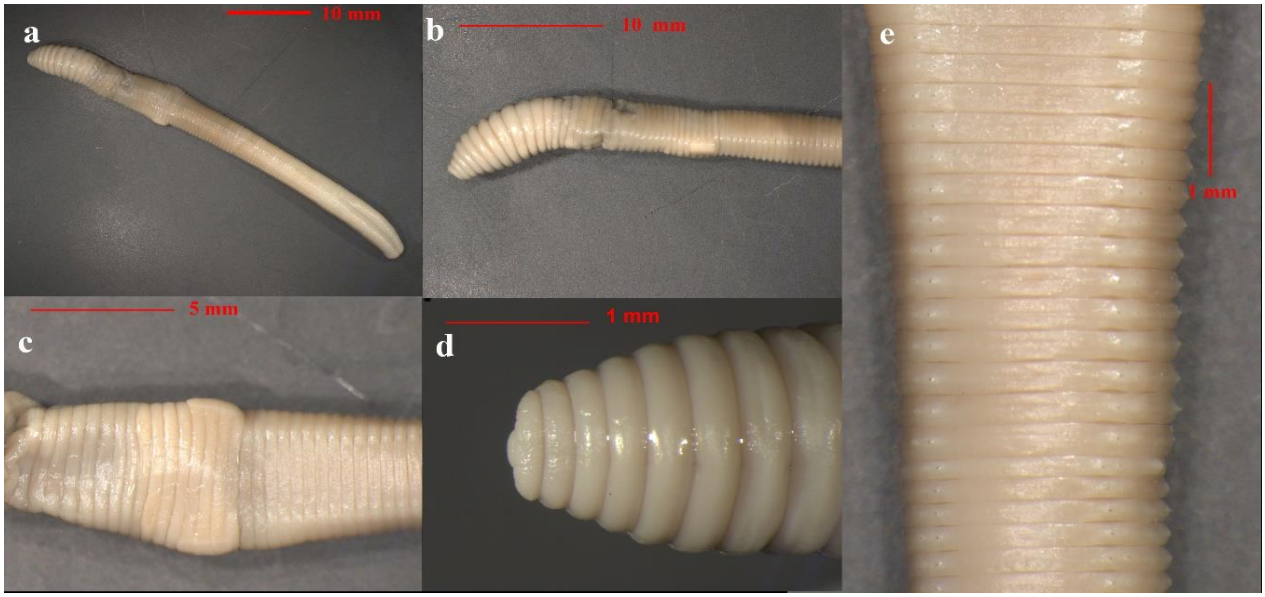

Figure 4. *Aporrectodea jassyensis jassyensis*, a) general body view; b) first part of the body; c) clitellum; d) epilobic prostomium; e) closely paired setae.

Distribution in Turkey: Adana, Ankara, Balıkesir, Bolu, Keşan-Gelibolu [18], Adapazarı, Bayburt, Çankırı, Çorum, Erzurum, Giresun, Samsun, Ordu, [13], Eskişehir [19], Isparta, İstanbul, Konya, Sinop, Trabzon [3].

Species *Aporrectodea rosea* (Savigny, 1826)

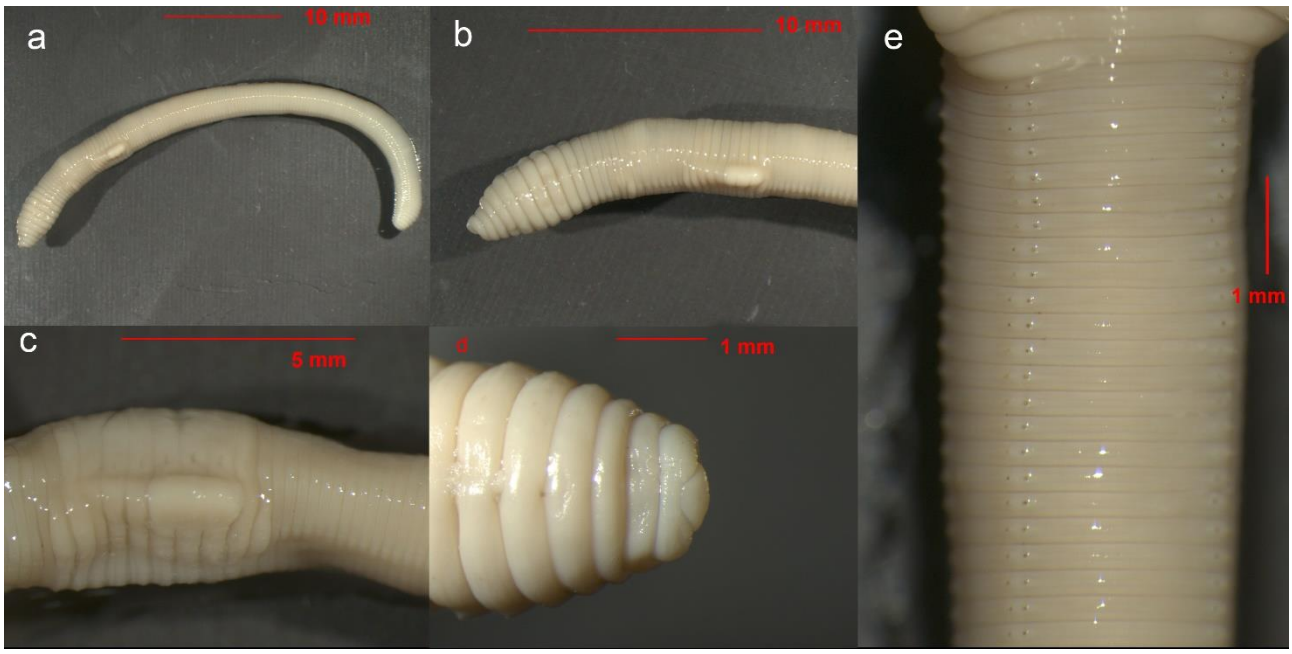

Figure 5. *Aporrectodea rosea*, a) general body view; b) first part of the body; c) clitellum; d) epilobic prostomium; e) closely paired setae.

Distribution in Turkey: Adana, Afyon, Ankara, Antalya, Amasya, Aydın, Balıkesir, Bolu, Burdur, Bursa, Çorum, Eskişehir, Kahramanmaraş, Kayseri, Konya, Kütahya, Muğla, Trabzon, Van [13].

Species *Aporrectodea trapezoides* (Dugès, 1828)

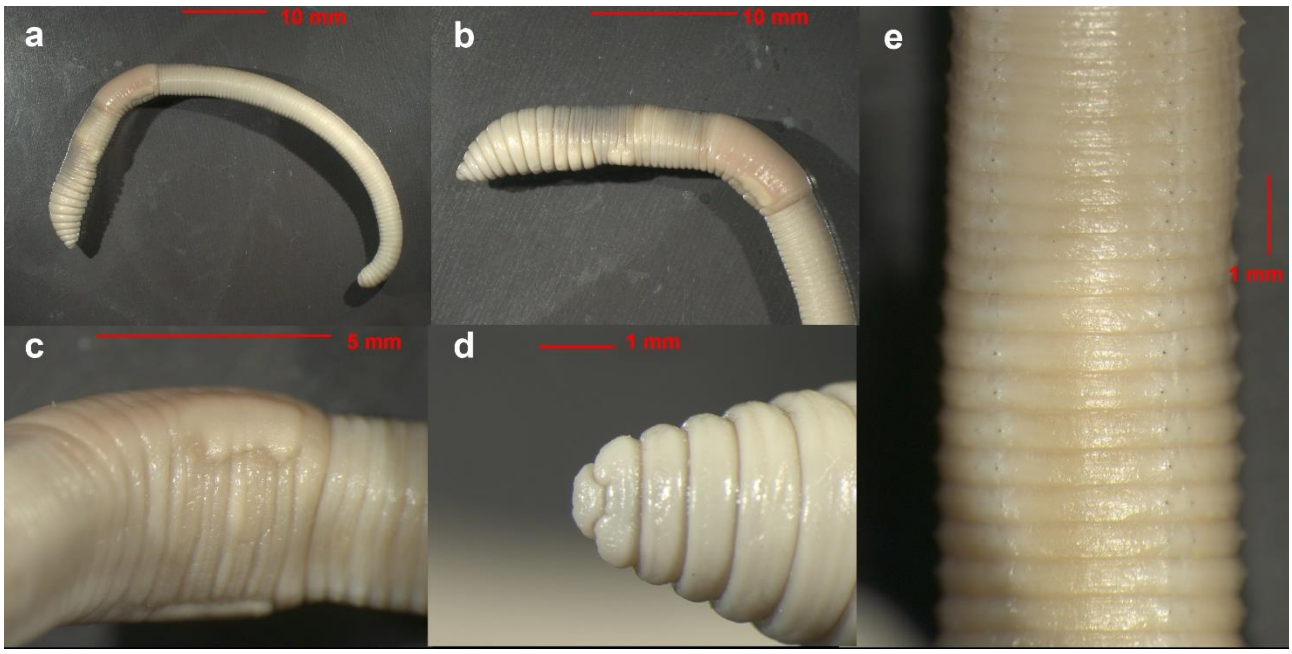

Figure 6. *Aporrectodea trapezoides*, a) general body view; b) first part of the body; c) clitellum; d) epilobic prostomium; e) closely paired setae.

Distribution in Turkey: Afyon**,** Ankara, Artvin, Bitlis, Bursa, Çankırı, Çorum, Denizli, Eskişehir, Giresun, Gümüşhane, Hatay, Kars, Kütahya, Ordu, Samsun, Tatvan, Tekirdağ Van [13].

Genus *Eiseniella* Michaelsen, 1900
Species *Eiseniella tetraedra tetraedra* (Savigny, 1826)

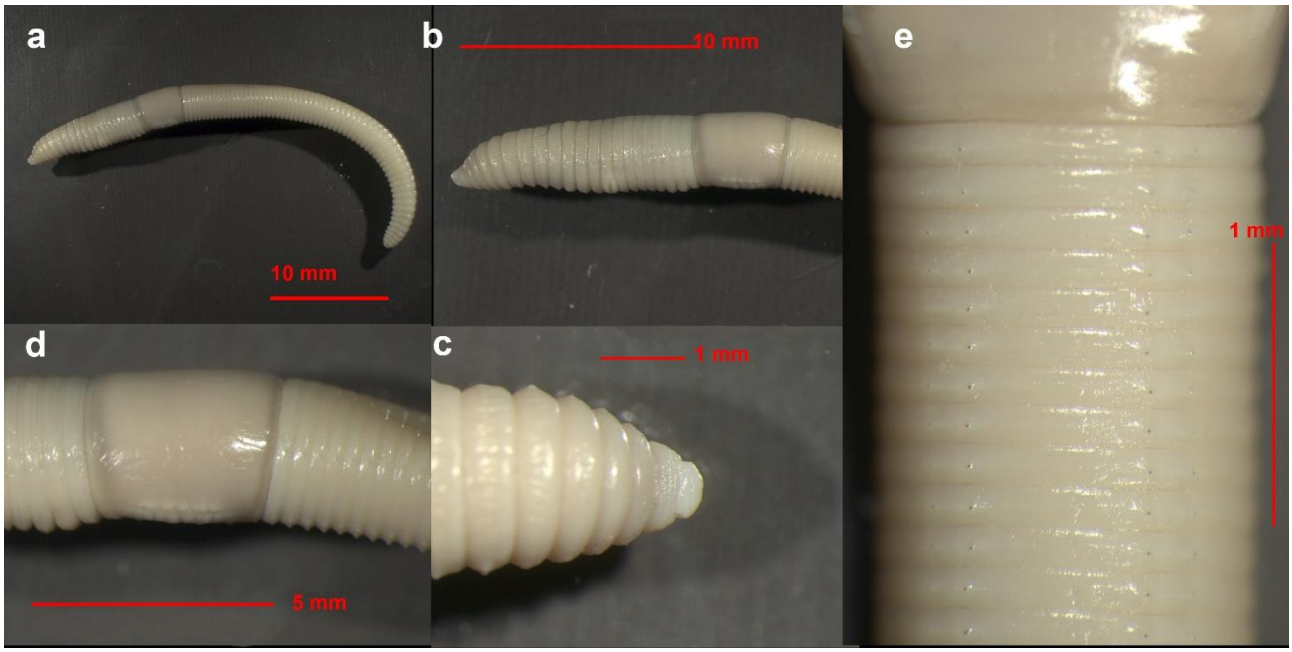

Figure 7. *Eiseniella tetraedra tetraedra*, a) general body view; b) first part of the body; c) clitellum; d) epilobic prostomium; e) closely paired setae.

Distribution in Turkey: Antalya, Artvin, Bolu, Bursa, Erzurum, Eskişehir, Gümüşhane, Hatay, Kayseri, İstanbul, İzmir, Kütahya, Ordu, Tekirdağ [13].

Genus *Lumbricus* Linnaeus, 1758
Species *Lumbricus rubellus* Hoffmeister, 1843

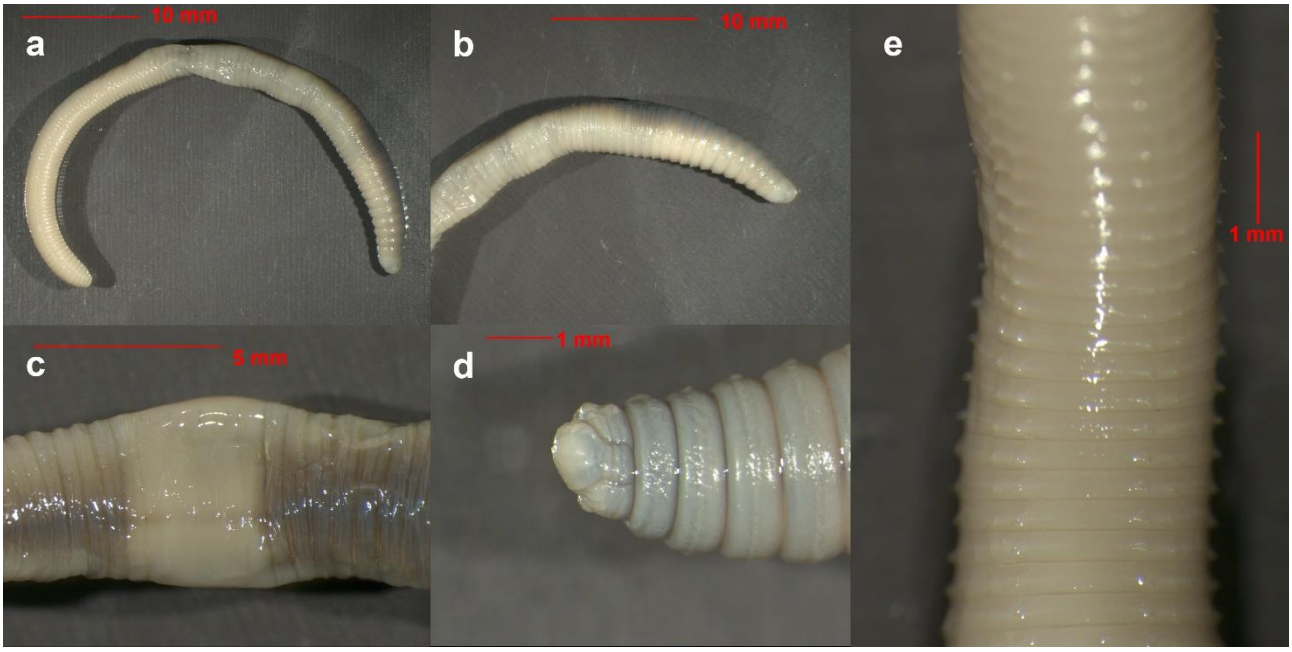

Figure 8. *Lumbricus rubellus*, a) general body view; b) first part of the body; c) clitellum; d) tanylobic prostomium; e) closely paired setae.

Distribution in Turkey: Artvin, Bolu-Abant, Bursa, Edirne, Edremit-Kazdağı, Eskişehir, Giresun-Görele, İstanbul-Belgrad, İstanbul-Kilyos, İstanbul-Yakacık, Kastamonu-Şenpazar, Konya, Rize, Trabzon [13], Yalova, İzmir, Ankara, Giresun, Ordu, Bilecik, Kastamonu, Kocaeli, Karabük [21].

Genus *Octodrilus* Omodeo, 1956
Species *Octodrilus transpadanus* (Rosa, 1884)

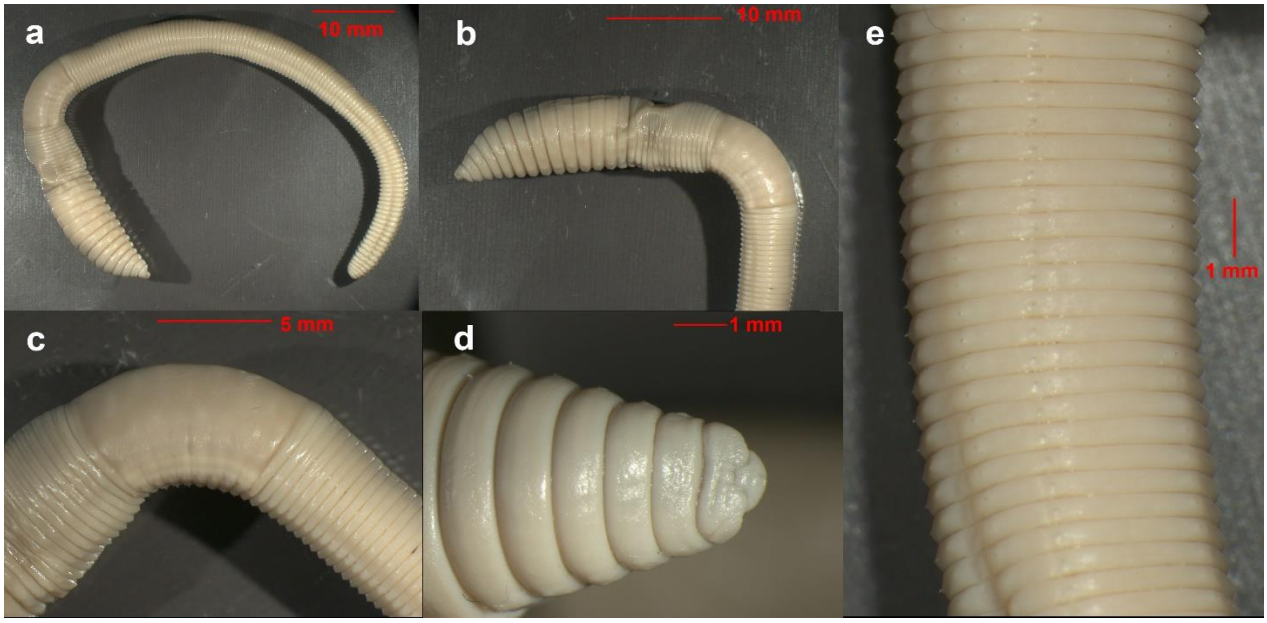

Figure 9. *Octodrilus transpadanus*, a) general body view; b) first part of the body; c) clitellum; d) epilobic prostomium; e) widely paired setae.

Distribution in Turkey: Bursa-Uludağ [23], Eskişehir [24], Adana-Yüreğir [25], Amasya, Balıkesir, Bilecik, Bolu, İstanbul, Kütahya, Mersin, Samsun [17].

Genus *Octolasion* Örley, 1885
Species *Octolasion lacteum* (Örley, 1881)

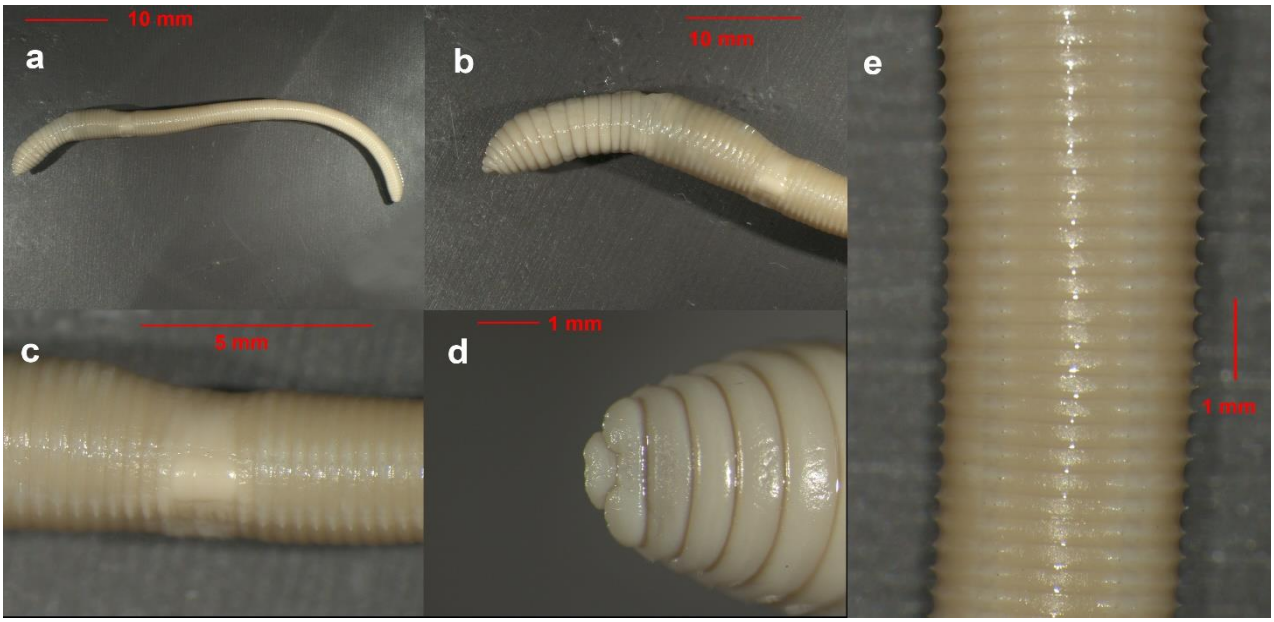

Figure 10. *Octolasion lacteum*, a) general body view; b) first part of the body; c) clitellum; d) epilobic prostomium; e) in closer pairs anteriorly and somewhat wider posteriorly.

Distribution in Turkey: Afyon, Artvin-Şavşat Geçidi, Bursa-Uludağ, Eskişehir [17, 22].

4. Conclusions and discussion

Out of the nine species collected in Edrine Province during the present study six are widely distributed peregrine (*Aporrectodea caliginosa*, *Ap. rosea*, *Ap. trapezoides*, *Lumbricus rubellus*, *Eiseniella tetraedra tetraedra*, *Octolasion lacteum*). Two species, *Aporrectodea dubiosa dubiosa Octodrilus transpadanus* show Trans-Aegean distribution and *Aporrectodea jassyensis jassyensis* is Eastern Mediterranean [13, 29].

Octodrilus transpadanus was previously recorded from several provinces of Marmara, Central Anatolia, the Black Sea, the Aegean and the Mediterranean regions [17, 20, 23, 24, 25].

The other Trans Aegean species, *Aporrectodea dubiosa dubiosa* was previously recorded only from Samsun (Black Sea Region) [19]. Now, it is recorded for the first time from the Thracian part of the Marmara region as well.

The other new record, *Octolasion lacteum* is a peregrine species that was previously recorded from the Marmara, Black Sea, Aegean and Central Anatolia regions [23, 26, 27]. Now, it is recorded from the Thracian part of the Marmara region as well.

Acknowledgements

We thank Prof Dr Csaba Csuzdi for checking and confirming the species' identifications, commenting and editing the final manuscript version. This study was performed as part of a master's thesis at the Graduate School of Natural and Applied Sciences of Eskişehir Osmangazi University. We respectfully commemorate Prof. Dr. Mete Mısırlıoğlu who died unexpectedly at the beginning of the research process of this study. May he rest in peace.

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Molecular and taxonomic studies on some *Acarospora* (Acarosporales, Ascomycota) species in Türkiye

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Abstract

Acarospora is a crustose lichen genus in the family Acarosporaceae and has a wide distribution. While the lichen genus *Acarospora* has more than 200 species in the world, the number of species so far determined in Türkiye is 41. Here we report three *Acarospora* species: *A. irregularis* H. Magn., *A. rosulata* (Th. Fr.) H. Magn., *A. thamnina* (Tuck.) Herre and two lichenicolous fungal species: *Lichenostigma svandae* Vondrák & Šoun, *Stigmidium fuscatae* (Arnold) R. Sant. new to Türkiye. Detailed information on these 5 taxa is provided along with photographs. The nrITS, β tubulin and mtSSU gene regions of the new *Acarospora* records are studied and their phylogenetical positions are discussed.

Key words: Türkiye, biodiversity, lichenized fungi, ITS gene region, *Acarospora*.

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Türkiye'deki bazı *Acarospora* (Acarosporales, Ascomycota) türleri üzerinde moleküler ve taksonomik çalışmalar

Özet

Acarospora, Acarosporaceae familyasında yer alan kabuksu bir liken cinsi olup, dünya üzerinde geniş bir yayılış alanına sahiptir. Acarospora cinsi içerisinde dünyada 200'den fazla tür bulunurken, Türkiye'de şu ana kadar tespit edilen tür sayısı 41'dir. Bu çalışma, Türkiye liken florası için üç likenleşmiş mantar ve iki likenikol mantar türü yeni kayıt olarak sunulmaktadır: *Acarospora irregularis* H. Magn., *Acarospora rosulata* (Th. Fr.) H. Magn., *Acarospora thamnina* (Tuck.) Herre, *Lichenostigma svandae* Vondrák & Šoun, *Stigmidium fuscatae* (Arnold) R. Sant. Bu 5 takson hakkında detaylı bilgiler fotoğraflarla birlikte verilmektedir. Yeni kayıtların nrITS, β tubulin ve mtSSU gen bölgeleri çalışılmış ve türlerin filogenetik konumu *Acarospora* cinsinde yer almış ve cinsin diğer türlerinden net olarak ayrılmıştır.

Anahtar kelimeler: Türkiye, biyoçeşitlilik, likenleşmiş mantarlar, ITS gen bölgesi, *Acarospora*.

1. Introduction

Acarospora is a cosmopolite crustose lichen genus in the family Acarosporaceae. This genus is represented by more than 200 species in the world and the number of species so far determined in Türkiye is 41. The vast majority of species belonging to the genus is characterized by having more than 100 ascospores per asci, usually the pseudo-lecanorine apothecia immersed in the thallus [1,2].

Turkey's flowering plant biodiversity is well known. The country is very rich in flowering plants, about 10765 species of flowering plants are known and the endemism rate is quite high. But compared to European countries, the

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history of lichen biodiversity studies in Türkiye is quite new. A checklist of lichenized and lichenicolous fungi was published quite recently by John and Turk (2017) and according to this checklist 1898 lichenized and lichenicolous fungal species are known from Türkiye. The estimated number of lichenized and lichenicolous fungi from Türkiye is over 2000 [3].

The floristic studies on lichenized fungi in Türkiye are mostly based on anatomical and morphological characters [4]. However, in addition to anatomical and morphological studies in lichenized fungi, studies on nuclear rDNA have started to increase in the last decades [5-8]. Among the ribosomal regions, ITS gene region has the highest probability of succesful identification. Here we present 12 ITS sequence data and related Maximum Likelihood dendrograms. This study provides three lichenized fungi and two lichenicolous fungi new records for the lichen mycobiota of Türkiye.

2. Materials and methods

2.1. Lichen Material

Lichenized and lichenicolous fungal samples were collected from different regions of the Türkiye (Table 1). The specimens examined are deposited in Erciyes University Herbarium Kayseri, Türkiye (ERCH). The "ACA" code was used for numbering the samples in the herbarium database. A dissecting binocular microscope was used to examine the morphology. Detailed examination of the anatomy of the thallus and apotechia of the samples was carried out with a compound microscope. The colour of asci, hypothecium, epithecium and medulla were recorded both before and after spot tests. Asci and ascospores were visualized in the sections taken from the apothecia and their types and sizes were recorded.

Table 1. Samples collected from different regions of Türkiye and their localities

Species & Herbarium Accession No.	**Localitiy**	**GenBank Accession No.**		
		ITS	**mtSSU**	**β-tubulin**
Acarospora irregularis ACA 0.073	Türkiye, Erzurum, Narman, alt. 2315 m, on siliceous rocks	MK996290	MN005097	MN005699
Acarospora rosulata ACA 0.011	Türkiye, Kars, Kağızman, alt. 1040 m, on siliceous rocks	MK996279	MN005094	-
Acarospora rosulata ACA 0.020	Türkiye, Kırıkkale, Keskin, alt. 1290 m, on siliceous rocks	MK996280	-	-
Acarospora rosulata ACA 0.022	Türkiye, Kırşehir, Akçakent, alt. 1475 m, on siliceous rocks	MK996281	-	-
Acarospora rosulata ACA 0.040	Türkiye, Balıkesir, Susurluk, alt. 200 m, on siliceous rocks	MK996282	-	-
Acarospora rosulata ACA 0.057	Türkiye, Erzurum, on the highway to Tortum-Erzurum, alt. 1880 m, on siliceous rocks	MK996283	-	-
Acarospora rosulata ACA 0.065	Türkiye, Kırşehir, Çiçekdağı, alt. 1085 m, on siliceous rocks	MK996284	-	-
Acarospora rosulata ACA 0.108	Türkiye, Kayseri, Erciyes Mountain, alt. 2530 m, on siliceous rocks	MK996285	MN005095	-
Acarospora rosulata ACA 0.164	Türkiye, Yozgat, Şefaatli, alt. 1010 m, on siliceous rocks	MK996286	MN005096	-
Acarospora rosulata ACA 0.171	Türkiye, Erzurum, Narman, alt. 1885 m, on siliceous rocks	MK996287	-	-
Acarospora rosulata ACA 0.309	Türkiye, Aksaray, Büyük Hasan Mountain, alt. 1960 m, on siliceous rocks	MK996288	-	-
Acarospora thamnina ACA 0.033	Türkiye, Ankara, Kızılcahamam, alt. 1380 m, on siliceous rocks	MK996289	-	-

2.2. Molecular Methods

2.2.1. DNA Isolation, PCR and Sequencing

DNA isolation and PCR processes were carried out in the Molecular Biology Laboratory of Erciyes University. The commercial kit for DNA isolation (Dneasy Plant Mini Kit-Qiagen) was performed according to the protocol provided by the manufacturer. DNAs obtained from DNA isolation were used as templates for PCR. Primers "ITS1-F (5′-CTTGGTCATTTAGAGGAAGTAA-3′)" and "ITS4 (5'- TCCTCCGCTTATTGATATGC-3')" were used in PCR to amplify the repeat of the nrITS region (nrITS1-5.8S-nrITS2, ca. 500 bp) of nuclear ribosomal DNA [9,10]. For PCR 50 µL reaction volumes were prepared using 36.8 µl dH_2O, 2 µl of genomic DNA, 0.2 µl Taq DNA polymerase, 2 µl 10 mM dNTP, 0.5 µl each primer, 4 µl $MgCl_2$ (50 mM), 4 µl of 10 x reaction buffer on a thermal cycler equipped with a heated lid. The conditions for PCR are as follows: "An initial denaturation 4 min at 95 °C; 10 cycles with 1 min at 95 °C, 1.30 min at 56 °C, and 1 min at 72 °C; and 15 cycles with 1 min at 95 °C, 1.30 min at 51 °C, and 1 min at 72 °C; a final extension step of 8 min at 72 °C was added, after which the samples were kept at 4 °C." The products obtained from PCR were run on agarose gel and DNA bands were obtained from nine lichenized fungal samples. 1.6% agarose gel was used for all samples for electrophoresis and for size estimation 1 Kb Plus DNA Ladder was used and compared with the samples. Sequencing was done at the BM Labosis laboratory.

2.2.2. Sequence alignment and phylogenetic analysis

Sequence analyzes were performed by the BM Labosis Laboratory. Sequence results were compared on the NCBI website using the BLAST program. diting of the sequences was carried out with the Bioedit program [11]. Alignment of the sequences was done with the "Clustal W" option in the Bioedit program. Data selection was made from GenBANK, considering both the molecular results obtained and the species with which the samples were morphologically related. The selection of lichen samples from genbank was chosen by taking into consideration the molecular results as well as morphological relationships the with the studied samples. Maximum Likelihood phylogenetic trees were constructed on the "MEGA 6 (Molecular Evolutionary Genetics Analysis)" program using the Kimura 2-parameter model [12]. Gaps in the data were removed by pairwise deletion and the reliability of the obtained phylogenetic tree was tested with 1000 bootstrap replications. The gaps in data were deleted by pairwise deletion and 1000 bootstrap replications tests was used for controlling the reliability of the inferred tree. The species associated with the in-groups were selected as out-groups for the phylogenetic trees.

3. Results

3.1. Acarospora irregularis H. Magn.

Specimens examined: Türkiye, Erzurum, Narman, on the highway to Pasinler-Oltu, on siliceous rocks, 40º 09' 578" N, 41º 53' 810" E, alt. 2315 m, 29 July 2013 [ACA 0.073].

Description: Thallus dispersed or contiguous, convex to flat areaoles or squamules, edges crenulate or entire, covering rocks up to 10 mm in diam. Lateral and upper surfaces brown to reddish brown, epruinose (Figure 1). Lower surface brown to reddish brown. Algal layer thick, up to 150-200 mm thick, lower and upper surfaces uneven, forming algal palisades, interrupted by hyphal bundles, ca. 30–50 mm wide. Algal cells ca. 10 mm in diam. Apothecia to 1 mm in diam., usually 1, sometimes 2 or 3 per areole or squamules. Disc reddish brown, epruinose. Hymenium hyaline (70–)100–120(–150) µm high, epihymenium reddish brown and 15 µm high. Asci clavate, ca. 70–80 x 15–20 µm. Ascospores hyaline, simple, ca. 4–6 x 2.0– 3.0 µm broadly ellipsoid to ellipsoid [13].

Chemistry: all spot tests negative.

Ecology: This species can be found on non-calcareous rocks in low and high altitudes. The sample we studied was collected from the siliceous rock from approximately 2300 m.

Distribution: Europe (Slovakia, Russia, Italy, Hungary, Greece, Czech Republic) [13].

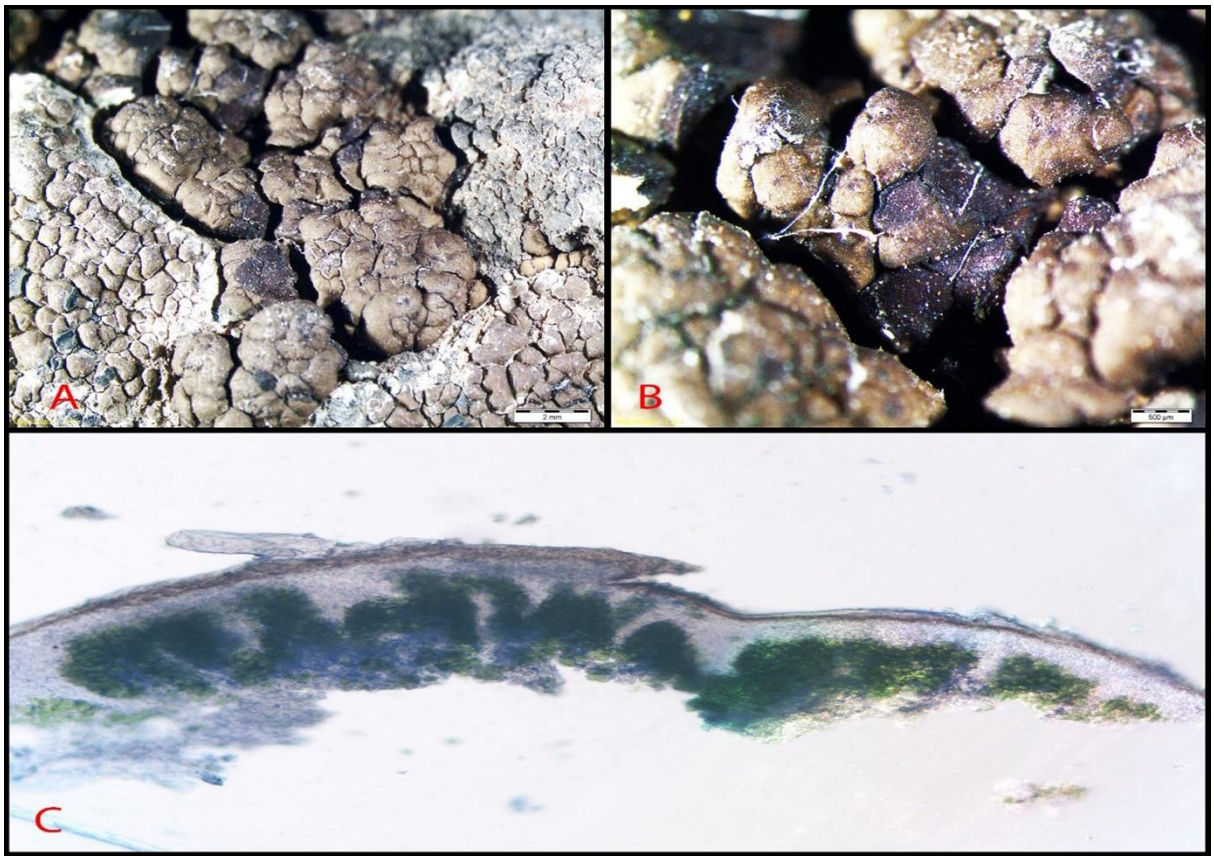

Figure 1. *Acarospora irregularis* A and B. Thallus with apothecia. C. Algal palisades with wide hyphal bundles.

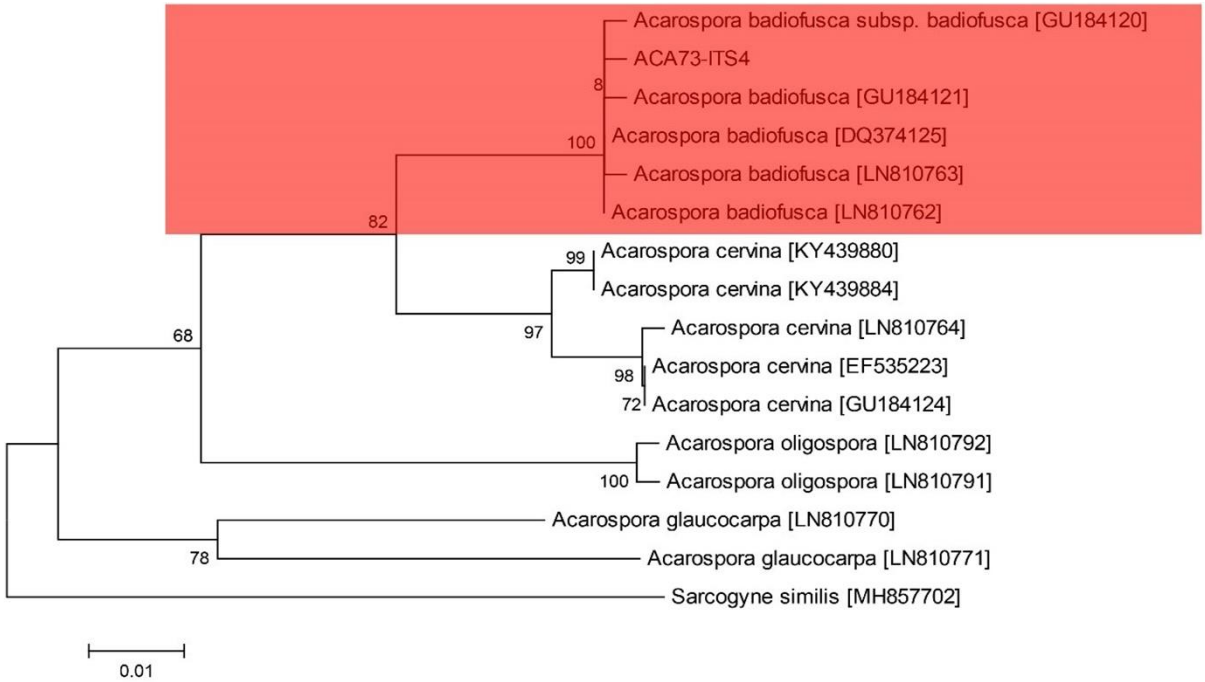

Figure 2. Maximum likelihood analysis inferred from ITS gene region sequences of *Acarospora irregularis* and related species.

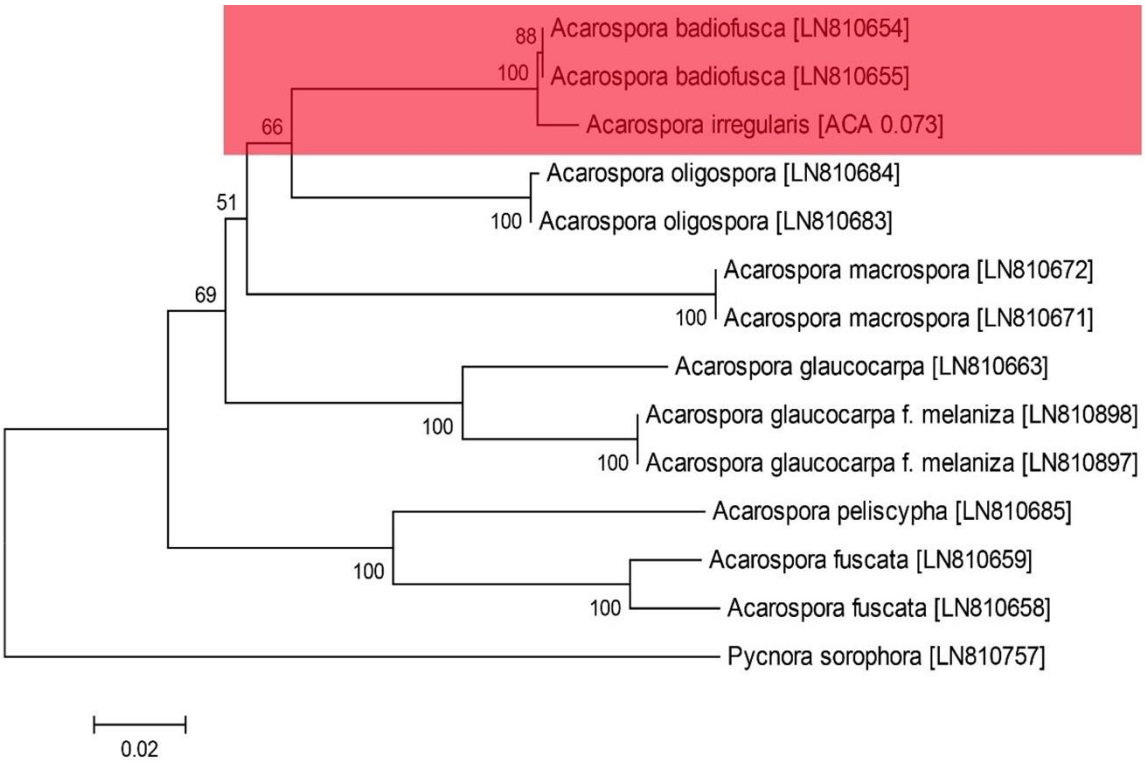

Figure 3. Maximum likelihood analysis inferred from β tubulin gene region sequences of *Acarospora irregularis* and related species.

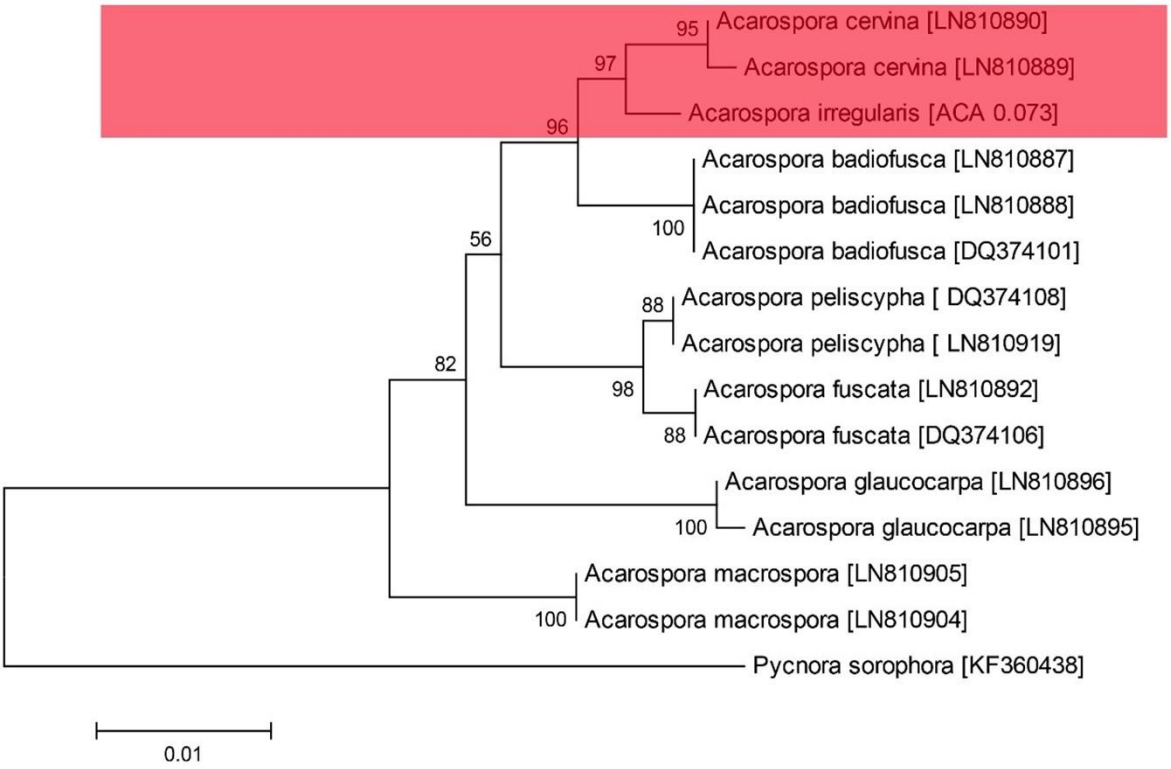

Figure 4. Maximum likelihood analysis inferred from mtSSU gene region sequences of *Acarospora irregularis* and related species.

3.2. Acarospora rosulata (Th. Fr.) H. Magn.

Specimens examined: Türkiye, Kars, Kağızman, Kuloğlu Village, on siliceous rocks, 40º 06' 342" N, 42º 59' 208" E, alt. 1290 m, 31 July 2013 [ACA 0.011]; Kırıkkale, Keskin, southwest of Keskin, Cabatobası Village, 39º 38' 11,5" N, 33º 15' 16" E, alt. 1040 m, 19 July 2012 [ACA 0.020]; Kırşehir, Akçakent, northwest of Halaçlı Köyü, on siliceous rocks, 39º 36' 01" N, 34º 12' 55" E, alt. 1475 m, 19 July 2012 [ACA 0.022]; Balıkesir, Susurluk, southeast of Karaköy, on siliceous rocks, 39º 52' 46" N, 28º 10' 52" E, alt. 200 m, 24 May 2012 [ACA 0.040]; Erzurum, on the highway to Tortum-Erzurum, on siliceous rocks, steppe vegetation, 40º 07' 267" N, 41º 25' 085" E, alt. 1880 m, 28 July 2013 [ACA 0.057]; Kırşehir, Çiçekdağı, 4 km southwest of Çiçekdağı, North of Alimpınar Village, 39º 35' 21" N, 34º 24' 14" E, alt. 1085 m, 19 July 2012 [ACA 0.065]; Kayseri, Erciyes Mountain, on siliceous rocks, 38º 33' 59.64" N, 35º 26' 02.32" E, alt. 2530 m, 20 August 2015 [ACA 0.108]; Yozgat, Şefaatli, on the highway to Karanlıkdere valley, on siliceous rocks, steppe vegetation, 39º 33' 569" N, 34º 41' 962" E, alt. 1010 m, 20 March 2015 [ACA 0.164]; Erzurum, Narman, on the highway to Pasinler-Oltu, southwest of Savatlı Village, on siliceous rocks, 40º 03' 700" N, 41º 49' 717" E, alt. 1885 m, 29 July 2013 [ACA 0.171]; Aksaray, Büyük Hasan Mountain, Near Karbeyaz Hotel, North of Basanbucağı, on siliceous rocks, steppe vegetation, 38º 09' 624" N, 34º 09' 917" E, alt. 1960 m, 05 June 2013 [ACA 0.309].

Description: Thallus areolate, dispersed to contiguous. Areoles angular to round, up to 1 mm diam, broadly attached wide. Surface dark brown to pale yellow brown, epruinose (Figure 5). Lateral and upper cortices paraplectenchymatous to subparaplectenchymatous, 30–50 µm thick, cells 3–7 × 2·5–6 µm, globose to elongate. Lower surface usually white or occasionaly brown. Photobiont green, chlorococcoid, algal cells up to 10 µm diam., 40– 100 µm thick as a continuous stratum. Medulla prosoplectenchymatous, hyaline. Apothecia one or many per areole, immersed and punctiform, 0.3–0.6 mm diam. Disc dark brown, epruinose, rough. Hymenium 70–120 µm tall, epihymenium reddish brown to dark brown. Paraphyses lax in water, 2-4 µm diam., septate, oil droplets sometimes present. Asci clavate, 80–100 × 22–26 µm. Ascospores 100–200 per asci, hyaline, simple, mostly 4–5 × 1.5–3 µm.
Chemistry: cortex KC+ pinkish red, C+ pinkish red.
Ecology: On siliceous and granite rocks, rarely on calcareous or limestone rocks. The samples we studied were collected from the siliceous rock at altitudes between 200-2500 m.
Distribution: Asia, western North America and Europe.

When examined morphologically, *Acarospora rosulata* (Th. Fr.) H. Magn. can often be confused with *A. bullata* (Th. Fr.) H. Mag. This species has morphological differences *A. bullata* - *Polysporinopsis rugulosa* (Körb.) Vězda. *Acarospora rosulata* differs from *A. bullata* in lacking large determinate thalli and distinctly rugulose apothecial discs [14]. In the Maximum Likelihood Dendrogram from ITS gene region sequences (Figure 6); *Acarospora rosulata* showed a close branch with *Acarospora bullata*. When we examined the dendrogram of the mtSSU gene region (Figure 7), *Acarospora rosulata* showed a good distinction.

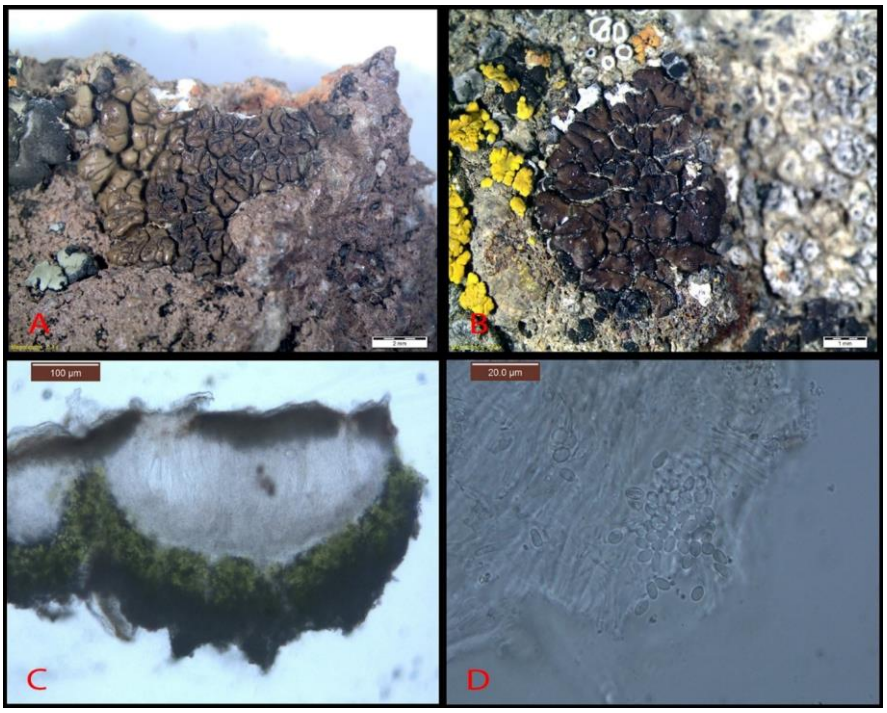

Figure 5. Morphological and anatomical images of *Acarospora rosulata* A and B. Thallus and Apothecia C. Hymenium D. Ascospores.

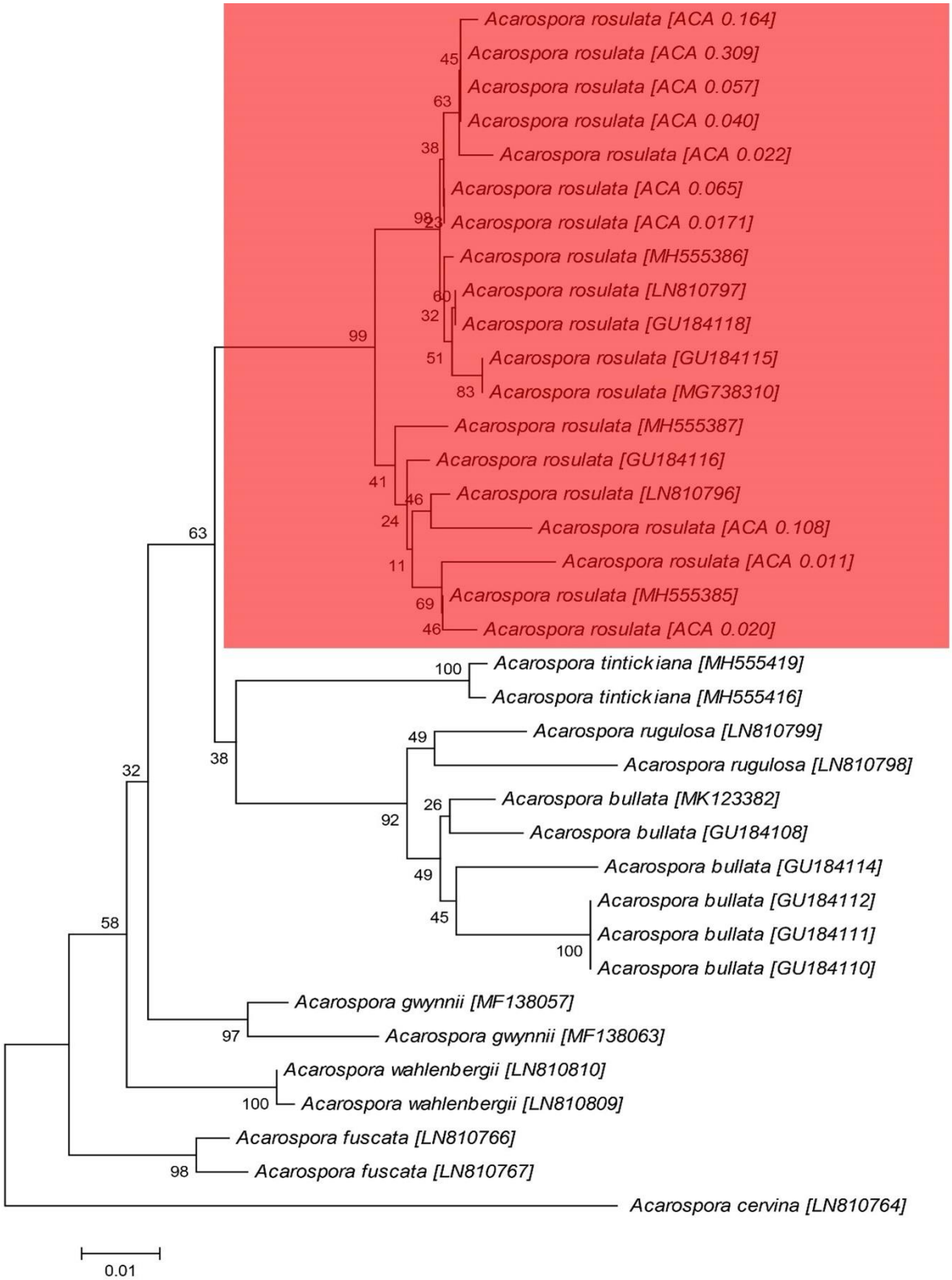

Figure 6. Maximum likelihood analysis inferred from ITS gene region sequences of *Acarospora rosulata* and related species.

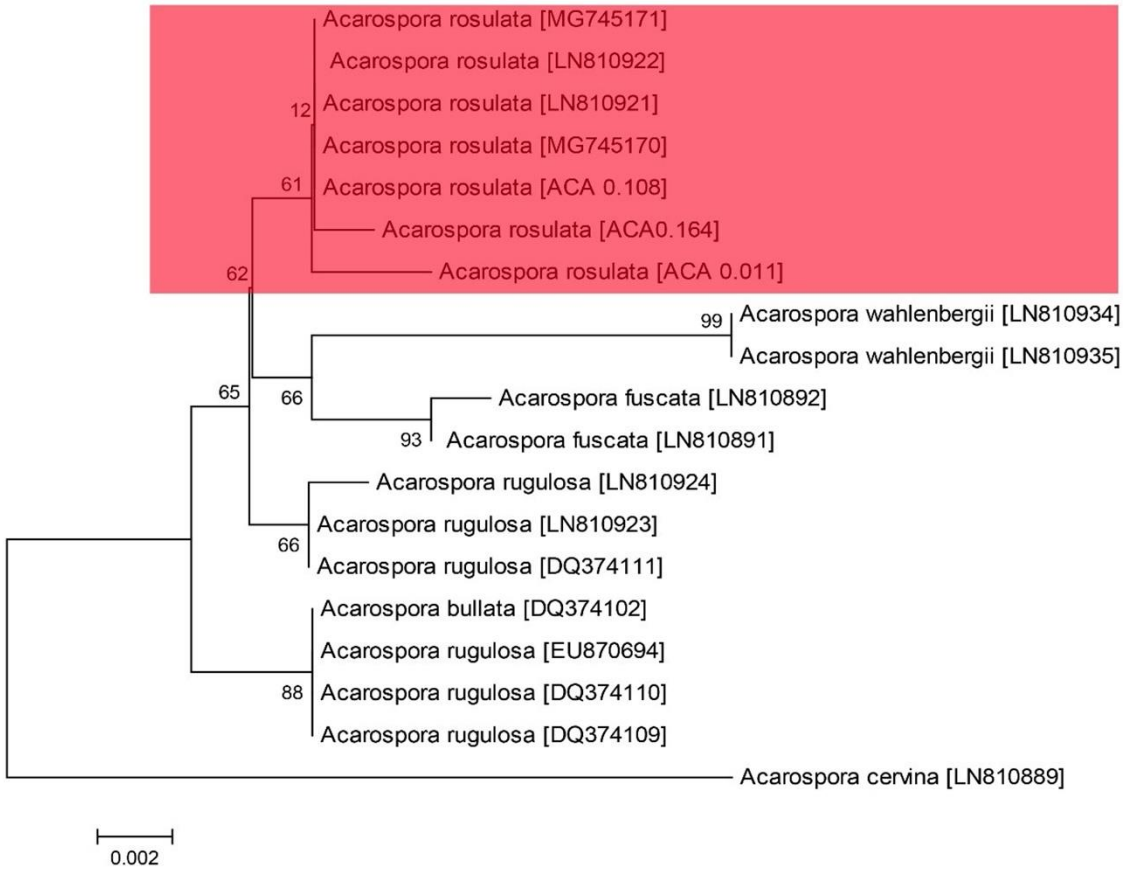

Figure 7. Maximum likelihood analysis inferred from mtSSU gene region sequences of *Acarospora rosulata* and related species.

3.3. Acarospora thamnina (Tuck.) Herre

Specimen examined: Türkiye, Ankara, Kızılcahamam, northwest of Dereiçi Village, on sliceous rocks, 40º 36' 44" N, 32º 31' 39" E, alt. 1380 m, 21 July 2012 [ACA 0.033].

Description: Tallus squamulose, on or among other lichens. Squamulose, irregular, sometimes lobed, thick, 0.3-1.5 mm in diam. The upper surface is in various shades of Brown (Figure 8). Medulla dirty brown or white. The lower surface carbonized or not, black. Apothecia, one or more per squamulose, round, 0.5 mm. The disc is very rough and usually black. Hymenium, golden yellow, 60-80 µm in diam. Asci 50-70 x 10-20 µm, with about 100 and more spores. Ascospores, hyaline, simple, often narrow ellipsoid, 5-7 x 2-3 µm.

Chemistry: strongly C + red and KC + red in cortex.

Ecology: In acidic rocks, it is generally found from the coast towards the inner parts. The sample we studied was collected from the siliceous rock from approximately 1400 m.

Distribution: Russia, Sweden, North America.

When examined morphologically, *Acarospora thamnina* (Tuck.) Herre can often be confused with *A. fuscata* (Ach.) Arnold. There are morphological differences between *Acarospora thamnina* and *A. fuscata*. Although *A. thamnina* sometimes grows on the same rock with a thallus in many shades of brown from yellowish to reddish, it has a strong C+ cortical reaction and thallus of *A. thamnina* is always shiny. In the Maximum Likelihood Dendrogram from ITS gene region sequences (Figure 9); the closest branching to *A. thamnina* is *A. insignis*. *Acarospora thamnina* is separated from *A. insignis* H. Magn. by its typical shininess, and its higher hymenium [15].

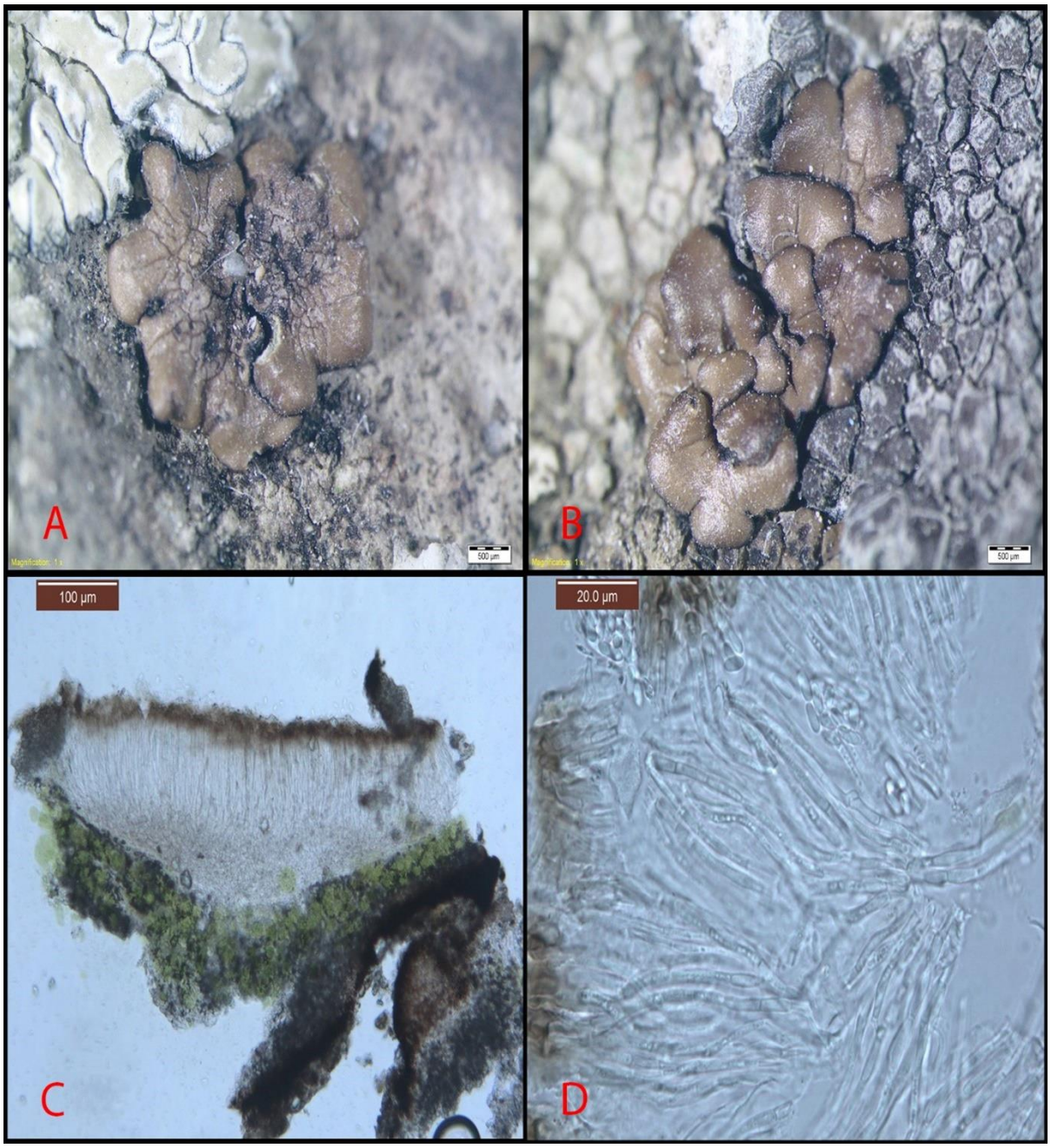

Figure 8. Morphological and anatomical images of *Acarospora thamnina* A and B. Thallus and Apothecia C. Hymenium D. Ascospores.

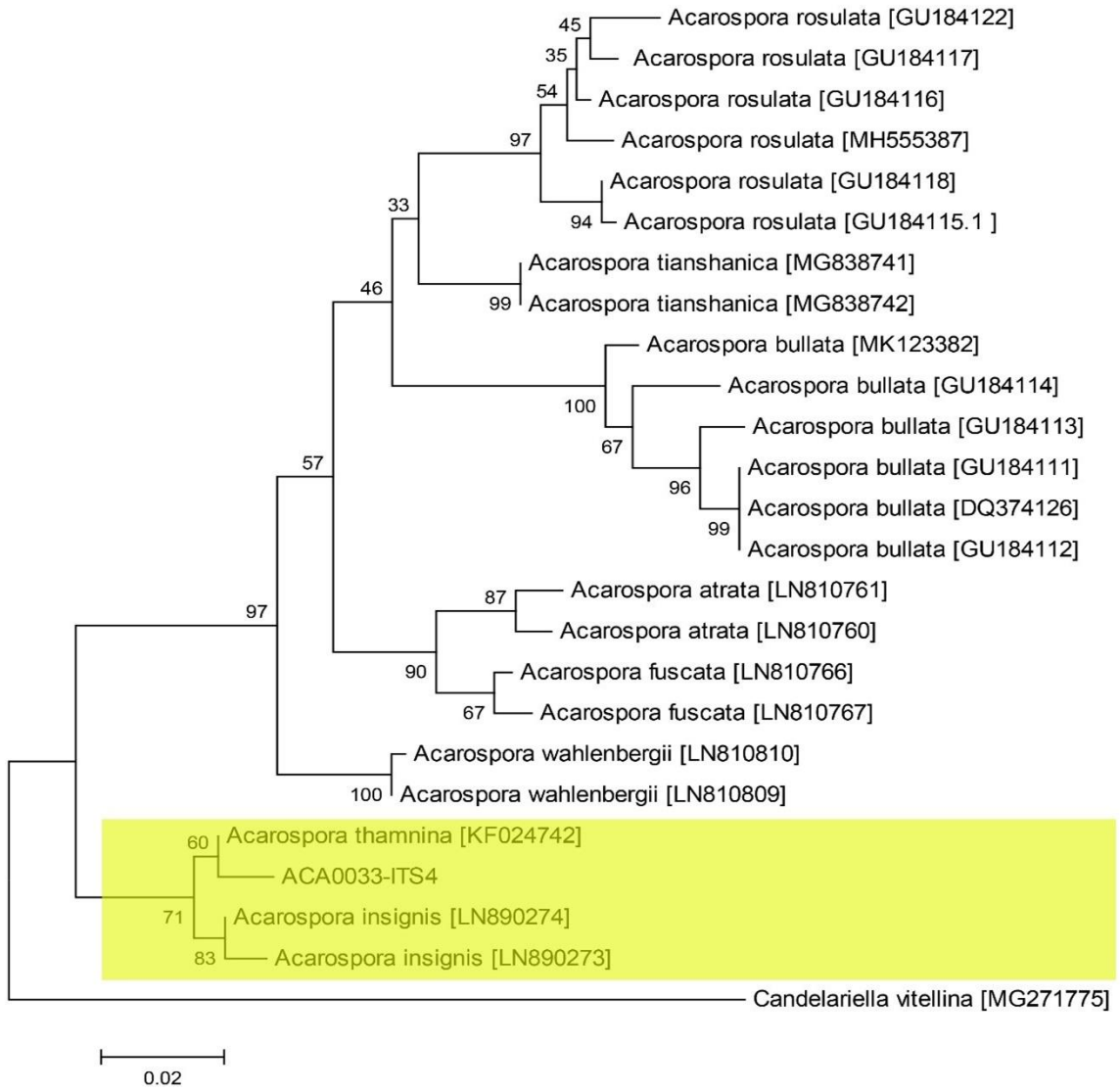

Figure 9. Maximum likelihood analysis inferred from ITS region sequences of *Acarospora thamnina* and related species.

3.4. Lichenostigma svandae Vondrák & Šoun

Specimen examined: Türkiye, Aydın, Çine, on sliceous rocks, 37º 38' 31.4" N, 28º 06' 07.4" E, alt. 520 m, 21 July 2016.

Description: Lichenicolous, on the thallus of *Acarospora cervina* A. Massal. It has irregular and superficial vegetative hyphae forming dark web-like patches over the apothecial discs or/and on the thallus (Figure 10). Ascomata black, shiny, scattered, cushion-like, rounded, 30–70 µm tall, 80–150 µm wide, Asci 6–8-spored, subglobose to broadly clavate. Ascospores hyaline at first, when old becoming greyish and then brownish, 1 septate. 11.5–12.5–13.5 × 6.2–7.1–8.0 µm [16].

Chemistry: Ascomatal tissue I-.

Ecology: This species grows on the apothecia and thalli of *Acarospora cervina* which grows on sun-exposed limestone rocks [16]. The sample we studied is grows on the areoles and apothecia of *Acarospora cervina* on calcareous rock.

Distribution: This species is only reported from Czech Republic and Ukraine (Crimean Peninsula) [16].

During our studies of the biodiversity of lichenicolous fungi in Turkey, we collected a brown, pruinose *Acarospora cervina* calcerous rocks from Turkey infected by a *Lichenostigma* species. The specimen was compared with three other *Lichenostigma* species (*Lichenostigma anatolica, L. gracile and L. subradians*) also found growing on *Acarospora spp.* [16,17]. We concluded that it is new to Turkey and describe it here. *Lichenostigma anatolica* does not have vegetative hyphae or poorly developed. However, vegetative hyphae in *L. svandae, L. gracile and L. subradians* are superficial and form black structures. Whereas *Lichenostigma svandae*, *L. gracile* and *L. subradians* has a negative reaction with ascomata tissue I, *L. anatolica* gives blue colour with ascomata tissue I. *Lichenostigma svandae* is found on *Acarospora cervina* species, while other *Lichenostigma* species are distributed on different *Acarospora* species [18].

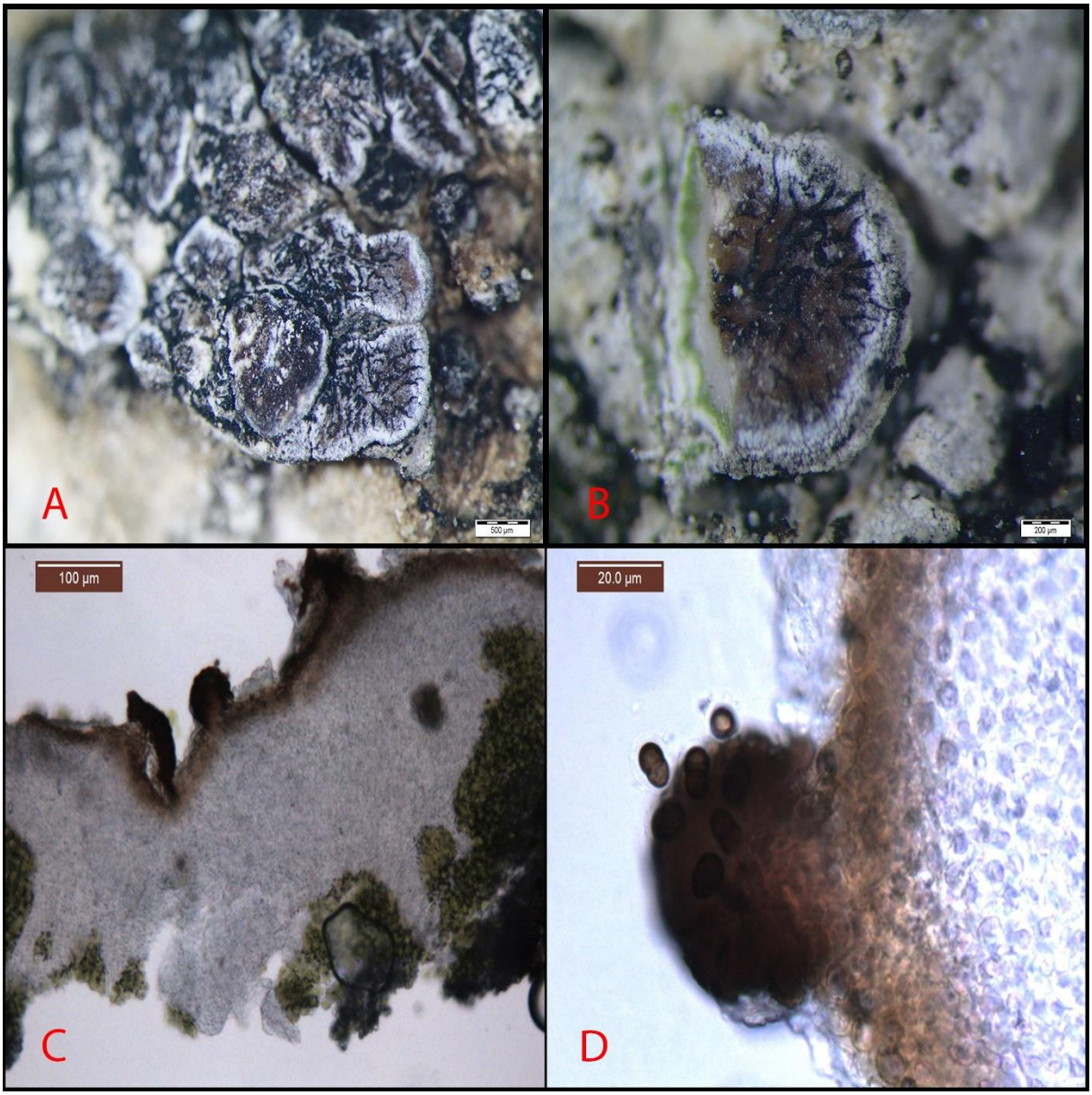

Figure 10. *Lichenostigma svandae*. A and B. Strongly infected thallus and apothecia of *Acarospora cervina* C. cross-section of an ascoma D. brown ascospores.

3.5. *Stigmidium fuscatae* (Arnold) R. Sant.

Specimen examined: Türkiye, Aydın, Çine, on sliceous rocks, 37º 38' 31.4" N, 28º 06' 07.4" E, alt. 520 m, 21 July 2016.

Description: Lichenicolous, on the thallus of *Acarospora fuscata* (Ach.) Arnold (Figure 11). Pseudothecia, black, globose, 50-100 µm wide and 50-100 µm high. Upper part of the wall dark brown. Asci, 8-spored, 30-40 x 10-15 µm, I-. Ascospores, hyaline, 1-septate, elipsoid, 10-13 x 4-5 µm. Pycnidia not seen [19].

Chemistry: Ascomatal tissue I-.

Ecology: *Stigmidium fuscatae* grows on apothecia and thalli *Acarospora fuscata* which grows on siliceous rocks. The sample we studied is grows on the areoles and apothecia of *Acarospora fuscata* on siliceous rock.

Distribution: *Stigmidium fuscatae* is known from Europe, Africa (South Africa) and North [19].

During our studies of the biodiversity of lichenicolous fungi in Turkey, we collected a brown, *Acarospora fuscata* siliceous rocks from Turkey infected by a *Stigmidium* species. The specimen was compared with two other *Stigmidium* species (*Stigmidium epixanthum, S. rouxianum*) also found growing on *Acarospora spp.*. We concluded that it is new to Turkey and describe it here. We compared *Stigmidium* species found on *Acarospora* in Table 2.

Table 2. Comparison of *Stigmidium* species growing on *Acarospora*.

Species	Ascomata size (µm)	Asci size (µm)	Ascospores (µm)	Host lichen	References
S.epixanthum	100–140 × 120–180	40–60 × 12–15	11–17× 5–7	yellow *Acarospora*	[19,20]
S.rouxianum	110–170 × 140–180	40–75× 13–18	(13.5–) 16–17.5–19 (–21) × 5.5–6.5	*A.cervina* *A.obpallens*	[21]
S. fuscatae	50–100× 50–100	30–40 × 10–15	(8–) 10–12× 4–5 (–5.5)	*A.fuscata*	Present paper

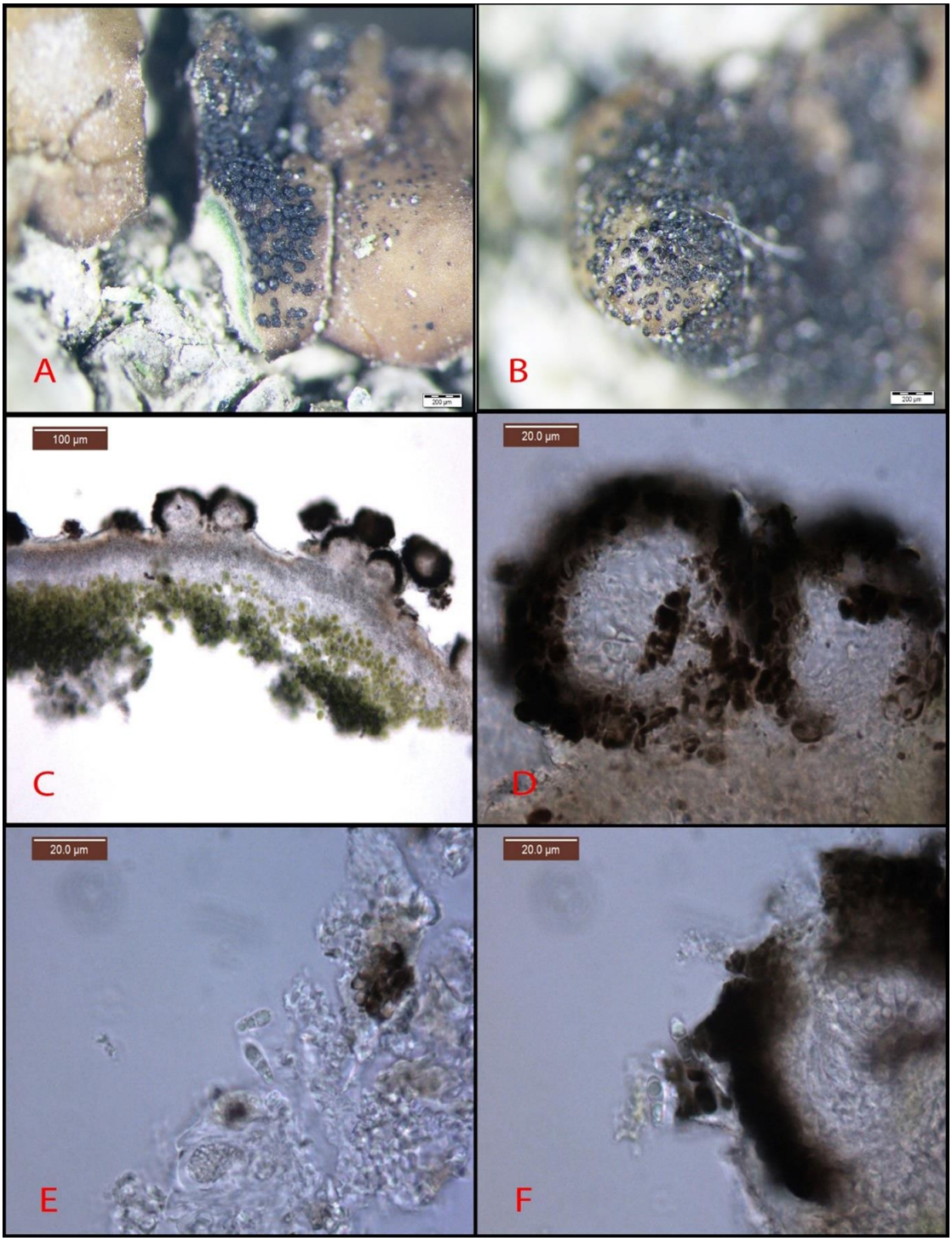

Figure 11. A and B. infected thallus of *Acarospora fuscata*. C and D. section of ascoma. E and F. Ascospores.

4. Conclusions and discussion

The circumscription of lichen-forming fungal species has traditionally been guided by morphological, chemical and ecological features. However, because lichens generally display few taxonomically useful characters, of which many are widely variable, the homology of character states within and among groups is difficult to assess. Therefore, molecular data have gained importance in lichen systematics and now have a significant impact on the classification and taxonomy of lichenized ascomycetes. In most cases, our phylogenetic analyses support the traditional species delimitation based on morphological and chemical traits.

Türkiye is a country rich in lichen biodiversity. It has a widespread distribution in our country in species belonging to the genus *Acarospora*. The *A. rosulata* (Th. Fr.) H. Magn. species described in this article is actually a lichen species found in almost every region of our country. However, this species has never been determined in previous studies. In this study, we concluded that some *A. bullata* Anzi species, which are herbarium material, are actually *A. rosulata* species as a result of molecular studies. *A. bullata* is a species confused with *A. rosulata*. *A. rosulata* differs from *A. bullata* in that it lacks a prominent thallus with fan-shaped lobes and a clearly rugulous apothecia disc [14]. When examined molecularly, these species showed good discrimination on ITS and mtSSU phylogenetic trees (Figure 6 and Figure 7).

In this study, molecular analyzes of ITS, mtSSU and β-tubulin gene regions were performed for 3 lichenized fungi (*Acarospora irregularis*, *A. rosulata* and *A. thamnina*), which are generally distributed on siliceous rocks in Türkiye. In addition, 2 lichenicolous fungi (*Lichenostigma svandae* and *Stigmidium fuscatae*) on brown *Acarospora* were studied morphologically and anatomically. Sometimes morphological characters used in lichen classification lead to misidentifications. Because of this, it is also important to make molecular studies in lichen taxonomy. ITS, mtSSU and β-tubulin sequences provided for this study are now in GenBank and can be used in the future phylogenetic studies of lichens.

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Cortinarius terribilis (Cortinariaceae): A new record for the Turkish mycota from Trabzon

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Abstract

The basidiocarps of *Cortinarius terribilis* Reumaux (Cortinariaceae) were collected from Trabzon, Maçka, Sevinç Neighborhood on 06 October 2021. The materials were examined by traditional methods and the species is presented as a new record for Turkey herein with field photos, microscopic illustrations and a short discussion. The new record is characterised with hemispherical, convex or relatively flat, pale reddish or chocolate brown and scaly pileus; dark brown, decurrent and sparse lamellae; club shaped, often curved, bulbous stipe; almond shaped, distinctly thorny, 10–15 × 5.7–8.5 µm basidiospores; club shaped and about 30–45 × 6–10 µm marginal cells.

Key words: Basidiomycota, Cortinariaceae, new record, Trabzon

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Cortinarius terribilis (Cortinariaceae): Türkiye mikotası için Trabzon'dan yeni bir kayıt

Özet

Cortinarius terribilis Reumaux (Cortinariaceae)'in bazidiyokarpları 06 Ekim 2021'de Trabzon, Maçka, Sevinç Mahallesi'nden toplandı. Materyaller geleneksel yöntemlerle incelendi ve bu tür burada arazi fotoğrafları, mikroskopik resimler ve kısa bir tartışma ile birlikte Türkiye için yeni bir kayıt olarak sunuldu. Yeni kayıt yarım küre, dışbükey veya nispeten düz, soluk kırmızımsı kahverengi, çikolata kahvesi ve pullu şapka; koyu kahverengi, saptan ayrık ve seyrek lameller; çomak biçiminde, genellikle eğri, tabanda soğansı sap; badem biçiminde, belirgin olarak dikenli, 10–15 × 5.7–8.5 µm bazidiyosporlar, çomak şeklinde ve 30–45 × 6–10 µm kenar hücreleri ile tanınır.

Anahtar kelimeler: Bazidiyomikota, Cortinariaceae, Trabzon, yeni kayıt

1. Giriş

Günümüzde Cortinariaceae Singer familyası (Örümcekmantarıgiller) dünyada yaklaşık 5815 Türkiye'de ise yaklaşık 145 kayıt ile temsil edilmektedir [1, 2]. Elbette bu kayıtlar gerçek tür sayısını göstermez fakat *Cortinarius*'un (Örümcekmantarı) mantarlar âleminin en zengin cinslerinden birisi olduğunu ortaya koyar. Önceki çalışmalarda ve özellikle son yıllarda bu cins üzerinde yapılan taksonomik çalışmalar ile bazı yeni tür (*Cortinarius gueneri* E. Sesli) ve yeni kayıtlar (*C. atroalbus* M. M. Moser, *C. cadi-aguirrei* Garrido-Ben., *C. caninus* (Fr.) Fr., *C. cinnamoviolaceus* M. M. Moser, *C. duracinobtusus* Rob. Henry, *C. leucopus* (Bull.) Fr., *C. variegatus* Bres.) tespit edilmiştir [3, 4, 5]. Araştırma sahasında daha sonra yapılan incelemelerde daha önce koleksiyonu yapılmamış daha birçok farklı meyvemsinin zaman zaman ortaya çıktığı gözlemlenmiş ve yeni örnekler toplanmıştır. Arazi gözlemleri cinsin özellikle sonbaharda yağmurlardan sonra çeşitli türleri ile yoğun öbekler halinde yayılış gösterdiğini ortaya koymaktadır. *Cortinarius* teşhisi zor cinslerden olmakla birlikte dikkatli bir gözlem ve inceleme ile farklı renk, şekil ve büyüklükte olabilen bazidiyokarpları, mikorizal ilişkileri, ilginç bazidiyosporları ve bazı türlerde rastlanan kenar hücreleri ile teşhis edilebilir.

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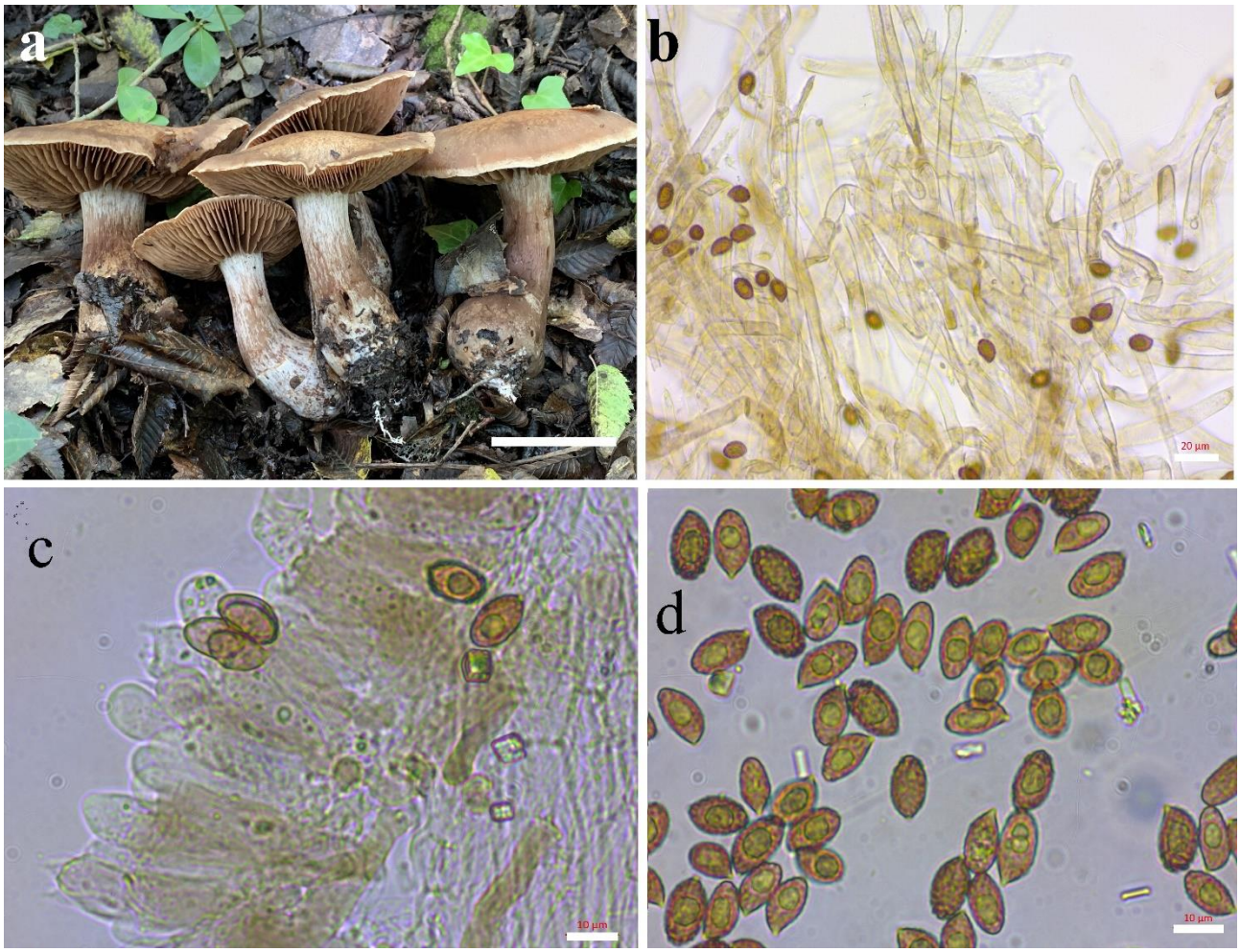
Cortinarius'ta kırmızıdan beyaza, maviden sarıya, turuncudan kahverengine değin çeşitli renklerde meyvemsiler bulunmaktadır. Onları diğer cinslerden ayırt edebilmek için en pratik yöntem arazide kortinanın olup olmadığına, laboratuvarda ise spor tipine bakmaktır. Bazıları zehirli, bazıları kötü kokulu veya üst yüzeyleri jelatinsi yapılarla kaplı veya lezzetsiz olduğundan genel olarak beslenme amaçlı tüketilmezler. Koleksiyoncular için iyi yönleri birkaç parçaya bölündükleri zaman çürümeden kolayca kurutulabilmeleri, sporlarının bol ve dayanıklı olması ve genellikle gençten yaşlıya kadar birçoğunun bir arada yetişiyor olmasıdır. Teşhiste zor yönleri ise sistityumlarının genellikle bulunmaması ve birbirine yakın özellikte çok sayıda türün bulunmasıdır. Araştırma sahası yoğun olarak gürgen ve meşe ağaçlarının bulunduğu, çürümekte olan ağaç yaprakları ve diğer döküntüler ile kaplı, nemli ve meyilli bir arazidir. Bu çalışmanın amacı konuya ilgi duyan ve *Cortinarius* konusunda çalışan araştırmacılara Türkiye mikotası için yeni bir kaydı tanıtmaktır.



Şekil 1. *Cortinarius terribilis*: a- meyvemsiler, b- şapka derisi hücreleri, c- bazidiyumlar ve bazidiyoller, d- bazidiyosporlar (ölçek çubukları: a: 40 mm, b: 20 µm, c ve d: 10 µm)

2. Materyal ve yöntem

Meyvemsiler 06.10.2021 tarihinde gerçekleştirilen arazi gezisinde Trabzon, Maçka Sevinç Mahallesi'nde tespit edilmiştir. İlk olarak materyalin fotoğrafı çekilmiş, bir spatula ile birkaç tanesi sökülmüş, kese kâğıtlarına konularak laboratuvara taşınmış, spor izleri alındıktan sonra elektrikli radyatör yardımı ile kurutulmuş ve numaralandırılarak fungaryum dolaplarına yerleştirilmiştir. Daha sonra hifler, bazidiyum ve diğer yapıların görüntülenebilmesi için bazidiyokarplardan binoküler mikroskop altında, keskin jilet ile ince kesitler alınmıştır. Kesitler %5'lik amonyak çözeltisi içerisinde 3-5 dakika tutulduktan sonra lam üzerine alınmış ve lamelle kapatılmıştır. Bazidiyumların incelenip görüntülenebilmesi için lamel üzerine işaret parmağı ile hafifçe bastırıldıktan sonra mikrofotografi sistemi sayesinde gerekli ölçümleri yapılmış ve fotoğrafları çekilmiştir. Bazidiyosporların görüntülenebilmesi için meyvemsiden küçük bir parça kesilerek %5'lik amonyak çözeltisi içerisine konulmuş, 3-5 dakika bekletildikten sonra bir pens yardımı ile lam üzerine alınmış ve birkaç defa sıkılıp bırakılarak kahverengimsi sarı bir sıvı elde edilmiştir. Ortaya çıkan posa pens yardımı ile lamel üzerinden temizlendikten sonra preparat üzerindeki fazla sıvı kurutma kâğıdı ile çekilmiş, immersiyon

objektifi (100x) altında inceleme yapılmış, yaklaşık 40 tanesinin eni ve boyu ayrı ayrı ölçülerek ortalaması alınmış ve mikrofotoğrafi sistemi sayesinde fotoğrafları çekilmiştir. Türün teşhisi ilgili literatürlere göre [6,7,8] yapılmış olup incelenen örnekler Trabzon Üniversitesi Fatih Eğitim Fakültesi'ndeki kişisel fungaryumda saklanmaktadır.

3. Bulgular

3.1. *Cortinarius terribilis* Reumaux (Cortinariaceae) / Leş Örümcekmantarı (Şekil 1)

Şapka gelişimin başlangıcında yarım küre biçiminde ve daha sonra dışbükey ve olgunlukta nispeten düz, yaklaşık 40–78 mm çapında, higroskopik; kenarları beyazımsı, başlangıçta içeriye kıvrık, bazen dalgalı veya loblu; yüzeyi soluk kırmızımsı kahverengi, çikolata kahvesi ve pulludur. Lameller koyu kahverengi veya çikolata renginde, seyrek, sapa birleşmemiş, merkeze doğru daha geniş, düz kenarlı ve bazıları tam olarak olgunlaşmamıştır. Etli kısmı merkezde kalın, kenarlarda ince, sulu, açık bej veya açık kahverengi ve kokusu pek belirgin değildir. Sap çomak biçiminde ve tabanda oldukça geniş veya soğansı yapıda, 40–80 × 10–35 mm, genellikle eğri, pembemsi kahverengi zemin üzerinde beyazımsı lifli, tabanda beyazımsı miselyumlu ve hemen hemen doludur. Bazidiyumlar çomak biçiminde ve 35–49 × 9–11 µm'dir. Bazidiyosporlar badem biçiminde, belirgin olarak dikenli, 10–15 × 5.7–8.5 µm'dir. Sistidiyoyitler / kenar hücreleri çomak şeklinde, 30–45 × 5–10 µm'dir. Şapka derisi paralel, nispeten düzgün, bazen dallanmış, silindirik, kancasız veya kancalı hiflerden oluşmuştur. Türkiye'de günümüze değin gerçekleştirilen çalışmalarda sadece Doğu Karadeniz Bölümünde saptanmıştır. Yenmez.

3.2. İncelenen örnekler

Türkiye, Trabzon, Maçka, Sevinç, 40°50'49.61" K ve 39°37'41.12" D, 732 m, gürgen ve meşe ağaçları altında, öbekler halinde, 06.10.2021, E. Sesli 4400.

4. Sonuçlar ve tartışma

Cortinarius terribilis türü ilk kez Atlas des Cortinaires eserinde yayımlanmıştır. Türkiye koleksiyonu 40–78 mm büyüklüğünde, soluk kırmızımsı kahverengi, çikolata kahvesi ve pullu şapkası; koyu kahverengi veya çikolata renginde, seyrek ve saptan ayrık lamelleri; çomak biçiminde ve soğanlı, 40–80 × 10–35 mm, genellikle eğri, pembemsi kahverengi, beyazımsı lifli ve tabanda beyazımsı miselyumlu sap; badem biçiminde ve 10–15 × 5.7–8.5 µm bazidiyosporları; çomak biçiminde ve 30–45 × 5–10 µm sistidiyoyit / kenar hücreleri ile teşhis edilir [6].

Renk ve büyüklük yönünden benzer bir tür olan *C. cotoneus* Fr. oval ve daha küçük (6.5–9.5 × 5.5–8 µm) olan bazidiyosporları ile farklılık gösterir. Renk olarak benzer fakat diğer farklı bir tür olan *C. melanotus* Kalchbr. daha küçük meyvemsiler ve yeni kayıttan oldukça küçük bazidiyosporlara (6–8 × 4–6 µm) sahiptir. Dış görünüş olarak benzerlik gösteren *C. balteatus* Fr. iğne yapraklı ağaç ormanlarında yayılış göstermesi, tabanda soğansı görünümde olmaması ve daha küçük bazidiyosporlu olması (9–12 × 5–6.5 µm) yönleri ile farklılık gösterir. Dış ve içyapısı itibariyle bir miktar benzerlik gösteren bir diğer tür, *C. cupreorufus* Brandrud iğne yapraklılarla mikorizal yaşaması, kükürt sarısı lamelleri, kenarlı sap tabanı ve bir miktar daha küçük bazidiyosporları (9–12 × 5.5–7 µm) ile ayırt edilir. Görünüş olarak yakın bir tür olan *C. riederi* (Weinm.)Fr. iğne yapraklı ağaç ormanlarında yetişir, turuncumsu veya kırmızımsı kahverengi şapkaya, beyazımsı içeriğe, leylak veya pas renginde lamellere ve az çok leylak renkli sapa sahiptir. *C. variecolor* (Pers.: Fr.) Fr. yeni kayda benzerlik göstermekle birlikte, iğne yapraklı ağaç ormanlarında yayılış göstermesi, beyazımsı etli kısmı, grimsi menekşe renkli lamelleri ve daha küçük bazidiyosporları (9–11.5 × 5–6.5 µm) ile farklılık gösterir. Hem iğne ve hem de geniş yapraklı ağaç ormanlarında yayılış gösteren *C. cyanites* Fr. yünsü şapka yüzeyi, soluk menekşe renkli içeriği, koyu mavi lamelleri ve daha küçük bazidiyosporları (9–11.5 × 5–6.5 µm) ile yeni kayıttan farklılık gösterir. *C. pseudocyanites* Hry. beyazımsı içeriğe, mavimsi veya menekşe renkli lamellere, hafif çıkıntılı ve nispeten küçük bazidiyosporlara (9–12.5 × 5–7 µm) sahiptir. Dış görünüş olarak benzer bir tür olan *C. brunneofulvus* Fr. hem iğne ve hem de karışık ağaçlı ormanlarda yetişir, yeni kayıttan farklı olarak silindirik saplı ve daha küçük bazidiyosporludur (8–11 × 5–7 µm). *C. impennis* Fr. ss. Mos. leylak veya pas renkli lamelleri, beyazımsı veya leylak renkli sapı ve oldukça küçük bazidiyosporları (7–9 × 4–6 µm) ile yeni kayıttan farklılık gösterir [1, 6, 7, 8, 9].

Teşekkür

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Researches on determination of saproxylic beetles (Coleoptera) on old hollow broad-leaved tree species in Cataldag (Balıkesir-Bursa) in Western Türkiye

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Abstract

With this study, Cataldag province extending at the provincial borders of Balıkesir and Bursa, the field studies were performed at 11 different study areas per three weeks using pitfall traps and window traps with old and hollow seven different original forest tree species (*Alnus glutinosa*, *Carpinus betulus*, *Platanus orientalis*, *Fagus orientalis*, *Quercus petrea*e, *Q. cerris*, *Q. cerris x Q. infectoria*) in between April and November months during 2014-2015. At the result of the study, 112 saproxylic beetles species belonging to 83 genus of 25 families were identified. *Anobium hederae* Ihssen, *Gastrallus corsicus* Schilsky, *Hemicoelus canaliculatus* (Thomson), *Cryptophagus pubescens* Sturm, *Symbiotes gibberosus* (Lucas), *Triplax russica* (Linnaeus), *T. scutellaris* Charpentier, *Hylis cariniceps* (Reitter), *Isorhipis marmottani* (Bonvouloir), *Phloiotrya tenuis* (Hampe), *Litargus balteatus* (LeConte), *Sacodes flavicollis* (Kiesenwetter), *Tetratoma desmarestii* Latreille and *Synchita undata* Guérin-Méneville are the new records for Turkish beetles fauna. 89 saproxylic beetles of 22 families are recorded for Balıkesir and Bursa provinces for the first time. 35 species in red list prepared for endangered saproxylic beetle species in Europe and Mediterrenean basin were determined. *Podeonius acuticornis* endangered (EN), *Cardiophorus gramineus*, *Megapenthes lugens*, *Mycetochara quadrimaculata* near threatened (NT), *Ischnodes sanguinicollis* and *Lucanus ibericus* vulnerable (VU) categories are included. 88 saproxylic beetle species were determined in Susurluk and the most species were collected from *P. orientalis* (32 species), nonetheless 56 saproxylic beetle species were determined in Mustafakemalpaşa and the most species were collected from *Q. cerris* (20 species). Saproxylic beetle species were collected with 82 % window trap and 25 % pitfall trap.

Key words: Coleoptera, saproxylic, red list, Cataldag, Türkiye.

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Çataldağ (Balıkesir-Bursa) bölgesindeki yaşlı çökük geniş yapraklı ağaç türlerinde bulunan saproksilik böcek türlerinin (Coleoptera) belirlenmesi üzerine araştırmalar

Özet

Bu çalışma kapsamında 2014-2015 Nisan-Kasım ayları arasında Çataldağ'ın (Susurluk-Mustafakemalpaşa) 11 farklı çalışma sahasında, üçer haftalık periyotlarla, yaşlı ve çökük yedi farklı geniş yapraklı asli orman ağacı türü (*Alnus glutinosa*, *Carpinus betulus*, *Platanus orientalis*, *Fagus orientalis*, *Quercus petrea*e, *Q. cerris*, *Q. cerris x Q. infectoria*) ile pencere ve çukur tuzak yöntemi kullanarak gerçekleştirilen arazi çalışmaları sonucunda 25 familyaya bağlı 83 cinse ait toplam 112 saproksilik kınkanatlı tür belirlenmiştir. Saproksilik kınkanatlı türlerden *Anobium hederae* Ihssen, *Gastrallus corsicus* Schilsky, *Hemicoelus canaliculatus* (Thomson) (Anobiidae), *Cryptophagus pubescens* Sturm (Cryptophagidae), *Symbiotes gibberosus* (Lucas) (Endomychidae), *Triplax russica* (Linnaeus), *T. scutellaris* Charpentier (Erotylidae), *Hylis cariniceps* (Reitter), *Isorhipis marmottani* (Bonvouloir) (Eucnemidae), *Phloiotrya tenuis* (Hampe) (Melandryidae), *Litargus balteatus* (LeConte) (Mycetophagidae), *Sacodes flavicollis* (Kiesenwetter)

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(Scirtidae), *Tetratoma desmarestii* Latreille (Tetratomidae) ve *Synchita undata* Guérin-Méneville (Zopheridae) türleri Türkiye kınkanatlı faunası için yeni kayıt niteliğindedir. Bu türler dışında bu çalışma ile 22 familyaya bağlı 89 saproksilik kınkanatlı türün Balıkesir ve Bursa illerinde ilk kez bulunduğu ortaya konmuştur. Avrupa ve Akdeniz havzası'nda tehdit altında bulunan saproksilik kınkanatlı türler için hazırlanan Kırmızı Listelerde bulunan 35 tür belirlenmiştir. Bu türlerden Avrupa Kırmızı Listesinde bulunan *Podeonius acuticornis* tehlikede (EN), *Cardiophorus gramineus*, *Megapenthes lugens*, *Mycetochara quadrimaculata* tehdite yakın (NT), *Ischnodes sanguinicollis* ve *Lucanus ibericus* duyarlı (VU) kategorilerinde yer almaktadır. Susurluk'ta 88 saproksilik kınkanatlı tür belirlenmiş ve en fazla tür *P. orientalis* (32 tür)'den Mustafakemalpaşa'da ise 56 tür belirlenmiş ve en fazla tür *Q. cerris* (20 tür)'ten toplanmıştır. Yakalanan saproksilik kınkanatlı türlerin % 82'si pencere tuzak ile % 25'i ise çukur tuzakla toplanmıştır.

Anahtar kelimeler: Coleoptera, saproksilik, kırmızı liste, Çataldağ, Türkiye.

1. Introduction

Turkey has the richest biodiversity in Europe and the Middle East and ranks ninth in terms of biodiversity on the European continent. With more than 1,000,000 known species worldwide, insects constitute more than 50% of global biodiversity, more than one third (1/3) of which belongs to the Coleoptera taxa with over 200 families and around 400,000 species. While there are more than 11900 species of Coleoptera in Turkiye, there are more than 33800 insect species in total [1].

Saproxylic species are organisms that live on dead or dying wood or in dead trees, or depend on wood-related fungi or other saproxylic organisms during certain periods of their life. Saproxylic organisms represent the core of forest biodiversity. Saproxylic invertebrates are one of the threatened animal groups that are intensively studied especially in the forests of Europe and more recently in the Mediterranean basin. Among saproxylic invertebrates, insects have a very high importance in terms of forest biodiversity. Playing a key role in forest ecosystem dynamics, Saproxylic insects have a vital ecological role for the sustainability of the food chain within natural ecosystems, decay processes of wood and decomposition of dead wood with fungi, and is important for revealing the relationships and interactions between organisms living in forest ecosystems through the perspectives of many different disciplines [2].

Saproxylic insect species and other saproxylic species are among the most threatened groups of organisms. Like all living species, saproxylic species are affected by the adverse conditions caused by loss of forests. Despite the increase in the number of forestlands, the habitats of these species are getting smaller. One of the most important reasons for this is economic uses, which have led to large rate reductions in the number of large diameter dead wood and large mature trees in forestlands [3,4,5]. Impairment of remaining forests and deforestation are among the primary threats to global biodiversity. Unlike many other groups of organisms, saproxylic organisms are more sensitive to the loss of forests. Half of the Earth's original forest cover has rapidly disappeared over the last few decades. Agricultural developments, large-scale cuttings and industrial factors are the main causes of this loss [6].

Saproxylic insects has different relationships with coniferous and broad-leaved primary tree species in forests that serve as their main habitats. Dahlberg and Stokland (2004) analyzed 1257 saproxylic insect species in Northern Europe to find that 329 species (26%) were associated with a single tree species [7]. In the same study, where the trees were grouped as coniferous (23%) and broad-leaved (52%), it was found that at least 75% of the species had a preference for only one of these tree groups, while 11% had a preference for both tree groups. It was further found that 75-90% of the saproxylic insects in Northern Europe tended for trees of two different classes as coniferous and broad-leaved trees. A similar trend was detected in studies conducted in China, suggesting that this is most likely a global trend [8].

According to the results of this and other similar studies, saproxylic insects prefer broad-leaved tree species more than other species. In recent centuries, various factors such as the human impact on old, dead or decayed wood resources, modern forestry practices in forestlands in much of Europe and the Mediterranean basin have led to a decrease in the nutrients (wood) used by these creatures for feeding, reproduction and other purposes and impairment of the natural outlook of forestlands. It is necessary to define the vital relationship between dead wood and saproxylic insects in order to ensure the protection and sustainability of forest biodiversity [2].

2. Materials and methods

2.1. Study area

Cataldag is a mountain in the South Marmara Region, located in the northeast of Balıkesir province, between 39º45′-39º58′ north latitudes and 28º11′-28º32′ east longitudes, hosting the provincial borders of the Balıkesir and Bursa (Figure 1). For this reason, some part of the mountain is located within the borders of Balıkesir and the other part is located within the borders of Bursa. Since Cataldag is an east-west facing mountain, there are clear differences between its northern and southern slopes in terms of floristic composition and climate. One of the most important indicators of this difference is that moisture-loving floristic elements such as *Abies bornmulleriana* (Uludag fir) and *Fagus orientalis*

(eastern beech) form groups on the northern slope, which stands out as a quite interesting property for a region in the Mediterranean climate zone.

Therefore, it is possible to see the floristic elements of the Black Sea Region on the northern slopes of Cataldag and floristic elements of the Mediterranean Region on the southern slopes owing to the effect of the exposure and geographical location of the slope. This difference between the two slopes of the mountain has led to both floristic richness and faunistic diversity. 45% of the floristic elements of Cataldag are species that are specific to the Black Sea phyto-geography region. Mediterranean climate elements have a share around 25%. In addition, floristic elements with unknown rigin have a share around 30% in the region [9].

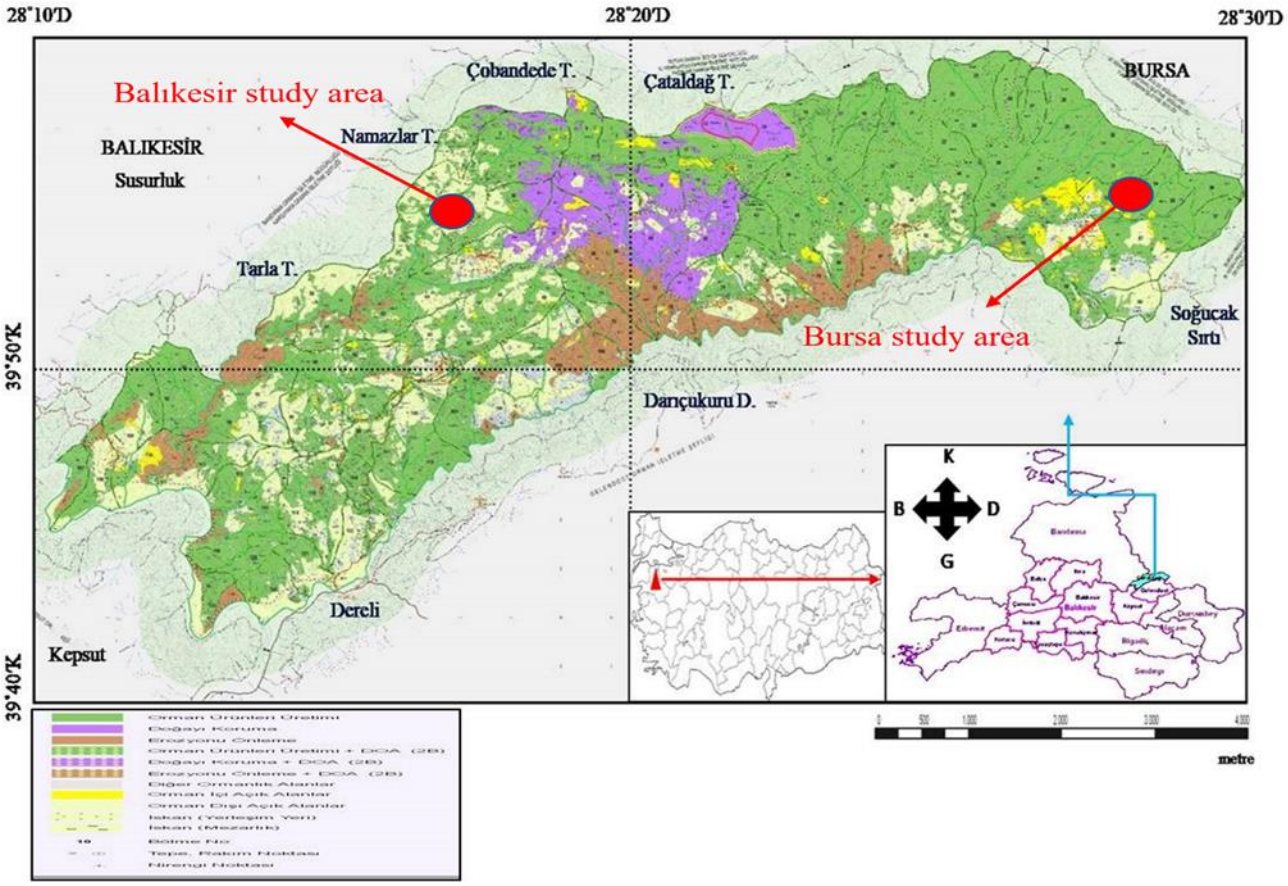

Figure 1. View of the study area (Cataldag, Balıkesir, Bursa)

2.2. Study materials

The main material of the study consisted of seven primary broad-leaved trees from *Quercus*, *Fagus*, *Alnus*, *Carpinus* and *Platanus* species (*Alnus glutinosa*, *Carpinus betulus*, *Platanus orientalis*, *Fagus orientalis*, *Quercus petreae*, *Q. cerris*, *Q. cerris* x *Q. infectoria*) representing the northern and western slopes of Cataldag (Susurluk and Mustafakemalpasa), in line with the forestry maps of Balikesir Regional Directorate of Forestry and the views of Forest Management Directorates of Balikesir and Bursa (Susurluk and Mustafa Kemalpasa-Pasalar) as well as Coleoptera taxa insects collected at three-week intervals with 54 trap trees in 11 different sampling areas using window (WT) and pitfall traps (PT), from April to November between 2014-2015 (Table 1, Table 2).

Field surveys were made to the sampling areas to select trap trees from old, decayed or decaying broad-leaved tree species. The habitats of saproxylic insect species are more related to tree structure than to forest associations. The degree of decay of the trees selected for the study, distribution of dead wood on the tree and position of the tree on the ground are significant in terms of the efficiency of the study. Selection of sampling areas were also influenced by Cataldag's being a west-east facing mountain, which leads to meteorological differences between the northern and southern slopes of the mountain caused by the difference in exposure of the slopes; distribution of different tree species at different elevations; and the altitude factor.

Table 1. Cataldag (Balıkesir-Susurluk) study area locality information

No	Coordinates	Altitude (m)	Tree species	Method
1.	39°56′777''N /28°12'388''E	46	*P. orientalis*	WT-PT
2.	39°56′771''N /28°12'385''E	50	*P. orientalis*	WT-PT
3.	39°56′783''N /28°12'397''E	58	*P. orientalis*	WT-PT
4.	39°56′786''N /28°12'399''E	58	*P. orientalis*	WT-PT
5.	39°57′010''N /28°12'963''E	84	*P. orientalis*	WT-PT
6.	39°57′008''N /28°12'963''E	97	*P.orientalis*	WT-PT
7.	39°57′000''N 28°12'954''E	114	*P. orientalis*	WT-PT
8.	39°57′002''N /28°12'947''E	99	*P. orientalis*	WT-PT
9.	39°56′307''N /28°14'708''E	262	*C. betulus*	WT-PT
10.	39°56′317''N /28°14'689''E	264	*C. betulus*	WT-PT
11.	39°56′312''N /28°14'676''E	262	*A. glutinosa*	WT-PT
12.	39°56′315''N /28°14'659''E	271	*C. betulus*	WT-PT
13.	39°56′312''N /28°14'653''E	299	*C. betulus*	WT-PT
14.	39°56′311''N /28°14'653''E	299	*F. orientalis*	WT-PT
15.	39°52′844''N /28°16'571''E	483	*A. glutinosa*	WT-PT
16.	39°52′833''N /28°16'582''E	497	*A. glutinosa*	WT-PT
17.	39°52′843''N /28°16'593''E	490	*A. glutinosa*	WT-PT
18.	39°52′017''N /28°16'726''E	563	*C. betulus*	WT-PT
19.	39°52′020''N /28°16'718''E	570	*A. glutinosa*	WT-PT
20.	39°52′005''N /28°17'114''E	601	*Q. petreae*	WT-PT
21.	39°52′007''N /28°17'097''E	601	*Q. petreae*	WT-PT
22.	39°52′010''N /28°17'094''E	617	*Q. petreae*	WT-PT
23.	39°52′991''N /28°17'114''E	613	*Q. petreae*	WT-PT
24.	39°52′013''N /28°17'112''E	617	*Q. petreae*	WT-PT
25.	39°51′784''N /28°17'607''E	688	*F. orientalis*	WT-PT
26.	39°51′793''N /28°17'598''E	688	*F. orientalis*	WT-PT
27.	39°51′793''N /28°17'592''E	671	*F. orientalis*	WT-PT
28.	39°51′785''N /28°17'598''E	669	*F. orientalis*	WT-PT
29.	39°51′796''N /28°17'559''E	664	*F. orientalis*	WT-PT

Table 2. Cataldag (Bursa-Mustafakemalpasa) study area locality information

No	Coordinates	Altitude (m)	Tree species	Trap methods
1.	39°55'307''N 28°20'168''E	655	*Q. cerris*	WT-PT
2.	39°55'279''N 28°20'156''E	666	*Q. cerris*	WT-PT
3.	39°55'277''N 28°20'144''E	659	*Q. petreae*	WT-PT
4.	39°55'280''N 28°20'131''E	651	*Q. cerris x Q. infectoria*	WT-PT
5.	39°55'293''N 28°20'137''E	644	*Q. cerris*	PT
6.	39°55'287''N 28°20'108''E	643	*Q. cerris*	WT-PT
7.	39°55'289''N 28°20'119''E	653	*Q. cerris*	PT
8.	39°55'289''N 28°20'104''E	660	*Q. cerris*	PT
9.	39°55'164''N 28°20'302''E	639	*F. orientalis*	WT-PT
10.	39°55'163''N 28°20'308''E	662	*F. orientalis*	WT-PT
11.	39°55'171''N 28°20'312''E	646	*F. orientalis*	WT-PT
12.	39°55'172''N 28°20'335''E	637	*F. orientalis*	WT-PT
13.	39°55'181''N 28°20'321''E	640	*F. orientalis*	PT
14.	39°55'172''N 28°20'333''E	602	*F. orientalis*	WT-PT
15.	39°55'181''N 28°20'651''E	455	*A. glutinosa*	WT-PT
16.	39°55'191''N 28°21'666''E	452	*A. glutinosa*	WT-PT
17.	39°55'202''N 28°21'686''E	455	*C. betulus*	WT-PT
18.	39°55'266''N 28°21'740''E	451	*A. glutinosa*	WT-PT
19.	39°55'669''N 28°22'452''E	287	*C. betulus*	PT
20.	39°55'662''N 28°22'429''E	280	*A. glutinosa*	WT-PT
21.	39°55'675''N 28°22'433''E	283	*C. betulus*	WT-PT
22.	39°55'736''N 28°22'901''E	180	*C. betulus*	WT-PT
23.	39°55'848''N 28°22'889''E	227	*C. betulus*	WT-PT
24.	39°55'875''N 28°22'980''E	205	*P. orientalis*	WT-PT
25.	39°55'810''N 28°23'097''E	230	*P. orientalis*	WT-PT

2.2. Sampling methods

Two different trap types, window and pitfall traps, were preferred in this study for the collection of saproxylic beetles. These two traps were used in the previously identified study fields, with one window and one pitfall trap in each tree. However, due to land conditions, forest structure and the large distance between the cavity entry and the tree soil, this target could not be achieved in some cases. Therefore, window and pitfall traps had to be set on two different trees in some parts of our study fields. Window and pitfall traps were used on 29 trees in Susurluk region of Cataldag, while window and pitfall traps were used on 20 trees and only pitfall traps were used on 5 trees in Mustafakemalpasa region. Consequently, considering the land conditions, tree structure and distribution of tree species in the study fields, the random parceling method was selected for each study field to perform sampling at three-week intervals from April to November between 2014-2015, with one window and one pitfall trap on each of the 5 trees, featuring a distance of at least 50-60 meters between each trap (except for single trap types).

2.2.1. Window trap

Window traps are one of the most effective methods used in the assessment of forest biodiversity. Besides, window traps are much more selective than other trap types (food traps and colored traps) [10]. Window traps are used to catch active species that can move on and around the tree trunk rather than wingless species. Different types of window traps have been used in many studies to compare their success in trapping saproxylic insect species [11,12,13].

In this study, window trap was preferred, which was placed near the tree trunk depending on the position of the cavity. Window traps were placed in different ways on the selected sample trees depending on the sample tree structure, degree of decay, condition of the cavity and the presence of fungi. Considering these parameters, window traps were placed near the trunk where tree cavities were present (< 1 m), at a 1.5 to 5-meter height from the ground according to the position of the trunk cavity on the tree depending on the degree of decay. The window trap was designed with a 30 x 60 cm bidirectional fiber glass transparent sheet, a 20 x 20 cm rectangular plastic funnel connected to the bottom of the sheet with a metal cable, and a 250 ml plastic bottle with a tip in a diameter of 3 cm, placed in the narrow tip of the funnel and connected with thin wires (Figure 2).

Figure 2. Window trap

2.2.1. Pitfall trap

Pitfall traps are the most effective trapping method used in combination with window traps to catch saproxylic insects (Figure 3). Although pitfall trapping is the simplest and cheapest method for capturing arthropods that move nocturnally on the forest floor, it is inadequate for trapping flying insects or insects that are stationary or move little on the ground. The use of special trapping types in special forestlands is very important for the results to be

obtained. For this purpose, they are used in combination with window traps to catch the species living in the debris at the base of the tree, species living at the base of the cavity or the predators feeding on the species living inside the cavity [14].

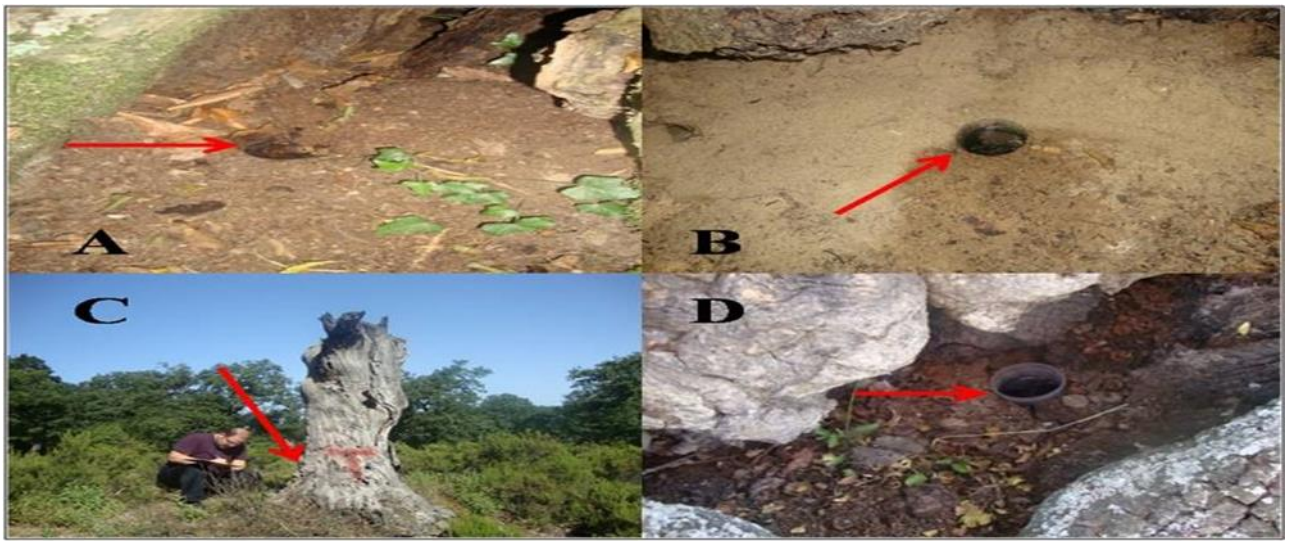

Figure 3. Pitfall trap **A)** Pitfall trap in the hollow on the ground **B)** Moist tree soil and pitfall trap in the hollow **C)** Pitfall trap in dead standing tree **D)** Pitfall trap in the hollow on the trunk.

2.3. Laboratory studies and diagnostics

2.3.1 Seperation of the samples and preparation for diagnostics

Samples were collected from the land and brought to the laboratory in labeled containers for purification from trap liquid with water using 0.1 mm wire strainers. Samples were separated on a 30 x 60 cm rectangular tray placed on a table under Soif Optical 5100L cold light source with LED light, 107 mm desktop latch magnifier with LED light and amplified light sources. Petri dishes, forceps of different thicknesses, 70 % alcohol, 15 and 50 ml falcons and 2 ml eppendorf tubes were used to separate the samples. The samples purified from the trap liquids were subjected to phenological separation according to their families and species. For identification, samples from certain families were preserved in boxes with cardboard lids while samples from some other families were preserved in 15 and 50 ml centrifuge tubes with twist caps and 2 ml eppendorf tubes (depending on their size) in 70% ethyl alcohol in accordance with preparation and labeling procedures, considering their characteristic features. In April and September every year, phenological separation and identification of the samples were carried out at Balikesir University, Faculty of Arts and Sciences, Department of Biology, Zoology Laboratory under the guidance of Nicklas Jansson and by the specialists in Linköping University in Sweden.

2.3.2 Diagnostics of the samples

In order to define the tree species from which the identified saproxylic insect species were collected, leaf and fruit samples were taken from the trap trees, which were then turned into herbarium material with standard techniques for identification of the tree species by Assistant Professor, Suleyman Sonmez. Identification of saproxylic beetles was carried out by; Dr Nicklas Jansson, Dr Jens Esser, Dr Giuseppe Platia, Dr Manfred Niehuis, Assoc. Dr Bekir Keskin, Prof. Dr Dr Serdar Tezcan, Assoc. Dr Nilay Gülpercin, Dr Jyrki Muona, Dr Denis Keith, Dr Roland Gerstemeier, Dr Colin Hawes, Dr Max Barclay, Dr Jiri Hava, Dr Tomas Lackner, Dr Thomas Barnouin and Prof. Dr Sinan Anlas. The identified samples are stored in the Zoology Museum of Balıkesir University, Faculty of Arts and Sciences, Department of Biology.

3. Results

As a result of the identification of the samples collected from 7 different broad-leaved tree species *(Alnus glutinosa*, *Carpinus betulus*, *Platanus orientalis*, *Fagus orientalis*, *Quercus petreae*, *Q. cerris*, Q. *cerris x Q. infectoria*) from 11 different study fields on Cataldag (Balikesir-Susurluk and Bursa-Kemalpasa) between 2014-2015 April-November, a total of 112 saproxylic beetles were identified in 83 species belonging to 25 families of the Coleoptera

taxa (Table 3). 35 of the saproxylic beetles identified belong to the insect species included in the European and Mediterranean red list [15,16,17] (Table 4).

Table 3. Distribution of the identified saproxylic beetles according to the study areas

Families	Saproxylic beetles	Balıkesir	Bursa	Tree species
Aderidae	*Aderus populneus*		x	*Q. cerris*
Anobiidae	*Anobium hederae*	x		*C. betulus*
	Falsogastrallus unistriatus	x		*F. orientalis*
	Gastrallus corsicus	x		*P. orientalis*
	Gastrallus laevigatus	x		*Q. petreae*
	Hemicoelus rufipennis	x	x	*C. betulus A. glutinosa F. orientalis*
	Hemicoelus canaliculatus	x	x	*C. betulus A. glutinosa F. orientalis Q. petreae*
	Hemicoleus fulvicornis	x	x	*C. betulus*
	Hemicoelus costatus	x		*F. orientalis*
	Oligomerus retowskii	x	x	*P. orientalis C. betulus F. orientalis Q. petreae Q. cerris A. glutinosa*
	Priobium carpini	x		*C. betulus A. glutinosa Q. petreae*
	Stagetus franzi	x	x	*C. betulus F. orientalis Q. petreae Q. cerris x infectoria A. glutinosa Q. cerris*
	Stagetus byrrhoides	x		*Q. petreae*
	Xestobium rufovillosum	x		*C. betulus*
	Xestobium plumbeum	x	x	*P. orientalis F. orientalis A. glutinosa*
Anobiidae	*Mesothes ferrugineus*	x	x	*Q. petreae Q. cerris*
	Ptilinus pectinicornis		x	*A. glutinosa C. betulus*
	Ptinus schlerethi	x		*Q. petreae*
	Metholcus phoenicis	x		*P. orientalis*
Bothrideridae	*Oxylaemus cylindricus*	x		*Q. petreae*
Biphyllidae	*Biphyllus lunatus*		x	*C. betulus*
Buprestidae	*Agrilus hastulifer*	x		*Q. petreae*
	Agrilus graminis	x		*F. orientalis*
	Agrilus laticornis	x		*Q. petreae*
	Agrilus relegatus alexeevi	x	x	*Q. petreae Q. cerris*
	Dicerca berolinensis	x		*A. glutinosa*
Cerambycidae	*Aegesoma scabricorne*	x		*P. orientalis*
	Prionus coriarius		x	*Q. cerris*
	Leiopus femoratus	x		*Q. petreae*
	Tetrops praeustus	x		*P. orientalis*
	Alosterna tabacicolor		x	*P. orientalis*
	Rutpela maculata		x	*A. glutinosa*
	Nathrius brevipennis	x		*P. orientalis*
	Xylotrechus arvicola	x		*C. betulus*
Cetoniidae	*Cetonia aurata*	x	x	*Q. petreae Q. cerris C. betulus*
	Protaetia cuprea	x		*P. orientalis*
	Valgus hemipterus	x	x	*P. orientalis Q. cerris*
Cleridae	*Clerus mutillaroides*	x		*P. orientalis*
Cryptophagidae	*Atomaria nigrirostris*	x		*P. orientalis*
	Cryptophagus dentatus	x	x	*P. orientalis Q. petreae*
	Cryptophagus denticulatus	x		*P. orientalis C. betulus*
	Cryptophagus reflexus	x	x	*C. betulus Q. petreae P. orientalis A. glutinosa Q. cerris*

Table 3. Continued

	Cryptophagus pallidus	x	x	*C. betulus Q. petreae F. orientalis A. glutinosa Q. Cerris*
	Cryptophagus punctipennis	x	x	*C. betulus P. orientalis*
	Cryptophagus micaceus	x	x	*F. orientalis Q. petreae*
	Cryptophagus cylindrellus	x		*C. betulus*
	Cryptophagus pubescens	x		*F. orientalis*
Dermestidae	*Attagenus schaefferi*	x		*Q. petreae*
	Dermestes erichsoni	x	x	*C. betulus Q. petreae P. orientalis Q. cerris*
	Trinodes hirtus	x		*A. glutinosa*
Elateridae	*Cardiophorus gramineus*	x		*C. betulus P. orientalis*
	Cardiophorus parvulus	x		*P. orientalis*
	Cardiophorus anticus	x		*C. betulus P. orientalis*
	Cardiophorus miniaticollis		x	*C. betulus*
	Ampedus pomorum	x		*P. orientalis*
	Athous fragariae	x		*C. betulus Q. petreae*
	Hypoganus inunctus	x		*A. glutinosa*
	Ischnodes sanguinicollis	x	x	*P. orientalis Q. cerris x Q. infectoria*
	Megapenthes lugens		x	*Q. petreae*
	Melanotus villosus	x	x	*F. orientalis C. betulus*
	Melanotus crassicollis		x	*C. betulus A. glutinosa*
	Melanotus fusciceps	x		*F. orientalis*
	Peripontius omissus	x	x	*C. betulus P. orientalis*
	Podeonius acuticornis		x	*Q. cerris*
	Prosternon tessellatum	x		*Q. petreae*
	Reitterelater dubius		x	*C. betulus*
Endomychidae	*Symbiotes gibberosus*		x	*F. orientalis*
Erotylidae	*Triplax russica*		x	*Q. cerris*
	Triplax scutellaris		x	*Q. cerris*
Eucnemidae	*Melasis buprestoides*	x	x	*C. betulus F. orientalis*
Eucnemidae	*Hylis cariniceps*		x	*C. betulus*
	Isoriphis marmottani	x	x	*C. betulus F. orientalis Q. petreae*
Histeridae	*Plegaderus caesus*	x		*F. orientalis A. glutinosa*
	Dendrophilus punctatus	x	x	*A. glutinosa Q. cerris*
	Carcinops pumilio	x	x	*P. orientalis Q. cerris*
	Margarinotus merdarius		x	*Q. petreae*
	Gnathoncus communis	x		*P. orientalis*
	Pseudepierus italicus	x		*A. glutinosa*
Latridiidae	*Latridius minutus*	x		*P. orientalis*
Lucanidae	*Lucanus ibericus*	x		*C. betulus F. orientalis P. orientalis*
	Dorcus parallelipipedus	x	x	*C. betulus F. orientalis A. glutinosa*
	Platycerus caraboides		x	*Q. cerris*
Melandryidae	*Abdera bifasciata*	x		*Q. petreae*
	Abdera quadrifasciata	x		*Q. petreae*
	Phloiotrya tenuis	x		*Q. petreae*
Mycetophagidae	*Litargus balteatus*	x		*P. orientalis*
	Litargus connexus	x		*P. orientalis*
	Mycetophagus quadripustulatus	x		*F. orientalis*
	Mycetophagus quadriguttatus	x		*F. orientalis*

Table 3. Continued

	Mycetophagus piceus	x		*F. orientalis*
Scirtidae	*Prionocyphon ornatus*	x	x	*Q. petreae*
	Sacodes flavicollis		x	*Q. cerris x Q. infectoria*
Silvanidae	*Ahasverus advena*	x		*P. orientalis*
Staphylinidae	*Lordithon exoletus*	x	x	*Q. cerris Q. petreae Q. cerris x Q. infectoria*
	Lordithon trinotatus	x	x	*F. orientalis Q. petreae Q. cerris x Q. infectoria*
	Hypnogyra angularis	x	x	*F. orientalis*
	Zeteotomus brevicornis	x	x	*A. glutinosa*
Tenebrionidae	*Mycetochara quadrimaculata*		x	*Q. petreae*
	Mycetochara maura		x	*Q. petreae*
	Mycetochara kazdagiica	x		*F. orientalis*
	Diaperis boleti		x	*A. glutinosa*
	Neomida haemorrhoidalis		x	*A. glutinosa*
	Palorus depressus	x		*C. betulus*
	Alphitobius diaperinus	x		*P. orientalis*
	Probaticus obesus	x	x	*P. orientalis Q. petreae Q. cerris*
	Pseudoprobaticus granipennis		x	*F. orientalis*
	Uloma cypraea	x	x	*P. orientalis Q. cerris*
Tetratomidae	*Tetratoma desmarestii*	x		*Q. petreae*
Zopheridae	*Colobicus hirtus*	x		*A. glutinosa*
	Synchita undata		x	*A. glutinosa*
	Nosodomodes diabolicus	x		*F. orientalis Q. petreae*
	Pycnomerus sulcicollis	x	x	*A. glutinosa C. betulus*

Table 4. European and Mediterranean red list distribution of the identified saproxylic beetles

Families	**Saproxylic beetles**	**Mediterranean red list category**	**European red list category**
Cerambycidae	*Aegosoma scabricorne*	NE	LC
	Prionus coriarius	NE	LC
	Alosterna tabacicolor		LC
	Rutpela maculata		LC
	Nathrius brevipennis	NE	DD
	Xylotrechus arvicola	NE	LC
Cetoniidae	*Valgus hemipterus*	NE	LC
Elateridae	*Cardiophorus gramineus*	NE	NT
	Cardiophorus anticus	LC	
Elateridae	*Ampedus pomorum*	NE	LC
	Hypoganus inunctus		LC
	Ischnodes sanguinicollis	NE	VU
	Megapenthes lugens	NE	NT
	Melanatus villosus	NE	LC
	Podeonius acuticornis	NE	EN
	Reitterelater dubius		DD
Erotylidae	*Triplax russica*	NE	LC
	Triplax scutellaris		LC
Eucnemidae	*Hylis cariniceps*	NE	LC
	Isoriphis marmottani	NE	LC
	Melasis buprestoides	NE	LC
Lucanidae	*Lucanus ibericus*		VU

Table 5. Continued

	Dorcus parallelipipedus	NE	LC
	Platycerus caraboides	NE	LC
Mycetophagidae	*Litargus connexus*	NE	LC
	Mycetophagus quadriguttatus		LC
	Mycetophagus piceus		LC
Tenebrionidae	*Mycetochara quadrimaculata*		NT
	Mycetochara maura		LC
	Diaperis boleti		LC
	Neomida haemorrhoidalis		LC
Zopheridae	*Colobicus hirtus*	NE	
	Synchita undata	LC	
	Nosodomodes diabolicus	LC	
	Pycnomerus sulcicollis	NE	

4. Conclusions and discussion

Among the saproxylic beetles species, 14 species from 10 families, *Anobium hederae*, *Gastrallus corsicus* and *H. canaliculatus* from Anobiidae, *C. pubescens* from Cryptophagidae, *S. gibberosus* from Endomychidae, *T. russica* and *T. scutellaris* from Erotylidae, *H. cariniceps* and *I. marmottani* from Eucnemidae, *P. tenuis* from Melandryidae, *L. balteatus* from Mycetophagidae, *S. flavicollis* from Scirtidae, *T. desmarestii* from Tetratomidae and *S. undata* from Zopheridae are indeed new records for the Coleoptera species in the fauna of Türkiye.

Nieto and Alexander (2010), Cálix et al. (2018) and García et al. (2018) conducted detailed studies for saproxylic beetles in both Europe and the Mediterranean basin under the coordination of IUCN [15,16,17]. Although species with insufficient ecology or distribution data were included in the lists in the end of these studies, they could not be assessed in the red list categories. 112 saproxylic beetles identified in this study were assessed based on these lists, which revealed that a total of 35 species were included in the studies conducted for saproxylic beetles in Europe and the Mediterranean basin. The highest number of red list species belongs to the Elateridae (9 species). This is followed by Cerambycidae (6 species), Tenebrionidae (4 species) and Zopheridae (4 species) families.

Considering the distribution of the red list saproxylic beetles identified on tree species from two study fields, a total of 20 saproxylic beetles included in the European and Mediterranean red lists were identified for Susurluk study field; namely two species of *Quercus petreae (I. marmottani*, *N. diabolicus*), six species of *F. orientalis (I. marmottani*, *M. villosus*, *L. ibericus*, *M. quadriguttatus*, *M. piceus*, *N. diabolicus*), seven species of *C. betulus (X. arvicola*, *C. gramineus*, *C. anticus*, *I. marmottani*, *M. buprestoides*, *L. ibericus*, *P. sulcicollis*), four species of *A. glutinosa (H. inunctus*, *D. parallelipipedus*, *C. hirtus*, *P. sulcicollis*), and nine species of *P. orientalis (A. scabricorne*, *N. brevipennis*, *V. hemipterus*, *C. gramineus*, C. *anticus*, *A. pomorum*, *I. sanguinicollis*, *L. ibericus*, *L. connexus*). Among the tree species studied, *P. orientalis* had the highest number of red list species caught, followed by *C. betulus*, *F. orientalis*, *A. glutinosa* and *Q. petreae*, subsequently. Within this distribution, they were caught from different tree species including *I. marmottani Q. petreae*, *F. orientalis* and *C. betulus*, *L. ibericus F. orientalis*, *C. betulus* and *P. orientalis*, *N. diabolicus Q. petreae* and *F. orientalis*, *P. sulcicollis C. betulus* and *A. glutinosa*, *C. gramineus C. betulus* and *P. orientalis*, *C. anticus C. betulus* and *P. orientalis*. A total of 22 saproxylic beetles included in the European and Mediterranean red lists were identified for Mustafakemalpasa study field; namely six species from *Q. cerris (P. coriarius*, *V. hemipterus*, *P. acuticornis*, *T. russica*, *T. scutellaris*, *P. caraboides*), one species from *Q. cerris x Q. infectoria (I. sanguinicollis*), three species from *Q. petreae (M. lugens*, *M. quadrimaculata*, *M. maura*), three species from *F. orientalis* (*I. marmottani*, *M. buprestoides*, *D. parallelipipedus)*, six species from *C. betulus* (*M. villosus*, *R. dubius*, *H. cariniceps*, *I. marmottani*, *D. parallelipipedus*, *P. sulcicollis*), four species from *A. glutinosa* (*R. maculata*, *D. boleti*, *N. haemorrhoidalis*, *S. undata*), and one species from, *P. orientalis* (*A. tabacicolor*).

As a result of the study, six species were identified with defined threat categories in the European red list. Of these species, *C. gramineus* and *M. lugens* are categorized as near threatened (NT), *I. sanguinicollis* is categorized as vulnerable (VU) and *P. acuticornis* is categorized as endangared (EN) under Elateriadae; *L. ibericus* is categorized as vulnerable (VU) under Lucanidae and *M. quadrimaculata* is categorized as near threatened (NT) under Tenebrionidae. *M. lugens* was caught from *C. gramineus*, *P. orientalis* and *C. betulus*; *I. sanguinicollis* was caught from *Q. petreae*; *P. acuticornis* was caught from *P. orientalis* and *Q. cerris x Q. infectoria*, *L. ibericus* was caught from *Q. cerris*; *M. quadrimaculata* was caught from *P. orientalis*, *C. betulus* , *F. orientalis* and *Q. petreae*. These species caught from different threat categories were identified from tree species of different diameters at different altitudes. Oak species *(Q. cerris*, *Q. petreae* and *Q. cerris* x *Q. infectoria*), eastern sycamore *(P. orientalis*), hornbeam *(C. betulus*) and eastern beech *(F. orientalis*) were found to be the tree species where saproxylic beetles (6 species) with threat categories in the red lists were caught. Tree species on which the species assessed for the red list (among the 35 species) were caught the

most are as follows, subsequently: *C. betulus* (11 species), *P. orientalis* (10 species), *A. glutinosa* (8 species), *F. orientalis* (8 species), *Q. cerris* (5 species), *Q. petreae* (5 species) and *Q. cerris* x *Q. infectoria* (1 species).

In this study, 82% of the saproxylic beetles were collected with window traps (92 species) and 25% (28 species) with pitfall traps. In the assessment of each study field; 88 saproxylic beetles were identified from Susurluk study field. This corresponds to 79% of all saproxylic beetles. Of the 88 saproxylic beetles, 83% (73 species) were collected with window traps and 24% (21 species) with pitfall traps. *A. diaperinus*, *C. denticulatus*, *C. reflexus*, C. *micaceus*, *D. erichsoni* and *D. parallelipipedus* species were caught with both pitfall and window traps in Susurluk study field. 56 saproxylic beetles were identified in Mustafakemalpasa study field. This corresponds to 79% of all saproxylic beetles. Of the 56 saproxylic beetles, 79% (44 species) were collected with window traps and 27% (15 species) with pitfall traps. Although there are differences between the study fields in terms of the number of species, there are similarities in terms of trapping methods. The species caught in each study field had similar rates regarding sampling with window and pitfall trap methods. Again, the window and pitfall trap capture rates of 112 saproxylic beetles caught during the study are similar to the rates found in each study field. In this study, 32 saproxylic beetles were identified in both Susurluk and Mustafakemalpasa study fields. The distribution of the 88 species caught in Susurluk study field according to tree species was as follows; *P. orientalis* with 36% (32 species), *Q. petreae* (30 species) with 36%, *F. orientalis* (22 species) with 25%, *C. betulus* (21 species) with 24% and *A. glutinosa* (15 species) with 17%. The distribution of the 56 species caught in the Mustafakemalpasa study field according to tree species was as follows; *Q. cerris* (20 species) with 35%, *C. betulus* (19 species) with 34%, *F. orientalis* (11 species) with 35%, *A. glutinosa* (10 species) with 18%, *Q. petreae* (8 species) with 14%, *Q. cerris x Q. infectoria* (5 species) with 10%, and *P. orientalis* (2 species) with 4%.

In the light of all study results, oak species *(Q. petreae*, *Q. cerris* and *Q. cerris* x *Q. infectoria*) seem to be very rich in saproxylic beetles. The data obtained in the study further reveal that, oak species also host more species in terms of red list species than other tree species. Oak *(Quercus* spp.) trees have a long life span and their decay process continues for many years. During this process and over the years, the structures on the tree that serve as micro-habitats for saproxylic insect species are extremely important for saproxylic insect diversity [18]. Oak trees have an important place considering the number of saproxylic beetles identified in both study fields. Türkiye has a very important area in terms of oak forests and oak species. *Quercus* are represented by 18 natural species in Türkiye [19]. Oak forests are being destroyed in the region as a result of human impact and social pressure, and habitat loss is likely to occur for species that depend on oak trees. In order to protect these regions and ensure sustainable species diversity, it is necessary to protect oak forests and prevent habitat loss due to old tree cutting and clearing, which will take place as a result of energy, grazing and forestry practices.

While decaying happens very fast in other broad-leaved tree species, oak trees have a short-term supporting effect on the habitats of saproxylic beetles. A significant number of saproxylic beetles were caught from broad-leaved tree species such as hornbeam *(C. betulus*), alder *(A. glutinosa*), beech *(F. orientalis*) and sycamore *(P. orientalis*). In addition, the fact that these tree species also contain red list saproxylic beetles reveals the importance of these tree species in forest ecosystems alongside oak species.

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Essential oil components of some *Lagoecia cuminoides* L. populations in Antalya/Türkiye

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Abstract

The genus *Lagoecia*, which is in the Umbelliferae family, is represented by *Lagoecia cuminoides* L., the only species belonging to the genus, in the natural flora of Turkiye. *L. cuminoides*, an annual herbaceous plant, blooms in April–June and spreads at altitudes from sea level to 1100 m. Known as "wild cumin", the essential oil of the plant is rich in the compound thymol. It is known that the plant, which was used in the past instead of cumin, has various medicinal uses, including as an analgesic for toothache, an anti-epileptic, and a repellent for bile stones. In addition, the plant is consumed as tea in the regions where it spreads.

The essential oil components of essential oils obtained by water distillation from samples collected from three different locations representing the west (Kemer), center (Aksu) and east (Alanya) of Antalya were analyzed by GC-MS/FID. According to the results, the essential oil yields were 0,47%, 1,66% and 0,93% for Kemer, Aksu and Alanya, respectively. Thymol, the main component of essential oils, was detected at 83,54%, 89,57% and 72,55% for Kemer, Aksu and Alanya, respectively. Other notable essential oil components were identified as cymene (5,29, 4,66 and 7,39%) and *γ*-terpinene (7,24, 3,74 and 14,97%)

Keywords: *Lagoecia cuminoides*, essential oil, thymol

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Antalya'daki bazı *Lagoecia cuminoides* L. popülasyonlarının uçucu yağ içerikleri

Özet

Umbelliferae ailesinde yer alan *Lagoecia* cinsi Türkiye doğal florasında cinse ait tek tür olan *Lagoecia cuminoides* L. ile temsil edilmektedir. Tek yıllık otsu bir bitki olan *L. cuminoides* ülkemizde Nisan-Haziran aylarında çiçeklenmekte ve deniz seviyesinden 1100 m yüksekliklere kadar yayılış göstermektedir. Yabani kimyon olarak adlandırılan bitkinin uçucu yağında ana bileşen olarak yüksek miktarda timol bulunmaktadır. Geçmişte kimyon yerine kullanılan bitkinin diş ağrısında bir çeşit analjezik olarak, anti-epileptik ve safra taşı önleyici ilaç olarak kullanılmasının yanı sıra yayılış gösterdiği yerlerde çay olarak tüketiminin olduğu da bilinmektedir.

Antalya'nın batı (Kemer), merkez (Aksu) ve doğusunu (Alanya) temsil eden üç farklı lokasyondan toplanan örneklerden su distilasyonu ile elde edilen uçucu yağlara ait uçucu yağ bileşenlerinin GC-MS/FID ile analizi yapılmıştır. Elde edilen sonuçlara göre uçucu yağ verimleri % 0,47 (Kemer), 1,66 (Aksu) ve 0,93 (Alanya) ve uçucu yağ ana bileşeni timol ise sırasıyla % 83,54, 89,57 ve 72,55 oranlarında tespit edilmiştir. Dikkat çeken diğer uçucu yağ bileşenleri ise sırasıyla simen için (% 5,29, 4,66 ve 7,39) ve *γ*-terpinen için (% 7,24, 3,74 ve 14,97) olarak belirlenmiştir.

Anahtar kelimeler: *Lagoecia cuminoides*, uçucu yağ, timol

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1. Giriş

Umbelliferae ailesinde yer alan *Lagoecia* cinsi ülkemiz doğal florasında cinse ait tek tür olan *L. cuminoides* ile temsil edilmektedir. Akdeniz elementi olan tür dünyada Akdeniz Bölgesi, Balkanlar, Suriye, Batı ve Güney İran ile Kuzey Irak'da yayılış gösterirken [1] ülkemizde Çatalca-Kocaeli, Ergene ve Güney Marmara Bölümleri; Ege Bölgesi; Hakkari Bölümü; Akdeniz Bölgesi ve Güneydoğu Anadolu Bölgesi'nde yayılış göstermektedir [2].

Tek yıllık otsu bir bitki olan *L. cuminoides* ülkemizde Nisan-Haziran aylarında çiçeklenmekte ve deniz seviyesinden 1100 m yüksekliklere kadar yayılış göstermektedir. Yol kenarları, kuru araziler ve yamaç araziler ile *Quercus* ve *Amygdalus* çalılıkları bitkinin doğada tercih ettiği habitatlardır [1].

Bitkinin gövdesi silindirimsi, olukcuklu, sert ve 6-40 cm uzunluğundadır. Alt yapraklar dar-dikdörtgensiden dar-yumurtamsıya değişmektedir. Yaprakçıklar yumurta biçimli, dişliden derin dişliye değişmektedir. Çiçek kümesi bileşik şemsiye, 9-18 mm çaplı küresel, çiçek sapı yaprakçığı 8-10 mm, pulsu yaprakçıklar 4 mm ve çiçek sapı yaprakçığına benzer. Çanak yapraklar tabanda birleşik ve meyvede kalıcı, 2-4 mm, meyve 1.5 mm kadardır [1].

Yabani kimyon olarak adlandırılan bitkinin uçucu yağında ana bileşen olarak yüksek miktarda timol bulunmaktadır [3, 4, 5]. Geçmişte kimyon yerine kullanılan bitkinin diş ağrılarında bir çeşit analjezik olarak da kullanıldığı kaydedilmiştir, [5]. Yayılış gösterdiği yerlerde çay olarak tüketimi de yapılmaktadır, [3]. İran'ın güney ve güneybatı bölgelerinde bulunan *L. cuminoides* bitkisisin anti-epileptik ve safra taşı önleyici ilaç olarak kullanılmakta olduğu da belirtilmektedir [6].

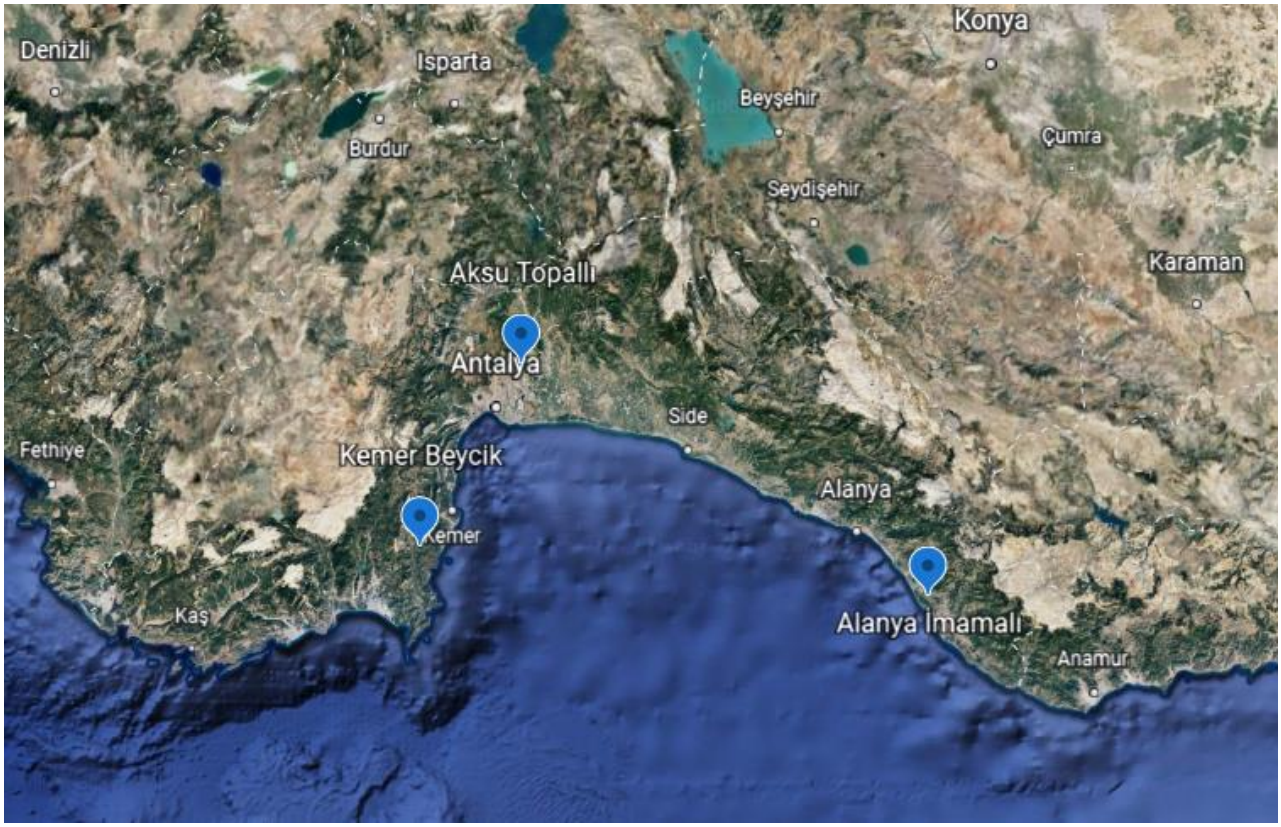
Bu çalışmada Antalya'nın batı, merkez ve doğusunu temsil eden üç farklı lokasyondan toplanan herba örneklerinden su distilasyonu ile uçucu yağ elde edilmiş ve uçucu yağ bileşenleri GC-MS/FID kullanılarak tespit edilmiştir.

2. Materyal ve yöntem

Bilindiği üzere genelde bitki savunma sistemi ile ilgili olan sekonder metabolitler, bitkinin genetik yapısına, bitkinin organlarına, bitkinin hayat devrelerine, bitkinin gün içindeki fizyolojik durumuna, yetiştiği yerin iklim, toprak rakım ve topografyası gibi çevre faktörlerine göre farklılık göstermektedir [7]. Bu nedenlerden dolayı çalışmada çevre etkisini en aza indirmek amacıyla örneklemeler bir hafta içinde ve günün aynı saatlerinde yapılmıştır. Batı lokasyonu olarak Kemer İlçesi Beycik Mahallesi, merkez lokasyonu olarak Aksu İlçesi Topallı Mahallesi, doğu lokasyonu olarak Alanya İlçesi İmamlı Mahallesi'nden 2020 yılında haziran ayının ilk yarısında arazi çalışmaları yapılarak saat 11:00-12:00 aralığında örneklemeler tamamlanmıştır. Lokasyon bilgileri Tablo 1'de, popülasyonların harita üzerindeki konumları ise Şekil 1'de işaretlenerek verilmiştir.

Tablo 1. Örneklerin toplandığı popülasyonlara ait lokasyon bilgileri

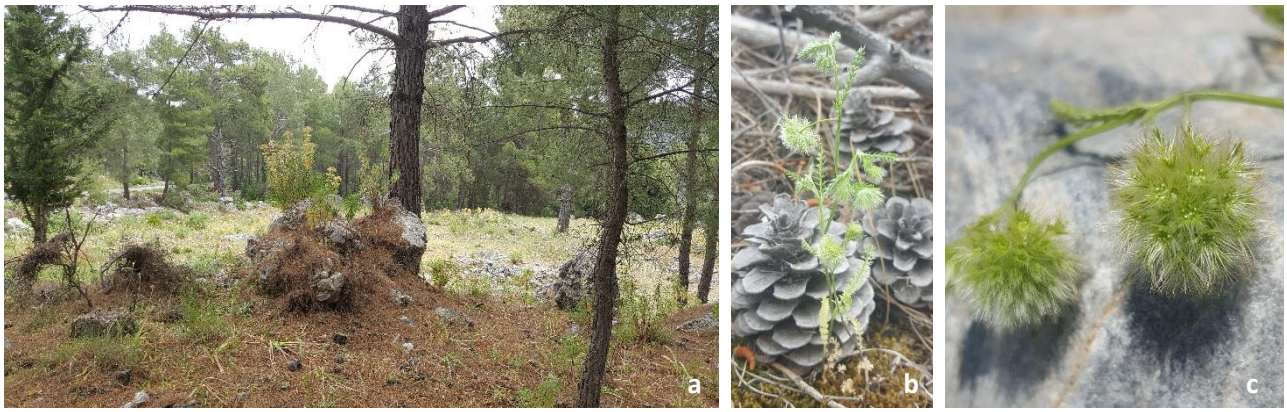
Lokasyon	**Yükseklik**	**Koordinatlar**	**Alan**
Kemer-Beycik	452 m	36°29'16''N 30°27'02''E	Orman içi, yol kenarı, taşlı açık alan
Aksu-Topallı	86 m	37°00'32''N 30°47'12''E	Tarla kenarları, yol kenarı, *Quercus* çalılığı çevresi
Alanya-İmamlı	126 m	36°20'48''N 32°14'27''E	Tarla kenarı, taşlık hafif eğimli açık alan



Şekil 1. Popülasyonların harita üzerindeki konumları

Toprak üstü aksamı alınan bitkiler kağıt zarflar içinde taşınarak etüvde 40°C sıcaklıkta 48 saat kurutulmuştur. 25 g kuru bitki materyali 120 dk, clevenger aparatı kullanılarak distile edilmiş ve elde edilen uçucu yağ oranı % olarak verilmiştir. Bitkinin genel fotoğrafları Şekil 2'de verilmiştir.

Uçucu yağ bileşen analizi GC-MS/FID (Gaz kromatografisi (Agilent 7890A)-kütle detektör (Agilent 5975C)) cihazı ile kapiler kolon (HP Innowax Capillary; 60.0 m x 0.25 mm x 0.25 µm) kullanılarak, Özek vd [8] metodu referans alınarak gerçekleştirilmiştir. Örnekler analiz edilmek üzere 1:50 oranında hekzan ile seyreltilmiştir. Analizde taşıyıcı gaz olarak 0.8 mL/dk akış hızında helyum gazı kullanılmış, örnekler cihaza 1 µL olarak 40:1 split oranı ile enjekte edilmiştir. Enjektör sıcaklığı 250°C, kolon sıcaklık programı 60°C (10 dakika), 60°C'den 220°C'ye 4°C/dakika ve 220°C (10 dakika) olacak şekilde ayarlanmıştır. Bu sıcaklık programı doğrultusunda toplam analiz süresi 60 dakika olarak gerçekleştirilmiştir. Kütle dedektörü için tarama aralığı (m/z) 35-450 atomik kütle ünitesi ve elektron bombardımanı iyonizasyonu 70 eV kullanılmıştır. Uçucu yağın bileşenlerinin teşhisinde ise WILEY ve OIL ADAMS kütüphanelerinin verileri esas alınmıştır. Sonuçların bileşen yüzdeleri FID dedektör kullanılarak, bileşenlerin teşhisi ise MS dedektör kullanılarak yapılmıştır.



Şekil 2. Bitkinin örneklendiği Kemer popülasyonu yayılış alanı (a), bitkinin genel fotoğrafları (b, c)

3. Bulgular

Elde edilen analiz sonuçlarına göre üç lokasyondan toplanan örneklerde toplam 14 bileşen belirlenmiştir. Bu 14 bileşenin altısı (*γ*-terpinen, simen, trans-sabinen hidrat, terpinen-4-ol, timol ve karvakrol) tüm örneklerde belirlenmiştir. Uçucu yağ verimi Antalya'nın batısını temsil eden Kemer-Beycik lokasyonunda % 0,47, merkezini temsil eden Aksu-Topallı lokasyonunda % 1,66 ve doğusunu temsil eden Alanya-İmamlı lokasyonunda % 0,93 olarak bulunmuştur. Lokasyonlardan toplanan örneklerde tespit edilen bileşen sayıları ise Kemer örneği için 11, Aksu örneği için 7 ve Alanya örneği için 10 olarak belirlenmiştir. Her üç örnek için de ana bileşen timol (sırasıyla % 83,54, 89,57, 72,55) olup, Kemer ve Alanya'dan toplanan örnekler için *γ*-terpinen (sırasıyla % 7,24, 14,97), Aksu'dan toplanan örnek için simen (% 4,66) ikinci ana bileşen olmuştur. Üçüncü ana bileşenler ise Kemer ve Alanya'dan toplanan örnek için simen (sırasıyla % 5,29, 7,39), Aksu'dan toplanan örnek için *γ*-terpinen (% 3,74) olarak tespit edilmiştir. Elde edilen sonuçlar detaylı olarak Tablo 2'de verilmiştir.

Tablo 2. Farklı lokasyonlardan toplanan örneklerin uçucu yağ bileşenleri ve uçucu yağ oranları (%)

R.T.	R.I.	Bileşenler	Kemer-Beycik	Aksu-Topallı	Alanya-İmamlı
13,789	1109	*β*-pinen	0,51	-	-
19,713	**1246**	***γ*-terpinen**	**7,24**	**3,74**	**14,97**
20,786	**1271**	**simen**	**5,29**	**4,66**	**7,39**
28,269	1467	*trans*-sabinen hidrat	0,22	0,42	0,43
31,109	1553	*cis*-sabinen hidrat	0,46	-	-
32,855	1609	terpinen-4-ol	1,14	0,98	1,09
35,636	1703	*α*-terpineol	0,28	-	0,39
37,330	1764	*δ*-kadinen	-	0,27	-
43,747	2012	karyofilen oksit	0,50	-	0,37
46,851	2143	spatulenol	0,53	-	-
47,723	**2181**	**timol**	**83,54**	**89,57**	**72,55**
48,424	2212	karvakrol	0,31	0,37	0,23
49,137	2244	*α*-eudesmol	-	-	0,32
49,320	2252	*β*-eudesmol	-	-	1,28
		tanımlanamayan	-	-	1,01
		Uçucu yağ oranı (%)	0,47	1,66	0,93

4. Sonuçlar ve tartışma

Berdanoğlu (2021) yapmış olduğu çalışmada 2018 yılında Aksu lokasyonundan iki farklı popülasyondan sağlanan *L. cuminoides* bitkisinin uçucu yağ miktar ve bileşenlerini değerlendirerek uçucu yağ verimini % 1,7 ve % 1,5, toplam bileşen sayısını 28 ve 27 olarak tespit etmişlerdir. Birinci popülasyonda ana bileşenler çalışmamızda elde ettiğimiz sonuçlarla paralellik göstererek % 85,7 timol, % 6,4 *γ*-terpinen ve % 9,4 p-simen olarak belirlenirken ikinci popülasyonda ana bileşenleri % 56,8 *γ*-terpinen, % 28,8 timol ve % 4,8 p-simen olarak tespit edilmiştir [9]. Baser ve Tümen [3] Türkiye'de üç lokasyondan (Balıkesir, Manisa, Kırklareli) toplanan örneklerle yaptıkları çalışmada toplam 14 bileşen belirlemişlerdir. Bu bileşenlerden timol % 72,83-94,76 oranlarda ana bileşen olarak tespit edilmiştir. Rowshan ve Khanpoor [5] yaptıkları çalışmada 28 bileşen tanımladıklarını ve uçucu yağ ana bileşenini % 56,4 oranı ile timol olarak tespit ettiklerini, timol bileşenini sırası ile (E)-*β*-farnesen (% 16,4), *γ*-terpinen (% 15,6) ve *p*-simen (% 6,34) bileşenlerinin izlediğini bildirmişlerdir. Sazdar ve ark. [4] yaptıkları çalışmada *L. cuminoides* bitkisinin hidrodistilasyon ve solventsiz mikrodalga ekstraksiyon yöntemleriyle elde ettikleri uçucu yağları karşılaştırmıştır. Hidrodistilasyon ile elde ettikleri uçucu yağda 22, solventsiz mikrodalga ekstraksiyonda elde ettikleri uçucu yağda 23 bileşen belirlediklerini, her ikisinde de ana bileşenin timol olduğunu (sırasıyla % 81,5 ve 76,5) belirtmişlerdir. Salehi ve ark [8] 2018 yılında timol kaynağı olan bitkilerle ilgili yaptıkları derlemede *L. cuminoides* bitkisinin toprak üstü aksamını timol kaynağı bitkiler listesinde vermiştir. Bahmanzadagan ve ark [6] 2022 yılında *L. cuminoides*'in hidrodistilasyon ve headspace yöntemleri kullanılarak uçucu yağların kimyasal bileşimini inceledikleri çalışmada uçucu yağın (EO) ana bileşenlerini; HD (hidrodistilasyon) yöntemiyle timol (% 56,4), (E)-*β*-farnesen (% 16,4), *γ*-terpinen (% 15,6) ve p-simen (% 6,3), HS (headspace) yöntemiyle *γ*-terpinen (% 56,1), *p*-simen (% 20,4), timol (% 13,8) ve (E)-*β*-farnesen (% 3,8) olarak bildirmişlerdir. Bizim çalışmamızda da timol bileşeni her üç lokasyon için ana bileşen olarak tespit edilmiş, bitki ile ilgili sınırlı sayıda yapılmış olan çalışmalardan elde edilen bulgularla benzerlik göstermiştir.

Bitkiler temel yaşam fonksiyonlarını gerçekleştirebilmek için protein, yağ ve karbonhidratlara yani primer metabolitlere mutlak ihtiyaç duymaktadırlar. Bununla birlikte bitkiler bulundukları çevredeki yaşam şansını artırmak için sekonder metabolitleri sentezlemektedir. Sekonder metabolitler alkoloitler, terpenoitler, fenolikler olarak üç ana grupta sınıflandırılmakta olup bitkilerdeki işlevleri yaşadıkları çevreye uyum ve adaptasyon, üreme ve yayılış, biyotik ve abiyotik stres yaratan etmenlere karşı savunmadır. Çevresel faktörlerle doğrudan ilişkili olan sekonder metabolitlerin bitkideki miktarı ve içeriği bitkinin genetik yapısına, bitkinin organlarına, bitkinin hayat devresine, bitkinin gün içindeki fizyolojik durumuna, yetiştiği yerin iklimine, toprak yapısına, rakımına, topoğrafyasına bağlı olarak değişim göstermektedir [7]. Bu durumun bir sonucu olarak aynı türün farklı popülasyonlarından alınan örneklerinde veya aynı popülasyonun farklı zamanlarda alınan örneklerinde yapılan sekonder metabolit çalışmalarından elde edilen sonuçlarında farklılıklar olması beklenen bir durumdur. Bu bağlamda çalışmada elde ettiğimiz sonuçlar ile *L. cuminoides* bitkisi ile ilgili yapılan diğer çalışmaların sonuçları karşılaştırıldığında uçucu yağ miktarı, uçucu yağ bileşen sayıları ve uçucu yağ ana bileşenlerinde farklılıklar bulunmaktadır. Bu farklılıkların genotipik, kemotipik, ontogenetik, diurnal ve çevresel varyabiliteden kaynaklandığı düşünülmektedir.

Son zamanlarda eczacılık, gıda ve kozmetik endüstrisinde çok çeşitli fonksiyonel kullanım olanakları ile dikkat çeken timol yaygın olarak *Thymus vulgaris* L. (Lamiaceae) bitkisinin uçucu yağının ana bileşeni olarak bilinmektedir. Esasında timol, karvakrol izomeri ve simenin doğal olarak oluşan bir fenol monoterpen türevidir. Çoğunluğu Lamiaceae familyasında olmak üzere başka bitkilerin de uçucu yağlarında önemli miktarlarda timol bulunduğuna dair çalışmalar [10, 11, 12, 13] mevcuttur. Bu bitkilerden Lamiaceae familyası dışında yer alan *L. cuminoides* türü içerdiği yüksek timol oranı ile en çok dikkat çeken türdür. Antalya'yı temsil ettiğini düşündüğümüz üç lokasyondan toplanan örneklerle gerçekleştirdiğimiz bu çalışma da daha önce yapılan çalışmalarla benzer sonuçlar vermiştir. Farklı lokasyonlardan elde edilen uçucu yağ miktarları ve timol oranlarının farklı olması nedeniyle tek yıllık olan bitkinin *in-vivo* ve *in-vitro* kültürel üretim koşullarının belirlenmesi standart bitkisel ürün ve timol eldesi için değerlendirilme olanaklarının araştırılması önem arz etmektedir.

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Determination of the sales profile of medicinal plants in herbalists: The case of Aksaray

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Abstract

In this study, medicinal plants growing in Aksaray province were determined**,** the parts of these plants sold by herbalists, the purposes of sale, and average sales amounts were investigated and also their economic importance was revealed. Face-to-face interviews were conducted with 15 volunteer herbalists out of 25 herbalists working in Aksaray and its counties. An interview form that was prepared before was applied between the dates of 07-31/8/2021. The data obtained from the interview form were analyzed with the SPSS program. In the research, the demographic and socioeconomic characteristics of herbalists selling medicinal and aromatic plants and their thoughts on the sale of medicinal plants were analyzed. Accordingly, it was determined that there are 54 plant species belonging to 26 families grown in Aksaray and sold for therapeutic purposes by herbalists. The families which have the most species are Asteraceae (9 species), Lamiaceae (6 species), and Rosaceae (5 species). Moreover, the most sold medicinal plant species are St. John's wort, golden herb, and yarrow. Furthermore, it was observed that these plants were mostly used for gastrovascular and respiratory diseases and consumer demands were influenced by factors such as packaging, price, and expiration date.

Keywords: Aksaray, medicinal plant, traditional medicine, herbalist.

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Tıbbi bitkilerin aktarlarda satış profilinin belirlenmesi: Aksaray örneği

Özet

Bu araştırmada Aksaray ilinde yetişen tıbbi bitkiler belirlenerek, bu bitkilerin aktarlarda satılan kısımları, satılma amaçları, ortalama satış miktarları araştırılmış ve ekonomik açıdan önemi ortaya konmuştur. Aksaray ili ve ilçelerinde faaliyet gösteren toplam 25 aktar içerisinden gönüllü olan 15 aktarla yüz yüze görüşmeler yapılmıştır. Önceden hazırlanan görüşme formu 07-31.08.2021 tarihleri arasında uygulanmıştır. Görüşme formundan elde edilen veriler SPSS paket programı ile analiz edilmiştir. Çalışmada, tıbbi ve aromatik bitki satışı yapan aktarların demografik ve sosyoekonomik özellikleri ile tıbbi bitki satışına yönelik düşünceleri analiz edilmiştir. Buna göre; Aksaray'da yetişen ve aktarlarda tedavi amaçlı satılan 26 familyaya ait 54 bitki türü olduğunu, en fazla türe sahip familyaların Asteraceae (9 tür), Lamiaceae (6 tür) ve Rosaceae(5 tür) olduğu, en çok satılan tıbbi bitki türlerinin sarı kantaron, altın otu, civanperçemi olduğu tespit edilmiştir. Bu bitkilerin çoğunlukla gastrovasküler ve solunum yolu hastalıklarında kullanıldığı, tüketici taleplerinin belirlenmesinde, ambalaj, fiyat ve son kullanım tarihinin belirleyici olduğu görülmüştür.

Anahtar kelimeler: Aksaray, tıbbi bitki, geleneksel tıp, aktar.

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1. Giriş

İnsanların rastgele ya da deneme yanılma yoluyla elde ettiği nesilden nesile aktararak geçmişten günümüze kadar getirdikleri bilgiler etnobotanik çalışmalar ile toplanıp bilimsel olarak değerlendirme sürecine alınabilmektedir. Dolayısıyla etnobotanik çalışmalar ekosistemin ve biyoçeşitliliğin korunması, kayıt altına alınması noktasında önemli bir rol oynamaktadır. Ayrıca çok miktarda ve bilinçsiz bir şekilde toplanan türlerin belirlenmesine, tehlike altındaki türlerin tespit edilmesine, korunmasına ve kültüre alma çalışmalarının yapılmasına imkân sağlamaktadır.

Ülkemiz, coğrafi konum itibariyle Avrupa-Sibirya, Akdeniz ve İran-Turan gibi üç gen merkezinin kesişim noktasında yer almasından; üç tarafının denizlerle çevrili olup kısa mesafelerde değişen yükselti farklılıkları, iklim tipleri, toprak yapısı, jeomorfolojik ve topografik özellikler göstermesinden dolayı zengin bir bitki çeşitliliğine sahiptir. Ayrıca yerleşik tarihi 10 bin yıl öncesine dayanan Anadolu topraklarının birçok uygarlığa ev sahipliği yapmış olması, göç yolları üzerinde yer alması da bitki çeşitliliğinin ve zenginliğinin artmasında önemli bir etken olmuştur [1]. Asya ve Avrupa kıtaları arasında kalan Anadolu toprakları 12 bine yakın bitki çeşitliliği ve 3700'e yakın endemik tür ile yaklaşık %34'lük bir endemizm oranına sahiptir. Anadolu'nun gen kaynağı bakımından zenginliği kültürel zenginliğe de yansımıştır [2,3].

İnsanlar çevrelerinde yetişen bitki türlerinden faydalanarak rastlantı sonucu ve deneme yanılma yoluyla hastalıklara çözüm aramış ve beraberinde geleneksel tedavi yöntemlerini bulmuştur. Halk hekimliği ya da ev tedavisi olarak da bilinen bu tedavi yöntemleri günümüz modern tıbbından farklılık göstermekte; toplumların kültürel yapıları, dini inanışları, felsefeleri ve tecrübelerinden etkilenerek şekillenmektedir. Geleneksel tedavi yöntemleri zaman içerisinde değişiklikler gösterse hatta bazıları işlevini yitirse de tarihsel süreç içerisinde varlığını hep sürdürmüş, nesilden nesile sözlü ve yazılı olarak aktarılarak günümüze kadar gelmiştir [4].

Bilimsel araştırmalar, tıbbi bitkilerin insana bilinenden çok daha faydalı, hastalıkların tedavisinde çok daha etkili ve yan etkilerinin ise yok denecek kadar az olduğunu göstermektedir. Bunun yanı sıra eczanelerde satılan sentetik ilaçların yan etkilerinin insanlar tarafından fark edilmiş olması ve satış fiyatlarının oldukça yüksek olması geleneksel tıpta kullanılan bitkilerin ve bitkisel ürünlerin hem önemini hem de değerini çokça artırmıştır [3]. Kumar [5] de, tıbbi bitkilerde piyasa değerinin yıllık yaklaşık 60 milyar dolar olduğunu ifade etmiştir [6]. Bunun yanında tıbbi bitkilerden elde edilen ürünlerin de uluslararası pazar payı oldukça yüksektir. Bitkisel ürünlerin Batı Avrupa'da 2003-2004'te yıllık cirosu 5 milyar doları, Çin'de 2005'te yıllık cirosu 14 milyar doları ve Brezilya'da da 2007 yılında yıllık cirosu 160 milyonu bulmuştur [7]. Dolaysıyla bu pazarın en önemli aktörlerinden biri hiç kuşkusuz ki aktarlardır.

Aktarlar bir taraftan tıbbi bitkilerin artan piyasa değerinde, ticarileşmesinde ve tüketicilerle tıbbi bitkilerin buluşturulmasında önemli rol oynamaktadırlar. Özellikle son yıllarda doğal bitkilere ve doğal tedavi yöntemlerine olan ilginin sürekli artması gerek iç gerekse dış piyasalarda bu bitkilere olan talebinde artırmaktadır. Bu talep ise aktarlar aracılığıyla karşılanmaktadır. Diğer yandan günümüzde sağlıklı yaşama verilen önemin artması, tüm dünyada tıbbi bitki pazarlarında satılan doğal bitkilerin kullanımını teşvik etmiştir. Bitkisel pazarlar ise sadece hastalıklar için bitkisel tedavi sağlamakla kalmaz, aynı zamanda geleneksel bilgiyi gelecek nesillere aktararak biyokültürel çeşitliliği de korur. Aktarlar bu bağlamda da geleneksel bilginin korunması ve gelecek kuşaklara aktarılmasında da önemli rol oynamaktadırlar. Bunun yanında aktarların yani bilirkişilerin ziraat ve eczalık fakültesinden, biyoloji ve botanik bilim dallarında eğitimini alan kişilerce ya da doğa bilimcilerince yapılması geleneksel bilgi kültürünün sürdürülebilirliğini etkin kılacaktır.

Bu araştırmada da tıbbi bitki talebinin karşılanmasında ve tüketici taleplerinin belirlenmesinde aktarların rolü ortaya konmuştur. Aktarların bakış açısından tüketicilerin bu bitkilere olan talepleri ve tıbbi bitkilerin hastalıkların tedavisinde destekleyici rolleri değerlendirilerek, bu bitkilerin pazar değeri vurgulanmıştır.

2. Materyal ve yöntem

Araştırmanın ana materyalini Aksaray'da tıbbi bitki satışı yapan aktarlarla yapılan yüz yüze görüşmelerden elde edilen veriler oluşturmaktadır.[2] Ayrıca, tıbbi bitkilere ilişkin yazılı ve görsel literatürden (ulusal ve uluslararası makaleler, raporlar, istatistikler, tezler vb.) elde edilen veriler de araştırmada kullanılmıştır. Araştırma amacına uygun olarak önceden hazırlanan görüşme formunda, aktarların tıbbi bitki talebine yönelik düşünceleri, sosyoekonomik ve demografik özellikleri, tüketici profili ve tercihlerini etkileyen faktörler, tıbbi bitkilerin tüketim amacı ve hangi hastalıkların tedavisinde hangi türlerin öncelikli olarak tercih edildiğine ilişkin değerlendirmeler yapılmıştır. Bu şekilde bölgede yaygın olarak kullanılan ve ticareti yapılan ve de ekonomik değeri olan türlerin tespiti hedeflenmiştir.

[2] Görüşme formu katılımcılara uygulanmadan önce Aksaray Üniversitesi İnsan Araştırmaları Etik Kurulu'na 2021/05-17 protokol numarası ile başvurulmuş olup bahsi geçen kurulun 21.06.2021 tarihli toplantısında araştırmanın etik ilkelere uygun olduğuna kurul üyeleri oy birliğiyle karar vermiştir.

Görüşmeler 01.07-31.08.2021 tarihleri arasında farklı günlerde gerçekleştirilmiştir. Aksaray ve çevresinde bulunan 25 aktar içerisinden yalnız 15 gönüllü aktara anket bilgi formu uygulanmıştır. Bu aktarlardan 12 tanesi merkezden 3 tanesi Ortaköy ilçesinden seçilmiştir. Diğer ilçelerde aktar bulunmamasından dolayı oralarda anket çalışması yapılamamıştır.

Anket uygulaması sonrası elde edilen veriler, nicel olarak SPSS(26) ve ANOVA paket programı ile analiz edilmiştir.

3. Bulgular

Araştırmada, Aksaray 'da tıbbi bitki satışı yapan aktarların yaş, cinsiyet, medeni durum, aylık gelir, eğitim seviyesi, aktarlıktan elde ettikleri gelir gibi demografik ve sosyoekonomik özellikleri ile tıbbi bitki satışına yönelik düşünceleri analiz edilmiştir.

3.1. Aktarların sosyoekonomik ve demografik özelliklerine ilişkin bulgular

Katılımcıların sosyo-demografik dağılımları göz önüne alındığında; %86.7 ile erkeklerin, %40 ile 36-45 yaş arasındakilerin, %45.8 ile de lise mezunlarının çoğunlukta olduğu tespit edilmiştir. Katılımcıların faaliyet yıllarına göre dağılımlarının ise %46.7'sinin 10 -19 yıl arası, %20'sinin 20-29 yıl arası, %20'sinin 30 ve üzeri yıl, %13.3'ünün 0-9 yıl arası olduğu görülmüştür. Ayrıca işletmelerin % 40'ında 1, %26.7'sinde 3, %20'sinde 2, %13.3'ünde ise 4 kişinin çalıştığı belirlenmiştir. Bununla birlikte aktarların %40'ında 501 -1000 çeşit ürün, %20'sinde 0- 500 çeşit ürün, 20'sinde 1001-1500 çeşit ürün, %20'sinin ise 1501 ve üzeri çeşit ürün bulunduğu tespit edilmiştir. Aktarların aylık cirolarına bakıldığında %40'ının 20 001-40 000 TL arasında, %33'ünün 0-20 000 TL arasında, %27'sinin ise 40001 TL ve üzeri olduğu belirlenmiştir. Ayrıca aktarların maliyet sonrası aylık ortalama kazançlarının %47'sinin 0-9000 TL arasında, %40'ının 9 001-15 000 TL arasında ve %13'ünün ise 15001 TL ve üzeri olduğu tespit edilmiştir (Tablo 1). Bu veriler değerlendirildiğinde Aksaray' da 10-19 yıl arası faaliyet gösteren aktar sayısının çoğunlukta olduğu, genel olarak tek kişinin çalıştığı ve bu aktarlarda 501–1000 ürün çeşidinin yaygın olarak bulunduğu söylenebilir. Ayrıca aylık ortalama net karlarının ise çoğunlukla 0-6000 TL arası olduğu tespit edilmiştir.[8] de Konya'da 63 aktar ile yapılan görüşme sonuçlarına göre aktarların %27'sinin üniversite mezunu, %30.2 gibi önemli bir bölümünün mesleki deneyim sürelerinin 1-5 yıl arasında olduğu saptanmıştır.

Tablo 11. Aktarların demografik özelliklerine ilişkin bilgiler(N:15)

Değişken	**Sayı**	**%**
Cinsiyet		
Erkek	13	86,7
Kadın	2	13,3
Yaş		
26-35	0	0
36-45	6	40
46-55	5	33,3
56 ve üstü	4	26,7
Eğitim Durumu		
İlkokul	63	11,2
Ortaokul	60	10,6
Lise	259	45,8
Ön lisans	92	16,3
Lisans ve lisansüstü	65	11,5
Faaliyet Yılı		
0-9 yıl arası	2	13,3
10-19 yıl arası	7	46,7
20-29 yıl arası	3	20
30 ve üzeri yıl	3	20

Değişken	**Sayı**	**%**
Çalışan sayısı		
1 kişi	6	40
2 kişi	3	20
3 kişi	4	26,7
4 ve üzeri kişi	2	13,3
Ürün Çeşidi Sayısı		
0-500	3	20
501-1000	6	40
10001-1500	3	20
15001 ve üzeri	3	20
Aylık Ortalama Ciro		
0-20 000 TL arası	5	33
20 001-40 000 TL arası	6	40
40 001 TL ve üzeri	4	27
Aylık Ortalama Net Kazanç		
0-6 000 TL arası	8	53
6 001-9 000 TL arası	5	33
9 001 TL ve üzeri	2	14
TOPLAM	**15**	**100**

3.2. Aktarların mesleki bilgi düzeyi ve bilgi kaynakları

Aktarların meslekleri ile ilgili sahip oldukları bilgileri %35.5'inin usta-çırak ilişkisinden, %24.4'ünün yazılı medyadan, %20'sinin görsel medyadan edindiği ve yalnız %4.4'ünün tıbbi bitkiler ve bitkisel tedavi yöntemleri hakkında eğitim aldığı tespit edilmiştir (Tablo 2). Araştırma sonuçları, bu konuya ilişkin bilgi birikiminin büyük bir çoğunluğunun usta -çırak ilişkisine dayandığı, bitkiler hakkındaki bilgilerinin uzun yıllar aktarlık mesleğini yapmalarından kaynaklandığını ortaya koymuştur. Bazı aktarlar ise usta-çırak ilişkisini baba mesleği olarak benimsemişlerdir. Yazılı ve görsel medyadan öğrendiğini ifade eden işletme sahiplerinin ise meraklı girişimcilerden oluştuğu ve yaş ortalamalarının ağırlıklı olarak 36-45 arasında olduğu dikkat çekmektedir. Aktarların bilgi birikimi (bitkilerin hangi kısımlarının hangi hastalığın tedavisinde ne şekilde kullanılacağı gibi tüketicilerin aktar tercihi ve ürün tercihi davranışlarını doğrudan etkilemektedir. Bu da aktarların müşteri profilini ve potansiyelini yansımaktadır.

Tablo 2. Aktarların meslekleri ile ilgili sahip oldukları bilgileri öğrendikleri yerler

Aktarlıkla İlgili Sahip Olunan Bilginin Öğrenildiği Yerler	**Sayı***	**%**
Aile büyükleri ve yakın çevre	4	8.9
Yazılı medya	11	24.4
Görsel medya	9	20
Aktarlarda usta-çırak ilişkisinden	17	37.7
Doktorlardan	2	4.5
Eğitimini aldım	2	4.5
TOPLAM	**45**	**100**

*Tabloda aktarların birden fazla verdikleri yanıtların toplamı gösterilmektedir.

3.3. Aksaray'da yetişen tıbbi bitkilerin aktarlardaki satış durumu

Aksaray ve çevresinde yetişen ve geleneksel tıpta kullanılan 70 bitki türü içerisinden 54 türün Aksaray ve çevresindeki aktarlarda satıldığı tespit edilmiştir. Bu türler familya düzeyinde değerlendirildiğinde; en fazla türe sahip familyaların sırasıyla Asteraceae(9 tür), Lamiaceae(6 tür), Rosaceae(5 tür), Malvaceae(3 tür) olduğu tespit edilmiştir(Tablo 4).

Geleneksel tıpta kullanılan bu familyalara ait bitki türlerinin tamamına yakınının birden fazla hastalık için kullanılabildiği ve farklı kısımlarının farklı şekillerde satışının yapıldığı tespit edilmiştir. Tedavi amaçlı kullanılan bu bitki türlerinin en çok satılan kısımlarının; sırasıyla çiçek(%28), yaprak (%27.7), meyve (%15.7), tohum (%9.9), toprak üstü kısımları (%4.5) ve yağı (%4.4) olduğu tespit edilmiştir. Ayrıca bazı tıbbi bitkilerin macun, krem, yağ veya toz olarak satıldığında elde edilen veriler arasındadır (Tablo 3). Bu türlere ait bitki kısımlarının farklı kısımlarını çeşitli şekillerde (çay, krem, macun vb.) kullanımının birçok hastalığın tedavisinde doğrudan ilaç olarak veya destekleyici olarak yaygın bir şekilde pazarlandığı dikkati çekmektedir.

Tablo 3. Bitkilerin kullanılan kısımlarına ilişkin yüzde oranları

Kullanılan Kısım	**Tür Sayısı**	**%**
Çiçek	203	28
Yaprak	201	27,7
Meyve	114	15,7
Tohum	72	9,9
Toprak üstü kısımları	33	4,5
Yağ	32	4,4
Macun	20	2,8
Kök	16	2,2
Püskül	13	1,8
Bütün	13	1,8
Toz	4	0,5
Krem	3	0,3
Sap	2	0,2

Aktarların büyük bir kısmı bitkileri aracı firmalardan tedarik ettiklerini söylerken, bazı aktarlarda doğrudan yerel halktan tedarik ettiklerini ifade etmişlerdir. Tedarik edilen bu bitkiler işletmelerde, dökme, çuval, şişe, paket, ambalaj vb. şekillerde depolanmakta ve satışa sunulmaktadır. Tüketicilerin bitkileri satın alırken daha çok paketli ve ambalajlı olmasına özen gösterdikleri, son kullanım tarihine önem verdikleri dikkati çekmektedir. Aktarlarda satışa sunulan ürünün fiyatı ürünün niteliğine ve miktarına ve de şekline (paket, dökme, şişe) göre değişiklik göstermektedir. Örneğin peri anasonu (*Pimpinella cappadocica* Boiss.&Balansa) tohumları dökme olarak satışa sunulmaktadır. Bir aktar bu bitki tohumundan yaklaşık olarak 44 kg/Yıl satmakta ve 2332 TL/Yıl net gelir elde etmektedir. Altınotu (*Helichrysum plicatum* DC),çiçek ve toprak üstü kısımları paket olarak, 244 paket/Yıl satılmakta ve net olarak 1708 TL/Yıl kazanç sağlanmaktadır. Aynı şekilde mavi hindiba (*Cichorium intybus* L.) yapraklarının 201 paket/Yıl satışından elde edilen net gelir 1407 TL/Yıl iken, köygöçüren (*Cirsium arvense* (L.) Scop.) çiçek ve tohumlarının 136 paket/Yıl satışından elde edilen net gelir 952 TL/Yıldır (Tablo 4).

Tablo 1. Aksaray'da yetişen ve aktarlarda satışı yapılan bitkilere ilişkin bilgiler

S	Familya Adı	Latince Adı	Yöresel Adı	Kullanılan Kısım	Kullanım Amacı	Kullanma Biçimi	Yıllık Ortalama Satış Miktarı (Paket(adet)–dökme(kg)-şişe (ml)-adet)/Yıl	Ortalama Piyasa Değeri (paket-dökme-şişe-adet)	Yıllık Ortalama Satış Geliri (TL/Yıl)
1	Amaryllidaceae (Nergisgiller)	*Allium cepa* L.	Soğan	Kök	Baharat olarak	Çiğ	14 kg	34 TL	476 TL
2	Amaryllidaceae (Nergisgiller)	*Allium sativum* L.	Sarımsak	Kök	Baharat olarak, bağışıklık sistemini güçlendirme, yüksek tansiyon, kanser önleme	Çiğ, pişirme	22 kg	61 TL	1342 TL
3	Apiaceae (Maydanozgiller)	*Eryngium campestre* L.	Boğa dikeni	Toprak üstü kısımları	Sindirim sistemi, karaciğer ve mide hastalıklarında, kas tutulmaları ve kramplarda, cinsel gücü arttırmada	Çiğ, çay	88 paket	7 TL	616 TL
4	Apiaceae (Maydanozgiller)	*Pimpinella cappadocica* Boiss.&Balansa	Peri anasonu	Tohum	Gaz ve şişkinlik gidermede, uyku bozukluklarında, sinir sistemi hastalıklarında, romatizmal hastalıklarda	Çiğ, çay	44 kg	53 TL	2332 TL
5	Asteraceae (Papatyagiller)	*Achillea millefolium* L.	Civanperçemi	Çiçek	Kadın hastalıklarında	Çay	214 paket	7 TL	1498 TL
6	Asteraceae (Papatyagiller)	*Artemisia absinthium* L.	Pelin otu	Çiçek, yaprak	Vücuttaki iltihapları gidermede, bağırsak kurtlarında, iştah açmada	Çay	141 paket	7 TL	987 TL
7	Asteraceae (Papatyagiller)	*Centaurea drabifolia* SM.	Öbek sarıbaş	Çiçek	Hemoroit tedavisinde	Çay, batırarak	183 paket	7 TL	1281 TL
8	Asteraceae (Papatyagiller)	*Chondrilla juncea* L.	Karakavuk	Yaprak	Sindirim sistemi, karaciğer ve şeker hastalıklarında	Çiğ, kavurarak,	127 paket	7 TL	889 TL
9	Asteraceae (Papatyagiller)	*Cichorium intybus* L.	Mavi hindiba	Yaprak	Sindirim sitemi, karaciğer ve safra kesesi hastalıklarında	Çiğ, çay, kavurarak	201 paket	7 TL	1407 TL
10	Asteraceae (Papatyagiller)	*Cirsium arvense* (L.) Scop.	Köygöçüren	Çiçek, tohum	Cinsel gücü arttırmada, mide ve karaciğer hastalıklarında	Çiğ, çay	136 paket	7 TL	952 TL
11	Asteraceae (Papatyagiller)	*Helichrysum plicatum* DC.	Altın otu	Çiçek, toprak üstü kısımları	Hemoroit ve prostat tedavisinde, mide hastalıklarında, ödem söktürme ve zayıflatmada	Çay	244 paket	7 TL	1708 TL
12	Asteraceae (Papatyagiller)	*Matricaria chamomilla* L.	Papatya	Çiçek, toprak üstü kısımları	Sinir sistemi ve mide hastalıklarında, uyku bozukluklarında, hazımsızlık, gaz ve şişkinlik gidermede, bağırsak kurtlarında	Çay	149 paket	7 TL	1043 TL
13	Asteraceae (Papatyagiller)	*Taraxacum bessarabicum*	Karahindiba	Yaprak, toprak üstü	Karaciğer, mide ve şeker hastalıklarında, kolestrol dengelemede	Çiğ, kavurarak	151 paket	7 TL	1057 TL

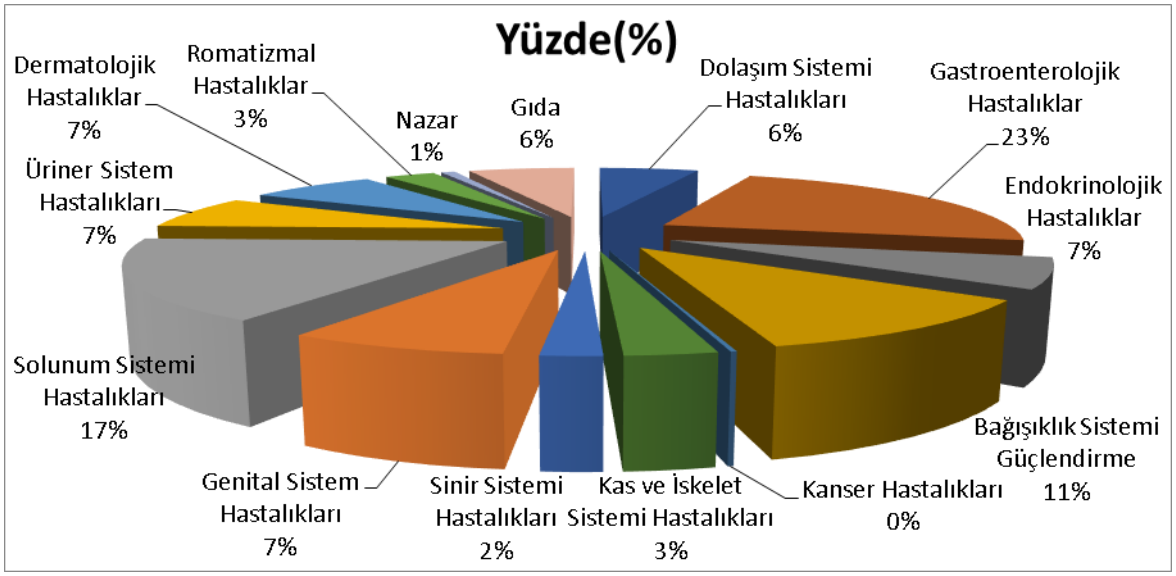
		(Hornem). Hand.-Mazz.		kısımları					
14	Boraginaceae (Hodangiller)	*Anchusa azurea* var. azurea Mill.	Sığırdili	Çiçek	Safra kesesi ve mide hastalıklarında	Lapa	96 paket	7 TL	672 TL
15	Boraginaceae (Hodangiller)	*Alkanna tinctoria* (L.)Tausch	Havacıva	Çiçek	Kas ve eklem ağrılarında, varis tedavisinde ve cilt hastalıklarında	Lapa, macun	96 paket	7 TL	672 TL
16	Brassicaceae (Turpgiller)	*Capsella bursa-pastoris* (L.) Medik.	Çobançantası	Toprak üstü kısımları	Hemoroit tedavisinde ve kadın hastalıklarında	Çay	170 paket	7 TL	1190 TL
17	Brassicaceae (Turpgiller)	*Sinapis arvensis* L.	Hardal	Tohum	Karaciğer, mide ve romatizmal hastalıklarda, huzursuz bacak sendromunda	Çay, çiğ	13 kg	28 TL	362 TL
18	Cupressaceae (Servigiller)	*Juniperus oxycedrus* L.	Ardıç	Tohum, yağ	Cilt hastalıkları ve kadın hastalıklarında	Yağ, çay	11 kg	50 TL	550 TL
19	Elaeagnaceae (İğdegiller)	*Elaeagnus angustifolia* L.	İğde	Meyve	Sinidirim sistemi, mide, bağırsak, safra kesesi ve böbrek hastalıklarında	Çiğ	24 kg	27 TL	648 TL
20	Fabaceae (Baklagiller)	*Robinia pseudoacacia* L.	Akasya	Toz	Ödem söktürücü ve zıyflatıcı olarak	Çiğ, çay, gargara	29 kg	30 TL	870 TL
21	Hyperiacaceae (Kantarongiller)	*Hypericum perforatum* L.	Sarı kantaron	Toprak üstü kısımları, yağ	Cilt hastalıkları, yanık, yara, egzema ve ameliyat izlerinde, mide hastalıklarında	Yağ, çay	271 paket	7 TL	1897 TL
22	Juglandaceae (Cevizgiller)	*Juglans regia* L.	Ceviz	Meyve	Gıda ve kuvvet vermede, bağışıklık sistemini güçlendirme, kolestrolü dengelemede ve Omega-3 olarak	Çiğ, kavrulmuş, suyu	233 kg	34 TL	7912 TL
23	Lamiaceae (Ballıbabagiller)	*Ajuga chamaepitys* (L.)	Acı yavşan	Yaprak	Ağız içi yaralarında	Çay	158 paket	7 TL	1106 TL
24	Lamiaceae (Ballıbabagiller)	*Mentha longifolia* (L.) L.	Dere nanesi	Yaprak	Baharat, öksürük, grip ve soğuk algınlığında, gaz ve şişkinlik gidermede	Çay, kurutulmuş	130 paket	7 TL	910 TL
25	Lamiaceae (Ballıbabagiller)	*Mentha spicata* L.	Kıvırcık nane	Yaprak	Baharat, öksürük, grip ve soğuk algınlığında, gaz ve şişkinlik gidermede	Çiğ, çay, kurutulmuş	130 paket	7 TL	910 TL
26	Lamiaceae (Ballıbabagiller)	*Salvia virgata* Jacq.	Fatmana otu	Çiçek	Doğum kolaylaştırmada	Lapa, çay	46 adet	5 TL	230 TL
27	Lamiaceae (Ballıbabagiller)	*Teucrium polium* subsp. polium	Bodur mahmut	Yaprak, çiçek	Şeker hastalıklarında ve ağız içi yaralarında	Çay	101 paket	7 TL	707 TL
28	Lamiaceae (Ballıbabagiller)	*Thymus sipyleus* Boiss.	Kekik	Toprak üstü kısımları, yaprak, çiçek	Baharat, bağışıklık sistemini güçlendirmede, öksürük, grip, nezle ve soğuk algınlığında, gaz ve şişkinlik gidermede	Kurutulmu, çay, çiğ	100 paket	7 TL	700 TL
29	Malvaceae (Ebegümecigiller)	*Althea officinalis* L.	Hatmi çiçeği	Çiçek	Öksürük ve balgam söktürmede, grip, nezle ve soğuk algınlığında	Çay	138 paket	7 TL	875 TL

30	Malvaceae (Ebegümecigiller)	*Malva sylvestris* L.	Ebegümeci	Çiçek	Vücuttaki iltihapları gidermede, yorgunluk ve halsizlikte, öksürük, grip ve soğuk algınlıklarında, mide hastalıklarında	Çiğ, kavurarak, çay	129 paket	7 TL	903 TL
31	Malvaceae (Ebegümecigiller)	*Tilia tomentosa* Moench	Ihlamur	Yaprak, çiçek	Bağışıklık sistemini güçlendirmede, öksürük, grip, nezle ve soğuk algınlığında	Çay	185 paket	7 TL	1225 TL
32	Moraceae (Dutgiller)	*Morus alba* L.	Akdut	Meyve	Gıda, vücuttaki iltihapları gidermede, egzema ve sedef hastalıklarında	Çiğ, kurutulmuş	105 kg	38 TL	3990 TL
33	Onagraceae (Yakıotugiller)	*Epilobium angustifolium L.*	Yakı otu	Yaprak, çiçek	Mesane ve idrar yolu iltihaplarında, prostat tedavisinde ve bağırsak hastalıklarında	-	174 paket	7 TL	1050 TL
34	Papaveraceae (Haşhaşgiller)	*Fumaria officinalis L.*	Şahtere	Yaprak, çiçek	Karaciğer ve cilt hastalıklarında, sedaf, egzema ve kaşıntı gibi hastalıkların tedavisinde, yüksek tansiyonda	Lapa, çay	105 paket	7 TL	735 TL
35	Plantaginaceae (Sinirotugiller)	*Plantago major* L.	Sinir otu	Yaprak, çiçek	Kalp ve damar hastalıklarında, cilt hastalıklarında, kolestrolü dengelemede, şeker ve akciğer hastalıklarında	Çay, lapa, çiğ,	108 paket	7 TL	756
36	Poaceae (Buğdaygiller)	*Triticum aestivum* L.	Buğday	Tohum	Gıda, cilt hastalıklarında	Çay, kavurarak	138 kg	6 TL	828 TL
37	Poaceae (Buğdaygiller)	*Zea mays* L.	Mısır	Püskül, tohum	Gıda, boşaltım sistemi hastalıklarında, mesane ve idrar yolu iltihaplarında	Çay, çiğ, haşlanmış	179 paket	7 TL	1225 TL
38	Ranunculaceae (Düğünçiçeğigiller)	*Nigella arvensis* L.	Çörek otu	Tohum, yağ	Baharat, bağışıklık sistemini güçlendirmede, vücuttaki iltihapları gidermede, kalp ve damar hastalıklarında, mide, karaciğer ve bağırsak hastalıklarında, eklem ağrılarında	Çiğ, kavurarak, pişirerek, yağ	172 kg	46 TL	7912 TL
39	Rosaceae (Gülgiller)	*Crataegus orientalis* Pallas ex M.bieb.	Alıç	Meyve	Gıda, kalp ve damar hastalıklarında, şeker hastalıklarında, tansiyon ve kolestrolü dengelemede	Çiğ, çay	45 kg	23 TL	1035 TL
40	Rosaceae (Gülgiller)	*Cydonia oblonga* Miller	Ayva	Yaprak	Öksürük, grip, nezle ve soğuk algınlığında, balgam söktürmede, solunum sistemi hastalıklarında	Çiğ, çay	137 paket	7 TL	875 TL
41	Rosaceae (Gülgiller)	*Potentilla reptans* L.	Reşatın otu	Tohum	Hormon bozukluklarında	Çay	180 paket	7 TL	1225 TL
42	Rosaceae (Gülgiller)	*Prunus divaricata* Ledeb.	Dağ eriği	Meyve	Gıda, mide ve bağırsak hastalıklarında, kansızlık tedavisinde ve zayıflatmada	Çiğ, çay	107 kg	34 TL	3638 TL
43	Rosaceae (Gülgiller)	*Rosa canina* L.	Kuşburnu	Meyve	Vücuttaki iltihapları gidermede, bağışıklık sistemini güçlendirmede, öksürük, grip, nezle ve soğuk algınlığında	Çay, marmela, komposto	98 kg	29 TL	2842 TL
44	Salicaceae (Söğütgiller)	*Populus alba* L.	Kavak	Yaprak	Romatizmal hastalıklarda, ağrı kesici olarak	Çay, lapa	70 paket	7 TL	490 TL
45	Salicaceae (Söğütgiller)	*Salix alba* L.	Söğüt	Yaprak, krem	Romatizmal hastalıklarda, siğil tedavisine, eklem ve kas ağrılarında ağrı kesici olarak	Çay, lapa	60 paket	7 TL	420 TL

46	Santalaceae (Güvelekgiller)	*Viscum album* L.	Ökseotu	Yaprak, çiçek	Sinir sistemi, şeker, kalp ve damar hastalıklarında, yüksek tansiyonda	Çay	107 paket	7 TL	749 TL
47	Urticaceae (Isırgangiller)	*Parietaria judaica* L.	Duvar fesleğeni	Yaprak	Akciğer hastalıklarında, öksürük ve balgam söktürmede	Çay	113 paket	7 TL	791 TL
48	Urticaceae (Isırgangiller)	*Urtica dioica* L.	Isırgan	Yaprak	Vücuttaki iltihapları gidermede, kanser hastalıklarını önlemede, sindirim sistemi, mide, karaciğer, böbrek, kalp ve damar hastalıklarında, idrar yolu iltihaplarında	Kavurarak, çay, çiğ	126 paket	7 TL	882 TL
49	Vitaceae (Asmagiller)	*Vitis vinifera* L.	Üzüm	Meyve	Bağışıklık sistemini güçlendirme, kansızlık tedavisi, kuvvet vermede, romatizmal hastalıklarda	Çiğ, kuru, pekmez	212 kg	28 TL	6006 TL
50	Zygophyllaceae (Çobançökertengiller)	*Peganum harmala* L.	Üzerlik	Toprak üstü kısımları, tohum	Nazarda, solunum yolu hastalıklarında, alerji, astım, bronşit ve mide hastalıklarında	Çiğ, kuru, tütsü	110 paket	7 TL	770 TL
51	Zygophyllaceae (Çobançökertengiller)	*Tribulus terrestris* L.	Çoban çökerten	Yaprak, çiçek, meyve	Böbrek, kalp ve damar hastalıklarında, böbrek taşı düşürmede, cinsel gücü arttırmada	Çay	126 paket	7 TL	882 TL
52	Pinaceae (Çamgiller)	*Pinus nigra* J.F.Arnold	Karaçam	Macun	KOAH, astım, bronşit, nefes darlığı hastalıklarında, solunum sistemi hastalıklarında	Çay, reçel, macun	72 şişe	48 TL	3456 TL
53	Pinaceae (Çamgiller)	*Pinus sylvestris* L.	Sarıçam	Macun	KOAH, astım, bronşit, nefes darlığı hastalıklarında, solunum sistemi hastalıklarında	Çay, reçel, macun	72 şişe	44 TL	3168 TL
54	Rhamnaceae (Cehrigiller)	*Ziziphus jujuba* Mill.	Hünnap	Meyve	Vücuttaki iltihapları gidermede, bağışıklık sistemini güçlendirmede, kalp ve damar hastalıklarında, cinsel gücü artırmada	Çiğ, kuru, çay, reçel	110 kg	22 TL	2420 TL

3.4. Aktarların tüketici profiline ilişkin görüşleri

Aktarların tüketici profilini çoğunlukla kadınlar ve bitki ile ilişkili konulara ilgisi olan erkeler oluşturmaktadır. Bu nedenle aktarlara bu tüketicilerin bu bitkileri "hangi amaçla satın aldıkları" da sorulmuştur. Bu soruya verilen yanıtlar dikkatlice değerlendirilerek ve bitkilerin benzer farmakolojik özellikleri dikkate alınarak bu amaçlar sınıflandırılmış ve 14 başlık altında gruplandırılmıştır. Tablo 5'de görüldüğü üzere 26 bitki türünün gastroentolojik hastalıklar olan mide, bağırsak, karaciğer, safra kesesi, sindirim sistemi rahatsızlıkları, gaz ve şişkinlik giderme, hemoroit tedavisinde; 17 bitki türünün bağışıklık sistemini güçlendirmede; 16 türün ile solunum sistemi hastalıkları olan grip, nezle, soğuk algınlığı, öksürük ve balgam söktürmede; 15 türün gıdada(baharat, kuruyemiş, meyve vb.), 10 türün endokrinolojik hastalıklar olan şeker, tansiyon kolestrol ve hormon bozukluklarının tedavisinde; 10 türün dolaşım sistemi hastalıkları olan kalp ve damar hastalıkları, varis tedavisi ve kansızlık için kullanıldığı tespit edilmiştir. Tüketicilerin benzer hastalıklarda destekleyici tedavi amaçlı benzer bitki türlerini satın aldıkları dikkat çekmektedir.
Bu bağlamda, Aksaray'da yetişen ve aktarlarda satılan 54 türün satılma amaçlarına bakıldığında; sırasıyla %22.8 ile gastroenterolojik hastalıklar, %17 ile solunum sistemi hastalıkları, %11.2 ile bağışıklık sistemi güçlendirme, %7.3 ile boşaltım sistemi hastalıkları, %7.2 ile genital sistem hastalıklar, %7.2 ile dermatolojik hastalıklar, %6.4 ile endokrinolojik hastalıklar, %6.2 ile gıda(baharat, kuruyemiş, meyve vb.), %5.8 ile dolaşım sistemi hastalıkları, %3 ile kas ve iskelet sistemi hastalıkları, %2.9 ile romatizmal hastalıklar, %2 ile sinir sistemi hastalıkları, %0.8 ile nazar, %0.2 ile kanser hastalıkları olduğu tespit edilmiştir (Şekil 1). Dolaysıyla en fazla bitki türünün toplumda çok yaygın olan "gastroenterolojik hastalıklar" için kullanıldığı oldukça dikkat çekicidir.[9]'da Kahramanmaraş ilinde 9 aktar ve 99 tüketici ile yapılan görüşme sonucu aktarlarda nane, kekik ve ıhlamur gibi bitkilerin en fazla satılan türler olduğu ve tüketicilerin bu bitkileri genel olarak sindirim, solunum, sinir sistemi, dolaşım sistemi hastalıkları için kullandığı saptanmıştır. Bu çalışma bizim araştırma sonuçlarımızla benzerlik göstermektedir.

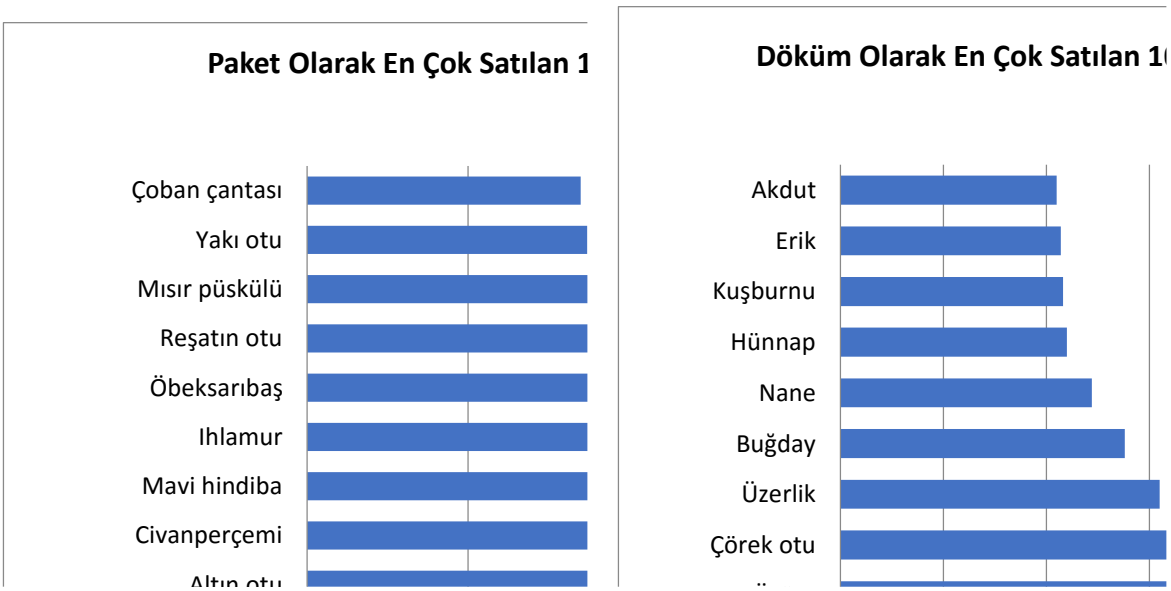


Şekil 1. Bitki türlerinin farmakolojik özelliklerine göre aktardaki satış oranları

Araştırmada 54 bitki türünden paketli olarak en fazla satılan 10 bitki türünün sırasıyla sarı kantaron (271 paket), altın otu(244 paket), civanperçemi(214 paket), mavi hindiba(201 paket), ıhlamur(185 paket), öbek sarıbaş(183 paket), reşatın otu(180 paket), mısır püskülü(179 paket), yakıotu(174 paket) ve çoban çantası(170 paket) olduğu; dökme yani kg olarak en çok satılan 10 bitki türünün ceviz(233 kg), üzüm(212 kg), çörek otu (172 kg), üzerlik(155 kg), buğday(138 kg), nane(122 kg), hünnap(110 kg), erik(107 kg), akdut(10 5kg), kuşburnu(108 kg) ve kekik(100 kg) olduğu tespit edilmiştir. Ayrıca bazı bitki türlerinin ise daha çok yağ, krem, şurup, macun, demet vb. şekillerde satıldığı; bunlar içerisinde de en çok satılan 5 bitki türünün sarı kantaron yağı (134 şişe-20ml), söğüt özlü krem (96 adet 150ml), çam kozalağı macunu (72 şişe 240ml), çörek otu yağı (43 şişe 50ml) ve havacıva kremi (40 adet 40ml) olduğu tespit edilmiştir (Şekil 2).

Tablo 5. Bitkilerin farmakolojik özelliklerine göre sınıflandırılması

Vücut Sistemleri	**Hastalık Kategorisi**	**Kullanılan Toplam Bitki Sayısı**		**Farmakolojik Özellklerine Göre Yüzde Oranı**
Dolaşım Sistemi	Kalp ve damar hastalıklarında	8	11	15.71
	Kansızlık tedavisinde	2		
	Varis tedavisinde	1		
Gastroentroloji	Mide hastalıklarında	14	26	37.14
	Bağırsak bozuklukları ve kurtlarında	6		
	Hemoroit tedavisinde	3		
	Karaciğer hastalıklarında	9		
	Gaz ve şişkinlik gidermede	4		
	Sindirim sistemi hastalıklarında	6		
	Safra kesesi hastalıklarında	3		
Endokrinoloji	Şeker hastalıklarında	6	10	14.29
	Kolesterolü dengelemede	4		
	Tansiyonu dengelemede	4		
	Hormon bozukluklarında	1		
Bağoşıklık Sistemi	Bağışıklığı güçlendirmede	7	17	24.29
	Vücuttaki iltihapları gidermede	9		
	Kuvvet vermede	3		
	Ağız içi yaralarında	3		
	İştah açmada	1		
Kanser	Kanseri önlemede	2	2	2.86
Kas ve İskelet Sistemi	Kas ve eklem ağrılarında	4	4	5.71
Sinir Sistemi	Uyku bozukluklarında	2	3	4.29
	Sinir sistemi hastalıklarında	3		
Genital Sistem	Cinsel gücü arttırmada	4	8	11.43
	Kadın hastalıklarında	3		
	Doğum kolaylaştırmada	1		
Solunum Sistemi	Grip, nezle ve soğuk algınlıklarında	8	16	22.86
	Öksürük ve balgam söktürmede	9		
	Solunum sistemi hastalıklarında	8		
	Koah, astım, bronşit gibi nefes darlığı hastalıklarında	3		
Üriner Sistem	Ödem söktürmede ve zayıflatmada	2	7	10
	İdrar yolu iltihaplarında	3		
	Boşaltım sistemi hastalıklarında	4		
	Prostat tedavisinde	2		
Dermatoloji	Cilt hastalıklarında	6	8	11.43
	Yanık, yara ve ameliyat izlerinde			
	Siğil tedavisinde	4		
Romatoloji	Romatizmal hastalıklarda	4	5	7.14
	Huzursuz bacak sendromunda	1		
Nazar	Nazar	1	1	1.43
Gıda	Baharat, kuruyemiş, meyve vb.	14	15	21.43



Şekil 2. Aksaray'da yetişen bitki türlerinden aktarlarda paket ve dökme olarak en çok satılan 10 bitki türü

4. Sonuçlar ve Tartışma

Bu çalışmada Aksaray'da tıbbi bitki satışı yapan aktarların sosyoekonomik, demografik özellikleri, tıbbi bitki talebi ve bu talebi etkileyen faktörler üzerinde durulmuştur. Tüketicilerin tıbbi bitkileri satın alma davranışlarında aktarların özellikle hangi bitkinin ne şekilde ve hangi hastalıkların tedavisinde kullanılabileceği konusunda bilgi birikiminin yönlendirici özellikte olduğu görülmektedir. Aktarların edindikleri bilgi birikiminin büyük bir kısmını usta-çırak ilişkisine (%37.7) dayandırdığı bunun yanında yazılı ve görsel medyanın da bu alanda son yıllarda önemli rol oynadığı ortaya çıkmıştır. Ancak burada bilgi kaynağının güvenilir olması dikkat edilmesi gereken önemli bir konudur. Özellikle yazılı ve görsel medyada yer alan reklam amaçlı kullanımlar tüketicileri yanlış yönlendirebilmekte ve çeşitli olumsuzlukların yaşanmasına neden olabilmektedir. Bu nedenle bilgi kaynağı, doğru bilginin aktarılmasında önemli rol oynar. Burada özellikle tercih edilen bilgi kaynaklarının; ziraat ve eczalık fakültesinden, biyoloji ve botanik bilim dallarında eğitim alan kişiler ya da bu konularda uzmanlaşmış sağlık bilimciler olması tercih edilmelidir. Ayrıca bitkisel tedavi yöntemlerinin asıl tedaviyi destekleyici rolleri olduğu ve bilinçli tüketim gerektirdiği göz ardı edilmemelidir.

Bölgede faaliyet gösteren aktarların ortalama 21 yıldır faaliyet gösterdiği, ortalama çalışan sayısının 2.13 kişi olduğu belirlenmiştir. Bunun yanında satışa sunulan ürün çeşidi sayısının ortalama 975 adet, aktarların ortalama yıllık cirolarının 420 000TL ve aktarların aylık ortalama kazançlarının ise 11 066 TL olduğu tespit edilmiştir. Elde edilen bu sonuçlar Koca ve Uzun'un [10] da Kahramanmaraş ilinde yaptığı çalışma ile büyük oranda benzerlik gösterdiği saptanmıştır. Koca ve Uzun [2020] de, aktarların mesleki bilgilerini %50 oranda usta-çırak ilişkisinden elde ettiklerini, aktar işletmelerinin ortalama 29 yıldır faaliyet gösterdiklerini, işletmelerde çalışan ortalama kişi sayısının 1.8, ürün çeşidi sayısının ortalama 422, işletmelerin ortalama yıllık cirolarının 181 111 TL ve aylık kazançlarının da ortalama 7 611 TL olduğu ifade edilmiştir[10]. Bu veriler bölgeler arası farklılık gösterse de ülkemizdeki aktar profilinin ortaya konması açısından son derece önemlidir.

Bununla birlikte, Aksaray'da yetişen ve tedavi amaçlı kullanılan 70 bitki türünden yalnız 54 tanesinin aktarda satıldığı diğerlerinin ise genellikle halk tarafından yetiştirildiği ya da direk olarak doğadan toplanıldığı tespit edilmiştir. Aktalarda satılan bu türlerin de %37.14'ünün gastroenterolojik hastalıklarda, %24.29'unun bağışıklık sistemini güçlendirmede, %22'sinin ile solunum sistemi hastalıklarında, %21.43'ünün gıdada(baharat, kuruyemiş, meyve vb.), %15.71'inin dolaşım sistemi hastalıklarında, %14.29'unun endokrinolojik hastalıklarda, %11.43'ünün genital sistem hastalıklarında, %11.43 dermatolojik hastalıklarda, %10'unun üriner sistem hastalıklarında, %7.14'ünün romatizmal hastalıklarda, %5.71'inin kas ve iskelet sistemi hastalıklarında, %4.29'unun sinir sistemi hastalıklarında, %2.86'sının kanser hastalıklarını önlemede ve %1.43'ünün nazarda kullanıldığı tespit edilmiştir. Araştırma sonuçları daha öncesinde Aksarayın Nizip bölgesinde [11] yapılmış detaylı flora çalışması ile karşılaştırıldığında; tespit edilen tıbbi bitkilerin %58.1'i gasro-intestinal hastalıklarında, %36.5'i genito-üriner sistem hastalıklarında, %25.7'sinin gıda olarak, %21.6'sı solunum sistemi hastalıklarında, %20'si kardiyo-vasküler hastalıklarda,%10.8'i şeker hastalıklarında, %5.4'ü sinir sistemi hastalıklarında kullanıldığı ve sonuçların birbirine yakın olduğu gözlenmiştir. Ayrıca araştırma sonuçlarına göre Aksaray'da en fazla talep edilen tıbbi bitki türlerinin sarı kantaron, altın otu ve civanperçemi olduğu görülmüştür. Aktarlardaki bu bitkilerin en fazla gastroenterolojik ve solunum sistemi hastalıkları için kullanıldığı; özellikle de mide ve karaciğer hastalıkları ile öksürük ve balgam söktürmede kullanıldığı tespit edilmiştir. Talep değeri yüksek olan bu bitkilerin aktarlarda paket, döküm veya cam şişelerde satışa sunulması tüketicilerde güven duygusunun oluşmasında

önemli rol oynamaktadır. Tüketiciler bu ürünleri tercih etmesinde ürünün paketli ve ambalajlı olması, son kullanım tarihinin olması ve fiyat gibi unsurların önemli rol oynadığı anlaşılmıştır. Burada ürünlerin niteliği tüketici memnuniyetini artırıcı bir faktör olarak rol oynamakta olup, aynı zamanda tüketicilerin aktar tercihlerini de etkilemektedir. Tüketicilerin aktarlara olan talebi özellikle hastalık sürecinde yoğunlaşmaktadır. Bu durum özellikle son yıllarda doğal bitki kaynaklı ilaçlara olan ilginin sürekli artmasının aktarların piyasa değerini artırmasına yol açmıştır.

Aktarla yapılan anket çalışması sonrasında aktarların satmış oldukları tıbbi bitkileri genellikle tedarikçilerden çok az bir kısmını da yöre halkından temin ettikleri tespit edilmiştir. Bu bitkilere olan talebin artması veya piyasa değerinin yükselmesi, bu talebin yöre halkından karşılanması, Proxy etkisi yaratarak bitkilerin değerinde de parelel bir artışa neden olacağı ve buna bağlı olarak hane halkı gelirine pozitif yönde sağlanan katma değerde de artış olacağı öngörülmektedir.

Sonuç olarak, tıbbi bitkilerin ve bu bitkilerden elde edilen ürünlerin toplumda önemli bir yere sahip olduğu, ticaretinin yaygınlaştığı ve hastalıkların tedavisinde değer kazandığı görülmektedir. Çalışmada, aktarların sosyoekonomik durumlarının, toplumun bilinç düzeyinin tıbbi bitki satış değerini etkilediği sonucuna varılmıştır. Ayrıca Aksaray ve çevresinde yetişen ve halk arasında yaygın olarak kullanılan tıbbi bitkilerin değeri, burada yaşayan yöre sakinlerinin geleneksel bitkilere bağımlılığının bir yansımasıdır.

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Anatomical studies on endemic *Verbascum stepporum* Murb., and *Verbascum tenue* Hub.-Mor., (Scrophulariaceae) species distributed in Şanlıurfa

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Abstract

The family Scrophulariaceae, commonly known as "figwort", consists of herbaceous plants and a genus of shrubs. The family has approximately 62 genera and 1830 recognized species. The genus *Verbascum* L. (Scrophulariaceae, Lamiales), which is known as "the mullein" in Turkey, consists of approximately 360 species, widely distributed in temperate regions of Europe, Africa and Asia. The gene center for this genus is Turkey, where it is represented by 6 imperfectly known or questionable records divided into 256 species, 131 hybrids and 13 partially artificial groups. Of these, 201 species are endemic to Turkey, indicating an endemism rate of approximately 80%. This genus is morphologically herbaceous and seldom small shrubs, with alternate or very rarely opposite simple or divided leaves, leaves at the base forming a rosette. The flowers are racemose, spica or paniculate above. The corolla is characterized by annual, biennial or perennial plants that are yellow, rarely violet or purple, brown or yellowish or bluish green, rotatable, actinomorphic or slightly zygomorphic. *Verbascum* species have long been used in traditional medicine. Its leaves have been used as diuretic, diaphoretic, expectorant, sedative, and its flowers have mucolytic and expectorant properties. For the first time in this study, the anatomical structures of the endemic *Verbascum stepporum* and *V. tenue* species distributed in Şanlıurfa were compared and clarified with sections taken from the roots, stems and leaves.

Key words: anatomy, endemic, Şanlıurfa, *Verbascum*

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Şanlıurfa'da yayılış gösteren endemik *Verbascum stepporum* Murb., ve *Verbascum tenue* Hub.-Mor., (Scrophulariaceae) türleri üzerinde anatomik araştırmalar

Özet

Genel olarak "sıracaotu" olarak bilinen Scrophulariaceae familyası, otsu bitkilerden ve bir cinsi ise çalıdan oluşur. Familyanın yaklaşık olarak 62 cinsi ve 1830 tanınmış türü vardır. Türkiye'de "sığırkuyruğu" olarak tanınan *Verbascum* L. (Scrophulariaceae, Lamiales) cinsi, Avrupa, Afrika ve Asya'daki ılıman bölgelerde geniş bir dağılım gösteren yaklaşık 360 türden oluşur. Bu cinsin gen merkezi, 256 tür, 131 hibrit ve 13 kısmen yapay gruba bölünmüş 6 ise tam olarak bilinmeyen veya şüpheli kayıt ile temsil edildiği Türkiye'dir. Bunlardan 201 tür Türkiye'ye endemiktir, bu da yaklaşık %80'lik bir endemizm oranını işaret etmektedir. Bu cins, morfolojik olarak otsu ve nadiren küçük çalılar, alternat veya çok nadiren karşılıklı basit veya bölünmüş yapraklara sahip, tabandaki yapraklar bir rozet oluşturur. Çiçekler üstte rasemoz, spika veya panikuladır. Korolla sarı, nadiren menekşe veya mor, kahverengi veya sarımsı veya mavimsi yeşil, rotat, aktinomorfik veya biraz zigomorfik, tek yıllık, iki yıllık veya çok yıllık bitkilerle karakterize edilir. *Verbascum* türleri geleneksel tıpta uzun süredir kullanılmaktadır. Yaprakları idrar söktürücü, terletici, balgam söktürücü, yatıştırıcı olarak kullanılmış olup, çiçekleri mukolitik ve balgam söktürücü özelliklere sahiptir. İlk kez bu çalışmada Şanlıurfa'da yayılış gösteren endemik *Verbascum stepporum* ve *V. tenue* türlerinin kök, gövde ve yapraklarından alınan enine kesitlerle anatomik yapıları karşılaştırılmış ve aydınlatılmıştır.

Anahtar kelimeler: anatomi, endemik**,** Şanlıurfa, *Verbascum*

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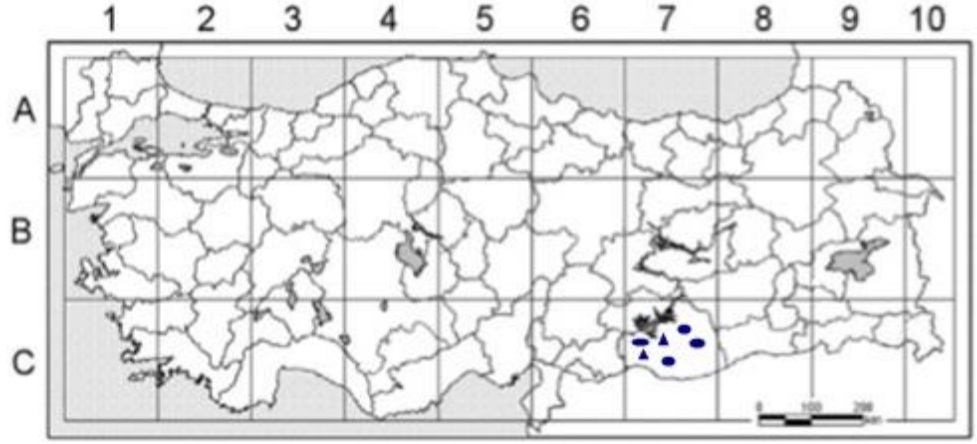
1. Giriş

Genel olarak "sıracaotu" olarak bilinen Scrophulariaceae familyası, otsu bitkilerden ve bir cins çalıdan oluşur. Familyanın yaklaşık olarak 62 cinsi ve 1830 tanınmış türü vardır. Türkiye'de "sığırkuyruğu" olarak tanınan *Verbascum* L. (Scrophulariaceae, Lamiales) cinsi, Avrupa, Afrika ve Asya'daki ılıman bölgelerde geniş bir dağılım gösteren yaklaşık 360 türden oluşur [1]. Bu cins için gen merkezi, 257 tür, 132 hibrit ve 13 kısmen yapay gruba bölünmüş 6 tam olarak bilinmeyen veya şüpheli kayıt ile temsil edildiği Türkiye'dir. Bunlardan 202 tür Türkiye'ye endemiktir, bu da yaklaşık %80'lik bir endemizm oranını işaret etmektedir [2-3]. Bu cins, morfolojik olarak nadiren küçük çalılar, alternat veya çok nadiren karşılıklı basit veya bölünmüş yapraklara sahip, tabandaki yapraklar bir rozet oluşturur. Çiçekler üstte rasemoz, spika veya panikuladır. Korolla sarı, nadiren menekşe veya mor, kahverengi veya sarımsı veya mavimsi yeşil, rotat, aktinomorfik veya biraz zigomorfik, tek yıllık, iki yıllık veya çok yıllık bitkilerle karakterize edilir [4-5]. *Verbascum* türleri geleneksel tıpta uzun süredir kullanılmaktadır. Eski zamanlardan beri şifalı bir bitki olarak kullanılan cinsin türleri, birçok rahatsızlığı tedavi etme konusunda büyük bir potansiyele sahiptir. Mullein'in triterpen, tetraglikozitler, saponinler, terpenler, flavonoidler, karotenoidler, tanenler, karbonhidratlar, fenolik asit, şekerler, proteinler ve mineraller dâhil olmak üzere önemli sayıda biyoaktif bileşenle yüklü olduğu varsayılmaktadır. Bu güçlü bitki bileşenlerinin varlığından dolayı, dünyanın farklı yerlerinde yerel halkın çoğunluğu için geleneksel olarak bir halk ilacı olarak kullanılmıştır. Türlerin antitümör, kardiyovasküler, antiinflamatuar, hepatoprotektif, antibakteriyel, antiviral, nefroprotektif, antelmintik, analjezik aktivite dâhil olmak üzere bir dizi farmakolojik aktivitesini ortaya koymaktadır [6]. Yaprakları idrar söktürücü, terletici, balgam söktürücü, yatıştırıcı olarak kullanılmış olup, çiçekleri mukolitik ve balgam söktürücü özelliklere sahiptir [7]. İlk kez bu çalışmada Şanlıurfa'da yayılış gösteren *Bothrosperma* seksiyonuna ait endemik *Verbascum stepporum* Murb. ve *V. tenue* Hub.-Mor. türlerinin kök, gövde ve yapraklarından alınan enine kesitlerle anatomik yapıları karşılaştırılmış ve aydınlatılmıştır.

2. Materyal ve yöntem

Araştırma sahası olan Şanlıurfa İli Güneydoğu Anadolu Bölgesi'nin Orta Fırat Bölümü'nde, 37˚49'12"-40˚10'00" doğu boylamları ile 36˚41'28"-37˚57'50" kuzey enlemleri arasında bulunmakta ve doğusunda Mardin, batısında Gaziantep, kuzeydoğusunda Diyarbakır, kuzeybatısında Adıyaman illeri ve güneyinde Suriye Devleti toprakları yer almaktadır. Genelde bir ova görünümündeki il merkezinin rakımı 518 m'dir. Şanlıurfa karasal iklim özelliği gösterir. Yazları çok kurak ve sıcak, kışları bol yağışlı ve nispeten ılıman geçmektedir. Bölgenin 600 m'den alçak kesimlerinde doğal bozkırlar yaygındır. Plato ve dağlar, meşe ormanları ekosistemine girer. Ormanların tahrip edildiği yerlerde antropojen bozkırlar yaygındır [8]. Şanlıurfa, İran-Turan Bitki Coğrafyası Bölgesi'ne aittir ve Davis (Davis 1965-1985) tarafından geliştirilen Grid sınıflandırma sistemine göre C6, C7 ve C8 karelerinde bulunmaktadır (Şekil 1).



Şekil 1. Şanlıurfa ilinin coğrafi konumu ve *Verbascum stepporum* (●) ve *V. tenue* (▲)türlerinin yayılışı

Bu çalışma, 2022-2023 yılları arasında Şanlıurfa ili Bozova, Haliliye, Karaköprü ve Viranşehir ilçelerinden toplanan iki *Verbascum* endemik türleri üzerinde yapılmıştır (Tablo 1). Bitki toplama çalışmaları, *Verbascum* türlerinin çiçeklenme dönemi olan Mayıs ayında gerçekleştirilmiştir. Bitki türlerini belirlemek için Davis'in Türkiye Florası [9] ve Türkiye Florası (Damarlı Bitkiler) kontrol listesi [10] kullanılmıştır. Toplanan örnekler anatomik çalışmalarda kullanılmak üzere %70 alkol içinde falcon tüplerinde muhafaza edilmiştir. Bitkilerin kök, gövde ve yaprak kısımlarından jilet yardımıyla elle alınan kesitler safranin-fast green ile boyanarak hazırlanmış ve ışık mikroskobu altında incelenerek fotoğrafları çekilmiştir [11]. Bu preparatların incelenmesi sonucunda türler arasında benzerlik ve farklılık gösteren anatomik özellikler belirlenmiştir. Işık mikroskobu ile çekilen fotoğraflar Mardin Artuklu Üniversitesi Bitkisel ve Hayvansal Üretim Bölümü'nde Isolab marka mikroskop ile çekilmiştir. Kök, gövde ve yaprak doku ve hücrelerinin biyometrik ölçümleri Tablo 2, 3, 4'de verilmiştir.

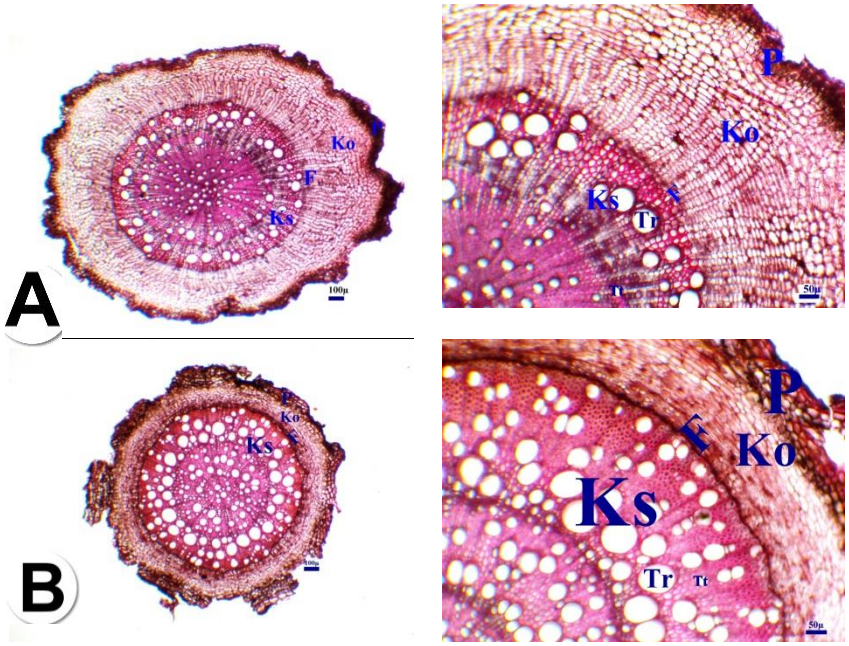
Tablo 1. Anatomik çalışmalarda kullanılan *Verbascum* türlerinin toplanıldığı lokaliteler

Tür	Lokalite ve habitat	Toplayıcı no
V. stepporum	Viranşehir-Urfa yolu, yol kenarı sağlı-sollu taşlık alan, otoyol (400-26/042) levhası civarı, 660 m	M.Kılıç&F.MunganKılıç 286
	Haliliye, Güzelyurt köyü kuzeyi, yol kenarı, 37°12'49"K 38°49'05"D, 665 m	M.Kılıç&F.MunganKılıç 289
	Karaköprü, Borsa İstanbul Ortaokulu güneyi, yol kenarı, 37°12'26"K 38°47'30"D, 606 m	M.Kılıç&F.MunganKılıç 293-1
	Karaköprü, Gölpınar Tabiat Parkı güneyi, yol kenarı, 37°14'05"K 38°49'30"D, 704 m	M.Kılıç&F.MunganKılıç 295-2
	Bozova, Yassıca mesire alanı, 37°27'25"K 38°23'26"D, 553 m	M.Kılıç&F.MunganKılıç 298
V. tenue	Şanlıurfa-Adıyaman otobanı, Mardin-Habur yol ayrımı, yol kenarı, kalkerli yamaç, 37°11'55"K 38°48'01"D, 717 m	M.Kılıç&F.MunganKılıç 296
	Bozova, Şanlıurfa-Bozova yolu, Bozova'ya varmadan Opet karşısı, yol kenarı, 37°20'40"K 38°32'02"D, 616 m	M.Kılıç&F.MunganKılıç 297

3. Bulgular

3.1. Kök anatomik özellikleri

Verbascum stepporum Murb.: Kökün enine kesitlerinde peridermis, korteks, floem ve ksilem dıştan içe doğru sıralanmıştır. Peridermis genellikle 3-5 katmanlı hücrelerde oluşur. Peridermisin altında yer alan birincil korteks, dar bir alanda hapsolmuş ve oval, dörtgen şekilli, düzensiz sıralı hücrelerden oluşur. Birincil korteks ile iletim demeti arasında yer alan çok katmanlı parankimatik korteks yer alır, genellikle eni boyundan daha büyük ve düzgün şekilli hücrelerden oluşur. Korteksin altında 3-5 katmanlı floem hücreleri yer alır. Kambiyum belirsizdir. Ksilem daha geniş bir alanı kaplar ve kökün ortasını doldurur. Trake hücreleri düzensiz yerleşmiş, trakeit hücrelerden daha büyük ve enleri boylarından fazladır. Floem, ksilemden daha dar bir alanı kaplar (Şekil 2, Table 2). *Verbascum tenue* Hub.-Mor.: Kökün enine kesitlerinde peridermis, korteks, floem ve ksilem dıştan içe doğru sıralanmıştır. Peridermis yer yer parçalanmış ve genellikle 5-9 katmanlı hücrelerde oluşur. Peridermisin altında yer alan birincil korteks, dar bir alanda hapsolmuş ve oval, şekilsiz, dörtgen şekilli, düzensiz sıralı hücrelerden oluşur. Birincil korteks ile iletim demeti arasında yer alan çok katmanlı parankimatik korteks yer alır, genellikle eni boyundan daha büyük ve düzgün şekilli hücrelerden oluşur. Korteksin altında çok katmanlı ve yer yer ezilmiş floem hücreleri yer alır. Kambiyum belirsizdir. Ksilem daha geniş bir alanı kaplar ve kökün ortasını doldurur. Trake hücreleri düzensiz yerleşmiş, trakeit hücrelerden daha büyük ve boyları enlerinden daha büyüktür. Floem, ksilemden daha dar bir alanı kaplar (Şekil 2, Table 2).



Şekil 2. *V. stepporum* (A) ve *V. tenue* (B) kök enine kesitleri. P: Peridermis, Ko: Korteks, F: Floem, Ks: Ksilem, Tr: Trake, Tt: Trakeit

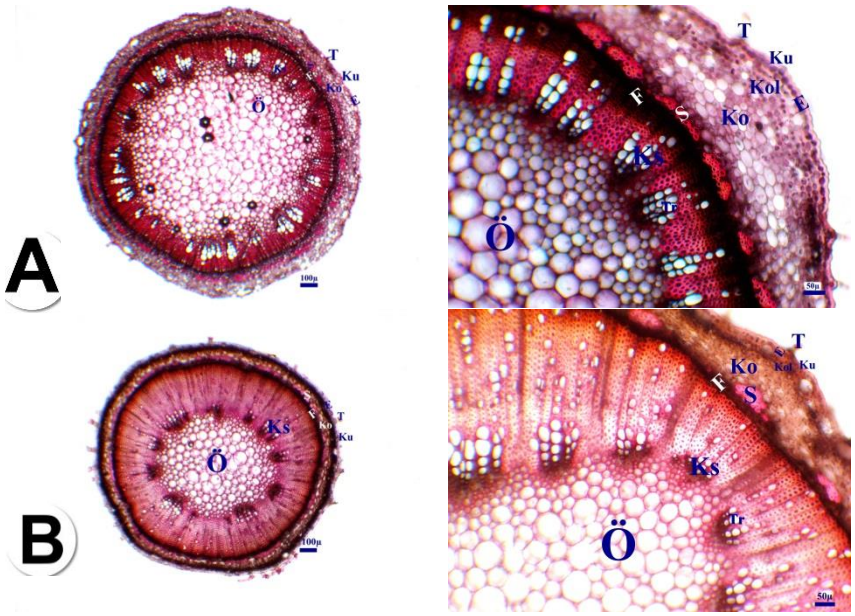
Tablo 2. *V. stepporum* ve *V. tenue* türlerinin kök anatomik ölçümleri

Tür	**Doku**	**En (µ)**		**Boy (µ)**	
		Min.–Max.	**Ort. ±S.D.**	**Min.–Max.**	**Ort. ±S.D.**
V. stepporum	Peridermis	13.77-28.79	21.24±4.84	8.34-22.04	14.53±3.37
	Korteks	13.15-33.02	24.29±5.33	6.23-14.77	10.27±2.73
	Floem	9.00-21.83	14.58±3.47	5.16-12,48	8.04±2.03
	Ksilem	16.92-76.56	42.19±19.07	17.64-71.22	41.53±18.30
V. tenue	Peridermis	15.15-74.09	42.66±17.17	8.66-31.39	20.34±5.65
	Korteks	17.64-53.18	31.65±11.64	6.47-21.62	13.38±3.53
	Floem	5.64-25.93	14.23±5.33	4.06-11.82	7.42±2.20
	Ksilem	12.47-95.73	45.48±22.04	12.94-102.26	49.75±25.86

3.2. Gövde anatomik özellikleri

Verbascum stepporum Murb.: Gövdenin enine kesitleri incelendiğinde peridermis en dışta kütikul tabakası ile kaplıdır. Epidermis, tek bir katman halinde düzenli hücrelerden ve düzgün sıralanmış hücrelerden oluşur. Epidermisin üstünde glandular ve eglandular tüyler yer almaktadır. Epidermisin hemen altında 5-7 katmandan oluşan kollenkima hücreleri bulunur. Kollenkima tabakasından sonra genellikle genişliği uzunluğundan daha büyük ve oval, dörtgen hücrelerden oluşan korteks gelir. Korteksteki parankimal doku diğer dokulara göre daha fazla alan kaplıyor. Korteks altında 2-3 sıralı sklerankima tabakası yer alır. Ksilem, floemden daha geniş bir alanı kaplar. Genellikle trakelerin genişlikleri uzunluklarından daha büyüktür. Gövdenin özü irili ufaklı parankimatik çokgen ve yuvarlak şekilli hücrelerden oluşur (Şekil 3, Tablo 3).

Verbascum tenue Hub.-Mor.: Gövdenin enine kesitleri incelendiğinde peridermis en dışta kütikul tabakası ile kaplıdır. Epidermis, tek bir katman halinde düzenli hücrelerden ve düzgün sıralanmış hücrelerden oluşur. Epidermisin üstünde glandular ve eglandular tüyler yer almaktadır. Epidermisin hemen altında 3-5 katmandan oluşan kollenkima hücreleri bulunur. Kollenkima tabakasından sonra genellikle genişliği uzunluğundan daha büyük ve oval, dörtgen hücrelerden oluşan korteks gelir. Korteks altında 2-4 sıralı sklerankima tabakası yer alır. Ksilem, floemden daha geniş bir alanı kaplar. Genellikle trakelerin uzunlukları genişliklerinden daha büyüktür. Gövdenin özü irili ufaklı parankimatik çokgen ve yuvarlak şekilli hücrelerden oluşur (Şekil 3, Tablo 3).



Şekil 3. *V. stepporum* (A) ve *V. tenue* (B) gövde enine kesitleri. T: Tüy, Ku: Kütikula, E: Epidermis, Kol: Kollenkima, Ko: Korteks, S: Sklerankima, F: Floem, Ks: Ksilem, Tr: Trake, Ö: Öz boşluk

Tablo 3. *V. stepporum* ve *V. tenue* türlerinin gövde anatomik ölçümleri

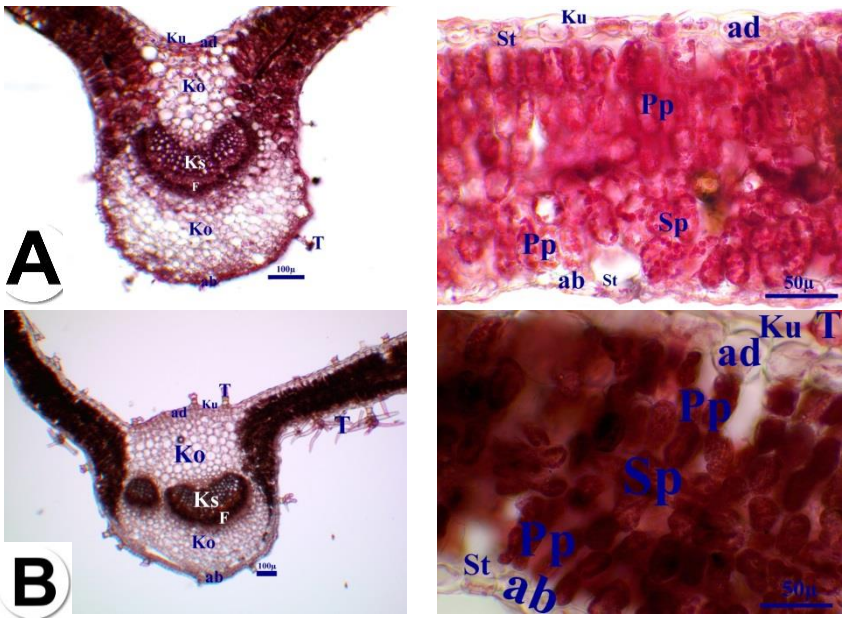
Tür	**Doku**	**En (µ)**		**Boy (µ)**	
		Min.–Max.	**Ort. ±S.D.**	**Min.–Max.**	**Ort. ±S.D.**
V. stepporum	Kütikula	–	-	7.12-12.83	9.93±1.77
	Epidermis	9.19-31.69	20.86±6.68	6.74-15.66	10.79±2.84
	Kollenkima	10.91-23.45	17.39±3.49	9.58-19.68	14.52±2.87
	Korteks	5.62-41.67	21.35±10.26	3.69-18.02	10.35±4.11
	Floem	3.95-13.07	7.53±2.33	2.68-6.50	4.65±1.01
	Ksilem	14.63-43.50	26.83±6.94	13.13-43.08	27.64±8.89
	Öz boşluk	5.12-40.56	21.48±12.69	4.84-39.36	21.95±12.98
V. tenue	Kütikula	–	-	6.86-11.56	8.59±1.10
	Epidermis	7.81-27.12	15.86±4.56	6.95-17.76	15.20±2.69
	Kollenkima	7.35-22.14	13.98±4.16	6.47-19.36	10.98±2.86
	Korteks	9.17-57.04	29.21±13.97	6.01-22.01	12.77±4.58
	Floem	3.13-13.41	7.75±2.67	3.04-10.94	5.84±1.93
	Ksilem	9.67-38.27	22.36±6.83	13.53-54.17	30.73±11.22
	Öz boşluk	13.96-115.41	57.41±29.72	17.13-131.39	60.50±31.18

3.3. Yaprak anatomik özellikleri

Verbascum stepporum Murb.: Yapraklarda, adaksiyal ve abaksiyal epidermisin dış yüzeyi kütikul ile kaplıdır. Adaksiyal ve abaksiyal epidermis tek katmanlıdır ve çoğunlukla 3-4 epidermis hücresi ile çevrili amaryllis tipi stomalara sahiptir. Mezofil dokusu, palizat ve sünger parankiması olarak ayrılır, adaksiyal epidermisin altında 2 tabaka ve abaksiyal epidermisin üzerinde 1 tabaka palizat parankiması vardır. Palizat parankiması hücreleri uzun, silindirik veya dörtgen şeklindedir ve düzenli olarak sıralanmıştır. Alt ve üst palizat parankim hücreleri arasında 3-4 sıralı hücrelerden oluşan sünger parankiması hücreleri bulunur. Sünger parankiması hücreleri oval veya poligonal ve hücreler arasında daha fazla boşluk vardır. Adaksiyal ve abaksiyal epidermis yüzeylerinde glandular, eglandular ve çok hücreli dallı tüyler vardır. Damar demetleri kollateraldir. Kavisli vasküler demet parankim hücreleri ile çevrilidir. Ksilem elemanları ışınsal olarak dizilmiş ve tek bir katman şeklindedir. Orta damar yanlara göre oldukça iyi gelişmiştir. Damar demetinin çevresinde yer alan korteks tabakası geniş bir alanı kaplar. Korteks dokusunun hücreleri çokgen şekilli ve sık sıralanmıştır (Şekil 4, Tablo 4).

Verbascum tenue Hub.-Mor.: Yapraklarda, adaksiyal ve abaksiyal epidermisin dış yüzeyi kalın kütikul tabakası ile kaplıdır. Adaksiyal ve abaksiyal epidermis tek katmanlıdır ve çoğunlukla 3-4 epidermis hücresi ile çevrili amaryllis tipi stomalara sahiptir. Mezofil dokusu, palizat ve sünger parankiması olarak ayrılır, adaksiyal epidermisin altında 2-3 tabaka ve abaksiyal epidermisin üzerinde 1-2 tabaka palizat parankiması vardır. Palizat parankiması hücreleri uzun, silindirik veya dörtgen şeklindedir ve düzenli olarak sıralanmıştır. Alt ve üst palizat parankim hücreleri arasında 3-4

sıralı hücrelerden oluşan sünger parankiması hücreleri bulunur. Sünger parankiması hücreleri oval veya poligonal ve hücreler arasında daha fazla boşluk vardır. Adaksiyal ve abaksiyal epidermis yüzeylerinde glandular, eglandular ve çok hücreli dallı tüyler vardır. Damar demetleri kollateraldir. Kavisli vasküler demet parankim hücreleri ile çevrilidir. Ksilem elemanları ışınsal olarak dizilmiş ve tek bir katman şeklindedir. Orta damar yanlara göre oldukça iyi gelişmiştir. Damar demetinin çevresinde yer alan korteks tabakası geniş bir alanı kaplar. Korteks dokusunun hücreleri çokgen şekilli ve sık sıralanmıştır (Şekil 4, Tablo 4).



Şekil 4. *V. stepporum* (A) ve *V. tenue* (B) yaprak enine kesitleri. T: Tüy, Ku: Kütikula, ad: Adaksiyal, Ko: Korteks, St: Stoma, F: Floem, Ks: Ksilem, Pp: Palizat parankiması, Sp: Sünger parankiması, ab: Abaksiyal

Tablo 4. *V. stepporum* ve *V. tenue* türlerinin yaprak anatomik ölçümleri

Tür	**Doku**	**En (µ)**		**Boy (µ)**	
		Min.–Max.	**Ort. ±S.D.**	**Min.–Max.**	**Ort. ±S.D.**
V. stepporum	Kütikula	-	-	2.56-10.13	5.48±1.91
	Adaksiyal	6.47-34.83	21.76±7.93	7.71-34.86	18.22±7.84
	Palisat parankiması	12.42-20.30	15.80±2.24	27.14-40.24	33.23±5.06
	Sünger parankiması	15.42-25.10	20.36±2.99	17.48-30.35	22.80±3.59
	Mezofil tabakası	-	-	167.13-253.23	193.52±21.85
	Abaksiyal	5.47-13.92	9.87±2.23	5.57-14.42	9.47±1.99
V. tenue	Kütikula	-	-	6.70-14.96	9.80±2.14
	Adaksiyal	19.18-41.63	27.77±6.45	21.22-35.86	28.02±4.08
	Palisat parankiması	11.96-20.66	16.14±2.31	28.02-46.34	37.21±5.38
	Sünger parankiması	9.79-27.03	18.06±5.04	9.88-28.48	19.98±5.16
	Mezofil tabakası	-	-	130.18-301.44	221.86±40.99
	Abaksiyal	7.93-18.77	12.72±3.14	3.89-17.08	10.28±2.99

4. Sonuçlar ve tartışma

Bu araştırmada, Şanlıurfa ilinde yayılış gösteren *Verbascum* cinsinin iki endemik türü anatomik olarak karşılaştırmalı olarak incelenmiştir. Kök, gövde ve yaprak anatomik ölçüleri sırasıyla Tablo 2, 3 ve 4'te gösterilmektedir. Çalışmada kullanılan *Verbascum* türleri *Bothrosperma* seksiyonuna aittir. *Verbascum* cinsiyle ilgili yapılmış anatomik çalışmalar oldukça azdır [12-15]. Bu yüzden cinse ait türleri birbiriyle karşılaştırma imkânı da fazla değildir. Bu çalışmada *V. stepporum* ve *V. tenue* türlerinin anatomik özellikleri ilk kez incelenmiş ve aydınlatılmıştır.

Türlerin kök, gövde ve yaprak anatomisine bakıldığında, ilk kez ayrıntılı olarak araştırılan anatomik özelliklerinin diğer bazı *Verbascum* üyeleriyle karşılaştırıldığında, elde edilen sonuçların literatürdeki diğer *Verbascum* türlerinin kök, gövde ve yaprak anatomik yapıları ile benzer olduğu belirlendi. Çalışmada *V. stepporum* ve *V. tenue* türlerinin kökte çok geniş bir ksilem alanına ve gövdede kalın kütikul tabakasına sahip olduğu gözlemlendi. Ayrıca aynı

özellikler araştırmacılar tarafından da belirtilmiştir [12-17]. Yapılan bazı çalışmalarda [12,14] kökte iletim demetinde kambiyumun belirsiz olduğu belirtilmiş ve bu çalışmada da türler için kökün benzer özellikte olduğu tespit edildi. Türlerin yaprak enine kesit analizlerinde ise, epidermal hücreler üzerinde yoğun glandular, eglandular ve çok hücreli dallı tüyler olduğu görülmüştür. Araştırılan diğer *Verbascum* türleri için de benzer sonuçlar bildirilmiştir [12, 14, 17].

Bitkilerin gövde kısmı çevresel etkilere daha az maruz kaldığı için damarlı bitkilerde anatomik çalışmalar daha çok bu organ üzerinden yapılmaktadır [18]. Bu iki türün gövde anatomileri, ayırt edici özellikler göstermeleri nedeniyle bu bilgiyi desteklemektedir.

Anatomik incelemelerde taksonların kök, gövde ve yaprak yapılarının benzer olduğu ancak şekil ve ölçülerinin yanı sıra doku tabaka sayılarının farklı olduğu görülmüştür. Tüm bu tartışılan veriler sonucunda, kökteki kambiyum, gövdedeki kollenkima katman sayısı, yapraklardaki mezofil formları ve orta damarın şekli gibi anatomik özellikler önemli taksonomik bilgiler sağlamaktadır.

Sonuç olarak türdeki anatomik karakterlerin önemli taksonomik bilgiler sağladığı görülmektedir. Morfolojik karakterlerin yanı sıra anatomik verilerin varlığı da tür ayrımının daha sağlıklı yapılabileceğini göstermektedir. Ayrıca bu tür çalışmaların yapılmasının ve teşvik edilmesinin, tür ve cinslerin taksonomik sınıflandırmasının yanı sıra modern bitki bilimine katkı sağlayacağı açıktır.

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Comparative anatomy and achene micromorphology assessment of two *Cousinia* Cass. (*Asteraceae*) species in view of taxonomy

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Abstract

Cousinia is a member of the monophyletic tribe Cardueae, which is traditionally subdivided into four taxonomic groups; however, the rank and boundaries of these taxa are highly controversial. The purpose of this study was to contribute to the genus taxonomy by determining the comparative anatomical and achene micromorphological features of *C. aintabensis* Boiss. & Hausskn. and C. *birecikensis* Hub.-Mor. that are morphologically similar to each other. In anatomical studies, stem, leaf, and midrib features were determined. Paraffin embedding, microtome sectioning, and safranin-fast green staining were used for the samples. The obtained sections were photographed, and the leaf, stem, and midrib characters were measured. The importance of anatomical characters between species was determined by applying Independent sample T-test test to quantitative characters. In addition, box plot and heatmap analyses of the studied species were carried out. Our results showed that the stem epidermis, inner sclerenchyma and phloem layer; For leaves; lower and upper epidermis mesophyll thickness, palisade parenchyma; In midrib; number of vascular bundles, collenchyma, and phloem are important characters that can be used in the differentiation of species. SEM microscope was used for achene micromorphological examinations. *C. aintabensis* achene surface ornamentation is identified as striate-retipylate. It was observed that *C. birecikensis* had striate and irregular reticulate-faveolate surface ornamentation.

Keywords: *Asteraceae*, Anatomy, *Cousinia*, micromorphology, Türkiye

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Taksonomik açıdan iki *Cousinia* türünün anatomik ve aken mikromorfolojik karşılaştırlması ve değerlendirilmesi

Özet

Cousinia, geleneksel olarak dört taksonomik gruba ayrılan monofiletik Cardueae tribusunun bir üyesidir; ancak bu taksonların sıralaması ve sınırları oldukça tartışmalıdır. Bu çalışma morfolojik olarak birbirine benzeyen *C. aintabensis* Boiss. & Hausskn. ve *C. birecikensis* Hub.-Mor. türlerinin karşılaştırmalı anatomik ve aken mikromorfolojik özellikleri belirlenerek cinsin taksonomisine katkı sağlamak amacıyla gerçekleştirilmiştir. Anatomik çalışmalarda gövde, yaprak ve orta damar özellikleri tespit edilmiştir. Örnekler için parafine gömme, mikrotomla kesit alma ve safranin-fast green boyama yöntemi uygulanmıştır. Elde edilen kesitler fotoğraflanıp yaprak, gövde ve orta damar karakterlerinin ölçümleri yapılmıştır. Nicel karakterlere bağımsız örneklem T-testi uygulanarak türler arasındaki anatomik karakterlerin önemi belirlenmiştir. Ayrıca çalışılan türler ile ilgili box plot ve heat map analizleri gerçekleştirilmiştir. Sonuçlarımız gövde epidermis, içteki sklerankima ve floem tabakası, yaprak için alt ve üst epidermis, mezofil kalınlığı, palizad parenkiması, orta damarda ise iletim demeti sayısı, kollenkima ve floem özellikleri bakımından türlerin ayrımında kullanılabilecek önemli karakterler olduğu belirlenmiştir. Aken mikromorfolojik incelemeler için SEM mikroskobu kullanılmış. *C. aintabensis* türü aken yüzeyi süsü striat-retipilat olarak belirlenmiştir. *C. birecikensis* türünde ise striat ve düzensiz retikulat-faveolat yüzey süsüne sahip olduğu görülmüştür.

Anahtar kelimeler: *Asteraceae*, Anatomi, *Cousinia*, Mikromorfoloji, Türkiye

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1. Introduction

The genus *Cousinia* (*Asteraceae*, *Cardueae*) is the third largest genus of the *Asteraceae* family after *Senecio* and *Vernonia* and the largest genus of the Cardueae tribe [1; 2; 3; 4] and is the largest of the flowering plants. It is among the 50 genera (5). There are roughly 700 species in this genus, which is found throughout Central and Western Asia. *Cousinia* has a high percentage of endemic species and is a typical genus for the Irano-Turanian region [6].

The genus *Cousinia* is part of the monophyletic tribus *Cardueae*, which is usually divided into four taxonomic groups. However, the distinction within the tribus is quite problematic [7; 4].

The *Arctium-Cousinia* complex and the genus *Arctium* L. are both included in the non-monophyletic genus *Cousinia* [8; 9].

The genus *Cousinia* was described by Huber-Morath in the Flora of Turkey. In Turkey, this genus is represented by a total of 38 species in 6 sections, and 26 of them are endemic. According to the list of plants of Turkey, there are 39 species in our country [10]. With the newly described species (*Cousinia agridaghensis* Tugay, Ertuğrul & Ulukuş), the number of taxa in the genus *Cousinia* has reached 40 in Turkey [11].

Due to the wide morphological variability in the genus, the taxonomy of *Cousinia* is complex and controversial [12]. In their anatomical study of 14 species belonging to the *Cousinia* sect. *Serratuloideae*, [13] stated that these species can be divided taxonomically according to the midrib and leaf structure. Recent anatomical and achene micromorphological studies on the genus [14, 15; 16; 17] have emphasized the importance of midripetal anatomy for the genus *Cousinia*.

The genus *Cousinia* is divided into 70 sections in the world, the largest of which is the *Cynaroideae* Bunge section with 89 species [1]. There are a total of 8 species, 4 of which are endemic, in the *Cousinia* genus sect. *Cynaroideae* in Turkey [18].

In systematic study of the section *Cynaroideae*, It has also been done in molecular and palynological studies. [19] aimed to use pollen characteristics in determining and defining species boundaries. [20] investigated the molecular phylogenetic relationships of 50 *Cousinia* species belonging to the section *Cynaroideae* distributed in Iran. There is only one study of *Cynaroideae* anatomy, and [21] studied the leaf, stem, and root anatomy of *C. mobayenii*.

Even after molecular studies [8, 21, 9, 12], it is still not clear how to identify and define species, how to group them into sections, and how they are related to each other.

In this study, it was aimed to determine these characteristics of *C. aintabensis and C. birecikensis*, whose anatomical and achene micromorphological features have not been determined until now, and to contribute to the use of these characters in the taxonomy of the genus.

2. Materials and methods

The materials utilized in this investigation were photographed and gathered from their distribution locations. For anatomical studies, live tissue was stored in 70% ethanol. Using the paraffin technique, we slice cross-sections of the stems and leaves. Using a Leica RM2125RT rotary microtome, sections between 5 and 12 µm thick were cut from paraffin wax-embedded materials. The safranin-fast green stain was used on all parts before they were mounted in Entellan [22]. The measurements and images were captured using a Leica DM1000 binocular light microscope and a Leica DFC280 camera.

At least 30 cell measurements were recorded, and the minimum, mean, maximum, and standard deviation were determined, so that stem, leaf and midrib anatomy could be compared based on cell size (Table 1). R 4.1.2 software was utilized for all statistical tests [23]. The stem, leaf and midrib features of each species were measured quantitatively, and box plots were provided (Figure 7,8,9). The heat map was created by using the cluster method (R 4.1.2 with library pheatmap) of the anatomical features of the species (Figure a). Independent sample T-test were used to assess the statistical significance of quantitative stem, midrib and leaf features (R 4.1.2). P-values <0.05 were regarded statistically significant (Table 2).

The texture of the achene coat was analyzed using scanning electron micrographs. In order to explain the scanning electron microscopy (SEM) features of the achene coat, we used the terminology of [24].

3. Results

Along with the anatomical features of the species, micromorphological studies of the achenes and photos of the species features were also given (Fig. 1).

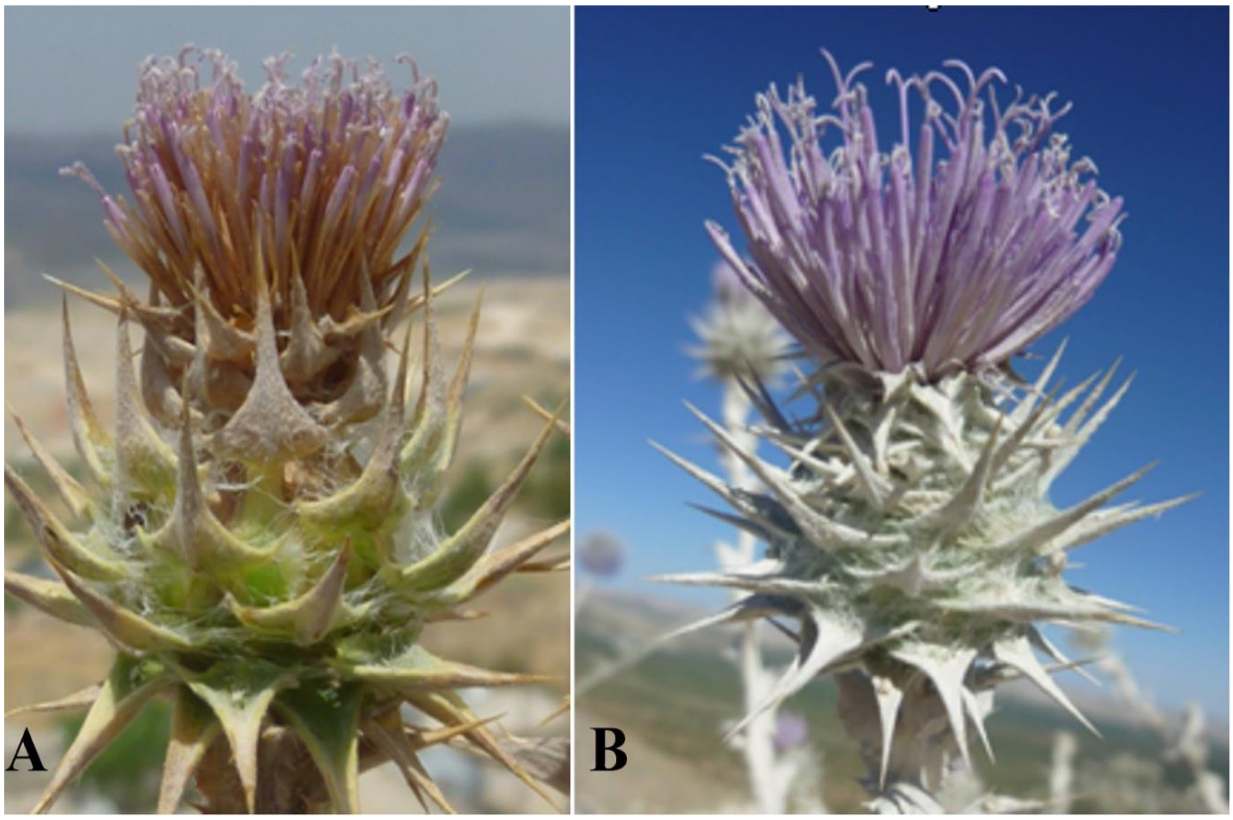

Figure 1. Photographs of studied *Cousinia aintabensis* (A) and *C. birecikensis* (B)

3.1. Anatomical properties

Stem
C. aintabensis

The *C. aintabensis* stem has a roughly round cross-section. The epidermis includes a single layer of cuticle-covered, oval or rectangular-shaped cells. Ovate, rectangular, and orbicular parenchymatous cells make up the cortex (9,88-74,07 µm), which has 8-11 layers. Sclerenchymatous cells surround the phloem. The thickness of sclerenchymatous fibers is between 26,08 and 156,50 above the external phloem and between 17,39 and 191,30 µm above the internal phloem. The cambium is not easily identifiable. Phloem dimensions are between 27,32 and 67,08 µm. It's estimated that the xylem ranges in size from 55,07 to 243,40 µm. There are many elliptical vascular bundles. The pith is made up of large parenchymatous cells that can be hexagonal, polygonal, or round (Table 1, Fig. 2A–B).

C. birecikensis

The *C. birecikensis* stem has a roughly round cross-section. The epidermis includes a single layer of cuticle-covered, oval or rectangular-shaped cells. Ovate, rectangular, and orbicular parenchymatous cells make up the cortex (14,46-35,74 µm), which has 6-9 layers. Sclerenchymatous cells surround the phloem. The thickness of sclerenchymatous fibers is between 65,18 and 133,30 µm above the external phloem and between 23,70 and 154 µm above the internal phloem. The cambium is not easily identifiable. Phloem dimensions are between 10,63 and 53,19 µm. It's estimated that the xylem ranges in size from 56,29 to 257,70 µm. There are many elliptical vascular bundles. The pith is made up of large parenchymatous cells that can be hexagonal, polygonal, or round (Table 1, Fig. 2C–D).

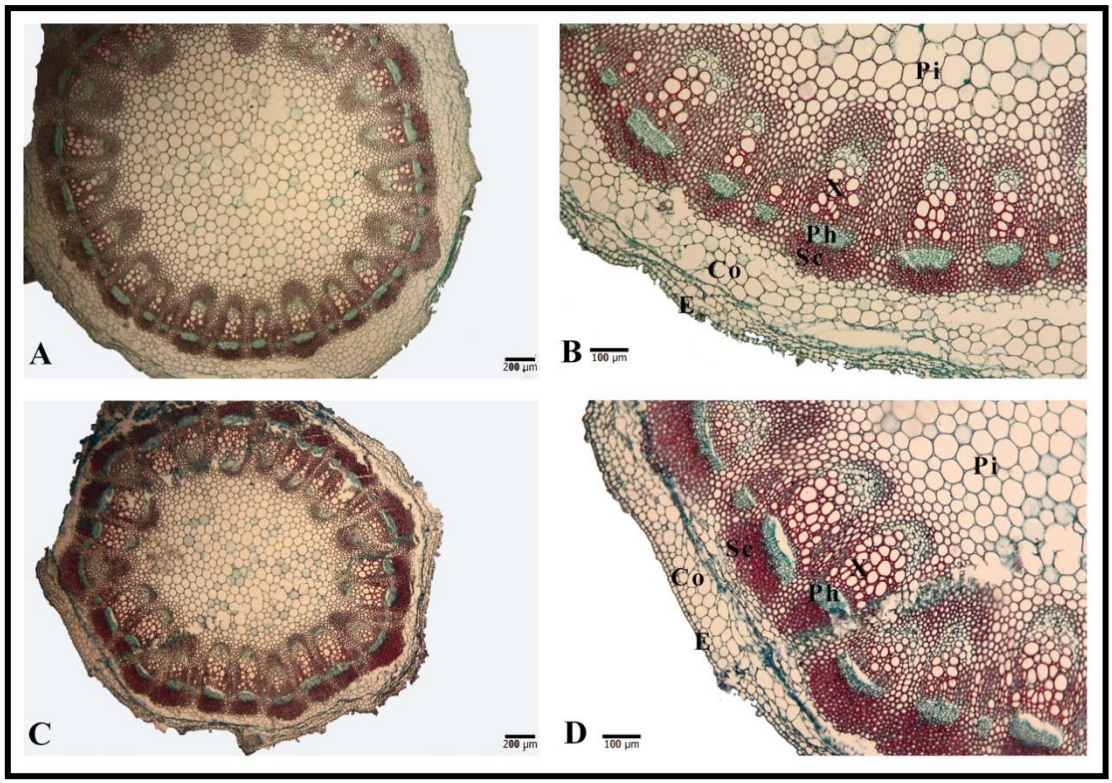

Figure 2. Transverse section of the stem; (A, B) *Cousinia aintabensis*, (C, D) *C. birecikensis*. (E epidermis, Co cortex, Sc sclerenchyma, Ph phloem, X xylem, Pi pith region)

Leaf

C. aintabensis

Lamina transverse sections of *C. aintabensis* reveal that the upper and lower epidermis are coated with a thin cuticle layer and eglandular hairs. Each epidermis is made up of a mix of uniseriate oval and rectangular cells. The mesophyll (178–205,60 µm) is composed of elongated palisade and spongy parenchyma cells. Palisade parenchyma is 1–2-rowed under the upper epidermis and 1-rowed under the lower epidermis. Spongiose cells can be round, irregular, compact, or cubic in shape (Table 1, Fig. 3A–B).

C. birecikensis

Transverse sections of the lamina of *C. birecikensis* show that the upper and lower epidermises have a thin layer of cuticle and eglandular hairs. Each epidermis is made up of a mix of uniseriate oval and rectangular cells. The mesophyll (227,50–312,80 µm) is composed of elongated palisade parenchyma cells. Palisade parenchyma is 1–2-rowed under the upper epidermis and 1-2-rowed under the lower epidermis. Spongiose cells can be round, irregular, compact, or cubic in shape (Table 1, Fig. 3C–D).

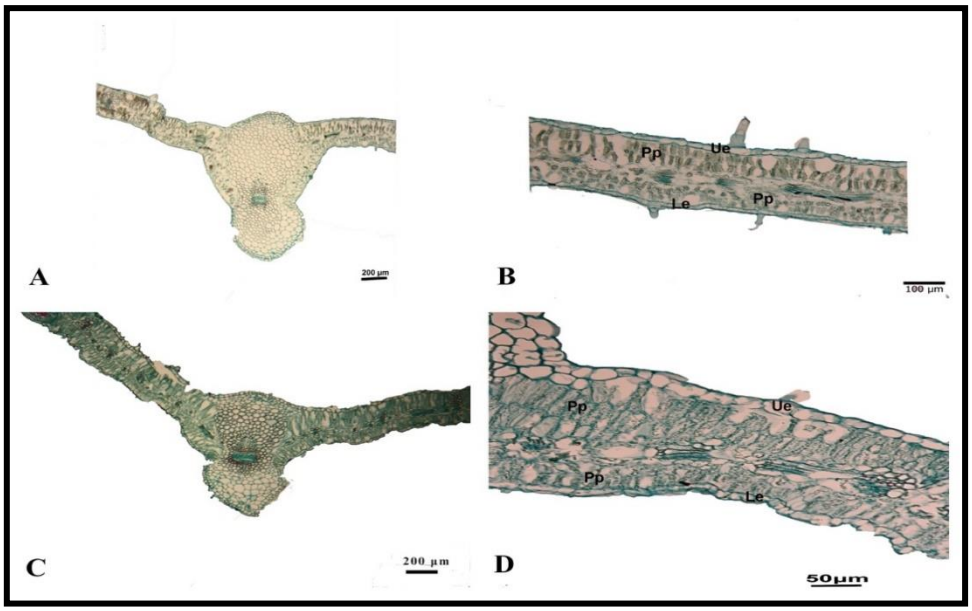

Figure 3. Transverse section of the lamina; (A, B) *Cousinia aintabensis*, (C, D) *C. birecikensis*. (Le lower epidermis, Pp palisade parenchyma, Ue upper epidermis).

Midrib

C. aintabensis

In the cross-sections of the leaf, there are six vascular bundles and a roughly semicircular midrib. One major vascular bundle is located in the middle, and it is encased by a parenchymatic bundle sheath on all sides. A tangential pattern is formed by the collenchyma beneath the lower epidermis. The thickness of the collenchyma beneath the lower and upper epidermis is 282,30-1011 µm and 382,30-900 µm, respectively (Table 1, Fig. 4A–B).

C. birecikensis

In the cross-sections of the leaf, There are nine vascular bundles and a roughly semicircular midrib. One major vascular bundle is located in the middle, and it is encased by a parenchymatic bundle sheath on all sides. A tangential pattern is formed by the collenchyma beneath the lower epidermis. The thickness of the collenchyma beneath the lower and upper epidermis is 38,29-868 µm and 76,59-578,70 µm, respectively (Table 1, Fig. 4C–D).

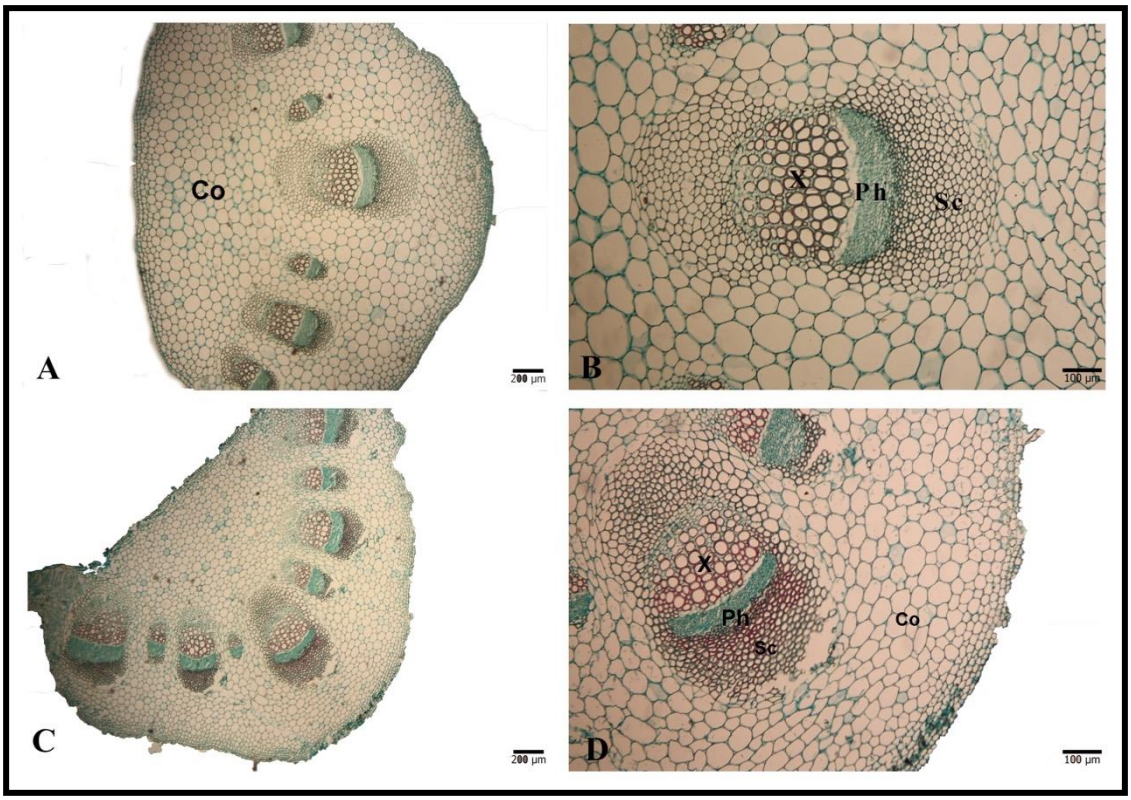

Figure 4. Transverse section of the midrib; (A, B) *Cousinia aintabensis*, (C, D) *C. birecikensis*. (Co collenchyma, Ph phloem, Sc sclerenchyma, X xylem).

TABLE 1. Comparative anatomy of the, stem, leaves and midrip *C. aintabensis* and *C. birecikensis.* Abbreviations: Mean: Average, SD: Standart deviation, Min: Minimum, Max: Maximum, µm: Micrometer

		C. aintabensis				*C. birecikensis*			
		Width (µm)		Length (µm)		Width (µm)		Length (µm)	
		min-max	mean± SD	min-max	mean± SD	min-max	mean ± SD	min-max	mean ± SD
Stem	Epidermis cell	7,41 - 28,39	15,76 ± 6,28	1,23 - 28,38	14,40± 6,61	4,79 - 23,93	9,48± 4,09	4,79 -12,23	7,96 ± 1,89
	Cortex cell	9,88 - 74,07	36,11 ± 18,10			14,46 - 35,74	24,68 ± 5,32		
	Outer sclerenchyma layer	26,08 - 156,50	86,92 ± 34,24			65,18 - 133,30	101,01 ± 19,75		
	Inner sclerenchyma layer	17,39 -191,30	96,93 ± 48,14			23,70 - 154,00	73,66 ± 31,95		
	Phloem layer	27,32 - 67,08	43,66 ± 9,49			10,63 - 53,19	30,99 ± 9,27		
	Xylem layer	55,07 - 243,40	150,41 ± 60,53			56,29 - 257,70	169,93 ± 53,89		
	Pith	9,37 - 111,80	54,32 ± 28,84			13,82 - 75,53	53,04± 13,81		
Leaf	Upper epidermis	15,85 – 89,28	41,07 ± 16,76	12,19 - 50,00	28,78 ± 9,61	11,55 - 41,77	21,71± 6,71	8,00 - 42,66	21,39 ± 9,23
	Lower epidermis	6,50 - 18,69	11,97 ± 3,76	7,32 - 16,26	10,46± 2,39	8,89- 44,44	21,77 ± 7,28	8,89 - 24,00	15,46 ± 3,57
	Mesophyll	178,00 - 205,60	192,50 ± 8,59			227,50 - 312,80	268,63± 21,87		
	Palisade parenchyma	8,87 - 17,07	12,17± 2,23	13,00 - 45,52	29,64 ± 8,42	8,00 - 23,11	16,14 ± 3,55	32,88 - 82,66	49,92 ± 9,60
Midrib	Upper collenchyma	282,30 - 1011,00	751,69 ± 214,71			38,29 - 868,00	454,28 ± 242,63		
	Lower collenchyma	382,30 - 900,00	569,56 ± 144,73			76,59 - 578,70	325,48± 129,51		
	Upper sclerenchyma	35,29 - 223,50	103,90 ± 65,40			25,53 - 161,70	97,70 ± 37,68		
	Lower sclerenchyma	41,17 - 258,80	97,05 ± 76,20			25,53 - 161,70	95,99 ± 38,16		
	Phloem layer	47,05 - 105,80	41,17 - 258,80			46,80 - 106,30	72,04 ± 17,61		
	Xylem layer	94,11 - 258,80	158,79 - 59,43			46,80 - 204,20	144,92 ± 49,65		

3.2. Achene micromorphology

C. aintabensis
Achenes are broadly obovate prominent margins at the wrinkled end and clearly toothed. Their achene surface pattern is striate and retipilate (Fig. 5A–B).

C. birecikensis
Achenes are oblong-obovate with prominent margins at the wrinkled end and are not clearly toothed. Their achene surface pattern is striate and irregularly reticulate-faveolate (Fig. 5C–D).

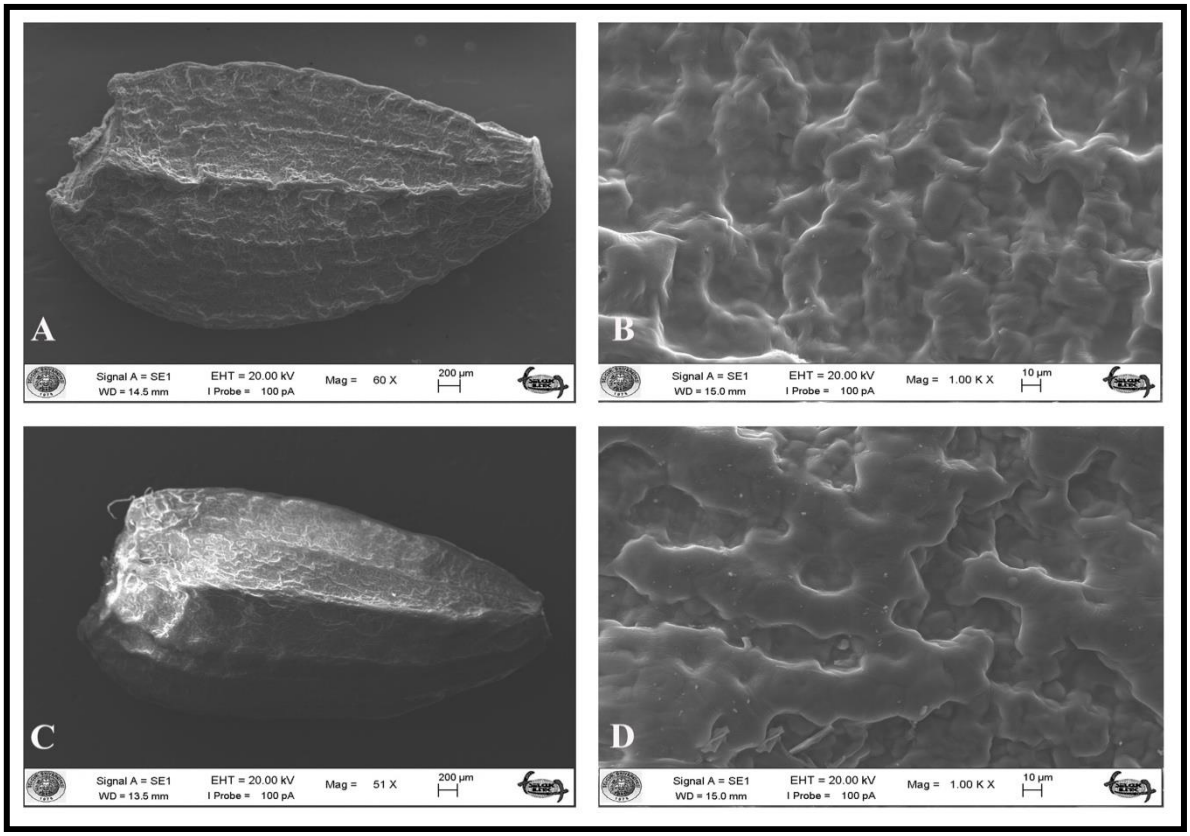

Figure 5. SEM micrographs of achenes of *Cousinia* species; (A, B), *Cousinia aintabensis*, (C, D) *C. birecikensis.*

3.3. Statistical analysis

According to the heatmap analyses made with the anatomical features of the stem, leaf, and midrib. *C. birecikensis* is clustered in terms of features such as leaf lower epirdemis, palisade parenchyma, and mesophyll thickness (Figure 6).

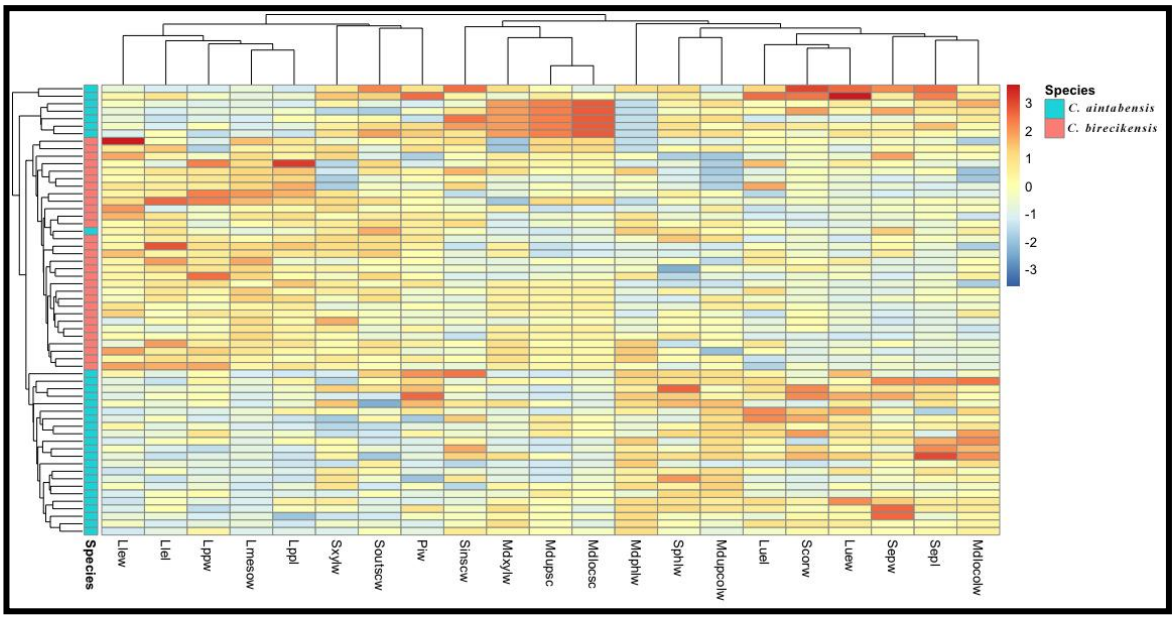

Figure 6. Heatmap for examined *Cousinia* species

Independent sample T-test show that stem epidermal cell length and width, cortex cell width, inner schylerenchyma width, and phloem layer width are all substantially different between *C. aintabensis* and *C. birecikensis* (Table 2, P<0.05). All of the leaf features used in this study were shown to be significant for the *C.aintabensis* and C. *birecikensis* (Table 2, P<0.05). *C. aintabensis* and *C. birecikensis* were significantly different from each other in terms of the midrib upper and lower collenchyma width, and phloem width (Table 2, P<0.05).

Table 2. Independent sample T-test based on the anatomical characters of the studied species

	Characteristics	*C. aintabensis-C. birecikensis*
Stem	Sepw	P< 0.05 *
	Sepl	P< 0.05 *
	Scorw	P< 0.05 *
	Soutscw	P>0.05 NS
	Sinscw	P< 0.05 *
	Sphlw	P< 0.05 *
	Sxylw	P>0.05 NS
	Piw	P>0.05 NS
Leaf	Luew	P< 0.05 *
	Luel	P< 0.05 *
	Llew	P< 0.05 *
	Llel	P< 0.05 *
	Lmesow	P< 0.05 *
	Lppw	P< 0.05 *
	Lppl	P< 0.05 *
Midrib	Mdupcolw	P< 0.05 *
	Mdlocolw	P< 0.05 *
	Mdupscw	P>0.05 NS
	Mdloscw	P>0.05 NS
	Mdphlw	P< 0.05 *
	Mdxylw	P>0.05 NS

NS = non-significant. * Significant at the level of 0.05.

Sepw: epidermis cell width of stem, Sepl: epidermis cell length of stem, Scorw: cortex cell width of stem, Soutscw: outer schylerenchyma width of stem, Sinscw: inner schylerenchyma width of stem, Sphlw: phloem width of stem, Sxylw: xylem width of stem, Piw: pith cell width of stem, Luew: upper epidermis width. Luew: upper epidermis width of leaf, Luel: upper epidermis length of leaf, Llew: lower epidermis width of leaf, Llel: lower epidermis length of leaf, Lmesow: mesophyll width, Lppw: palisade parenchyma cells width, Lppl: palisade parenchyma cells length. Mdupcolw: upper collenchyma width of midrib, Mdlocolw: lower collenchyma width of midrib, Mdupscw: upper schylerenchyma width of midrib, Mdloscw: lower schylerenchyma width of midrib, , Mphlw: phloem width of midrib, Mxylw: xylem width of midrib.

The results of the independent t-test were consistent with the results of the box plots. The mean trends of the stem (epidermis, schylerenchyma, and phloem layer), midrib (collenchyma, and phloem layer), and all leaf characters revealed significant differences between the taxonomic pairs (Table 2, Figs. 7-9).

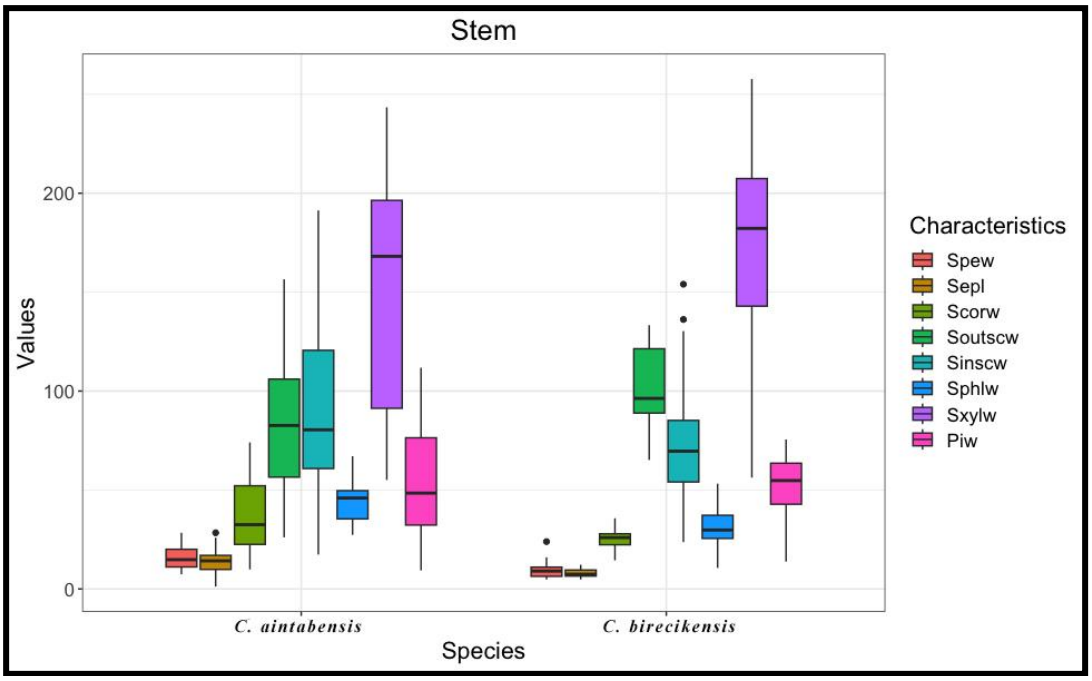

Figure 7. Box plots of examined stem characters

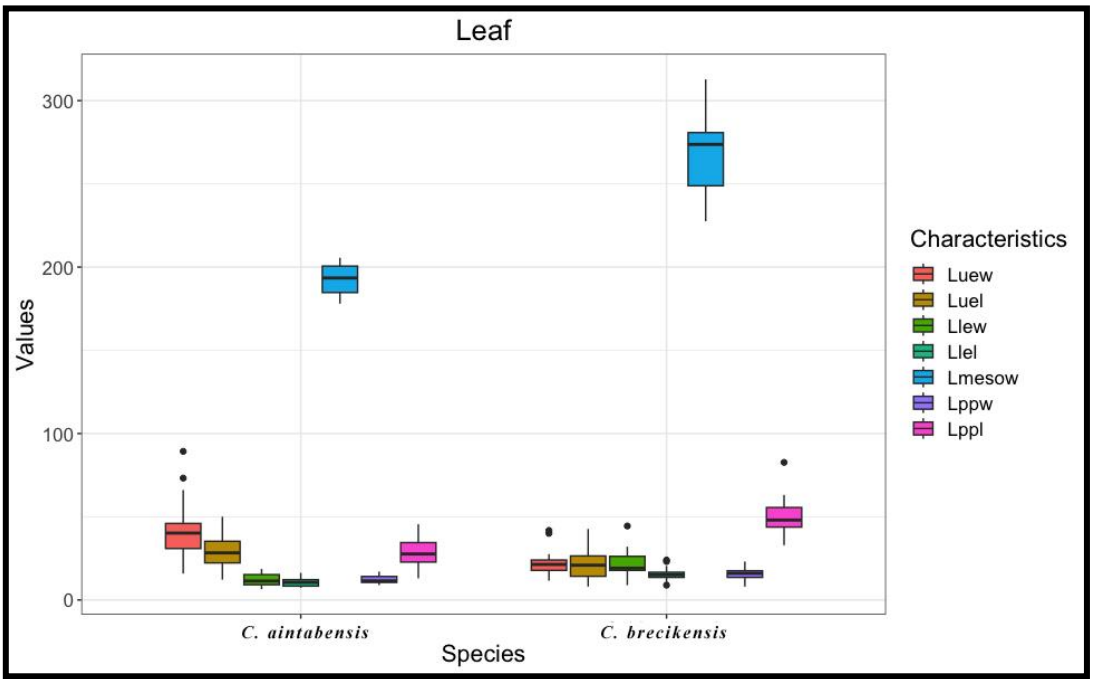

Figure 8. Box plots of examined leaf characters

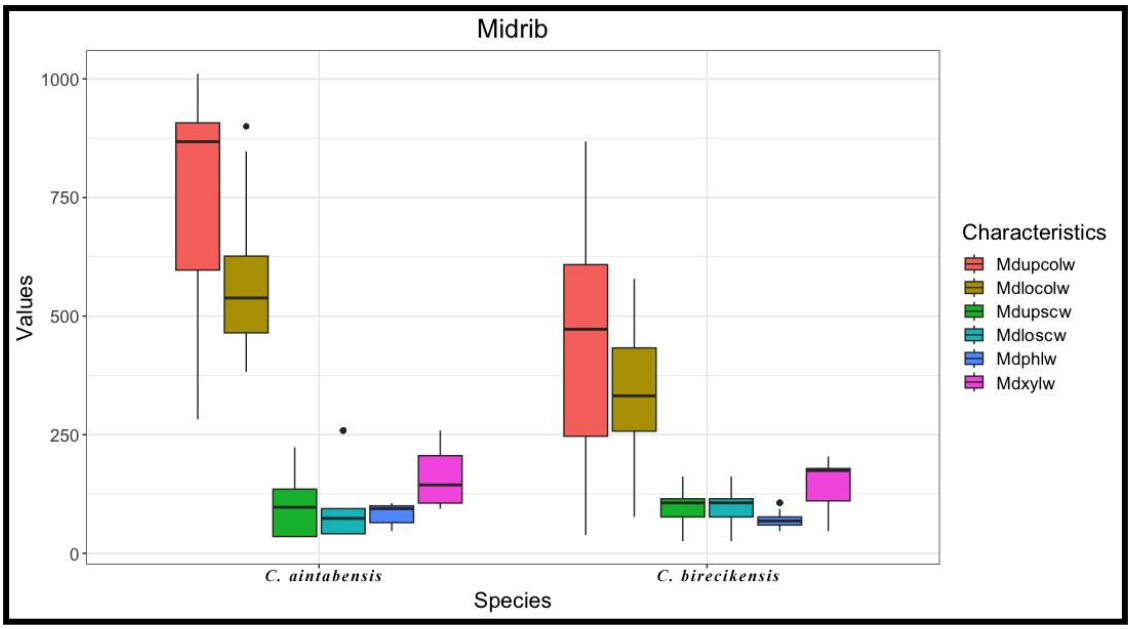

Figure 9. Box plots of examined midrib characters

4. Conclusions and Discussion

According to the stem anatomy results, the size of the epidermis cells, cortex layers, inner schylerenchyma, and phloem are taxonomically significant characters (Table 1). Moreover, it has been found that all anatomical characteristics of the leaves are significant taxonomic characters in distinguishing the investigated species (Table 1). According to midrib anatomy, the collenchyma and phloem characteristics of the examined species are important taxonomic characters (Table 1).

The findings of the study, which were obtained by anatomical, and achene micromorphological examinations, were analyzed and discussed with reference to the relevant literature. According to the literature, some anatomical studies have been done recently on the genus *Cousinia*. In these studies, [11] studied the stem and leaf midrib anatomy of *C. urumiensis* Bornm. and *C. agridaghensis*. In terms of the anatomy of the stem, leaf, and midrib, our findings partially concur with their conclusions. [14] reported that the midrib shape of *C. halysensis* Hub.-Mor. was semi-circular, and the number of vascular bundles was 10. [25] stated that *C. decolarans* Freyn & Sint. have 3 vascular bundles in the midrib. In our study, the midrib shape was also semicircular, but in the midrib, the number of vascular bundles was 6 in *C. aintabensis* and 9 in *C. birecikensis*, respectively. According to [15, 21], the mesophyll type is bifacial in leaf anatomy. In our study, we observed that all species examined have equifacial leaves. [11], [14], and [25] reported that midrib shape and the number of vascular bundles are important taxonomic characters. Our findings showed that they were consistent with theirs.

In the micromorphological examinations of achene belonging to the *Cousinia* genus, *C. iconica* Hub.-Mor. is reticulate-sitriate [15], *C. agridaghensis* and *C. urumiensis* are reticulate-faveolate [11], *C. boissieri* Buhse is reticulate [26], and *C. decolorans* is retipilate [25] (surface ornaments were encountered). According to our study, we observed that *C. aintabensis* seeds were retipilated, while *C. birecikensis* seeds were reticulate-faveolate. We predict that these variations in achene surface ornamentation will serve as a useful criterion for distinguishing species within the genus.

In this study, a total of eight stem, seven leaf, and six midrib anatomical characters were evaluated for their taxonomic significance in relation to *C. aintabensis* and *C. birecikensis*. The present study verified that comparative root and leaf anatomical traits can be used as an additional tool for correct species identification and to clarify the taxonomy of *C. aintabensis* and *C. birecikensis*. This study demonstrated that comparing stem, leaf, and midrib anatomical features can be utilized as an additional tool for accurate species identification and to clarify the taxonomy of *C. aintabensis* and *C. birecikensis*. In particular, the transverse section of the leaf displayed a remarkable amount of significant variation. Hence, the anatomical characteristics of the leaf have a greater potential for use in taxonomy than the stem or the midrib.

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We would like to extend our gratitude for the financial support provided by the Scientific and Technological Research Council of Turkey (TÜBTAK-TBAG Project No. 111T364). We want to express our gratitude to the curators of the herbaria AEF, ANK, E, G, GAZI, HUB, ISTE, ISTF, K, and LE who gave us permission to examine the *Cousinia* specimens in their collections.

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Research on Ephemeroptera (Insecta) fauna of Aydın and Denizli (Türkiye) provinces

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Abstract

Although studies on the order Ephemeroptera are at a sufficient level in many of the provinces in the Aegean region, there is no comprehensive study on the provinces of Aydın and Denizli. Until now, four species from Aydın and two species from Denizli province have been reported from the Ephemeroptera order. The research being done in these provinces, which are the study regions, aims to fill in the gaps in the Aegean Area and provide more precise information about the national Ephemeroptera fauna.

With the aid of sieves and water scoops, nymphs were gathered from the habitats of each locality's various biological characteristics during the field experiments, which were conducted in 25 different locations throughout two provinces. Thirteen species were recognized after examination of the 1177 collected specimens.

In the study, five of the species identified from Aydın province and 12 of the species identified from Denizli province were recorded for the first time from the related provinces within the research area.

Keywords: Ephemeroptera, fauna, Aegean district, Türkiye

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Aydın ve Denizli (Türkiye) illeri Ephemeroptera (Insecta) faunası üzerine araştırmalar

Özet

Ege bölgesinde bulunan illerin birçoğunda Ephemeroptera takımı ile ilgili çalışmalar yeterli sayılabilecek düzeyde olmasına rağmen Aydın ve Denizli illeri ile ilgili yapılmış kapsamlı bir çalışma bulunmamaktadır. Ephemeroptera takımından günümüze kadar Aydın ilinden 4, Denizli ilinden ise 2 tür bildirilmiştir. Araştırma alanı olan bu illerde gerçekleştirilen çalışma ile Ege Bölgesi'ndeki eksikliklerin tamamlanması ve dolayısıyla ülkemizin Ephemeroptera faunası hakkında daha net verilerin ortaya konması amaçlanmıştır.

Arazi çalışmaları, iki ilden 25 farklı lokaliteden gerçekleştirilmiş ve her bir lokalitenin farklı ekolojik özelliklere sahip habitatlarından elek ve su kepçesi yardımıyla larvalar toplanmıştır. Toplanan 1177 örneğin teşhisi yapılmış ve 13 tür tespit edilmiştir.

Çalışmada Aydın ilinden tespit edilen türlerden 5 tanesi; Denizli ilinden tespit edilen türlerin ise 12 tanesi araştırma bölgesi içerisinde kalan ilgili illerden ilk kez tespit edilmişlerdir.

Anahtar kelimeler: Ephemeroptera, fauna, Ege bölgesi, Türkiye

1. Introduction

The Ephemeroptera order, which dates to the late Carboniferous or Permian periods, contains the earliest known primitive flying insects (approx. 290 million years ago) [1, 2].

Since they have a winged, immature stage known as the subimago, they stand apart from other insects. Ephemeroptera spend the most of their life cycles in water, and this period is the nymphal period with the highest morphological diversity as a result of their adaptation to different habitats in the water [3].

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The order Ephemeroptera is one of the significant groups investigated in zoogeographic studies due of the characteristics that limit their distribution, like as their extremely short adult lifespans, poor flying abilities during this time, and the fact that their nymphs are entirely aquatic [4].

Even though mayflies can be found in practically all sorts of freshwater habitats, each species in the order Ephemeroptera has a limited tolerance range and is extremely sensitive to organic contamination, which is why Ephemeroptera species are frequently utilized in water quality assessments. As a result of this, they have an important role in many biotic indices prepared [5]. Although it is recommended to use taxa at the species level in determining the water quality [6]; it is known that the Baetidae and Caenidae were highly tolerant to organic pollution, while the Heptageniidae, Ephemerellidae, and Leptophlebiidae families were considered as intolerant [7, 8, 9]. In addition, they are distributed in almost all fresh waters, can take toxic substances homogeneously with their different feeding habits, and gradual and long-term reactions to environmental changes provide a very important advantage in their usage as a bioindicator [10].

Although the studies on the Ephemeroptera fauna in the Aegean Region are at a level that can be considered sufficient in many provinces, there is no comprehensive study in Aydın and Denizli provinces. With this preliminary study carried out in these provinces, it was aimed to complete these deficiencies in the Aegean Region and to contribute the Ephemeroptera fauna of Türkiye.

2. Materials and methods

This study was carried out in 25 localities determined in Aydın and Denizli provinces between 27-30 June 2022 (Figure 1). In the field studies, sampling was made from areas with different ecological characteristics (stony or sandy ground structure, flow rate, presence of aquatic vegetation, clarity of water, etc.) in each locality. Larval specimens were collected using a sieve with 1mm mesh and water hand net from freshwater habitats and taken into sampling bottles containing 96% ethyl alcohol and values such as date, locality, altitude, and GPS coordinates were recorded (Table 1).

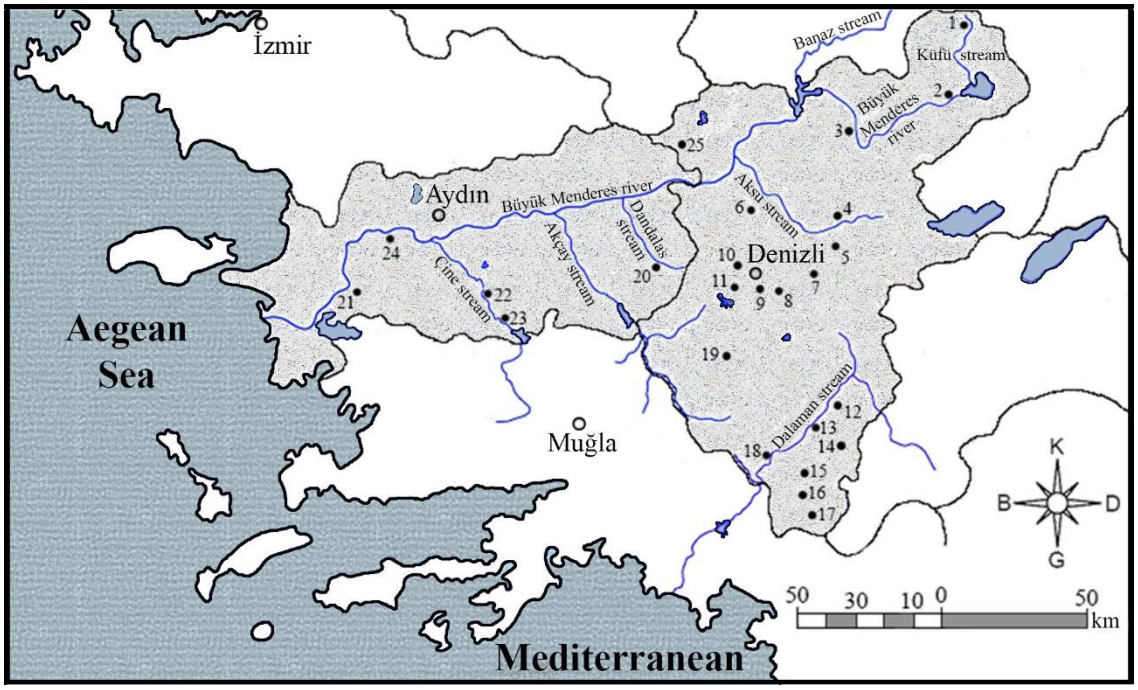

Figure 1. The geographical location of the study area and the sampling stations

All morphological and taxonomic features of the collected larvae were evaluated and microscope slides of taxonomic characters were prepared and identified. They were identified at the species level using references that Grandi (1960), Müller-Liebenau (1969), Belfiore (1983), Malzacher (1984), Elliott et al. (1988), Harker (1989), Hefti et al. (1989), Studemann et al. (1992), Novikova & Kluge (1994), Bauernfeind (1995), Kluge (1997), Eiseler (2005), Gattolliat & Sartori (2008), Bauernfeind & Soldán (2012), and Godunko et al. (2015) [11-25].

Leica MZ12.5 stereomicroscope and Leica DM LS2 microscope were used to examine samples and microscope slides. Examined larvae are labeled and kept as museum specimens in ESTU Zoology Museum, Eskişehir Technical University, Faculty of Science, Department of Biology.

Table 1. General information of sampling stations

Station	Location Name	Geographic Coordinates (N, E)	Elevation a.s.l (m)
1	Çağlayan village	38°20'53.6", 29°50'19.8"	870
2	Seraserli district	38°12'49.1", 29°49'15.2"	817
3	Hançalar bridge	38°07'53.8", 29°26'00.0"	676
4	Başçeşme village	37°49'53.2", 29°33'01.1"	785
5	Çambaşı village	37°46'47.5", 29°31'06.5"	720
6	Kaklık cave	37°51'20.5", 29°23'07.4"	518
7	Pınarbaşı Göz picnic ground	37°45'16.3", 29°14'47.8"	500
8	Gökpınar village	37°44'34.8", 29°09'44.3"	419
9	Gökpınar village	37°44'47.7", 29°09'21.8"	405
10	Karakurt village	37°46'21.0", 29°08'09.0"	347
11	Kayıhan village	37°45'29.3", 29°08'20.2"	364
12	Akşar village	37°12'43.2", 29°16'22.8"	798
13	Gölcük village	37°10'03.8", 29°12'57.2"	743
14	Yaylapınar village	37°08'33.6", 29°14'54.4"	1290
15	Kolak (Kusur) Lake	37°04'56.2", 29°11'40.5"	932
16	Sarıkavak village	37°01'49.8", 29°11'35.9"	710
17	Kirazlıyayla village	36°59'02.2", 29°12'26.1"	818
18	Sandalcık village	37°05'40.7", 29°06'08.0"	607
19	Medet village	37°30'42.2", 29°01'07.2"	900
20	Karacasu village	37°44'31.2", 28°37'33.6"	346
21	Bağarası village	37°43'00.3", 27°33'17.5"	17
22	Çaltı bridge	37°39'01.7", 28°00'00.6"	49
23	Eski Çine district	37°32'32.4", 28°03'45.4"	68
24	Koçarlı district	37°45'24.1", 27°41'28.0"	45
25	Buldan Yayla Lake	37°32'32.4", 28°03'45.4"	1158

3. Results

In this study, 1177 specimens belonging to six families, seven genera, and 13 species were identified from 25 collecting sites. Sampling data and the number of collected individuals per each species are given below:

List of Taxa
Baetidea Leach, 1815
***Baetis* Leach, 1815**
Baetis (Baetis) buceratus Eaton, 1870
Material examined: Loc-1, 28.06.2022, 4 larvae; Loc-3, 28.06.2022, 13 larvae; Loc-5, 28.06.2022, 18 larvae; Loc-6, 28.06.2022, 63 larvae; Loc-7, 28.06.2022, 3 larvae; Loc-8, 28.06.2022, 12 larvae; Loc-12, 29.06.2022, 2 larvae; Loc-13, 29.06.2022, 5 larvae; Loc-16, 29.06.2022, 5 larvae; Loc-18, 29.06.2022, 6 larvae; Loc-20, 29.06.2022, 19 larvae; Loc-22, 30.06.2022, 15 larvae; Loc-23, 30.06.2022, 1 larva.

Baetis (Baetis) fuscatus (Linnaeus, 1761)
Material examined: Loc-16, 29.06.2022, 5 larvae; Loc-18, 29.06.2022, 22 larvae; Loc-22, 30.06.2022, 2 larvae.

Baetis (*Baetis*) *lutheri* Müller-Liebenau, 1967
Material examined: Loc-5, 28.06.2022, 6 larvae; Loc-7, 28.06.2022, 3 larvae; Loc-12, 28.06.2022, 1 larva; Loc-13, 29.06.2022, 1 larva; Loc-17, 29.06.2022, 24 larvae.

Baetis (Baetis) nexus Navás, 1918
Material examined: Loc-1, 28.06.2022, 14 larvae; Loc-2, 28.06.2022, 15 larvae; Loc-3, 28.06.2022, 41 larva; Loc-5, 28.06.2022, 6 larvae.

Baetis (Baetis) vernus Curtis, 1834

Material examined: Loc-1, 28.06.2022, 40 larvae; Loc-3, 28.06.2022, 4 larvae; Loc-5, 28.06.2022, 19 larvae; Loc-6, 28.06.2022, 6 larvae; Loc-8, 28.06.2022, 2 larvae; Loc-12, 29.06.2022, 60 larvae; Loc-17, 29.06.2022, 3 larvae; Loc-20, 29.06.2022, 36 larvae; Loc-22, 30.06.2022, 25 larvae.

Baetis (*Rhodobaetis*) *rhodani* (Pictet, 1843)
Material examined: Loc-5, 28.06.2022, 27 larvae; Loc-7, 28.06.2022, 18 larvae; Loc-8, 28.06.2022, 2 larvae; Loc-12, 29.06.2022, 13 larvae; Loc-14, 29.06.2022, 50 larvae; Loc-16, 29.06.2022, 92 larvae; Loc-17, 29.06.2022, 99 larvae; Loc-18, 29.06.2022, 10 larvae; Loc-22, 30.06.2022, 2 larvae.

Baetis (Nigrobaetis) muticus (Linnaeus, 1758)
Material examined: Loc-18, 29.06.2022, 6 larvae.

***Cloeon* Leach, 1815**
Cloeon dipterum (Linnaeus, 1761)
Material examined: Loc-1, 28.06.2022, 5 larvae; Loc-6, 28.06.2022, 2 larvae; Loc-15, 29.06.2022, 15 larvae; Loc-19, 29.06.2022, 76 larvae; Loc-21, 30.06.2022, 59 larvae; Loc-22, 30.06.2022, 1 larva; Loc-23, 30.06.2022, 4 larvae; Loc-25, 30.06.2022, 21 larva.

Heptageniidae Needham in Needham & Betten, 1901
***Epeorus* Eaton, 1881**
Epeorus (Epeorus) zaitzevi Tshernova 1981
Material examined: Loc-18, 29.06.2022, 9 larvae.

***Ecdyonurus* Eaton, 1865**
Ecdyonurus (Ecdyonurus) russevi Braasch & Soldán, 1985
Material examined: Loc-16, 29.06.2022, 4 larvae.

Potamanthidae Albarda in Selys-Longchamps, 1888
***Potamanthus* Pictet, 1843**
Potamanthus luteus (Linnaeus, 1767)
Material examined: Loc-16, 29.06.2022, 3 larvae.

Ephemerellidae Klapálek, 1909
***Ephemerella* Walsh, 1863**
Ephemerella ignita (Poda, 1761)
Material examined: Loc-16, 29.06.2022, 58 larvae; Loc-17, 29.06.2022, 15 larvae; Loc-18, 29.06.2022, 3 larvae.

Caenidae Newman, 1853
***Caenis* Stephens, 1835**
Caenis macrura Stephens, 1836
Material examined: Loc-5, 28.06.2022, 2 larvae; Loc-15, 29.06.2022, 15 larvae; Loc-16, 29.06.2022, 5 larvae; Loc-21, 30.06.2022, 29 larvae.

4. Conclusions and discussion

According to the most recent studies, despite the fact that the order Ephemeroptera is represented by 166 species in Türkiye, there are still unexplored territories [26, 27]. Among previous studies on the Turkish Ephemeroptera order, there are no detailed studies on the Aydın and Denizli provinces, which are the research areas. However, four species (*Siphlonurus lacustris* Eaton, 1870; *Dacnogenia coerulans coerulans* Rostock, 1878; *C. macrura* Stephens, 1836 and *P. luteus* (Linnaeus, 1767)) from the Aydın province and two species (*Ephemera vulgata* Linnaeus, 1758 and *P. luteus*) from the Denizli province were reported from the Ephemeroptera order [28].

In the study, five of the identified species from Aydın province (*B. (B.) buceratus*, *B. (B.) fuscatus*, *B. (B.) vernus*, *B.* (*R.*) *rhodani*, and *C. dipterum*) and 12 of the identified species from Denizli province (*B. (B.) buceratus*, *B. (B.) fuscatus*, *B.* (*B.*) *lutheri*, *B. (B.) nexus*, *B. (B.) vernus*, *B.* (*R.*) *rhodani*, *B. (N.) muticus*, *C. dipterum*, *E. (E.) zaitzevi*, *E. (E.) russevi*, *E. ignita*, *C. macrura*) were recorded for the first time from which related provinces within the studying area.

The distribution of *E. russevi* on the same vertical line only in the eastern part of Bulgaria [29] and in the west of Türkiye (Balıkesir [28] and Denizli [in this article]), reveals that this species spreads over the Macedonia-Thrace line and is distributed only in limited regions.

Similarly, *E. zaitzevi* has a limited distribution around the world including Armenia, Türkiye, Syria, Iran, Iraq and Israel [30- 33]. It has been reported from the northeastern (Ardahan, Erzurum, Bayburt, Giresun, Gümüşhane, Kars, Tunceli) and southeastern (Hakkari, Şanlıurfa, Şırnak) regions of Anatolia [34]. When the distribution in our country is examined, it is seen that this species shows a linear distribution in the horizontal plane (independently of each other) including the Caucasian line in the north (except Tunceli) and the Eremial line in the south. Considering the entranceways of the aquatic fauna elements to Anatolia [35] and the distribution of this species in the Anatolia; the existence of this species in the Aegean Region (in Denizli province), where boreal fauna elements are dominant, indicates that this species originated from the south Caspian basin and spread into Anatolia through the Iran-Caucasus entranceways. It is possible that this species may have reached Western Anatolia through the inland water system in Central Anatolia and remained in a limited area in Denizli province.

Considering the geographical and ecological characteristics of the study area, it was concluded that the number of identified species was less than expected. Water pollution comes first among the main reasons for this situation: It has been reported that untreated domestic wastewater; livestock and mining wastes; discharge of textile and leather industry (especially concentrated in Denizli and Uşak provinces) waste to surface waters without treatment; uncontrolled use of chemical fertilizers and pesticides in agricultural areas; high boron concentration originating from geothermal power plants, and olive mill wastewater in Aydın province cause significant pollution in the water resources in the study area [36, 37]. In addition to all these, the dominance of *Baetis* species with high pollution tolerance among the species identified in the study also indicates the presence of organic pollution in the waters in the study area. However, the intensive use of surface waters for agricultural activities rapidly depletes natural reserves or causes deterioration of aquatic ecosystems, destroying the habitats and biodiversity of aquatic organisms. In addition, it was observed that many aquatic habitats dried up due to the decrease in precipitation and the increase in temperature during the study period.

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Bibliometric analysis of climate crisis and climate change research

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Abstract

Climate change is a worldwide issue that can influence the way of life of all living beings. This study aims to perform a bibliometric analysis of climate crisis and climate change scientific studies. Bibliometric analyses give an in-depth assessment of the literature's publications on the subject, the identification of scientific research trends on the subject, the evaluation of researcher collaboration, and the evaluation of significant issues. The study is qualitative research, and a bibliometric research method was used. The research data was first accessed on 04 August 2022 (Time: 14:34) from the "Web of Science" database as an online search. However, some data were revised on 18 July 2023 (Time: 15:00) using the same database in order to include up-to-date data in the study. The obtained data were transferred to VOSviewer software and analyzed. According to the survey, climate-related articles most used keywords include climate change, climate crisis, sustainability, environment, climate justice, and Anthropocene. Most of the studied papers are from many disciplines, such as environmental sciences, meteorology atmospheric studies, ecology, geosciences multidisciplinary, and environmental studies. When the publications on climate catastrophe are examined by country, the most cited countries are England, Canada, United States, Sweden, and Norway. As a result, international scientific collaboration and data exchange are critical for a successful battle against climate change and the climate crisis. Collaboration and information exchange between disciplines can result in more effective and inclusive solutions. Encouraging studies in other languages and knowing common terminology can help to promote global collaboration. The examination and assessment of scientific findings are vital in enhancing societal awareness and resilience, as well as in developing long-term policy.

Keywords: Disaster, Bibliometric analysis, Climate change, Climate crisis, Sustainability

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İklim krizi ve iklim değişikliği araştırmalarının bibliyometrik analizi

Özet

İklim değişikliği tüm canlıların yaşam şekillerini etkileyebilecek küresel bir sorun olarak görünmektedir. Çalışmada, iklim krizi ve iklim değişikliği alanında yapılan bilimsel çalışmaların bibliyometrik analizinin gerçekleştirilmesi amaçlanmıştır. Bibliyometrik analizler, literatürdeki konuya ilişkin yayınların derinlemesine incelenmesini, konuya ilişkin bilimsel araştırma eğilimlerinin belirlenmesini, araştırmacılar arasındaki iş birliğinin ve ön plana çıkan konuların değerlendirilmesini sağlar. Çalışma nitel bir araştırma olup bibliyometrik araştırma yönteminden yararlanılmıştır. Araştırma verilerine ilk olarak 04 Ağustos 2022 (Saat: 14:34) tarihinde "Web of Science" veri tabanından çevrimiçi tarama şeklinde ulaşılmıştır. Ancak güncel verilerin çalışmaya dahil edilebilmesi için bazı veriler 18 Temmuz 2023 tarihinde (Saat: 15:00) aynı veri tabanı kullanılarak revize edilmiştir. Elde edilen veriler VOSviewer yazılımına aktarılarak analiz edilmiştir. Çalışmada, iklim krizi ile ilgili yayınlarda en sık kullanılan anahtar kelimelerin iklim değişikliği, iklim krizi, sürdürülebilirlik, çevre, iklim adaleti ve antroposen olduğu belirlenmiştir. Analiz edilen yayınların çoğunluğunu çevre bilimleri, meteoroloji, atmosfer bilimleri, ekoloji, multidisipliner yer bilimleri ve çevre çalışmaları

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olmak üzere farklı disiplinlere ait çalışmaların oluşturduğu tespit edilmiştir. İklim krizi ile ilgili yayınların ülkelere göre değerlendirilmesi yapıldığında, en fazla atıf alan ülkelerin İngiltere, Kanada, Amerika Birleşik Devletleri, İsveç ve Norveç olduğu tespit edilmiştir. Sonuç olarak iklim değişikliği ve iklim krizi ile etkili mücadele için ülkeler arasında bilimsel iş birliği ve veri paylaşımı önemlidir. Farklı disiplinler arasında iş birliği ve bilgi paylaşımını teşvik ederek daha etkili ve kapsayıcı çözümler üretilebilir. Aynı zamanda, farklı dillerde yapılan çalışmaların teşvik edilmesi ve ortak terminolojiye hakim olunması, küresel işbirliğini güçlendirebilir. Toplumsal farkındalığın ve dirençliliğin artırılmasında, sürdürülebilir politikaların oluşturulmasında bilimsel çalışmaların analiz edilmesinin ve değerlendirilmesinin önemli olduğu düşünülmektedir.

Anahtar kelimeler: Afet, Bibliyometrik analiz, İklim değişikliği, İklim krizi, Sürdürülebilirlik

1. Introduction

Climate change is a worldwide issue that threatens the planet and can potentially impact the way of life of all living beings [1]. It can be stated that climate change has become a global problem. As a result of changing climatic conditions, temperatures are increasing, glaciers are melting, and sea levels are rising. Therefore, this situation worries societies and states [2]. It is important to know the negative consequences of climate change and to develop plans in this direction. Efforts to reduce greenhouse gases can be an important step towards reducing the negative effects of climate change [3].

The rural and urban populations are essential in climate change action plans and research. Over half of the world's population (55%) lives in cities, which is expected to rise in the future years. It is estimated that urban activities account for around 70% of greenhouse gas emissions at the global warming point [4]. Carbon dioxide emissions are predicted to rise as the consumption of coal, oil, and other fossil fuels rises, resulting in higher greenhouse gas emissions [5]. Many variables, such as greenhouse gas emissions, can be assessed as contributing to global warming. Situations that contribute to global warming include the usage of fossil fuels, environmental deterioration, unplanned urbanization, and unregulated industry. These circumstances might be viewed as variables that exacerbate the detrimental effects of climate change on a global scale [6, 7]. In order to combat climate change, it is vital to reduce the impacts of elements that contribute to climate change and raise climate change awareness [8]. Measuring climate change awareness is a critical step in planning and implementing successful climate change mitigation strategies [9]. Because climate change is a global issue, nations have chosen to adopt a series of measures or design programs that incorporate international policy as well as their own. Climate change action plans are being produced, governments are paying more attention to climate change in their own development goals, climate change adaptation strategies are being developed, and human and institutional capacity is being sought to be built. Specific pledges to address climate change are being executed [10]. States have acknowledged climate change as a public catastrophe and an urgent need for governance and have taken steps to address it. They design strategies to reduce greenhouse gas emissions and manage climate-related hazards [11]. Government institutions must finance technical advancements in the battle against global warming and climate change. Technological advancements can lead to developing of solutions that are less detrimental to the environment and based on renewable energy sources [12].

Climate change should not be regarded just as a rise in temperature. Various occurrences may occur due to climate change, putting animals, plants, communities, and ecosystems in danger. Droughts, intense hurricanes, floods, melting glaciers, increasing sea levels, and other crises are examples of occurrences within this scope [13, 14]. Therefore, one of the significant impacts of climate change is catastrophes connected to climate and extreme weather conditions. It is well known that the frequency of climate-related disasters rises as the planet warms and climatic circumstances change. Heat waves, droughts, and typhoons that inflict major worldwide devastation may be said to occur in practically every part of the world, causing substantial harm to the global economy and dragging millions of people into poverty. Most disasters are related to climate change [15]. As a result, humans bear significant responsibilities in preventing environmental degradation. Because the preservation of biodiversity and environmental integrity is critical for human and animal health [16]. Concerns such as climate change, biodiversity loss, and environmental contamination, must be thoroughly investigated with global involvement [17]. It has been underlined that studies are conducted to establish probable future circumstances using climatic data and that these scientific outputs play an essential role in the appraisal of conceivable situations that may arise in biological diversity [18]. This global change has also caused some concepts to be pronounced differently over time. In this context, it has been observed that the global climate has altered; this phenomenon was once referred to as global warming before being superseded by the phrase global climate change. Today, considering the current conditions, it has been seen that climate activists or experts have started to use the terms climate crisis or climate emergency to describe the situation [19]. The climate crisis is a notion that calls attention to serious issues such as global warming and climate change. The climate crisis can refer to various phenomena such as flooding, drought, desertification, and glacier melting [20]. The climate problem may be viewed as a worldwide threat that needs urgent and long-term remedies. As a result, planning for good disaster and emergency management gives a massive potential for societal reform that also considers the climate problem [21]. In this context, national plans, commitments and financial management should include strategies to strengthen the fight against the climate crisis [22]. It is critical to be socially

conscious of the climate catastrophe and to promote awareness. The active engagement and knowledge of many elements of society are critical in the battle against the climate problem [23, 24]. To summarize, the climate problem is a critical issue that must be handled in the short and long term by all segments of society. In this perspective, it may be agreed that the implementation of social awareness and transformational policies, as well as their scientific debate, play a key role in combating the climate crisis.

This research aims to conduct a bibliometric analysis of scholarly papers on the climate crisis and climate change. This sort of study examines publications in the literature in depth, identifies scientific research trends on the subject, evaluates researcher collaboration, and examines significant concerns. Therefore, it is acknowledged that this study will make an essential contribution to the literature by assessing the present state of research on the climate crisis and climate change and laying the groundwork for future researchers. It is also accepted as a separate value that the research results will provide valuable information to the relevant stakeholders, policymakers, and researchers, and that they will enable potential cooperation opportunities as a result of determining the trends in the literature. The research question created in this direction is as follows:

How do the publishing categories, nation distribution, citation density, author distribution, and distribution by years compare in the bibliometric study of academic works on climate change and climate crisis?

2. Materials and methods

The study is developed as a qualitative study. The bibliometric research approach is preference for the investigation [25, 26]. Bibliometric research can assist in determining trends in a certain on the subject by quantifying investigations and analysing the results [27]. Bibliometric analysis helps review current publications, analyzing publications, and summarizing scientific trends in a particular field. This analysis provides an essential resource for trending publications, tracking scientific progress and understanding research outputs [28]. The study's goal is to review and bibliometrically assess works on "Climate Crisis and Climate Change" published between 1997 and 2023 in the "Web of Science" database, which has a significant international presence.

The research data was first accessed on 04 August 2022 (Time: 14:34) from the "Web of Science" database as an online search. However, some data were revised on 18 July 2023 (Time: 15:00) using the same database in order to include up-to-date data in the study. Combining and evaluating disparate datasets may provide particular challenges in bibliometric analysis investigations. These difficulties might include discrepancies in indexing algorithms and data formats [29]. Therefore, the "Web of Science" database, which is used as a vital publication search tool, was preferred in this study.

In the study, data scanning according to keywords was carried out in two stages. In the first stage, a large-scale scanning was conducted to construct an overall profile of climate change. In this context, "Climate Change" was written in the search section and scans were carried out under this title. In the initial scan results, you may see categories, publishers, years, journals, and so on. Because there were no limits for "Articles, Papers, Book Chapters, etc." from 1980 and 2023, all publications are available. The generic search yielded 446473 studies on "Climate Change" in the "Web of Science Core Collection" database. Since too many publications are in the climate change category, a year restriction has been applied. In this context, it was decided to evaluate the publications between the years 1997-2023 to evaluate the climate crisis category equally. In this way, it is planned to gain a holistic perspective. After the year restriction, 441380 publications were evaluated.

When the second keyword, "Climate Crisis" is scanned, it is seen that 2681 studies were recorded between 1997 and 2023 without any restrictions. In 1997, it was seen that a study was carried out on the climate crisis (Climate Crisis). It has been determined that there was no study on the subject between 1998-2001. In this context, since no restriction criteria were created, all data were transferred to the VOSviewer program and evaluated. Within the scope of the study, it is planned to evaluate the publications from a holistic perspective. For this reason, all publications containing related keywords (climate crisis-climate change) were included in the study.

The export method takes the data is taken from the "Web of Science" website. The data file was downloaded in “Tab Delimited File” format. Since all publications accessed from the Web of Science Core Collection database cannot be downloaded as a single file, they have been downloaded in parts. Each record contains information such as "Author(s), Title, Source, Abstract, Document Type, Keywords, Cited References, Hot Paper, WoS Categories". The obtained data files were transferred to the VOSviewer software (https://www.vosviewer.com). This software has been used to do bibliographic matching of texts, bibliographic matching of authors, co-citation analysis of authors, citation analysis between institutions, publication analysis by nation, and author word analysis. VOSviewer is an analytical tool for building and displaying network-based maps. It enables us to uncover correlations in datasets such as scientific journals, publishing networks, researchers, nations, research institutes, and keywords using network analysis [30]. In the analysis of other data, the Excel program, and the automatic analysis system of the "Web of Science" database were used.

The fact that the study data was obtained from the "Web of Science" database allows researchers to access the same data set and obtain the same results. This is important for the validity and reliability of the study. "Web of Science"

is an internationally accepted data access base and is known as a data source based on detailed classification criteria. Since the study data were obtained from an open-access database, it was accepted as valid and reliable.

The fact that the study data were not obtained from a single database can be considered as a limitation. This may cause the publications to include only the publications indexed in the "Web of Science" database and not include the publications in other databases. This may affect the generalization and content validity of the results of the study.

The data of the study were accessed from the Web of Science database, which is open access. Therefore, ethics committee approval was not required. Data usage, confidentiality and security measures were complied with to conduct the study in according to scientific ethical rules.

3. Results

The findings of the data accessible on the "Climate Crisis" and "Climate Change" databases from the "Web of Science" database are presented in this section of the research. The findings connected to the climate crisis are presented in the first section, and the findings related to climate change are presented in the second section.

3.1. Findings on the Climate Crisis

On 18.07.2023, 2681 data were obtained by searching Web of Science with the term "Climate Crisis" and choosing "all fields." Publications from numerous fields were identified when the data was sorted by year, with the earliest publication dating back to 1997 and the most recent in 2023. These publications include 1975 articles, 260 editorial materials, 183 review articles, 171 book chapters, 170 early access, 130 book reviews, 81 proceeding papers, 24 letters, 13 news items, ten books, eight meeting abstracts, two corrections, and one poetry (Figure 1). After categorizing the papers, it was concluded that the bulk of the publications (478 publications), environmental sciences (376 publications), green sustainable scientific technology (184 publications), geography (137 publications), energy fuels (123 publications), and political science (122 publications).

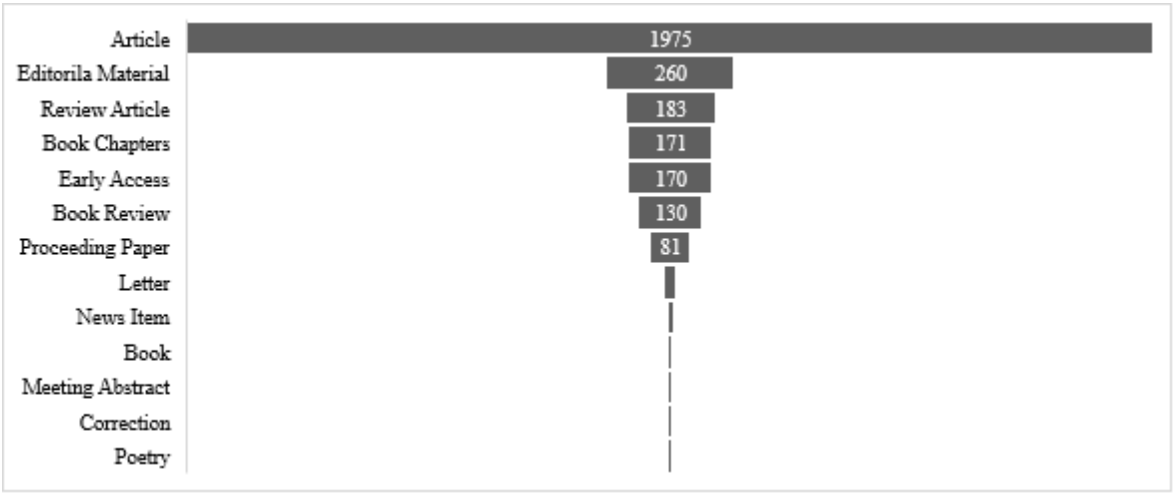

Figure 1. Evaluation by document types (climate crisis)

When the distribution of publications on the topic of climate crisis is investigated in the study, it is discovered that the number of publications has gradually grown. It is seen that there are 827 publications in 2022, 566 publications in 2021, 416 publications in 2020, 129 publications in 2019 and 96 publications in 2018. It has been determined that the number of publications in 2020 is relatively high compared to the previous year (2019). Although the 2023 calendar year has yet to be completed, it is seen that it has a very high publication rate (Figure 2).

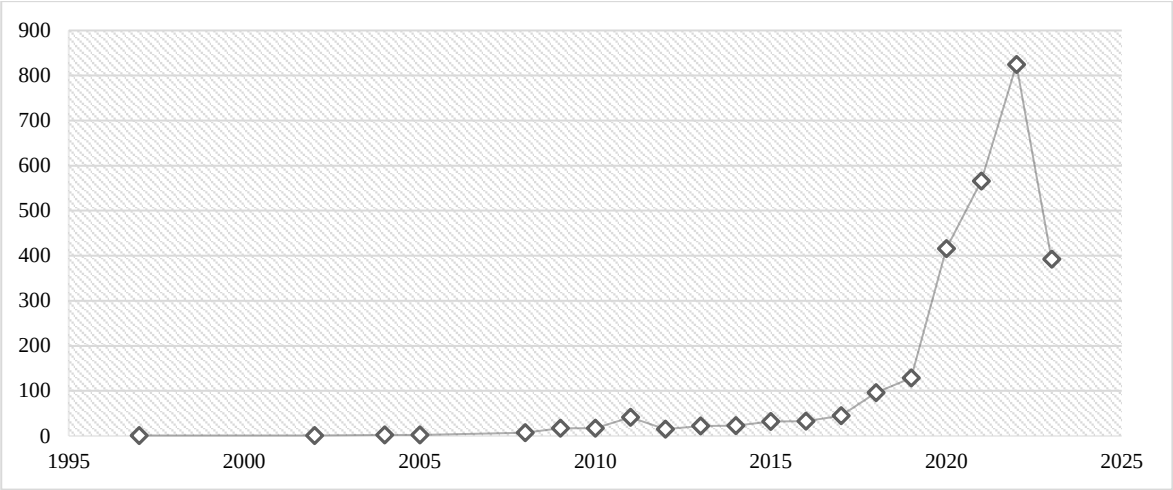

Figure 2. Distribution of publications by years (climate crisis)

In the study, keyword analysis related to the climate crisis was made. A total of 3473 keywords were identified based on documents. In the analysis phase, it was determined that at least two words should be familiar as a criterion. In this case, 493 data with at least two words in common were obtained. Climate change (272 keywords), climate crisis (82 keywords), sustainability (47 keywords), environment (32 keywords), climate justice (31 keywords) and Anthropocene (26 keywords) are the most used terms in climate-related articles. Climate change, climate crisis, environment, climate justice and sustainability have created the most potent expressions regarding total connection power. According to the findings of the research, there were 47 clusters and 473 items. It was discovered that the first cluster included 47 things, the second cluster contained 37 items, and the third cluster contained 27 items. Furthermore, 2202 connections and 2798 total connection strengths were calculated (Figure 3).

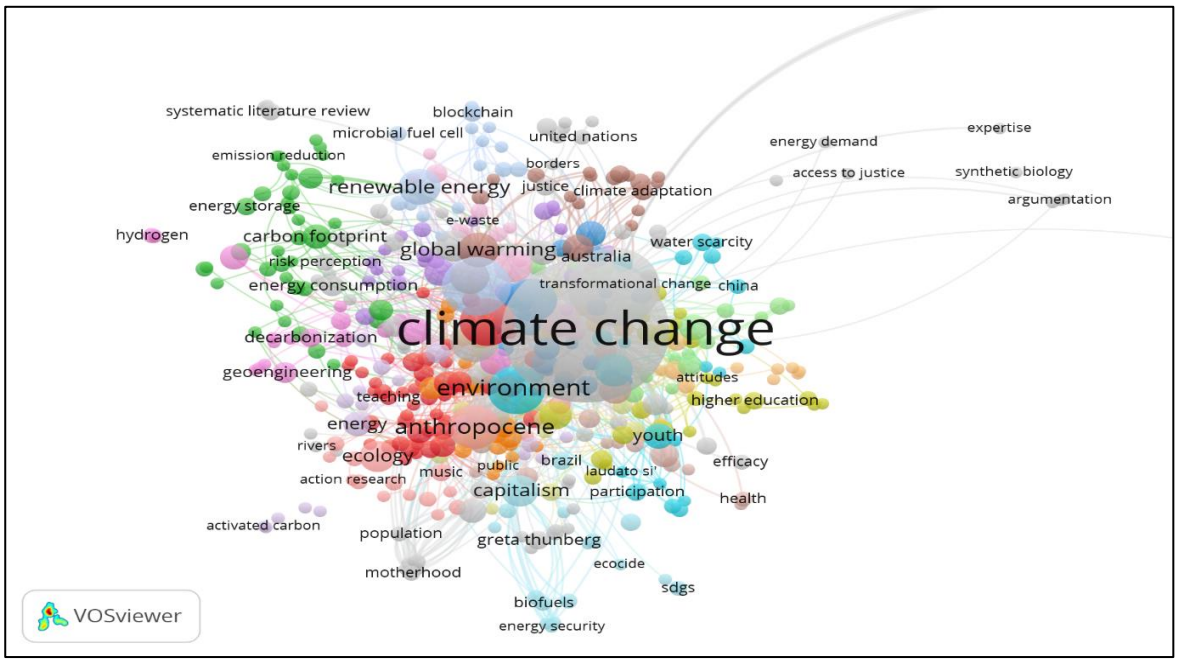

Figure 3. Most frequently used keyword links (climate crisis)

In the study, publishing at least one work and getting one citation were chosen as the criteria for mapping the citations received by the publications by country. In this context, 77 out of 88 countries is found to meet this value. It has been determined that the most cited countries are England (2919 citations), Canada (2366 citations), USA (2273 citations), Sweden (2109 citations) and Norway (1998 citations). England, Canada, the United States, and Norway are the top four countries in total connection strength. When evaluated in terms of the number of works, they are listed as the USA (273 publications), England 156 publications), Germany (91 publications), Australia (84 publications), Canada (75

publications) and Spain (54 publications). In addition, 10 clusters of 83 connections and 149 total connection strengths were determined (Figure 4).

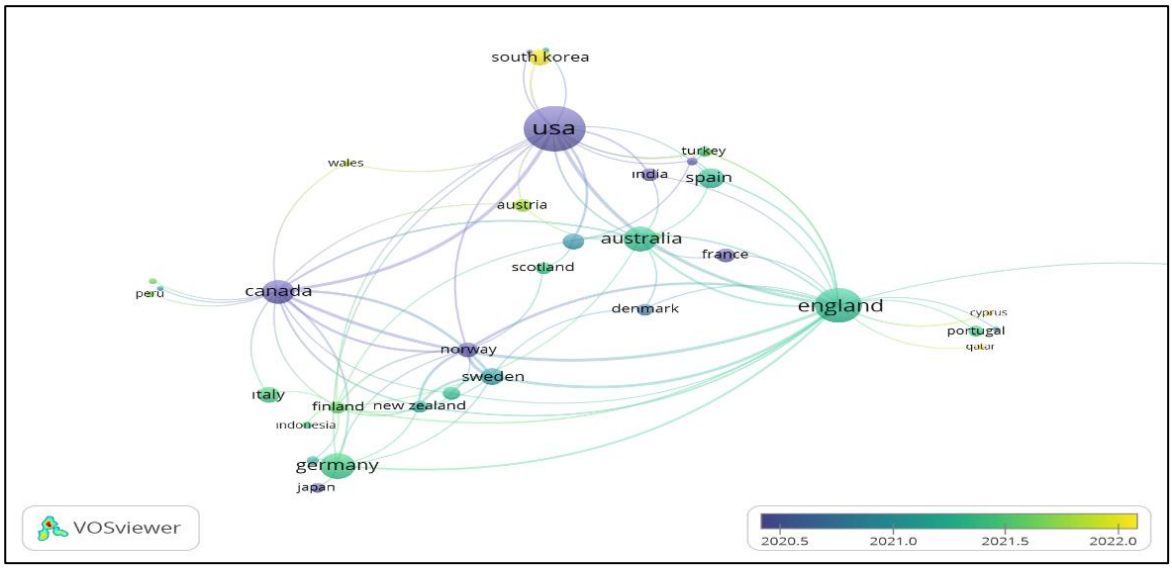

Figure 4. Citation network analysis of countries (climate crisis)

The study selected publishing at least one work and getting one citation as criteria for mapping inter-institutional citations. In this context, it was determined that 905 out of 1324 institutions met the threshold value. As a result of the analysis, a total of 14 clusters, 219 connections and 230 total connection strengths were determined. The institutions of the most cited publications were determined as Lund University (1999 citations), University Surrey (1890 citations), University Waterloo (1836 citations), Linnaeus University (1821 citations). In terms of work, it has been identified as University Sydney (17 publications), University Oxford (17 publications), University Cambridge (15 publications), University British Columbia (13 publications). In terms of total connection strength, it was determined as Linnaeus University (connection strength 26), Lund University (connection strength 22), Western Norway Research Institute (connection strength 22) (Figure 5).

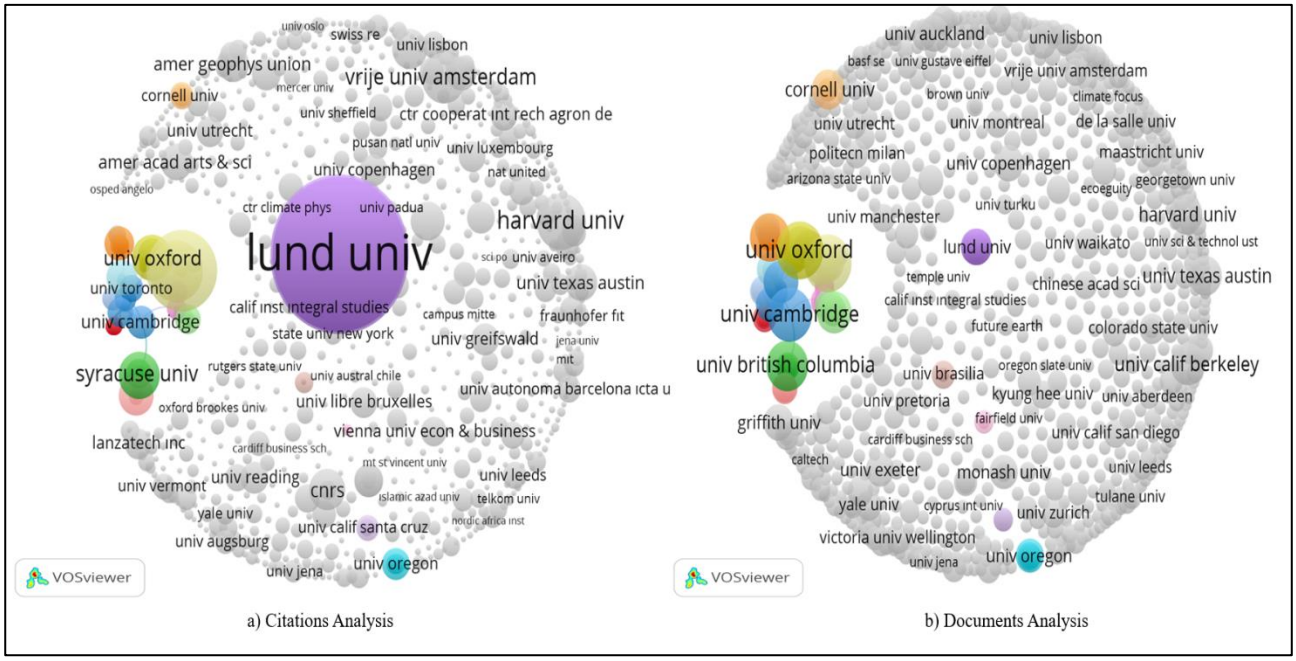

Figure 5. Organizations citations (a) and documents (b) analysis (climate crisis)

In the study, the evaluation was made by choosing a minimum of 10 citations in mapping the authors' co-citation analysis. In this context, it was seen that 244 out of 39522 authors met the determined value. As a result of the analysis, it was determined that the most cited authors were IPCC (157 citations), European Commission (91 citations), United Nations (66 citations). The data analysis determined 10 clusters, 5371 connections and 17300 total connection strengths (Figure 6).

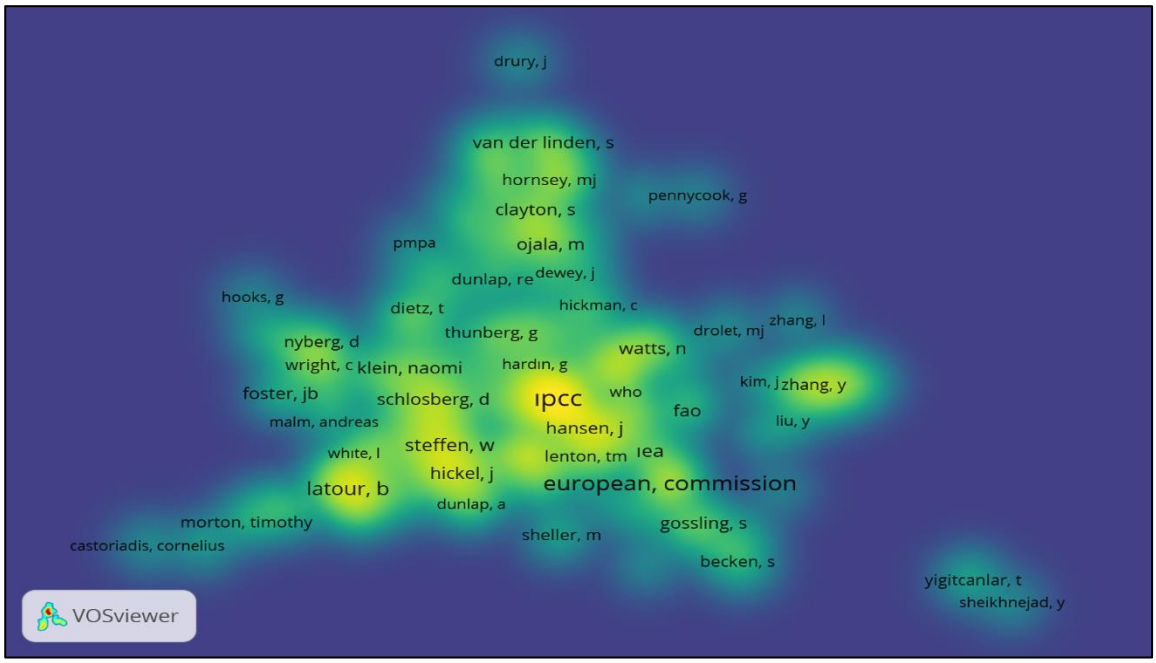

Figure 6. Citation analysis by authors (climate crisis)

In the study, evaluation was made by choosing the criteria of having at least one study published and one cited in mapping the bibliographic match analysis of the authors. In this context, it was seen that 1829 out of 4989 authors met the determined value. The writers with the greatest bibliographic matches were identified to be Gossling Stefan (1783 citations), Scott Daniel (1783 citations), and Hall C. Michael (1780 citations) as a result of the investigation. The data analysis determined 41 clusters, 26116 connections and 243517 total connection strengths (Figure 7).

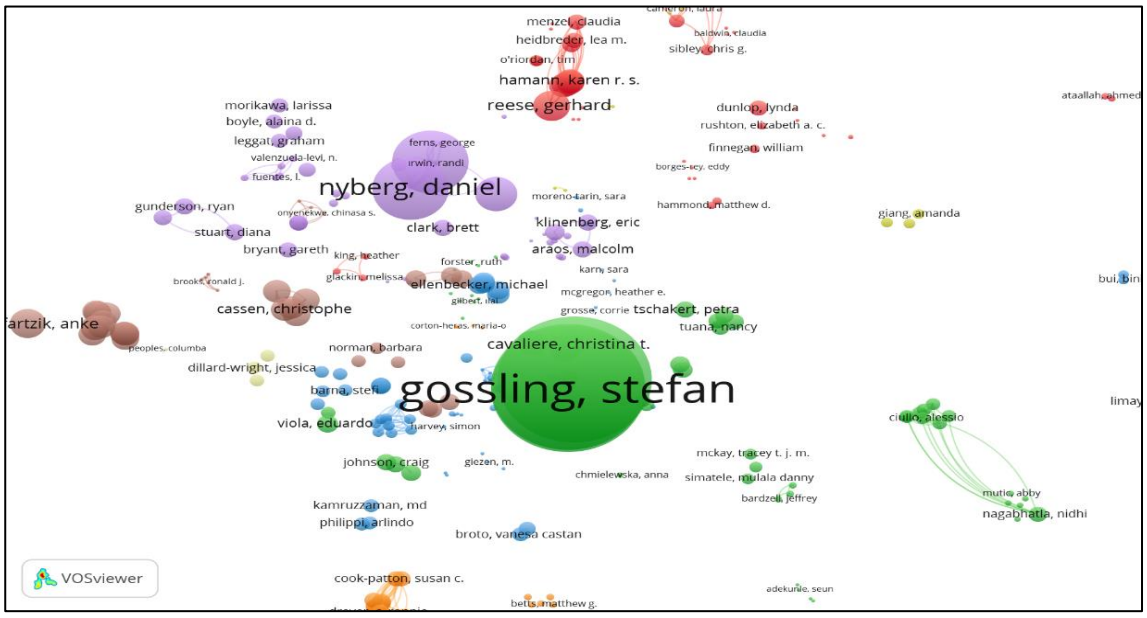

Figure 7. Authors' bibliographic match analysis (climate crisis)

In the study, evaluation was made by choosing at least one citation criterion in the mapping of the bibliographic match analysis of the texts. In this context, it was seen that 634 out of 1730 documents met the specified value. The publications with the most citations were Gossling (2021), Wright (2017), Pattberg (2008), Wright (2012), and Manzanedo (2020). As a result of the analysis, a total of 21 clusters, 5368 connections and 6939 total connection strengths were determined (Figure 8).

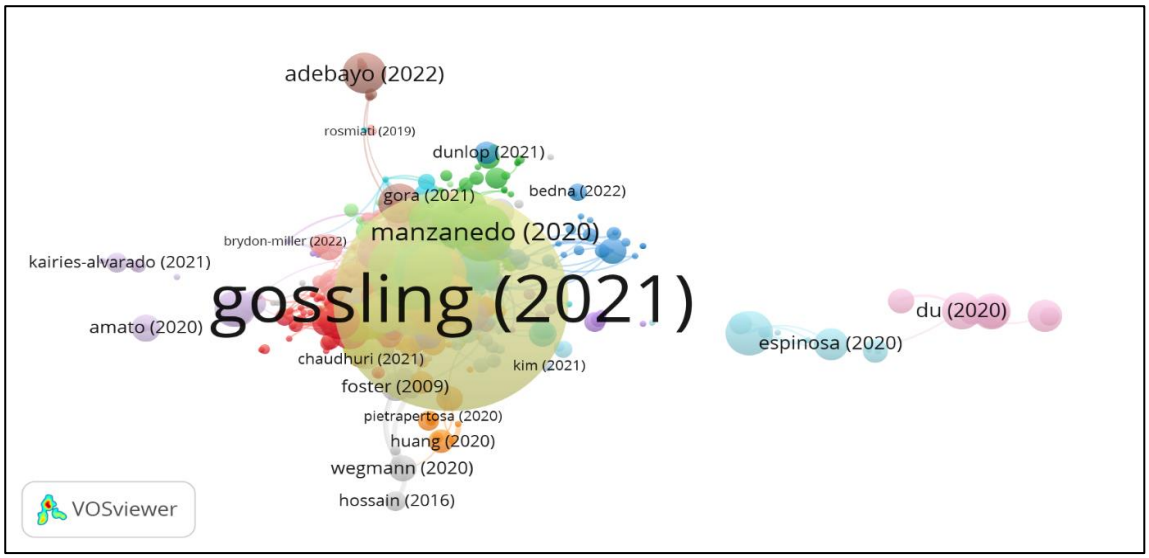

Figure 8. Bibliographic analysis of texts (climate crisis)

3.2. Findings on Climate Change

In the study, 446473 data were reached by selecting "all fields" in Web of Science with the keyword "Climate Change". When analyzed by years, it was seen that the oldest publication was in 1980 (8 publications), and the newest publication was in 2023 (23338 publications) from various disciplines. Because the study reviewed papers from 1997 to 2023, other years were included in the scope, resulting in 441380 climate change-related publications being evaluated. Five of the first lines of these publications were found to be articles, with 368845 articles, 29380 proceeding papers, 27785 review articles, 18404 book chapters, and 13131 editorial materials (Figure 9). 335457 of the publications are scanned as Science Citation Index Expanded (SCI-EXPANDED), 83671 as Social Sciences Citation Index (SSCI) and 30810 as Emerging Sources Citation Index (ESCI).

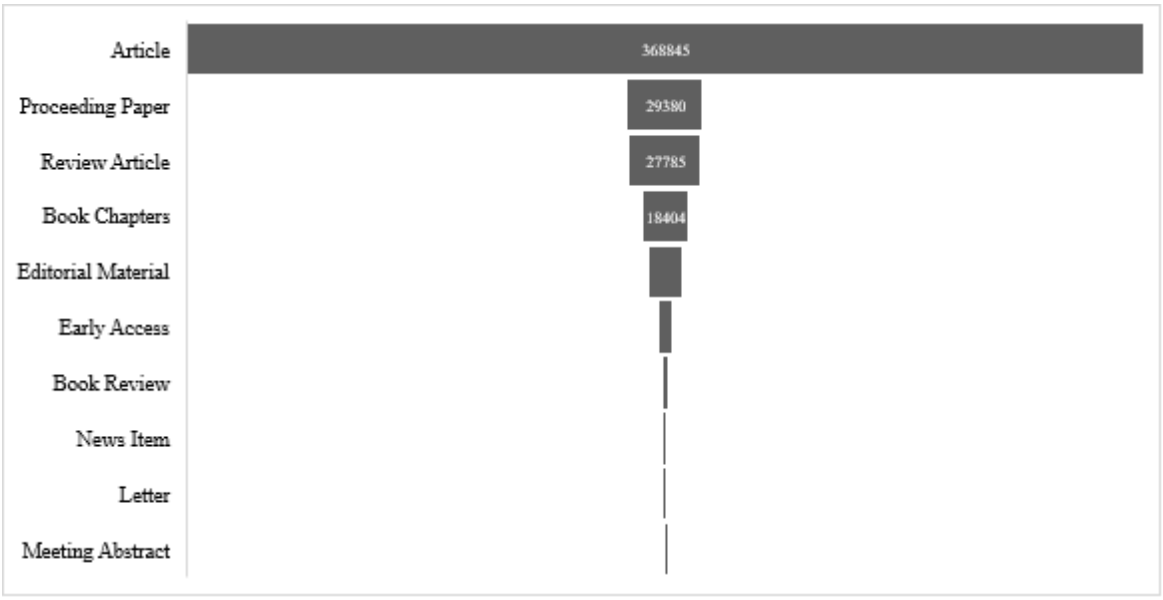

Figure 9. Evaluation by document types (climate change)

In the study, when the distribution of publications in the field of climate change is examined, it has been determined that the number of publications has increased gradually. It is seen that there are 49108 publications in 2022, 47153 publications in 2021, 42188 publications in 2020, 36820 publications in 2019 and 32250 publications in 2018. It has yet to be determined that the number of publications in 2020 is relatively high compared to the previous year (2019). Although the 2023 calendar year has yet to be completed, it is seen that it has a very high publication rate (23338 publications) (Figure 10).

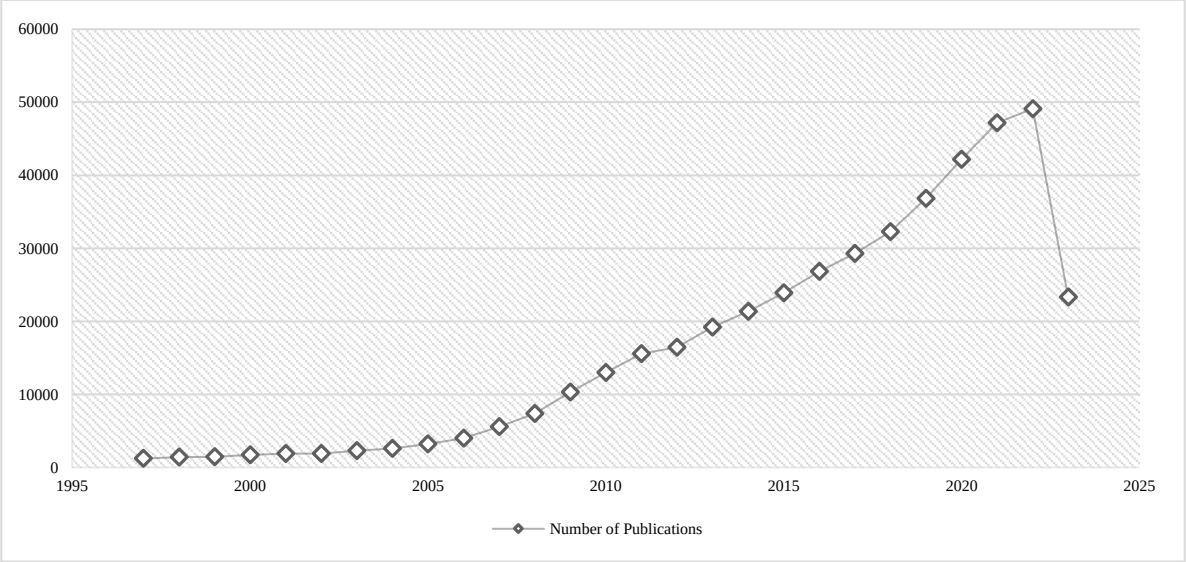

Figure 10. Analysis of publications by years (climate change)

When evaluated in terms of language, English (434542 publications), Spanish (2235 publications), German (1150 publications), French (783 publications), and Chinese (505 publications) are in the top five (Figure 11).

When examined in terms of disciplines, it has been determined that most of the publications are environmental sciences (118090 publications), meteorology atmospheric sciences (52795 publications), ecology (48632 publications), environmental studies (46779 publications) and geosciences multidisciplinary (46645 publications) (Figure 11).

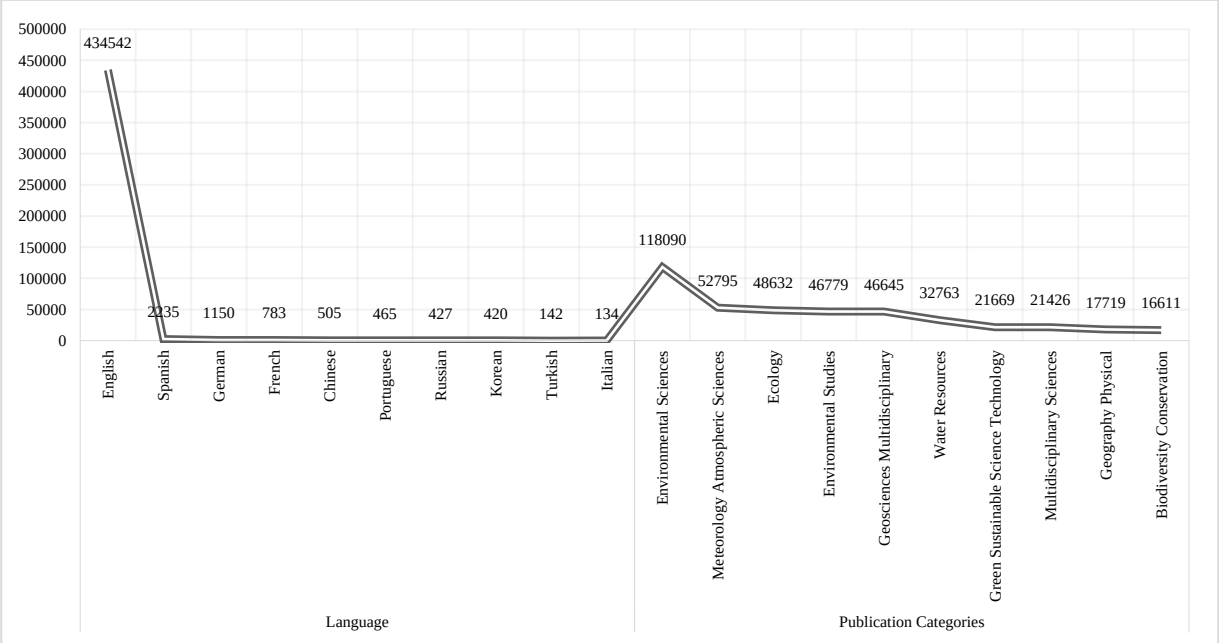

Figure 11. Analysis of publications by categories and publication languages (climate change)

When evaluated in terms of countries, USA (122032 publications), China (64354 publications), England (48523 publications), Australia (38559 publications), and Germany (38321 publications) are in the top five (Figure 12).

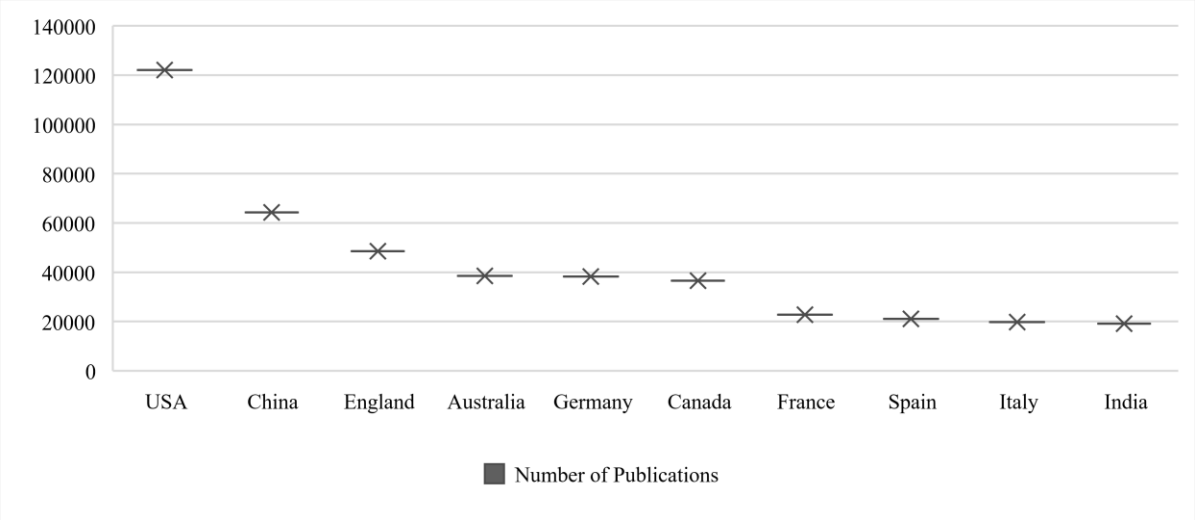

Figure 12. Analysis of publications by country (climate change)

4. Conclusion and discussion

Climate-related issues are a worldwide danger to all living beings. Countries create numerous policies and strive to execute various action plans to mitigate the harmful consequences of climate change. The strategies established to address climate issues must be scientifically sound and practical. This study's bibliometric analysis was performed to acquire a comprehensive perspective on the climate crisis and climate change. As a result, this section of the research includes a discussion of the studied data.

This study, it was determined that the most frequently used keywords in publications related to climate crisis are climate change, climate crisis, sustainability, environment, climate justice and Anthropocene. Climate change, climate crisis, environment, climate justice and sustainability have created the most vital expressions regarding total connection power. Wang et al. [31], it has been mentioned that keywords such as adaptation, vulnerability, agriculture, sustainability, climate change, ecosystem, and vulnerability are concentrated. The phrase climate change was prevalent in a study on climate change and food security, followed by phrases like food security, drought, adaptation, agriculture, and water scarcity [32]. One of the most well-known notions is climate change. In addition, it is seen that words such as impact, adaptation, greenhouse gas, technology, policy, and cost are common [33]. According to a climate research, terms like temperature, precipitation, reduction, sensitivity, sanitation, food system, sustainable usage, organization, interaction, and authority came to the fore in various groups [34]. According to another survey, phrases like global warming, climate modeling, climate influence, and hot were commonly utilized [35]. X. Li et al. [36], stated that words such as drinking water, shallow lake and climate are trending. Regarding word cloud, the study's data may have comparable contents to the literature. Furthermore, given that keywords are the emphasis and representation of academic research, consideration is given to keyword selection in terms of inclusivity and substance in the publications included in the study.

The distribution of climate-related (climate crisis) publications was investigated in this study. The number of publications is seen to rise with time. While there were 96 papers published in 2018, the number is increased to 129 in 2019, 416 in 2020, 566 in 2021, and 827 in 2022. Furthermore, the distribution of climate change articles was investigated. There has been an upsurge in the number of publications on this subject. While there were 32250 publications in 2018, the number was determined to reach 36820 in 2019, 42188 in 2020, 47153 in 2021, and 49108 in 2022. In 2020, a significant increase was detected in the number of publications compared to the previous year. Although the 2023 calendar year has not been completed, a very high number of publications (23338 publications) has also been made this year. According to climate engineering research, climate engineering publications increased between 1988 and 2011. It is reported that 56% of broadcasts have been carried out since 2008 [37]. According to another research, publications on climate change and food safety have increased from 1981 to 2019 and have received significant traction, particularly after 2008 [32]. The number of articles on climate change was 1582 in 2001, and this number climbed to 2776 in 2006. Similarly, whereas the number of climate change research was 10006 in 2013, it increased to 15311 in 2018 [38]. It has been said that the number of research studying the consequences of ecosystems and species in the face of changing conditions has grown [39]. The number of publications on climate change has grown considerably. The number of publications addressing climate change grew tenfold between 1991 and 2010 [33]. There has been an increase in

publications on global warming and climate change [40]. From 1980 to 2012, the number of scientific publications climbed gradually [41]. The growth rate of the number of scientific publications may be higher than expected [42]. Climate crises and climate change concerns are gaining academic and scientific attention. The rise in the number of publications indicates the growing relevance and understanding of research in this sector. Even though the calendar year has not yet ended, the number of publications in 2023 is significant. This condition might be linked to the fact that researchers and scientists working in the sector continue to conduct study and studies to give more knowledge on relevant concerns.

In this study, 1975 articles about the climate crisis, 260 editorial materials, 183 review articles, 171 book chapters, 170 early access, 130 book reviews, 81 proceeding papers, 24 letters, 13 news items, ten books, eight meetings abstract, two corrections and one poetry type work were reached. Regarding climate change, it was determined that 368845 articles, 29380 proceeding papers, 27785 review articles, 18404 book chapters and 13131 editorial materials took the first five places. In the study conducted by Sweileh [32], it was stated that research articles and review articles rank first, similar to our study. Research and review article types are standard in the climate crisis and climate change publications.

In this study (Climate crisis), the authors with the most cited sources and the most bibliographic matches were evaluated. In this context, the most commonly cited source was the IPCC [43] and the author with the most bibliographic matches was Gossling Stefan. Similar to our findings, Hou and Wang [44] identified that the most often mentioned sources were IPCC. When several of Gossling Stefan's research are evaluated [45-48] it can be stated that he is an interactive scientist.

In this study, when climate change studies were examined in terms of disciplines, it was determined that most of the publications were from different disciplines, including environmental sciences, meteorology, atmospheric sciences, ecology, geosciences multidisciplinary and environmental studies. Most climate crisis studies have been identified as environmental studies, environmental sciences, green sustainable science technology, geography, energy fuels, and political science research. According to a climate change research, environmental sciences were top in terms of publishing, followed by meteorological and atmospheric sciences, ecology, and interdisciplinary earth sciences [49]. According to a research on climate engineering, the first two ranks of the publishing categories were environmental sciences, meteorology, and atmospheric sciences [37]. The relevance of social sciences, natural sciences, and humanities in climate change research was underlined [50]. From a scientific perspective it has been observed in the emergence, development, or loss of usefulness of new scientific disciplines [51]. Another survey indicated that environmental sciences, agriculture and biology, social sciences, and earth sciences were the most popular publishing categories [32]. The formation of new scientific disciplines and interdisciplinary research may be stated to be useful in every subject. Examining climate change research in terms of disciplines reveals that diverse viewpoints and areas of knowledge intersect on this problem. As a result, it is critical to recognize the complexity and multidimensionality of climatic concerns.

In this study, it has been seen that English, Spanish and German are at the forefront in terms of publication language. According to Becerra et al. [52], it was stated that the number of publications in English was relatively high. It can be accepted that the acceptance of English as an academic and international language is reflected in the number of publications at the same rate [53]. According to another study, most publications were written in English. In addition, it can be said that it attracts attention in its publications in Chinese, French and Spanish [32]. It can be said that the data of our study and the literature data are similar in terms of the widespread use of the English language. It can be said that writing the publications in English, which is an academic and international language, is effective in reaching large audiences. However, encouraging publication in different languages on climate change and climate crisis could be an important implication.

This study determined that the most cited publications were Lund University, University Surrey, University Waterloo, and Linnaeus University. Regarding work, it has been determined as University Sydney, University Oxford, University Cambridge, and University British Columbia. Regarding overall connection strength, Linnaeus University is designated Lund University and the Western Norway Research Institute. According to a disaster and climate change resilience study, the University of California System ranked first among universities with 349 publications on climate change resilience [54]. It has been stated that the most prolific universities in the Arab world are King Abdulaziz University, King Saud University, and King Abdullah University of Science and Technology [35]. According to another research, among the universities that produced substantial additions to the literature between 1999 and 2021 were University Queensland, University Sydney, Macquarie University, and University Newcastle [55]. Identifying the institutions that interact the most with the climate issue gives crucial data for understanding collaboration and relationships in academic circles. Identifying institutional organizations is a critical step that may be objectively examined.

In this study, when the publications related to the climate crisis were evaluated according to the countries, it was determined that the most cited countries were England, Canada, USA, Sweden, and Norway. In terms of total connection strength, England, Canada, the USA, and Norway are in the top four places. When evaluated in terms of the number of works, they are listed as USA, England, Germany, Australia, Canada, and Spain. When the climate change related publications are evaluated in terms of countries, the USA, China, England, Australia, and Germany are in the top five. A study on climate change stated that USA, Australia and England have published many publications on climate

change resilience [54]. Another study stated that USA, England and Australia were productive in publications on climate [56]. It has been specified that the United States of America, China, Germany, Canada, England, Sweden, Australia, France, and the Netherlands are fertile in terms of climate problem articles and citations [49]. In a climate-focused study, it was mentioned that USA is a pioneer in terms of publications on climate. It is mentioned that climate studies have gained momentum in countries such as England, Australia, Denmark, Sweden, India, China, France, Kenya, Nigeria, Netherlands and Spain [52]. The United States, the United Kingdom, and China are among the nations that publish on climate change [32]. According to Fu and Waltman [38], the United States of America holds 73% of the total publications on global climate change and is a prolific country. The United States of America has been reported to be the leader in climate change publications, followed by England, Germany, and Canada [33]. Li et al. [57], mentioned that the tendency of countries to produce publications is similar to the literature. When the data from our study and the data from the literature are combined, nations such as the United States, England, Canada, and Australia are more effective in publishing climate research. As a result, other nations should contribute more to such an essential scientific topic. Furthermore, more investment should be done in climate change and associated issues.

As a result, it is critical to fund climate change and climate crisis research in developing and developed countries. More effective and comprehensive policies may be produced with scientific studies on climate change. Increasing university collaboration and the intensity of scientific data is a significant milestone. By building a more robust and more effective global collaboration, more resilient and sustainable solutions to climate change may be identified. Encouraging studies on climate change issues in different languages may be necessary. Fostering collaboration and information exchange across disciplines is critical to generate more effective and inclusive climate change solutions. It is considered essential to master common terminology and practices to provide easy access to studies in the field of climate change and climate crisis and to accelerate the flow of information.

Note: The Web of Science database was used to retrieve the data.

Declarations

Conflict of interest

The author have disclosed that there are no potential conflicts of interest in relation to the research, authorship, and/or publication of this article.

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***Contents* / İçindekiler**

Page No. Order No.

01. **75 Contribution to the earthworm fauna of Edirne province Türkiye (Clitellata, Megadrili)**
02. **84 Molecular and taxonomic studies on some *Acarospora* (Acarosporales, Ascomycota) species in Türkiye**
03. **98 *Cortinarius terribilis* (Cortinariaceae): A new record for the Turkish mycota from Trabzo**
04. **102 Researches on determination of saproxylic beetles (Coleoptera) on old hollow broad-leaved tree species in Cataldag (Balıkesir-Bursa) in Western Türkiye**
05. **114 Essential oil components of some *Lagoecia cuminoides* L. populations in Antalya/Türkiye**
06. **120 Determination of the sales profile of medicinal plants in herbalists: The case of Aksaray**
07. **132 Anatomical studies on endemic *Verbascum stepporum* Murb., and *Verbascum tenue* Hub.-Mor., (Scrophulariaceae) species distributed in Şanlıurfa**
08. **140 Comparative anatomy and achene micromorphology assessment of two *Cousinia* Cass. (*Asteraceae*) species in view of taxonomy**
09. **152 Research on Ephemeroptera (Insecta) fauna of Aydın and Denizli (Türkiye) provinces**
10. **158 Bibliometric analysis of climate crisis and climate change research**

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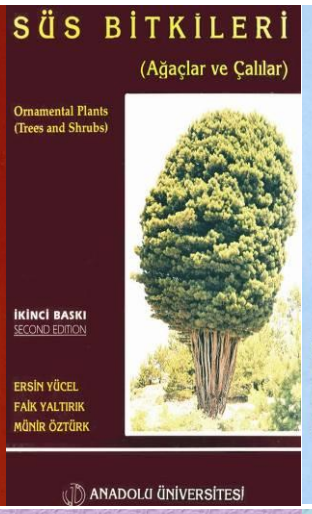

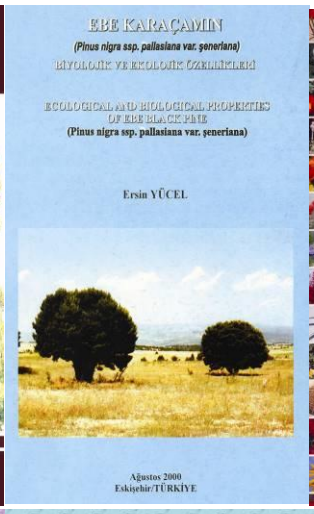

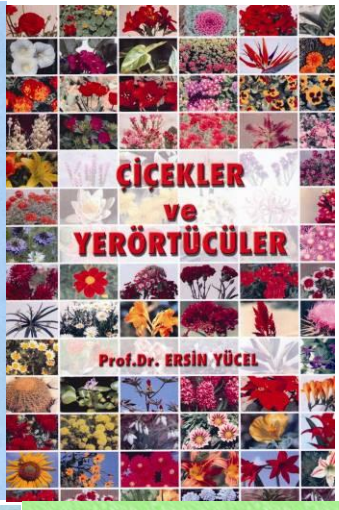

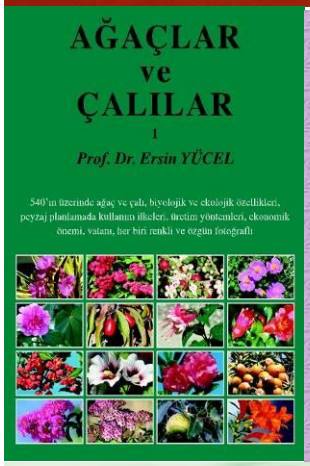

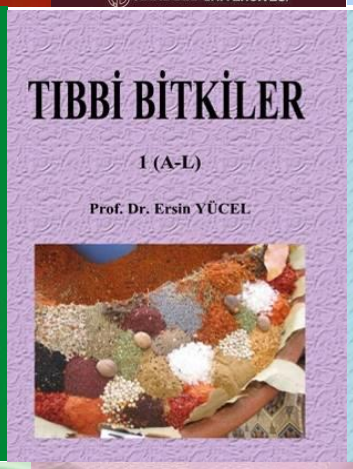

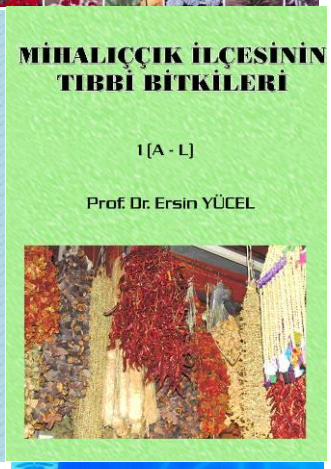

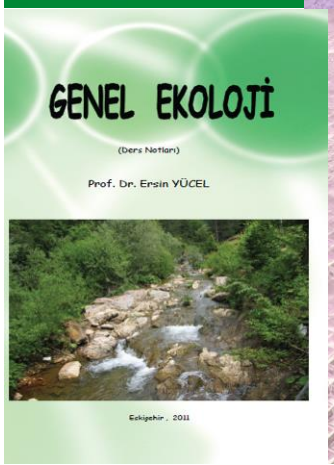

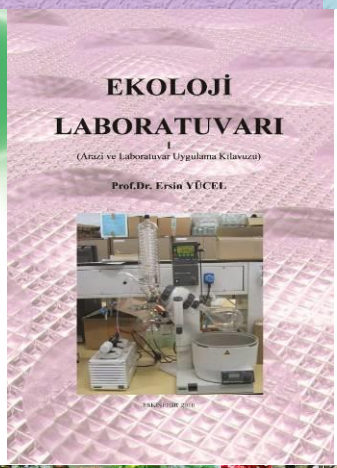

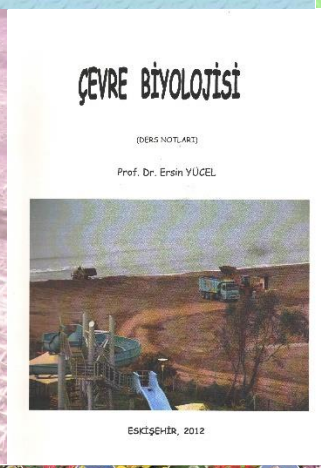

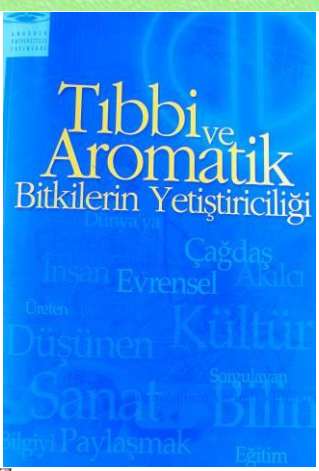

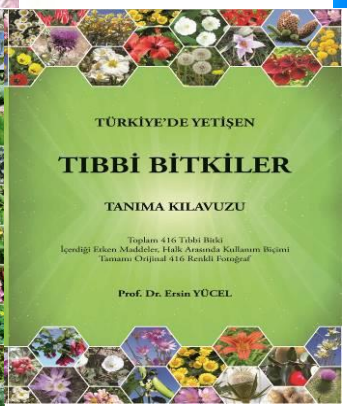

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***Contents* / İçindekiler**

Page No. Order No.

01. **75 Contribution to the earthworm fauna of Edirne province Türkiye (Clitellata, Megadrili)**
02. **84 Molecular and taxonomic studies on some *Acarospora* (Acarosporales, Ascomycota) species in Türkiye**
03. **98 *Cortinarius terribilis* (Cortinariaceae): A new record for the Turkish mycota from Trabzo**
04. **102 Researches on determination of saproxylic beetles (Coleoptera) on old hollow broad-leaved tree species in Cataldag (Balıkesir-Bursa) in Western Türkiye**
05. **114 Essential oil components of some *Lagoecia cuminoides* L. populations in Antalya/Türkiye**
06. **120 Determination of the sales profile of medicinal plants in herbalists: The case of Aksaray**
07. **132 Anatomical studies on endemic *Verbascum stepporum* Murb., and *Verbascum tenue* Hub.-Mor., (Scrophulariaceae) species distributed in Şanlıurfa**
08. **140 Comparative anatomy and achene micromorphology assessment of two *Cousinia* Cass. (*Asteraceae*) species in view of taxonomy**
09. **152 Research on Ephemeroptera (Insecta) fauna of Aydın and Denizli (Türkiye) provinces**
10. **158 Bibliometric analysis of climate crisis and climate change research**

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