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Identification of some lichenized fungi species around Akkuyu Nuclear Power Plant (Gülnar, İçel)

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Abstract

In this study, several lichenized fungi species near the Akkuyu Nuclear Power Plant located in the Gulnar district of Mersin province in Türkiye have been identified. Detailed descriptions, photographs, and phylogenetic analyses of the nine lichenized fungi species collected by the second author are provided: *Kuettlingeria erythrocarpa* (Pers.) I.V. Frolov, Vondrák & Arup, *Circinaria calcarea* (L.) A. Nordin, Savić & Tibell, *Flavoplaca communis* (Vondrák, Říha, Arup & Søchting) Arup, Søchting & Frödén, *Flavoplaca havaasii* (H. Magn.) Arup, Frödén & Søchting, *Lecania rabenhorstii* (Hepp) Arnold, *Lobothallia radiosa* (Hoffm.) Hafellner, *Megaspora verrucosa* (Ach.) Arcadia & A. Nordin, *Physcia stellaris* (L.) Nyl. and *Xanthocarpia marmorata* (Bagl.) Frödén, Arup & Søchting.
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Keywords: Akkuyu Nuclear Power Plant, biodiversity, *nrITS*, lichenized fungi

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Akkuyu Nükleer Santrali (Gülnar, İçel) civarında yayılış gösteren bazı likenleşmiş mantar türlerinin tanımlanması

Özet

Bu çalışmada Türkiye'nin İçel ili Gülnar ilçesi'nde yer alan Akkuyu Nükleer Santrali civarında yayılış gösteren bazı likenleşmiş mantar türlerinin tanımlanması yapılmıştır. İkinci yazar tarafından toplanan şu dokuz likenleşmiş mantar türüne ait detaylı deskripsiyonlar, fotoğraflar ve filogenetik analizler paylaşılmıştır: *Kuettlingeria erythrocarpa* (Pers.) I.V. Frolov, Vondrák & Arup, *Circinaria calcarea* (L.) A. Nordin, Savić & Tibell, *Flavoplaca communis* (Vondrák, Říha, Arup & Søchting) Arup, Søchting & Frödén, *Flavoplaca havaasii* (H. Magn.) Arup, Frödén & Søchting, *Lecania rabenhorstii* (Hepp) Arnold, *Lobothallia radiosa* (Hoffm.) Hafellner, *Megaspora verrucosa* (Ach.) Arcadia & A. Nordin, *Physcia stellaris* (L.) Nyl. ve *Xanthocarpia marmorata* (Bagl.) Frödén, Arup & Søchting.

Anahtar kelimeler: Akkuyu Nükleer Santrali, biyoçeşitlilik, *nrITS*, likenleşmiş mantar

1. Introduction

Research on the lichen biodiversity of Türkiye commenced nearly a century ago, primarily through travel accounts documented by foreign explorers. Consequently, the number of species identified in these early studies was quite limited. Since the 1980s, Turkish lichenologists have been actively engaged in research, focusing on the revision of specific species, the regional diversity of lichens, and the biological functions of lichen metabolites [1]. The most extensive compilation of lichenized fungi found in Türkiye was published as a list in 2017 [2], identifying 1,898 species of lichenized and lichenicolous fungi in the country. An update by John and Güvenç [3] added 689 additional species, bringing the estimated total of lichen species in Türkiye to approximately 3,150.

The Akkuyu Nuclear Power Plant, currently under construction, is Türkiye's inaugural nuclear power plant in the Gülnar District of Mersin Province. Research indicates that 116 lichen species have been documented in Mersin

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Province [3]. Notably, only 2 lichenized fungi species have been recorded from the Akkuyu area: *Psora taurensis* Timdal, Bendiksby, Kahraman & Halıcı identified from Akkuyu by Timdal et al. [4] and *Roccella elisabethae* Tehler reported for the first time from Akkuyu by Halıcı and Kahraman [5].

In this study, lichen samples were collected from the Akkuyu region by the second author, and these samples were subsequently identified using anatomical, morphological, and molecular techniques to determine lichen biodiversity in Akkuyu. Also, lichens have been reported as effective collectors of atmospheric trace element pollution due to their relatively high accumulation capacity for heavy metals and radionuclides and their dependence on atmospheric nutrients because they do not have a root system or cuticles like vascular plants. Energy is provided by heat in nuclear power plants. To provide heat, uranium atoms are put into a chain reaction. In this process, heavy metals and radionuclides are also released into nature. Lichens are used as the first bioindicators of this effect created by nuclear power plants, as they are the first step of succession and are considered effective collectors of atmospheric trace element pollution. Therefore, this study will serve as a starting point for future lichen biodiversity studies in the same area and shed light on future studies [6].

2. Materials and methods

2.1. Lichen material

The specimens were collected from Akkuyu and nearby regions (Figure 1) by the second author. The lichen samples were morphologically and anatomically identified by authors using various flora books and identification keys [7-12]. The lichen samples are stored in the Department of Biology, Herbarium of Erciyes University (ERCH), Kayseri, Türkiye.

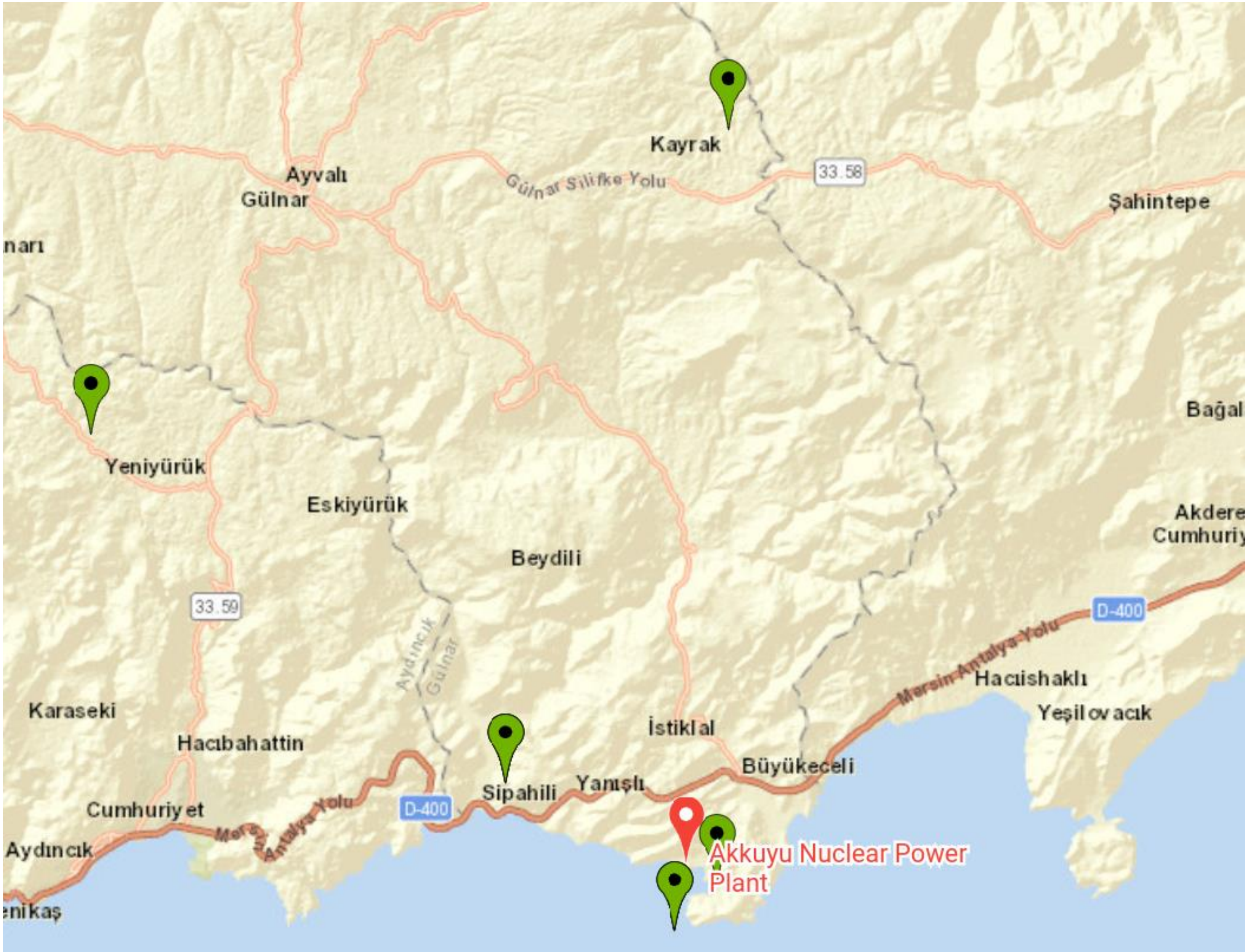

Figure 1. Locations where samples were collected from Akkuyu and nearby regions. The red spot indicates Akkuyu Nuclear Power Plant and the green spots indicate the locations where samples were collected. The map was made with the Map Marker App using Here Technologies Location Services (https://www.mapmarker.app/)

2.2. DNA isolation and PCR amplification

In the process of DNA isolation, samples from lichenized fungi, particularly the apothecium sections, were collected into Eppendorf tubes and labeled accordingly. These labeled samples were subsequently processed at the Biochemistry and Molecular Laboratory within the Faculty of Science at Erciyes University. The DNeasy Plant DNA Kit (Catalog No: 69104) was used to isolate DNA.

nrITS (*ITSF1-5' CTT GGT CAT TTA GAG GAA GTA A 3', ITS4-5' TCC TCC GCT TAT TGA TAT GC 3'*) primers used for PCR analysis [13, 14]. PCR analysis was carried out in 50 µl reaction volumes using, 4 µl of 10 x reaction buffer, 4 µl $MgCl_2$ (50 mM), 0.5 µl each primer, 2 µl dNTP (10 mM), 0.1 µl Taq DNA polymerase, 3 µl of genomic DNA and 35.9 µl dH2O on a thermal cycler equipped with a heated lid for both primers. The PCR was performed for *nrITS* under the following conditions: An initial denaturation of 5 min at 91 °C; 1 cycle with 1 min at 94 °C, 1 min at 56-50 °C, and 2 min at 72 °C; and 20 cycles with 1 min at 94 °C, 1 min at 55 °C, and 2 min at 72 °C; a final extension step of 1 min at 72 °C was added after the samples were kept at 4 °C. The PCR products were analyzed via agarose gel electrophoresis, and sequence analysis was performed on ten lichen samples from which DNA bands were obtained. PCR products run on 1% agarose gel with 0.6 µl /ml ethidium bromide. The loading buffer was prepared by diluting 1X with a concentration of 50X of stock prepared using 40 mM tris acetate and 2 mM $Na_2EDTA.2H_2O$. Thermo SM0321 was used as a DNA ladder. Electrophoresis was conducted at 90 volts for a duration of 60 minutes. Sequence analysis was subsequently performed on the lichenized fungi samples from which DNA bands were obtained [15].

2.3. Phylogenetic analysis

The "ABI PRISM Big Dye Version II" reaction kit was used for DNA sequence analysis. Bidirectional sequences were obtained after DNA sequence analysis. The sequences obtained in bidirectional (forward and reverse) sequence analysis were compared with the "Bioedit" program, edited, and aligned with the DNA sequences of other taxa to be selected as outgroups. Data analysis was performed using Maximum Likelihood analysis with the "MEGA XI" software [16, 17].

Table 1. The specimens' herbarium numbers and GenBank accession numbers

Specimen	***nrITS* GenBank Number**
Circinaria calcarea (ERCH AMEKA 0.111)	PQ167719
Flavoplaca communis (ERCH AMEKA 0.110)	PQ167720
Flavoplaca havaasii (ERCH AMEKA 0.105)	PQ167721
Kuettlingeria erythrocarpa (ERCH AMEKA 0.041)	PQ167718
Lecania rabenhorstii (ERCH AMEKA 0.109)	PQ167722
Lobothallia radiosa (ERCH AMEKA 0.051)	PQ167723
Megaspora verrucosa (ERCH AMEKA 0.091)	PQ167724
Physcia stellaris (ERCH AMEKA 0.020)	PQ167725
Xanthocarpia marmorata (ERCH AMEKA 0.099)	PQ167726

3. Results

Taxonomic descriptions, photographs, habitat records, and molecular positions of lichenized fungi species studied for this paper are given below.

3.1. Circinaria calcarea (L.) A. Nordin, Savić & Tibell

Thallus usually large, to 30 cm diam or more, forming circular patches, thick, finely cracked-areolate. Areoles radially orientated especially at outer edge of thallus, concave to plane when old, matt, chalk white to pale grey, rarely stained rust-coloured, cortex smooth; prothallus usually delimiting, dark grey. Apothecia aspicilioid, (0.3─)0.35─*0.45*─0.55(─0.65) mm diam and immersed. The thalline margin of apothecia was slightly raised. Apothecial disc black, usually not pruinose. Epihymenium 54 µm, black-green. Hymenium 72 µm and hyaline. Hypothecium 72 µm and brown. Ascus 4-spored and ascospores are broadly ellipsoid, hyaline, simple, 20–23.5 × 13.5–21 µm, and with a thin epispore. Cortex and medulla Pd- and K- (Figure 2).

Ecology and distribution: On hard limestones and memorials, intolerant of nutrient enrichment; common. Widely distributed in Europe, Macaronesia, South America, Asia, Africa, Australia, Eurasia, the Arctic [16], and Türkiye [2].

Specimens examined: Türkiye, Mersin, Gülnar-Akkuyu, East sides of the port, on calcareous rock, Station 5, 36°08'15.9"N 33°32'54.5" E alt., 10 m., ERCH AMEKA 0.111, leg. M. G. Halıcı.

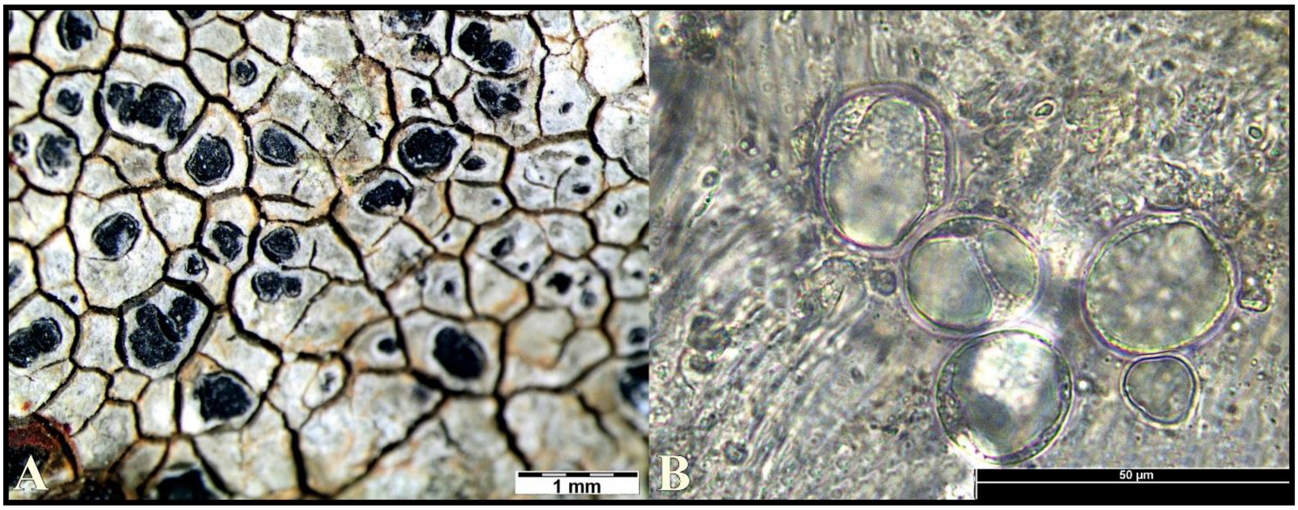

Figure 2. *Circinaria calcarea* A. Habitus, B. Ascospores

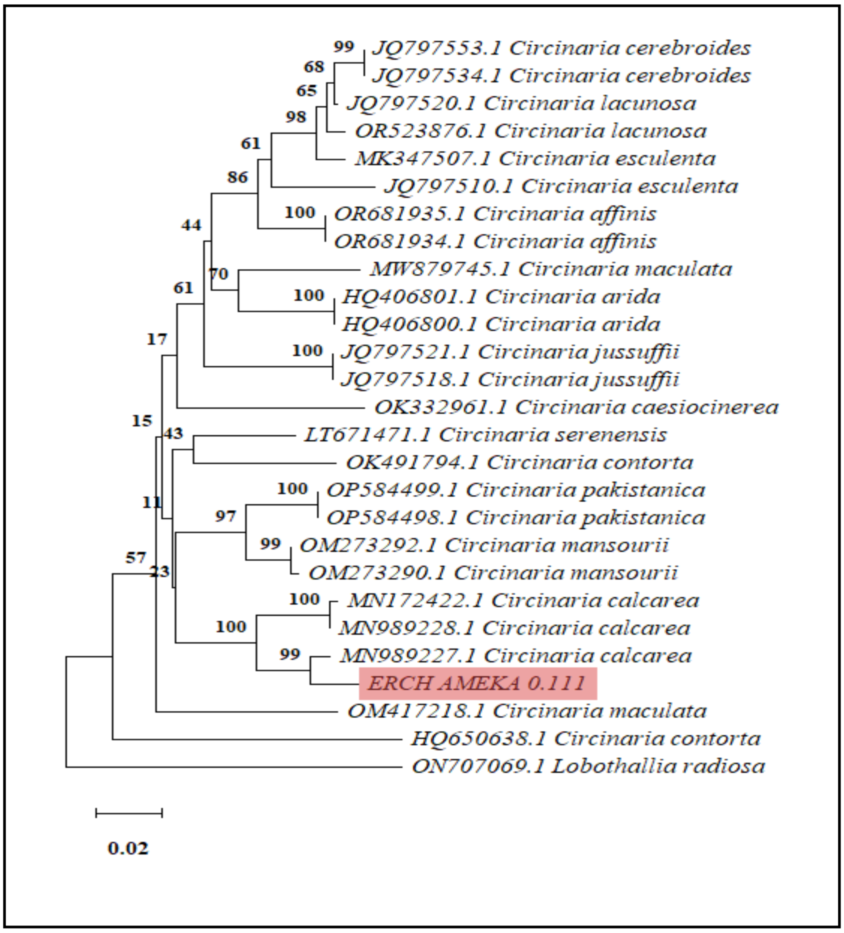

Figure 3. *nrITS* ML dendrogram of *Circinaria calcarea*

3.2. Flavoplaca communis (Vondrák, Říha, Arup & Søchting) Arup, Søchting & Frödén

Thallus crustose, yellow-orange, areolate. Areoles swollen, sometimes weakly squamulose, when thallus well developed surface of thallus has coarse granules—Apothecia common and (0,25─)0.3─*0.5*─0.7(─0,85) mm diam. Apothecia disc is slightly concave at mature ones and margin usually crenulate. Hymenium 78 µm, epihymenium 63 µm and brown. Ascus 8-spored and ascospores hyaline, polaribilocular 10─11.5 × 5.5─7 µm. Septa 4─5 µm. Apothecia K+ red, C- and Pd- (Figure 4).

Ecology and distribution: On hard siliceous rocks, especially near seashore. Distributed in Marmara Region, East Mediterranean Region, Bulgaria, Greece, Ukraine and Türkiye (İstanbul, Kastamonu, Kırklareli, Ordu, Yalova, Zongulgak) [18].

Specimens examined: Türkiye, Mersin, Gülnar-Akkuyu, East sides of the port, on calcareous rock, Station 4, 36°08'15.9"N 33°32'54.5" E alt., 10 m., ERCH AMEKA 0.110, leg. M. G. Halıcı.

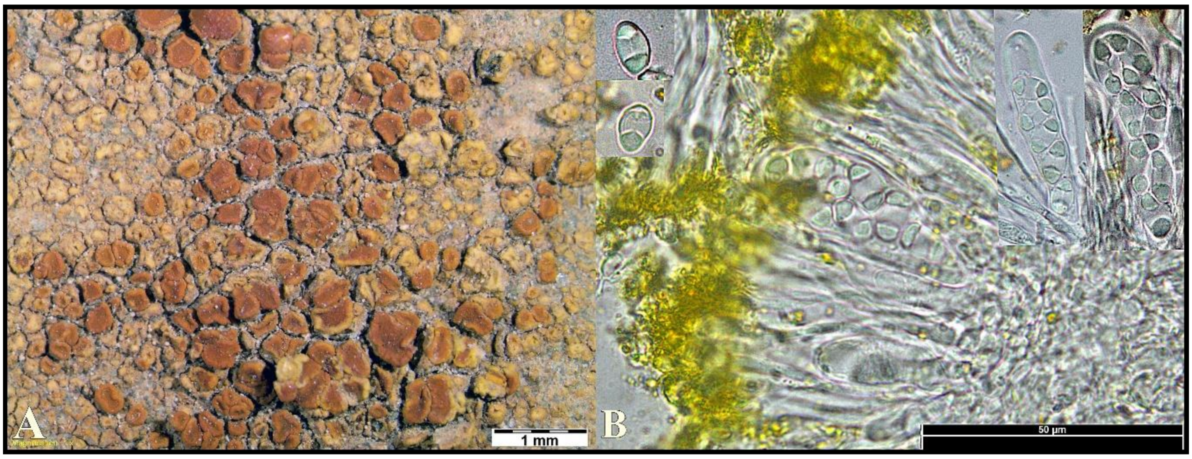

Figure 4. *Flavoplaca communis* A. Habitus, B. Ascospores

3.3. Flavoplaca havaasii (H. Magn.) Arup, Frödén & Søchting

Tallus crustose, verruculose, orange yellow to yellowish orange, 0.1─0.4 mm diam and 0.15─0.4 mm thick. Thallus has 2.5 cm patches in the form of areoles or squamules. Prothallus present or absent. Apothecia abundant and (0.25─)0.3─*0.4*─0.5(─0.6) mm diam, K+ purple, C-, Pd-. Apothecial disc zeorine, shades of orange, plane or convex. Epihymenium 48-52 µm. Hymenium 110 µm and brown. Hypothecium 150-230 µm, K-, N-. Ascus 8-spored, ascospores hyaline, polaribilocular, 11,5─)11,85─*14,1*─16,4(─17) µm length, (6,5─)6,58─*6,65*─6,88(─7) µm width and septa (4─)4.5─*5.5*─6.5(─7) µm. Paraphyses simple and 2─2.5 µm (Figure 5).

Ecology and distribution: Usually occurs on calcareous rocks near the seashore. Distributed in Norway, Holland, Türkiye (Çanakkale, Giresun, Mersin) [18].

Specimens examined: Türkiye, Mersin, Gülnar-Akkuyu, East sides of the port, on calcareous rock, Station 4, 36°08'15.9"N 33°32'54.5" E alt., 10 m., AMEKA 0.105, leg. M. G. Halıcı.

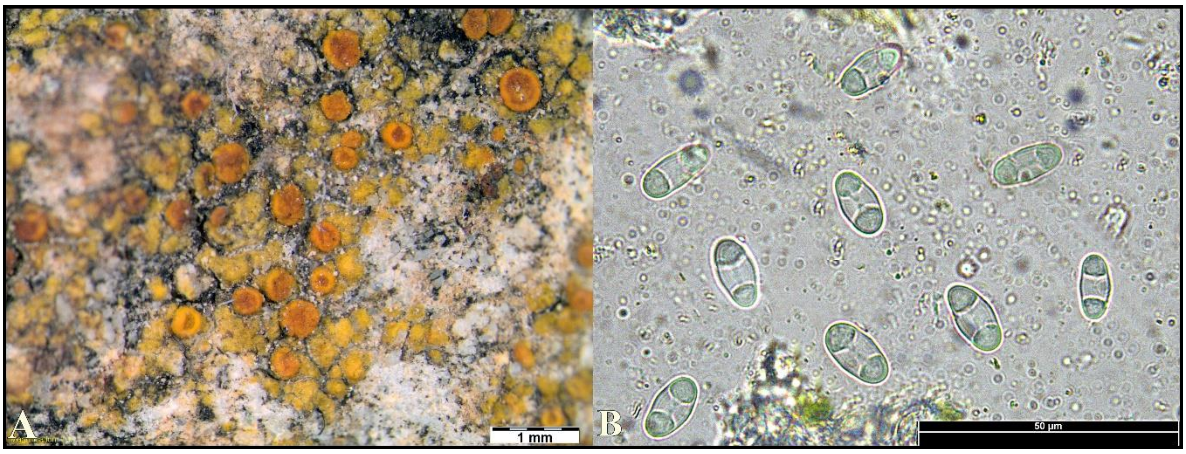

Figure 5. *Flavoplaca havaasii*. A. Habitus, B. Ascospores.

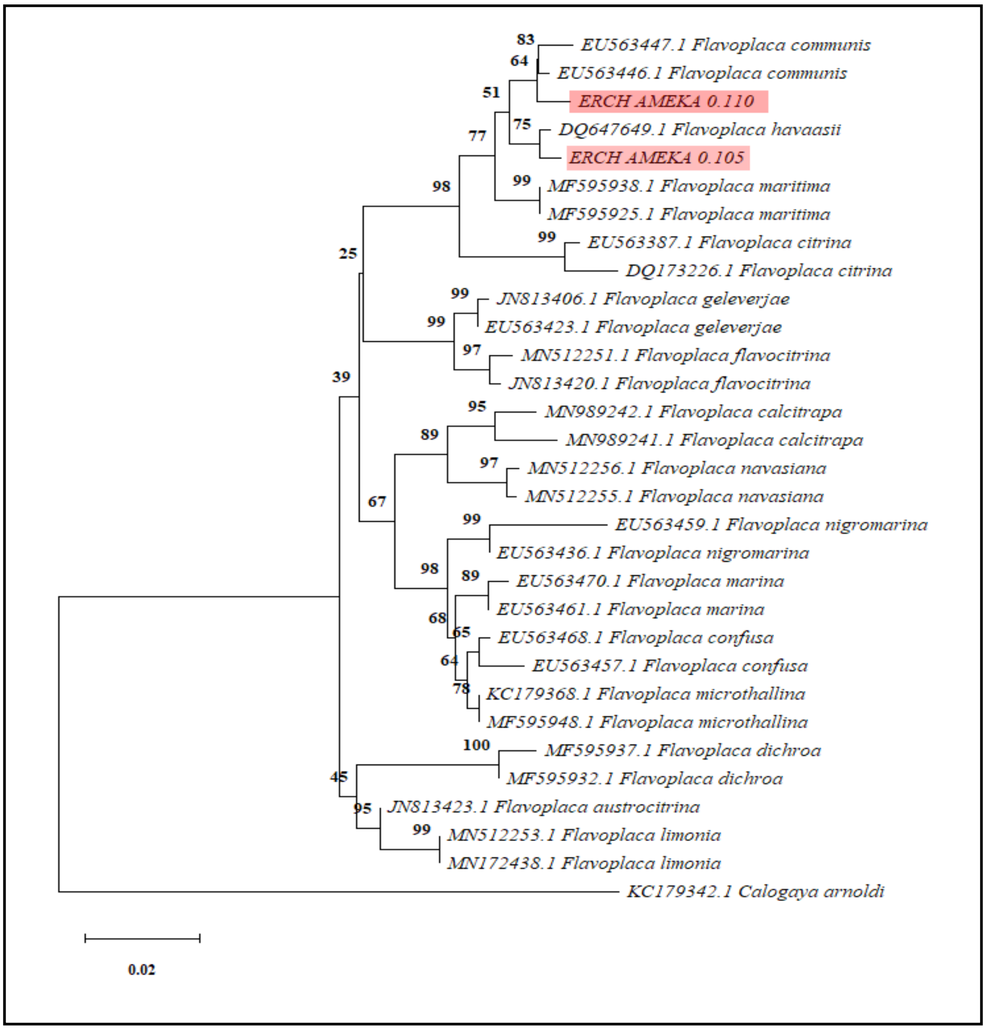

Figure 6. *nrITS* ML dendrogram of *F. communis* and *F. Havaasii*

3.4. Kuettlingeria erythrocarpa (Pers.) I.V. Frolov, Vondrák & Arup

Thallus crustose, rimose-areolate, white. Apothecia red, shiny, smooth, and sessile, 0.2–0.5 mm, C+ red. Ascus 8-spored, 65 × 20 µm. Ascospores characteristically polaribilocular and hyaline, ascospores (13.5–)14.5–*15*–15.5–(16) × (5.5–)7.5–*8.5*–9.5(–10) µm and septa (3–)–*3.5*–(–4.5) µm (n=15). Epihymenium brown, 33–49 µm, hymenium hyaline 80–90 µm, hypothecium hyaline, 60–88 µm (Figure 7).

Ecology and distribution: Mostly on limestone, calcareous schist, and weak calcareous rocks. It has been known in Middle Europe and the Mediterranean region and is widely distributed in Türkiye [2].

Specimens examined: Türkiye, Mersin, Gülnar, upper Sipahi river, on calcareous rock, 36°10'01.5"N 33°28'20.5" E alt., 185–195 m., ERC AMEKA 0.041, leg. M. G. Halıcı.

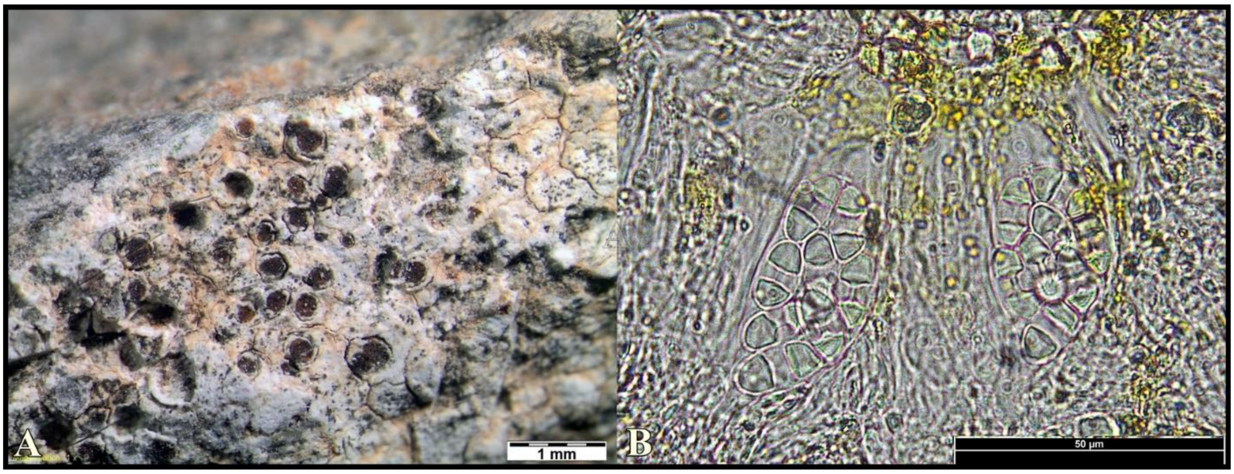

Figure 7. *Kuettlingeria erythrocarpa* A. Habitus, B. Ascospores inside asci.

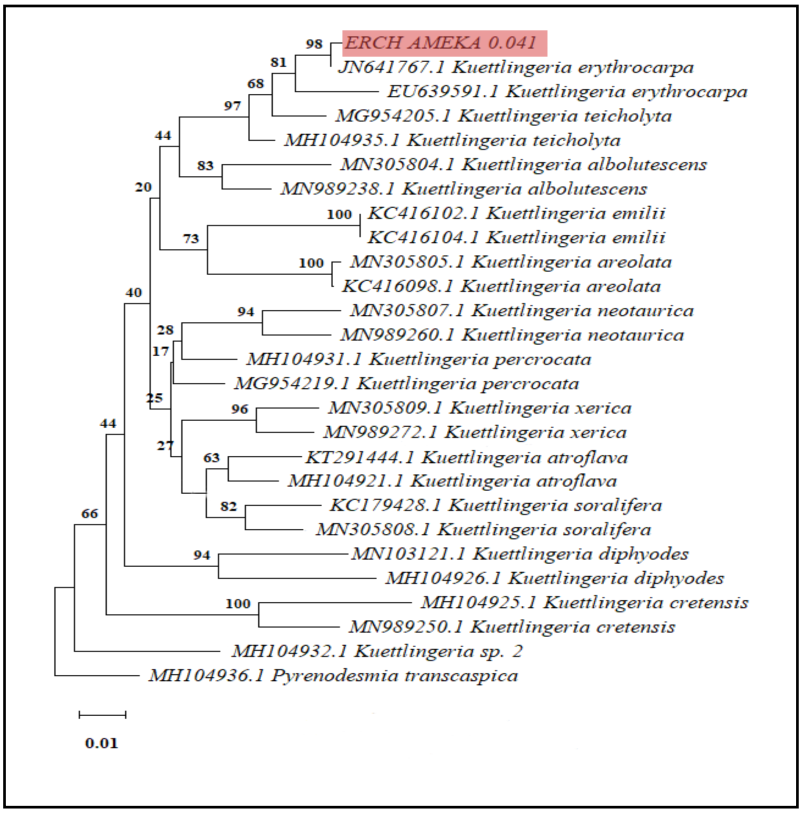

Figure 8. *nrITS* ML dendrogram of *Kuettlingeria erythrocarpa.*

3.5. *Lecania rabenhorstii (Hepp) Arnold*

Thallus usually in orbicular patches, thick, continuous, angular areoles, the edges often curling upwards. Surface of thallus dark, yellow-grey-brown, sometimes with small, scattered angular or lobe-like fragments. Apothecia usually wide, abundant and covers areoles' surface, (0.35─)0.4─*0.5*─0,6(─0.65) mm diam, brownish black. Epihymenium brown, 78 µm, hymenium hyaline, and 100 µm. Ascus 8 spored, *Bacidia*-type, 45.5 × 105.5 µm diam. Ascospores 12─13.5 × 5 µm, hyaline. Pycnidia rare. All spot tests are negative (Figure 9).

Ecology and distribution: On base-rich rocks, limestone, etc., particularly in coastal areas, common. Throughout the British Isles, Europe, North Mediterranean, Macaronesia, Africa, North America, and Middle Europe [10] and common in Türkiye [2].

Specimen examined: Türkiye, Mersin, Akkuyu, Beş Parmak Island, on siliceous rock, Station 5, 36°07'27.1"N 33°31'59.6" E alt., 32 m., ERC AMEKA 0.109, leg. M. G. Halıcı.

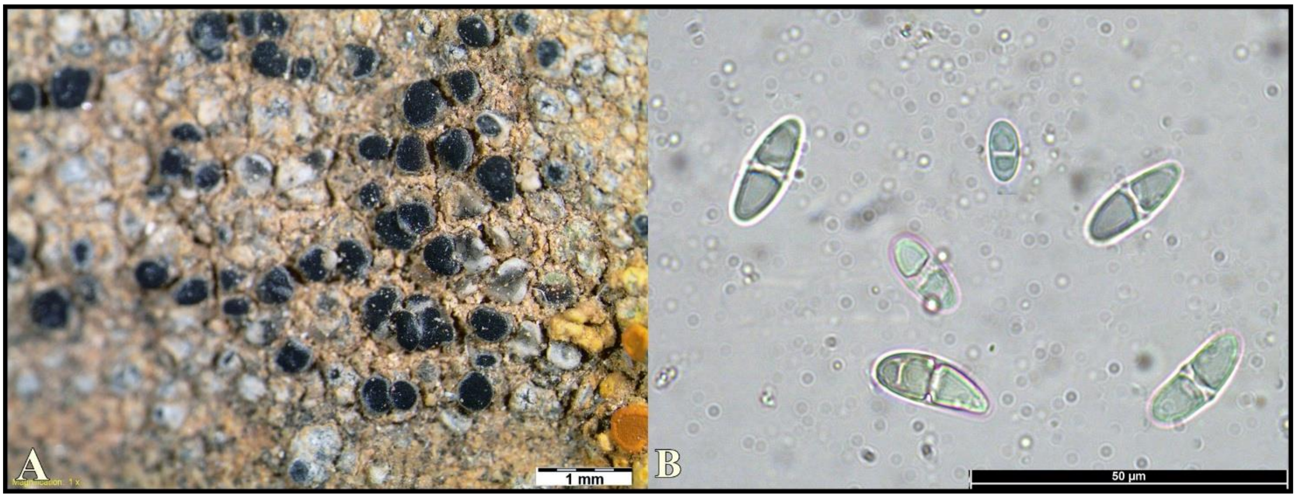

Figure 9. *Lecania rabenhorstii*. A. Habitus, B. Ascospores

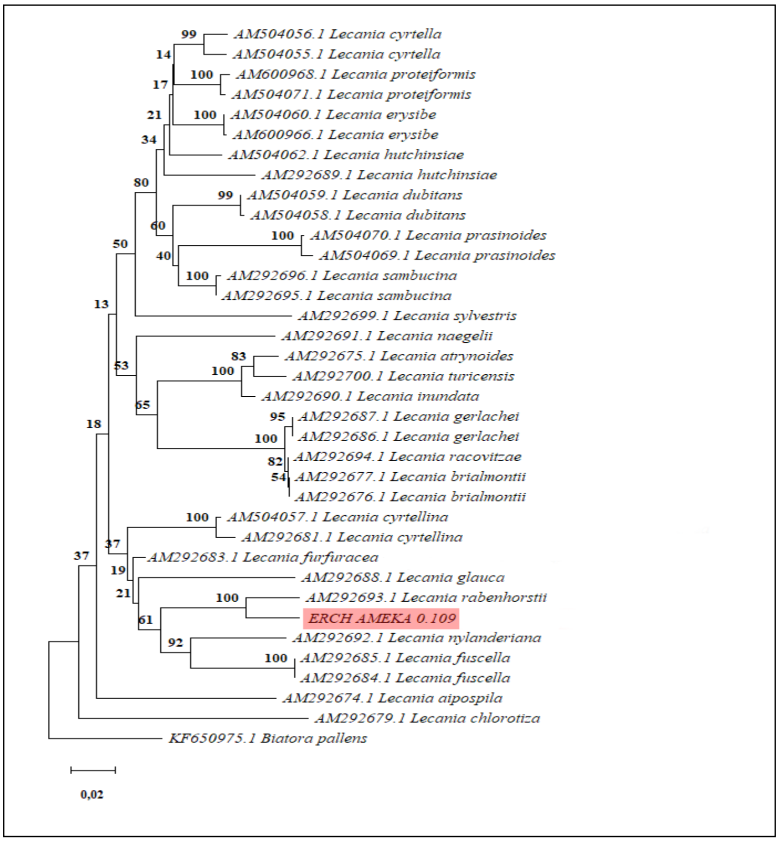

Figure 10. *nrITS* ML dendrogram of *Lecania rabenhorstii*

3.6. Lobothallia radiosa (Hoffm.) Hafellner

Thallus placoid, circular, to 8 cm diam, 0.25─0.5 mm thick, usually angular on main line. Lobes confluent, tightly adnate. Lobe length 2.5─4.5 µm and lobe width 0.8─1 µm. Upper surface usually dark grey, greenish, olive green, greenish gray to greyish brown. Apothecia abundant, centrally dense, sesile and (0.25─)0.35─*0.5*─0.65(─0.7) mm diam. Apothecial disc red-brown to grey-brown, sometimes black to brownish black, at first concave, then plane, and usually not pruinose. Epihymenium 10─15 µm and hyaline, hymenium 70─80 µm and hyaline. Hypothecium 30 µm. Ascus rectangular-elliptic, 8-spored, and 64 × 23 µm. Ascospores hyaline, simple, ellipsoid, (10.5─)11─*12.5*─14(─14.5) µm × (7.5─)8.5─*9*─9.5(─10) µm width. Paraphyses slender, tips clavate, 2─3 µm. Thallus K- or K+ faint brown, C-, KC-, P-, Medulla and cortex P+ yellow and C- (Figure 11).

Ecology and distribution: Occurs on rigid siliceous substrates, including basalt and various organic rocks, granite, and rhyolite, or on silicate-carbonate formations, where the silica content is nearly equal to calcium or magnesium.

Distributed through Europe, Asia, and North America in the World and Türkiye, it is very common on hard siliceous rocks [2, 10].

Species examined: Türkiye, Mersin, Through Aydıncık-Gülnar road to Yassıhan village, on calcareous rock, 36°16'06.5"N 33°19'23.3" E alt., 750–760 m., ERC AMEKA 0.051, leg. M. G. Halıcı.

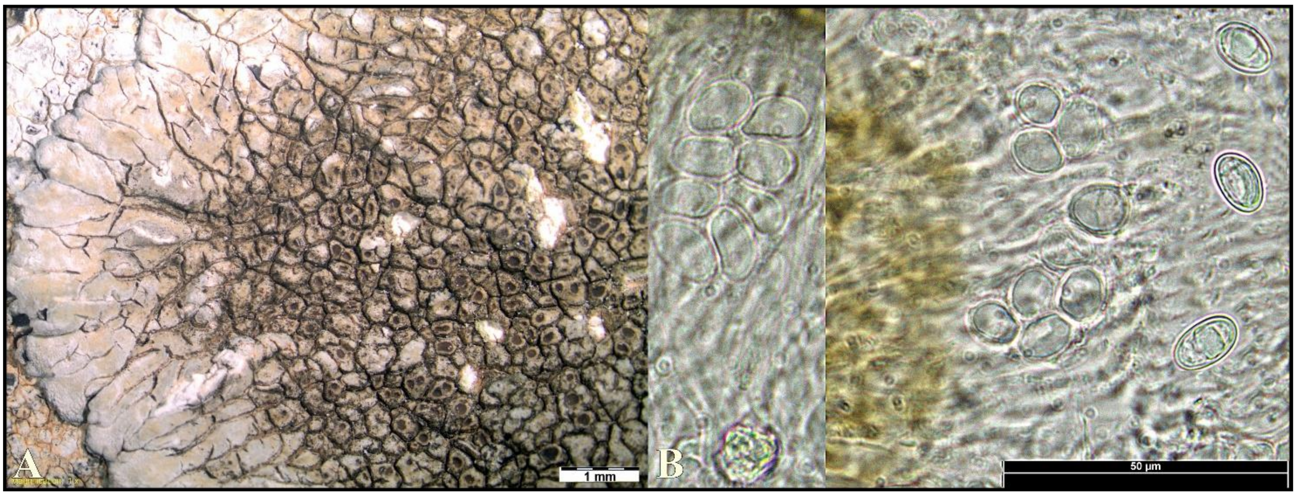

Figure 11. *Lobothallia radiosa* A. Habitus, B. Ascospores

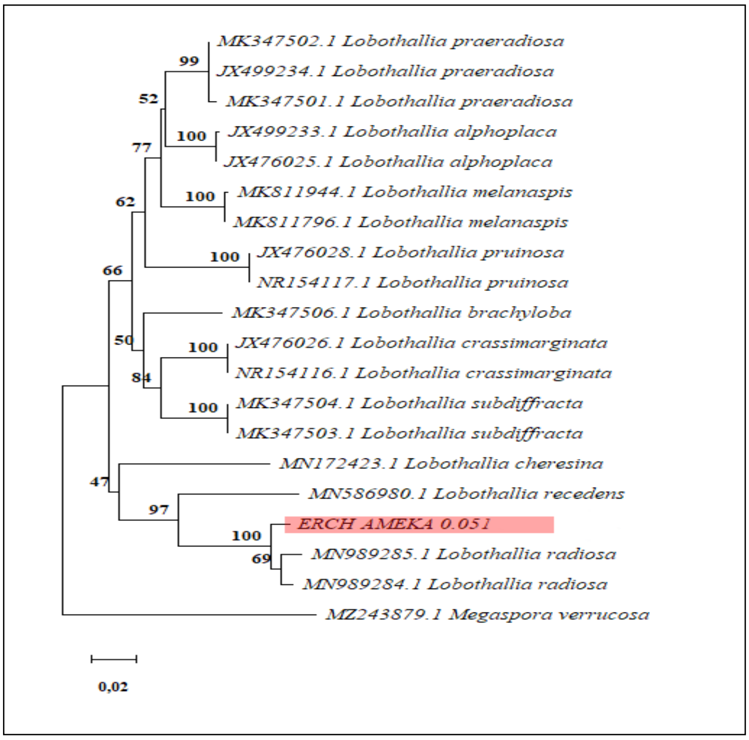

Figure 11. *nrITS* ML dendrogram of *Lobothallia radiosa*

3.7. Megaspora verrucosa (Ach.) Arcadia & A. Nordin

Thallus crustose, olivaceous green-whitish green, partially pruinose, soredia and isidia absent, hypotallus ambiguous. Apotechia immersed to areoles, (0.3─)0.35─*0.5*─0.65(─0,7) mm diam. Apotechial disc black, deeply concave, at first ostiolate then gradually narrowing. Hymenium I+ blue, 200─250 µm and hyaline. Hypothecium pale yellowish to brownish. Ascus clavate, 8-spored, 200─230 × 45─50 µm. Ascospores has thick walls, often has oil drops, and (38─)38.5─*46.5*─54.5(─60) µm × (20.5─)23.5─*26.5*─29.5(─30) µm. All chemical spots test are negative (Figure 13).

Ecology and distribution: Occurs on moss, humus, and soils and can also occur on barks in the Arctic, Europe, Macaronesia, Asia, South America, and North America [19, 20].

Specimen examined: Türkiye, Mersin, Gülnar, Gülnar- Silifke Highway, Kayrak exit, on calcareous rock, 36°21'24.5"N 33°33'08.8"E alt., 1000─1020 m. Corrupted forests and cliffs, ERC AMEKA 0.091**,** leg. M. G. Halıcı.

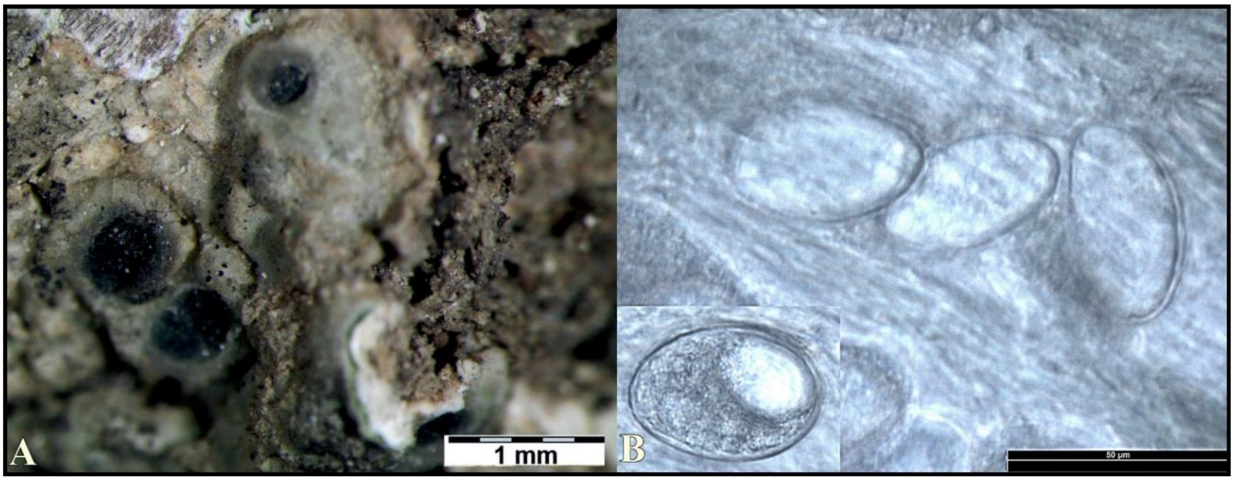

Figure 13. *Megaspora verrucosa* A. Thallus, B. Ascospores

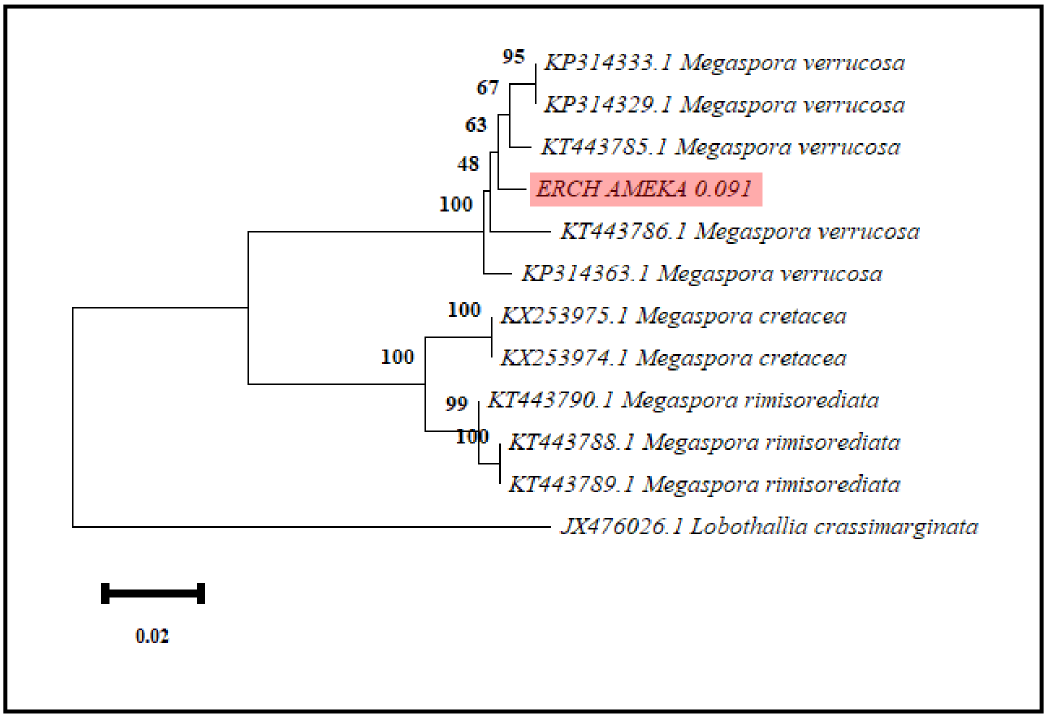

Figure 14. *nrITS* ML dendrogram of *Megaspora verrucosa*

3.8. Physcia stellaris (L.) Nyl.

Thallus up to 3─6 cm diam, usually orbicular, closely adpressed. Lobes 0.5─1.5 mm wide, radiating, white to darkish grey, rarely with a bluish tinge, not indistinctly white-flecked, not pruinose, without soredia or isidia, bullate warts or secondary lobules sometimes at the center of thallus and on apothecia margins. Lowe side of the thallus whitish to pale brown-white or pale grey, with numerous simple or branched, whitish to dark brown or grey rhizines that often protrude beyond the lobe margins. Apothecia usually present, (1─)1.2─*1.5*─1.8(─2.3) mm diam and disc-shaped. Apothecial disc black and often white pruinose. Hymenium 87 µm and hyaline. Ascus 8-spored and 60 × 25 µm. Ascospores brown, 1-septate, (15.5─)17─*17.5*─18(─19) × (8.5─)─*9.0*─(─10) µm. Pycnidia common and immersed. Cortex K+, yellow C-, KC-, Pd+, medulla K-, C-, KC-, P- (Figure 15).

Ecology and distribution: Occurs on bark—Cosmopolitan except Antarctica [10]. Very common on barks in Türkiye [2].

Specimen examined: Türkiye, Mersin, Gülnar, Gülnar- Silifke Highway, Kayrak exit, on calcareous rock, 36°21'24.5"N 33°33'08.8"E alt, 1000–1020 m. Corrupted forests and cliffs, **ERC AMEKA 0.020,** leg. M. G. Halıcı.,

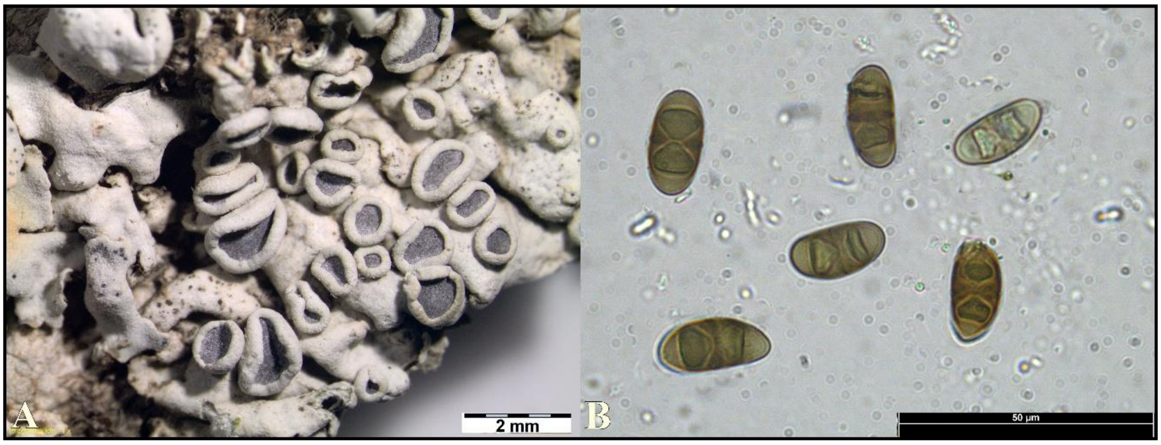

Figure 15. *Physcia stellaris*. A. Thallus, B. Ascospores

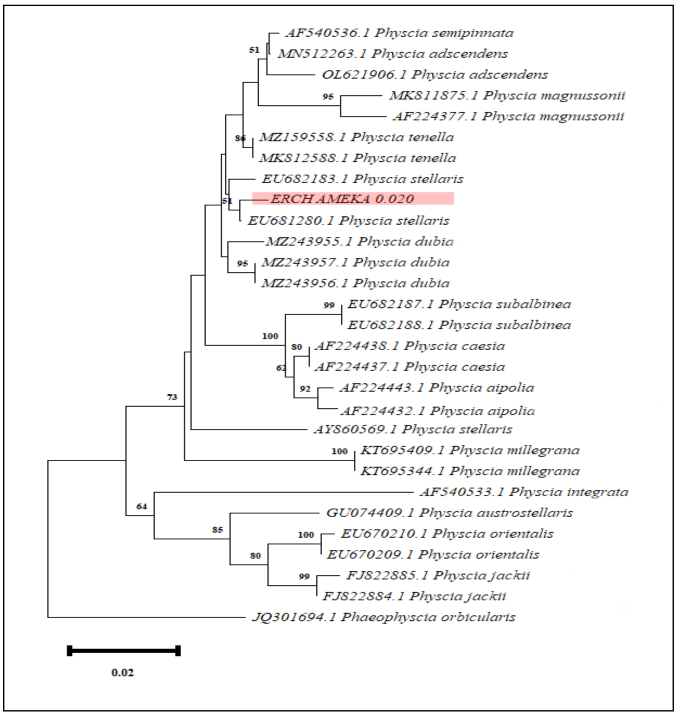

Figure 16. *nrITS* ML dendrogram of of *Physcia stellaris* (ERC AMEKA 0.020)

3.9. Xanthocarpia marmorata (Bagl.) Frödén, Arup & Søchting

Thallus crustose, immersed. Prothallus absent. Apothecia adnate, (0.25─)0.3─*0.4*─0.5(─0.65) mm diam. Apothecial disc reddish brown to dark orange, smooth to convex, not pruinose. Epihymenium goldish, K+ red, and 40 µm. Hymenium 65 µm and hyaline. Paraphyses apically swollen, apices 1-2 µ.. Hypothecium 55 µm. Ascus cylindrical, 8-spored and 65 × 25 µm. Ascospores hyaline, polaribilocular, polaribilocular (12─)13─*14*─15(─16) µm × (5.5─)6.5─*7*─7.5(─8) µm and septa (2─)2.5─*3.5*─4.5(─5) µm (Figure 16).

Ecology and distribution: Occurs on calcareous rocks and soft calcareous sea shells. Throughout Europe and North America [10].

Specimen examined: Türkiye, Mersin, Gülnar, upper Sipahi river, on calcareous rock, 36°10'01.5"N 33°28'20.5" E alt., 185–195 m., ERC AMEKA 0.099, leg. M. G. Halıcı.,

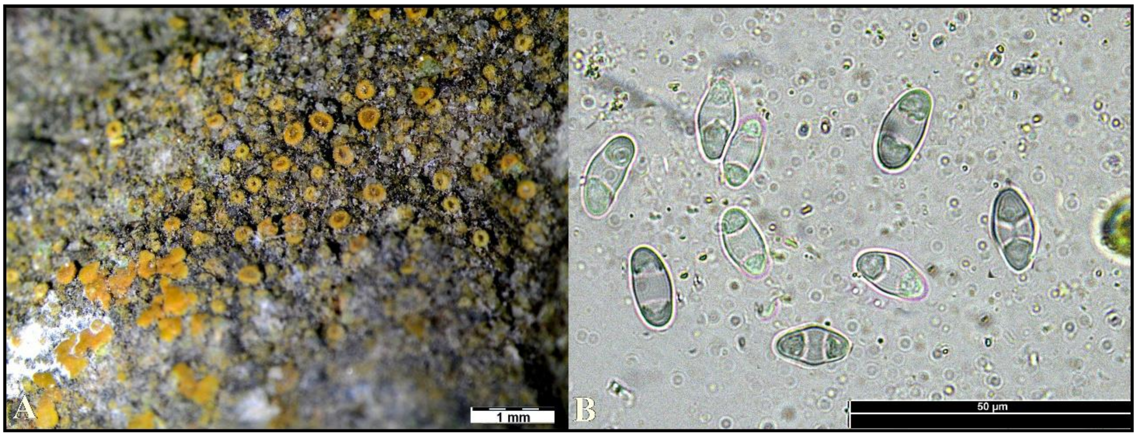

Figure 17**.** *Xanthocarpia marmorata* A. Thallus, B. Ascospores

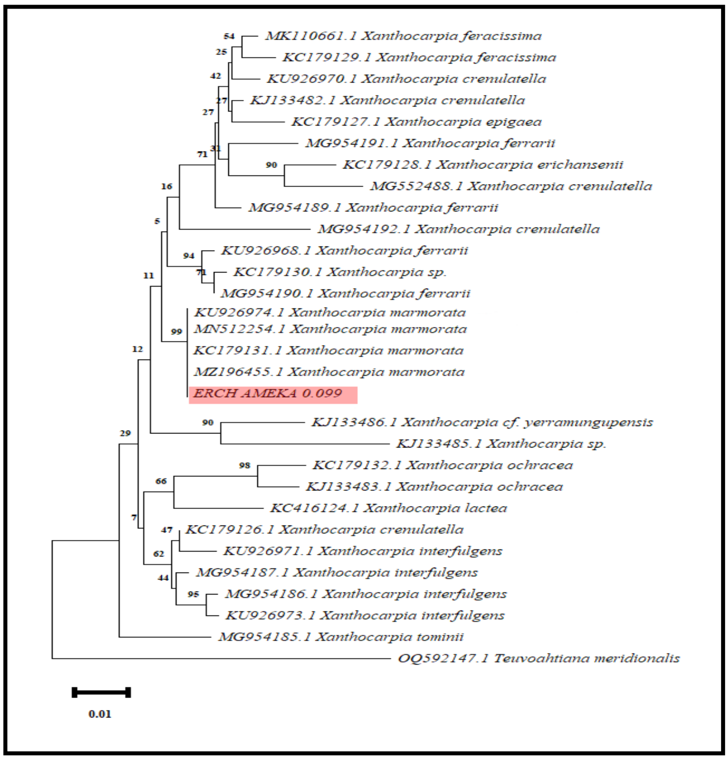

Figure 18. *nrITS* ML dendrogram of *Xanthocarpia marmorata*

4. Conclusions and discussion

As a result of this study, nine species collected from the study area and diagnosed molecularly are *Circinaria calcarea*, *Flavaploca havaasii*, *Flavoplaca communis*, *Kuettlingeria erythrocarpa*, *Lecania rabenhorstii*, *Lobothallia radiosa*, *Megaspora verrucosa*, *Physcia stellaris* and *Xanthocarpia marmorata*.

In the *nrITS* ML dendrogram of *C. calcarea* (Figure 3), a sample from the Akkuyu region (ERC AMEKA 0.111) matches *Circinaria calcarea*. *Circinaria mansourii* (Sohrabi) Sohrabi is closely related to *C. calcarea*. While *C. calcarea* is a saxiolous lichen which grows on basic, calciferous and calcareous rock, *C. mansourii* is a terricolous species wgich grows on soil or plant debris. Also *C. calcarea* characteristicly have immersed apothecia into its thallus, in contrast, apothecia or pycnidia have rarely been observed in *C. mansourii* [21]. *C. calcarea* exhibits anatomical and morphological similarities to *C. contorta* (Hoffm.) A. Nordin, Savić & Tibell. However, the apothecia of *C. contorta* are characterized by a crater-like shape, and its ascospores are more spherical and narrower than those of *C. calcarea*. Additionally, *Hymenelia cyanocarpa* (Anzi) Lutzoni bears a superficial resemblance but is distinct in its occurrence on siliceous substrates [10].

In the *nrITS* ML dendrogram of *F. communis* and *F. havaasii* (Figure 6), it is clear that samples from the Akkuyu region (ERC AMEKA 0.105 and ERC AMEKA 0.110) match *F. havaasii* and *F. communis*. It isn't easy to distinguish between *F. havaasii* and *F.communis* species morphologically. *F. communis* is typically found on siliceous substrates along shorelines, whereas *F. havaasii* does not share this habitat preference. Additionally, the thallus of *F. communis* is less developed and lacks the coarse granules that characterize *F. havaasii*. As seen in Figure 5, molecular analysis reveals that *F. maritima* (B. de Lesd.) Arup, Frödén & Søchting, *F. communis,* and *F. havaasii* are grouped within the same clade. *F. communis* grows on siliceous rocks, whereas *F. havaasii* prefers a different habitat. The distribution of *F. maritima* is restricted to coastal areas or rocky shorelines. Furthermore, *F. maritima* exhibits more reddish-orange apothecia and ascospores with more minor septa than *F. havaasii* [23].

In the *nrITS* ML dendrogram of *K. erythrocarpa* (Figure 8), it is clear that the sample from the Akkuyu region (ERC AMEKA 0.041) matches with *Kuettlingeria erythrocarpa*. *Kuettlingeria teicholyta* (Ach.) Trevis is closely related to *K. erythrocarpa*. However, it is differentiated from *K. teicholyta* by its distinctive vegetative propagation [10].

In the *nrITS* ML dendrogram of *L. rabenhorstii* (Figure 10); it is clear that sample from Akkuyu region (ERC AMEKA 0.109) matches *Lecania rabenhorstii. L. rabenhorstii* is anatomically similar to *Lecania inundata* (Hepp ex Körb.) M. Mayrhofer. *L. inundata* has more dense papillate thallus surface than *L. rabenhorstii*. Furthermore, it exhibits morphological similarities with *Lecania turicensis* (Hepp) Müll. Arg., yet can be distinguished by its more whitish-gray thallus [9]. As seen in Figure 9, L. rabenhorstii is closely related to *L. nylanderiana* A. Massal. *L. nylanderiana* has no papillate surface, and also it has 3-septate ascospores, unlike *L. rabenhorstii* [24].

In the *nrITS* ML dendrogram of *L. radiosa* (Figure 12), it is clear that the sample from the Akkuyu region (ERC AMEKA 0.051) matches *Lobothallia radiosa*. *Lobothallia radiosa* is similar to *Lobothallia praeradiosa* (Nyl.) Hafellner both morphologically and anatomically. However, the *L. radiosa* has thinner adnate tallus and thinner lobes. The absence of hyphal packets in the medulla also differentiates this species from *L. praeradiosa*. *Lobothallia recedens*, the closest relative of *Lobothallia radiosa* according to *nrITS* gene region. It can be differentiated from *L. radiosa* by its thicker thallus, the medulla's K- and Pd- reactions, and its less frequent distribution [25].

In the nrITS ML dendrogram of *M. verrucosa* (Figure 14), it is clear that the sample from the Akkuyu region (ERC AMEKA 0.091) matches *Megaspora verrucosa.* M. verrucosa anatomically resembles *M. rimisorediata* Valadb. & A. Nordin. However, *M. verrucosa* can be distinguished from *M. rimisorediata* by its longer hymenium, which measures between 200─250 µm, as well as its larger ascus dimensions (200─230 × 45─50 µm) and larger ascospores (30─60 × 21─42 µm) [10]. *M. verrucosa* is closely related to M. cretacea Gasparyan, Zakeri & Aptroot, as seen in Figure 13. In contrast, *M. cretacea* is characterized by the presence of soredia, a 4-spored ascus, smaller ascospores, and a habitat restricted to barks, distinguishing it from *M. verrucosa* [26].

In the *nrITS ML* dendrogram (Figure 16), it is clear that the sample from the Akkuyu region (ERC AMEKA 0.020) matches with *P. stellaris.* The closest branch is *P. dubia* (Hoffm.) Lettau. It differs from *P. dubia* by not containing vegetative propagules like soredia or isidia. Notably, *P. stellaris* is distinguished from *P. dubia* by the absence of vegetative propagules such as soredia or isidia. Furthermore, *P. stellaris* is often anatomically and morphologically mistaken for *P. aipolia* (Ehrh. ex Humb.) Fürnr., with which it commonly coexists. However, it can be differentiated by the absence of white-flecked lobes, particularly evident when the specimen is moist, as well as by its medulla reaction K- and the lack of zeorine [10, 11].

In the *nrITS* ML dendrogram (Figure 18), it is clear that our samples from the Akkuyu region (ERC AMEKA 0.081 and ERC AMEKA 0.099) are branching with *Xanthorcarpia marmorata.* This species is phylogeneticly, anatomically and morphologically very similar with *Xanthocarpia diffusa* and *X. crenulatella* species are very similar. However, it is distinguished by the presence of dark red apothecia discs and a very thin whitish tallus [27].

Numerous investigations into the biodiversity of lichenized fungi have been conducted within Türkiye. Due to their distinctive characteristics, Lichens represent unique biological associations, and understanding their biodiversity is poised to make a substantial contribution to existing scholarly literature. This research aims to enhance the body of knowledge regarding lichen biodiversity. Additionally, the significance of the study area adds another layer of importance to this investigation. The research focuses on lichens found in the Akkuyu region, which is slated for the establishment of a nuclear power plant in Mersin Province. Lichens are recognized for their efficacy as bioindicators of atmospheric trace element pollution, attributed to their considerable capacity for accumulating heavy metals and radionuclides and their reliance on atmospheric nutrients. The operation of nuclear power plants is associated with releasing heavy metals and radionuclides into the environment. Consequently, lichens serve as primary bioindicators of the ecological impacts induced by nuclear power facilities, marking the initial phase of environmental succession and acting as effective collectors of atmospheric pollutants. Thus, this study is anticipated to serve as a foundational reference for future research on the region's lichen biodiversity and provide insights for subsequent investigations.

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