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Contributions to lichen diversity of Turkey from the Sarısu area (Kocaeli)

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Abstract: A total of 85 lichen taxa from the Sarısu area of the district of Kandıra in Kocaeli Province were listed. Three new records for the biota of Turkey, *Coenogonium pineti* (Ach.) Lücking & Lumbsch, *Lecania cuprea* (A.Massal.) Van den Boom & Coppins, and *Opegrapha calcarea* Turner ex Sm., have been identified within the context of this study along with 81 new taxa for the province of Kocaeli.

Key words: Lichenised fungi, biodiversity, biota, Kocaeli

1. Introduction

Lichens have been studied for over 150 years, with an increasing number of publications that have neared 500 in recent years in Turkey. Records pertaining to lichens from the province of Kocaeli are rather limited (Pisut, 1970; John, 2002; Çobanoğlu, 2005), and there have been no previous studies investigating the Sarısu area in particular. As the first detailed lichenological survey of this region, our study identified a total of 85 taxa, the majority of which were new findings for Kandıra District and Kocaeli Province, as well as Turkey.

The province of Kocaeli is situated within the eastern boundaries of the Marmara Region in Turkey (Figure). The region is located to the east of İstanbul and is surrounded by the Black Sea towards the north. The only coastal town of the Black Sea in Kocaeli Province is Kandıra, which has a 52-km coast along the sea and an area of 933 km^2 that is dotted with small hills (the highest ones reaching 400 m in altitude). Its main noticeable feature is its economy, which is based on agriculture and livestock. The area of research, Sarısu, is located 8 km from Kandıra within the boundaries of the village of Babaköy. Sarısu is covered by forests along the coast that are composed of fast-growing native pine species, juniper, natural oak, beech, hornbeam, linden, chestnut, and red dogwood trees. Sarısu has an interesting geography; it is crossed by the 25-km-long Sarısu creek that joins the Black Sea, and its last 1 km runs parallel with the coast and reaches the sea through a beach. Tourism based on backpacking and camping is common in the region.

The climate of Kocaeli Province is temperate along the Black Sea and the gulf coasts; a harsher climate prevails in the mountainous regions. The climate of Kandıra District is under the influence of the climate of the Western Black Sea and Marmara regions. This climate is transitional between the climates of the Mediterranean and the Black Sea. The mountainous range along the coast creates a barrier against the harsh winds from the north. Extreme temperatures are not experienced during the winter season, and the irregular precipitation is usually in the form of rain and less often in the form of snow. The region receives most of its precipitation during the winter and spring. Rainfall is lowest during the months of May, June, July, August, and September. The mean annual temperature is 14.6 °C and annual precipitation is approximately 816.4 mm (Akman, 1990).

Kocaeli Province has a dense industrial area in its central regions (around İzmit) and also towards the north-west and around the Gulf of İzmit. The activities in these industrial regions are likely to affect a broad area across Kocaeli Province. There is only one study in which the pollution of the city was analysed using biomonitor lichens, and it was carried out recently by Doğrul-Demiray et al. (2012). This study described severe levels of atmospheric metal pollution in some of the districts of Kocaeli Province, excluding Kandıra.

The aim of this study regarding lichen diversity in the area and vicinity of Kandıra is to contribute to the knowledge on Turkey's lichen biota.

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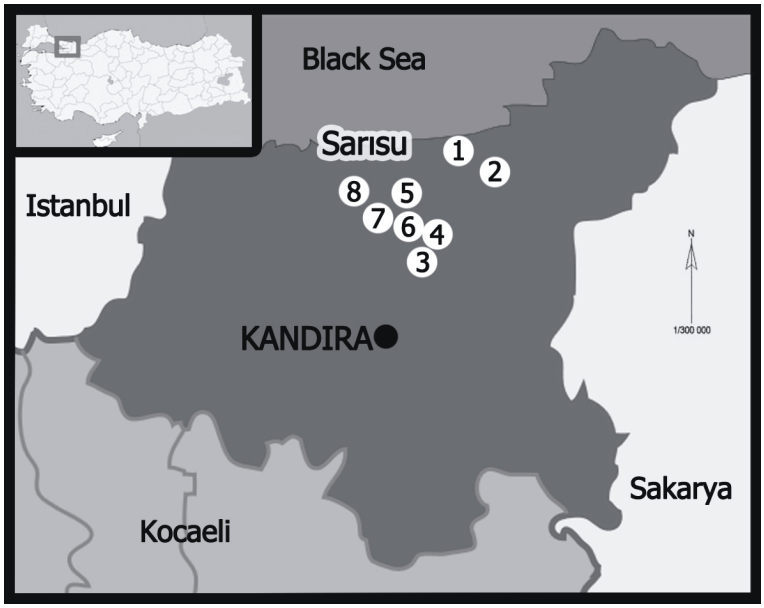

Figure. Map of the research area (Sarısu). Collection sites indicated with numbers.

2. Materials and methods

This study is based on lichen specimens collected during 3 short excursions (23–24.05.2009, 23.04.2010, and 22.10.2010) to the Sarısu area in Kandıra District of Kocaeli. Lichen material was collected from 8 sites in the vicinity of Marmara University's Research Centre for the Nature Plants and Water Products from a variety of substrates including tree bark, stumps, wood, siliceous and calcareous rock and stone, walls, soil, metal, and pine cones. The abbreviations for the substrates are provided below together with the number of lichen taxa distributed on each type. The information regarding the locations is provided in the Table.

The specimens were examined by using light microscopy (Olympus SZ40) and chemical spot tests (standard K, C, P, and I). Lichen taxa were identified with the aid of flora books and identification keys (Wirth, 1995; Smith et al., 2009). The collected materials are preserved in the herbarium of the Faculty of Science and Arts, Marmara University, İstanbul (MUFE).

3. Results

Lichen taxa are alphabetically listed below and include 85 taxa (84 species with 3 subspecies, 3 varieties, and 3 forma levels). In this list, the numbers of the collecting sites and the types of substrate are specified with the herbarium numbers (*G.Çoban.* 2368 to 2452) for each taxon.

The nomenclature mainly follows the Index Fungorum (www.indexfungorum.com) and recent literature (Blanco et al., 2004; Smith et al., 2009). The names of the authors are abbreviated according to Brummitt and Powell (1992).

An asterisk indicates new records for the province and a plus sign indicates new records for Turkey.

List of taxa

**Acarospora fuscata* (Nyl.) Th.Fr., loc. no.: 1, 3, 5, 6, wall, calcareous rock, slightly calcareous rock, *G.Çoban.* 2368.

**Aspicilia calcarea* (L.) Mudd, loc. no.: 1, 4, calcareous rock, *G.Çoban.* 2369.

**Aspicilia cinerea* (L.) Körb., loc. no.: 1, 3, calcareous rock, *G.Çoban.* 2370.

**Aspicilia radiosa* (Hoffm.) Poelt & Leuckert, loc. no.: 5, siliceous rock, *G.Çoban.* 2371.

**Bacidia arceutina* (Ach.) Rehm & Arnold, loc. no.: 1, *Juniperus oxycedrus* L., *G.Çoban.* 2372.

**Caloplaca alociza* (A.Massal.) Mig., loc. no.: 1, calcareous rock, *G.Çoban.* 2373.

**Caloplaca aurantia* (Pers.) Hellb., loc. no.: 4, calcareous rock, *G.Çoban.* 2374.

**Caloplaca cerina* (Hedw.) Th.Fr. var. *cerina*, loc. no.: 1, *Juniperus oxycedrus* L., *G.Çoban.* 2375.

Caloplaca citrina (Hoffm.) Th.Fr., loc. no.: 1, 3, 4, calcareous rock, wall, calcareous rock, *G.Çoban.* 2376.

**Caloplaca crenularia* (With.) Q.R. Laundon, loc. no.: 1, calcareous rock, *G.Çoban.* 2377.

**Caloplaca erythrocarpa* (Pers.) Zwackh, loc. no.: 1, calcareous rock, *G.Çoban.* 2378.

**Caloplaca flavescens* (Huds.) Q.R. Laundon, loc. no.: 1, calcareous rock, *G.Çoban.* 2379.

**Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth., loc. no.: 1, calcareous rock, *G.Çoban.* 2380.

Table. Information regarding collection sites in the research area.

Locality number	Situation	GPS	Altitude	Date of collection
1	Marmara University, Research Centre for Native Flora and Fishery Products of Turkey, surroundings	41°08′23.4″N, 030°09′34.4″E	8–13 m	23–24.05.2009 23.04.2010 22.10.2010
2	Kerpe road	41°08′22.0″N, 030°09′44.1″E	11 m	23.04.2010
3	Babadağ peak and Babaköy village mosque surroundings	41°06′50.2″N, 030°11′28.8″E	215 m	23.04.2010
4	Road between Babadağ hill and Sarısu	41°06′40.5″N, 030°11′24.02″E	124 m	23.04.2010
5	Road from Babadağ down to Sarısu	41°06′40.08″N, 030°11′18.00″E	117 m	23.04.2010
6	South-eastern slope on the opposite side of the road by Sarısu creek	41°08′13.9″N, 030°09′42.6″E	25 m	22.10.2010
7	Side of the road along the Sarısu creek	41°08′01.08″N, 030°09′36.4″E	4 m	22.10.2010
8	Around the pond	41°08′06.8″N, 030°08′47.1″E	12 m	22.10.2010

**Caloplaca holocarpa* (Hoffm.) A.E. Wade, loc. no.: 1, 3, 6, calcareous rock, wall, calcareous rock, slightly calcareous rock, *G.Çoban.* 2381.

**Caloplaca lactea* (A.Massal.) Zahlbr., loc. no.: 1, 5, calcareous rock, slightly calcareous rock, *G.Çoban.* 2382.

**Caloplaca polycarpa* (A.Massal.) Zahlbr., loc. no.: 1, *A. calcarea*, *V. nigrescens, G.Çoban.* 2383.

**Caloplaca saxicola* (Hoffm.) Nordin, loc. no.: 1, 3, 4, calcareous rock, *G.Çoban.* 2384.

**Caloplaca variabilis* (Pers.) Müll.Arg., loc. no.: 1, calcareous rock, *G.Çoban.* 2385.

**Candelariella aurella* (Hoffm.) Zahlbr. f. *aurella*, loc. no.: 1, calcareous rock, *G.Çoban.* 2386.

**Candelariella vitellina* (Ehrh.) Müll.Arg. f. *vitellina*, loc. no.: 3, 5, 6, calcareous rock, slightly calcareous rock, *G.Çoban.* 2387.

**Cladonia chlorophaea* (Flörke ex Sommerf.) Spreng., loc. no.: 4, 5, 6, soil, *G.Çoban.* 2388.

**Cladonia coniocraea* (Flörke) Spreng., loc. no.: 5, 6, soil, *G.Çoban.* 2389.

**Cladonia convoluta* (Lamkey) Anders, loc. no.: 5, soil, *G.Çoban.* 2390.

**Cladonia fimbriata* (L.) Fr., loc. no.: 4, 5, soil, *G.Çoban.* 2391.

**Cladonia furcata* (Huds.) Schrad. subsp. *furcata*, loc. no.: 5, soil, *G.Çoban.* 2392.

**Cladonia furcata* subsp. *subrangiformis* (L.Scriba ex Sandst.) Pišút, loc. no.: 6, soil, *G.Çoban.* 2393.

**Cladonia pocillum* (Ach.) O.Q. Rich., loc. no.: 2, 5, soil, *G.Çoban.* 2394.

**Cladonia pyxidata* (L.) Hoffm., loc. no.: 1, 2, 4, 6, soil, *Juniperus oxycedrus* L., *Quercus infectoria* Olivier, *G.Çoban.* 2395.

**Cladonia rangiformis* Hoffm., loc. no.: 2, 5, soil, *G.Çoban.* 2396.

+**Coenogonium pineti* (Ach.) Lücking & Lumbsch, loc. no.: 2, bark, *G.Çoban.* 2397.

**Collema crispum* (Huds.) Weber ex F.H. Wigg. var. *crispum*, loc. no.: 1, calcareous rock, *G.Çoban.* 2398.

**Collema cristatum* (L.) Weber ex F.H. Wigg. var. *cristatum*, loc. no.: 1, 3, calcareous rock, *G.Çoban.* 2399.

**Diploicia canescens* (Dicks.) A.Massal., loc. no.: 5, siliceous rock, *G.Çoban.* 2400.

**Diplotomma alboatrum* (Hoffm.) Flot., loc. no.: 1, 7, calcareous rock, *G.Çoban.* 2401.

**Diplotomma hedinii* (H.Magn.) P.Clerc & Cl.Roux, loc. no.: 1, calcareous rock, *G.Çoban.* 2402.

**Evernia prunastri* (L.) Ach., loc. no.: 6, bark, *G.Çoban.* 2403.

**Flavoparmelia caperata* (L.) Hale, loc. no.: 6, bark, *G.Çoban.* 2404.

**Graphis scripta* (L.) Ach., loc. no.: 6, 8, bark, cone of *Pinus pinaster* Ait., *G.Çoban.* 2405.

**Hypotrachyna revoluta* (Flörke) Hale, loc. no.: 6, bark, *G.Çoban.* 2406.

+**Lecania cuprea* (A.Massal.) Van den Boom & Coppins, loc. no.: 3, calcareous rock, *G.Çoban.* 2407.

**Lecania cyrtella* (Ach.) Th.Fr., loc. no.: 1, *Juniperus oxycedrus* L., *G.Çoban.* 2408.

**Lecania cyrtellina* (Nyl.) Sandst., loc. no.: 3, *Quercus infectoria* Olivier, *G.Çoban.* 2409.

**Lecanora albescens* (Hoffm.) Branth & Rostr., loc. no.: 1, 4, *Quercus infectoria* Olivier, calcareous rock, *G.Çoban.* 2410.

**Lecanora campestris* (Schaer.) Hue, loc. no.: 1, 3, 6, 7, calcareous rock, bark, slightly calcareous rock, *G.Çoban.* 2411.

**Lecanora carpinea* (L.) Vain., loc. no.: 1, *Quercus infectoria* Olivier, *G.Çoban.* 2412.

**Lecanora cenisia* Ach., loc. no.: 5, siliceous rock, *G.Çoban.* 2413.

**Lecanora chlarotera* Nyl., loc. no.: 3, 5, 6, *Quercus infectoria* Olivier, bark, *G.Çoban.* 2414.

**Lecanora crenulata* Hook., loc. no.: 1, calcareous rock, *G.Çoban.* 2415.

**Lecanora dispersa* (Pers.) Röhl., loc. no.: 1, 3, 6, calcareous rock, wall, bark, slightly calcareous rock, *G.Çoban.* 2416.

**Lecanora strobilina* (Spreng.) Kieff., loc. no.: 1, 2, 3, 4, 6, 8, *Quercus infectoria* Olivier, *Juniperus oxycedrus* L., bark, cone of *Pinus pinaster* Ait., *G.Çoban.* 2417.

**Lecidella anomaloides* (A.Massal.) Hertel & H.Kilias, loc. no.: 5, 6, siliceous rock, *G.Çoban.* 2418.

**Lecidella elaeochroma* (Ach.) M.Choisy f. *elaeochroma*, loc. no.: 1, 3, 4, 5, 7, *Quercus infectoria* Olivier, *Juniperus oxycedrus* L., *Pinus nigra* L., *G.Çoban.* 2419.

**Melanelixia fuliginosa* subsp. *glabratula* (Lamy) Q.R. Laundon, loc. no.: 1, 2, 3, 4, 5, *Quercus infectoria* Olivier, *Juniperus oxycedrus* L., *G.Çoban.* 2420.

**Mycobilimbia pilularis* (Körb.) Hafellner & Türk, loc. no.: 3, *Quercus infectoria* Olivier, *G.Çoban.* 2421.

**Ochrolechia parella* (L.) A.Massal, loc. no.: 5, siliceous rock, *G.Çoban.* 2422.

**Opegrapha atra* Pers., loc. no.: 1, 6, 8, *Quercus infectoria* Olivier, *Juniperus oxycedrus* L., bark, cone of *Pinus pinaster* Ait., *G.Çoban.* 2423.

+**Opegrapha calcarea* Turner ex Sm., loc. no.: 1, 3, 4, calcareous rock, *G.Çoban.* 2424.

**Opegrapha herbarum* Mont., loc. no.: 1, 4, *Juniperus oxycedrus* L., *Quercus infectoria* Olivier, *G.Çoban.* 2425.

**Parmelia sulcata* Taylor, loc. no.: 1, 2, 3, 4, *Quercus infectoria* Olivier, *Juniperus oxycedrus* L., *G.Çoban.* 2426.

**Pertusaria pustulata* (Ach.) Duby, loc. no.: 3, 7, bark, *Quercus infectoria* Olivier, *G.Çoban.* 2427.

**Phaeophyscia orbicularis* (Neck.) Moberg, loc. no.: 3, *Ficus* sp., *G.Çoban.* 2428.

**Physcia adscendens* (Fr.) H.Olivier, loc. no.: 1, 3, 4, 5, 6, calcareous rock, *Quercus infectoria* Olivier, *Juniperus oxycedrus* L., calcareous rock, bark, *G.Çoban.* 2429.

**Physcia tenella* (Scop.) DC., loc. no.: 5, bark, *G.Çoban.* 2430.

**Placynthium nigrum* (Huds.) Gray, loc. no.: 1, calcareous rock, *G.Çoban.* 2431.

**Porpidia crustulata* (Ach.) Hertel & Knoph, loc. no.: 6, siliceous rock, *G.Çoban.* 2432.

**Protoparmeliopsis muralis* (Schreb.) M.Choisy, loc. no.: 1, 3, 5, 6, calcareous rock, wall, slightly calcareous rock, siliceous rock, *G.Çoban.* 2433.

**Ramalina canariensis* Q.Steiner, loc. no.: 1, 3, 4, 5, 6, *Quercus infectoria* Olivier, bark, *G.Çoban.* 2434.

**Ramalina farinacea* (L.) Ach., loc. no.: 3, 4, 6, *Quercus infectoria* Olivier, bark, *G.Çoban.* 2435.

**Rhizocarpon geminatum* Körb., loc. no.: 1, calcareous rock, *G.Çoban.* 2436.

**Rhizocarpon geographicum* (L.) DC., loc. no.: 6, siliceous rock, *G.Çoban.* 2437.

**Rhizocarpon petraeum* (Wulfen) A.Massal., loc. no.: 6, siliceous rock, *G.Çoban.* 2438.

**Rinodina olea* Bagl., loc. no.: 1, 3, calcareous rock, *G.Çoban.* 2439.

**Rinodina parasitica* H.Mayrhofer & Poelt, loc. no.: 1, *A. calcarea*, *G.Çoban.* 2440.

**Sarcogyne regularis* Körb., loc. no.: 3, calcareous rock, *G.Çoban.* 2441.

**Scoliciosporum chlorococcum* (Graewe ex Stenh.) Vězda, loc. no.: 1, calcareous rock, *G.Çoban.* 2442.

**Trapelia coarctata* (Turner ex Sm.) M.Choisy, loc. no.: 2, siliceous rock, *G.Çoban.* 2443.

**Verrucaria calciseda* DC., loc. no.: 1, calcareous rock, *G.Çoban.* 2444.

**Verrucaria fuscella* (Turner) Winch, loc. no.: 1, calcareous rock, *G.Çoban.* 2445.

**Verrucaria hochstetteri* Fr., loc. no.: 1, 3, calcareous rock, *G.Çoban.* 2446.

**Verrucaria muralis* Ach., loc. no.: 1, 4, calcareous rock, *G.Çoban.* 2447.

Verrucaria nigrescens Pers., loc. no.: 1, 3, 4, calcareous rock, *G.Çoban.* 2448.

**Xanthoparmelia conspersa* (Ehrh. ex Ach.) Hale, loc. no.: 1, slightly calcareous rock, *G.Çoban.* 2449.

**Xanthoparmelia verruculifera* (Nyl.) O.Blanco, A.Crespo, Elix, D.Hawksw. & Lumbsch, loc. no.: 5, 6, siliceous rock, *L. radiosa*, *G.Çoban.* 2450.

Xanthoria calcicola Oxner, loc. no.: 1, calcareous rock, *G.Çoban.* 2451.

Xanthoria parietina (L.) Th.Fr., loc. no.: 1, 2, 3, 4, 5, 6, 7, 8, calcareous rock, *Quercus infectoria* Olivier, *Juniperus oxycedrus* L., bark, metal, cone of *Pinus pinaster* Ait., *G.Çoban.* 2452.

4. Discussion

Only a limited number of studies have been conducted until now regarding the lichen biota of Kocaeli Province. Earlier records include 4 species from Karamürsel (Pisut, 1970), 5 species from Kefken (John, 2002), and 1 species from Eskihisar (Çobanoğlu, 2005). Four of the listed taxa in this study were recorded in the literature: *Caloplaca citrina* (Pisut, 1970), *Verrucaria nigrescens* and *Xanthoria calcicola* (John, 2002), and *X. parietina* (Çobanoğlu, 2005). As the lichen biota of Kocaeli have not been sufficiently evaluated, most taxa (81) in the current study, the first around Sarısu-Kandıra District, are new for Kocaeli Province (all taxa for Kandıra), and 3 taxa are new for Turkey as whole. In this sense, the present study has brought numerous new records and contributed to the lichen diversity in Turkey.

The distribution of the number of species in the region was as follows. Numerous lichen genera (37) are present; the first genus with the highest number of species is *Caloplaca* with 13 species, the second is *Cladonia* with 9 species, and the third is *Lecanora* with 8. The species composition is similar to that observed in the Black Sea coastal regions (John & Breuss, 2004). The saxicolous taxa were in the majority within the study area and concentrated particularly on calcareous coastal rocks. They are represented by the *Aspicilia calcarea*, *Caloplaca alociza*, *C. aurantia*, *C. flavescens*, *C. saxicola*, *C. variabilis*, *Collema*, *Diplotomma*, *Opegrapha calcarea*, *Xanthoria calcicola*, and *Verrucaria* species. Regarding occurrences in similar substrates, similar species can be found in different regions. For example, in spite of being far from our research area, most of the same calcareous species were recorded in many other regions (John & Breuss, 2004; Karagöz & Aslan, 2012).

Lichen species have adapted to living on specific substrate types. Calcareous rocks are rich in calcium carbonate minerals and harbour characteristic lichen species such as *Lecanora dispersa*, *Caloplaca*, and *Verrucaria*. Siliceous rocks, which are low in calcium carbonate but rich in silicates, are also common, especially in inland regions, and harbour some species of *Rhizocarpon* and *Xanthoparmelia* (Brodo et al., 2001).

Terricolous lichens were represented only by the *Cladonia* taxa. Acidity and humidity are important factors for the selection of soil by lichens (Brodo et al., 2001). The presence of a high number of *Cladonia* species in the area can be attributed to the effect of the Sarısu creek and the high level of humidity in comparison to the climate of the Black Sea.

The epiphytic taxa represent nearly half of the taxa identified in our list, including many corticolous samples, mainly from the bark of *Quercus*, *Juniperus*, and *Pinus*, as well as 4 crustose species from pine cones. *Quercus infectoria* and other deciduous trees such as beech, hornbeam, linden, chestnut, and red dogwood are richer in lichen species than conifers such as pine species.

In terms of chemical composition, conifers are high in organic resins and gums but low in inorganic nutrients. They also tend to be relatively more acidic. The forest habitat of the study area is composed of *Pinus pinaster* forests. The bark of *Pinus* has poor lichen cover; its cones, however, were invaded by some taxa. Certain species of lichens prefer the bark of deciduous trees, which are low in acidity, more stable, and contain more moisture, such as the bark of *Quercus* from the study area. For instance, considering that oak species differ in terms of bark features, Oran and Öztürk (2012) indicated differences in variety and preferences of the epiphytic lichens on 2 species of *Quercus* in the Marmara region. The most notable example is *Xanthoria parietina*, which covers the surface of trunks and branches of many kinds of deciduous trees in the area.

Habitat and substratum diversity is extremely important when considering the richness of species diversity for lichens (Löhmus et al., 2007). Hence, the rich diversity of species identified during this study is very likely due to both the climatic conditions and the substrate diversity that is characteristic of the study region.

In morphological terms, the lichens in the area are composed mainly of crustose taxa (60 taxa, including 6 placodioid forms), followed by foliose (13 taxa), squamulose (9 taxa; 3 with branched tubular podetia, 5 with cups, and 1 foliose-like), and fruticose (3 taxa).

Xanthoria parietina and *Physcia adscendens* are the 2 most common foliose lichen species in the area. *X. parietina* in particular was collected over a broad range of substrates such as cone, stone, calcareous rock, metal, and tree bark. Along with *Evernia prunastri* and *Ramalina* species, they are known as cosmopolitan taxa and are indicative of a moderate level of air pollution in terms of SO_2 concentration (Kirschbaum & Wirth, 1997). However, an actual list of Turkish lichens having indicator values has not been provided yet. For this reason, the lichen diversity of the research area needs to be evaluated in order to gain a better understanding of local pollution. Systematic studies will enlighten future research in the same area.

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