

LICHEN DIVERSITY OF GÖLCÜK NATURE PARK (ISPARTA), INCLUDING NEW RECORDS FOR TURKEY

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Abstract. In this study where the lichen biodiversity of Gölcük Nature Park and its surroundings in Isparta province located in the north-western part of Mediterranean Region of Turkey is assessed, a list of 189 lichenized fungi species (192 taxa) is reported. The most frequent 3 species in the study area are *Melanohalea exasperata*, *Anaptychia ciliaris* and *Lecidella elaeochroma*. Distribution of lichenized fungi depending on the substrate, respectively, is (41.67%) epiphytic, (36.56%) saxicolous, (14.52%) terricolous, (3.76%) muscicolous and (3.49%) lichenicolous. On a morphological basis, the crustose lichen taxa predominate in the area with 55.50% percentage, followed by the foliose (25.13%) and the squamulose (7.85%) taxa, while the leprose taxa are the fewest. Among the identified taxa, 73 species are firstly recorded for the research area and Isparta province. *Diplotomma pharcidium* (Ach.) M. Choisy, *Flavoplaca granulosa* (Müll. Arg.) Arup, Frödén & Söchting, and *Miriquidica pycnocarpa* (Körb.) are three new records for Turkish Lichen Mycota.

Keywords: Lichenized fungi, diversity, Mediterranean Turkey.

Rezumat. Diversitatea lichenilor din Parcul Natural Gölcük (Isparta), inclusiv înregistrări noi pentru Turcia. În acest studiu, este evaluată biodiversitatea lichenilor din Parcul Natural Gölcük și împrejurimile sale din provincia Isparta situată în partea de nord-vest a regiunii mediteraneene a Turciei, fiind raportată o listă cu 189 specii de fungi lichenizați (192 taxoni). Cele mai frecvente 3 specii din zona studiată sunt *Melanohalea exasperata*, *Anaptychia ciliaris* și *Lecidella elaeochroma*. Distribuția fungilor lichenizați, în funcție de substrat, este (41,67%) epifită, (36,56%) saxicolă, 14,52% tericolă, 3,76% muscicolă și 3,39% lichenicolă. Din punct de vedere morfologic, taxonomia lichenilor crustoși predomină în zonă cu un procent de 55,50%, urmată de taxonii foliați (25,13%) și scuamoși (7,85%), în timp ce restul taxonilor sunt reduși. Dintre taxonii identificați, 73 de specii sunt înregistrate în primul rând pentru zona de cercetare și provincia Isparta. *Diplotomma pharcidium* (Ach.) M. Choisy, *Flavoplaca granulosa* (Müll. Arg.) Arup, Frödén & Söchting și *Miriquidica pycnocarpa* (Körb.) sunt trei noi înregistrări pentru Lichen Mycota din Turcia.

Keywords: fungi lichenizați, diversitate, zona mediteraneană a Turciei.

INTRODUCTION

Lichens are by definition symbiotic organisms, usually composed of a fungal partner, the mycobiont, and one or more photosynthetic partners, the photobiont, which is most often either a green alga or a cyanobacterium (NASH, 2008). Being sensitive to environmental changes due to their physiological and ecological characteristics (HAWKSWORTH & ROSE, 1976; SALO et al., 2012) lichens have been used as indicators for air pollution, climatic changes, forest structures and dynamics regarding the quality of biodiversity (GIORDANI et al., 2012).

Studies on “lichen biodiversity of Turkey” have more importance and value than it had in past, since the country has a great degree of lichen biodiversity that must be protected as well as the plant biodiversity. In spite of the increased number of studies concerning the diversity of lichens in Turkey in recent decades, there is yet insufficient information regarding lichen mycota in many areas of the country.

Isparta is a province located in the northwestern part of Mediterranean Region of Turkey. Lichen mycota of Gölcük Nature Park, located in southwestern part of Isparta province, has never been comprehensively studied before, although there have been several studies already reporting lichens from the province of Isparta. The publications including lichen records from Isparta province are SZATALA (1960); MAYRHOFER (1984); MAYRHOFER et al. (1990); KAYNAK et al. 1997; ÖZTÜRK et al. (1998); ÖZTÜRK & KAYNAK (1997, 1999); ÖZTÜRK et al. (2005); ÇOBANOĞLU & YAVUZ (2006); CZEIKA & CZEIKA (2007); ORAN et al. (2007); ŞENKARDEŞLER (2009); HALICI et al. (2012, 2013); KOÇ et al. (2014); TÜRK et al. (2015); SEZER (2016); KOÇ et al. (2016), and VONDRAK et al. (2016), in chronological order. According to this relevant literature from previous researches, a total number of 347 taxa have been recorded from Isparta province.

The present study aims to determine the diversity of lichenized fungi of the study area “Gölcük Nature Park” in Isparta and to contribute to the Turkish lichen mycota.

MATERIALS AND METHODS

Study Area. The study area including the Gölcük Nature Park and its surroundings within the borders of Isparta province covers a surface area of 5,925 ha. The Gölcük Nature Park is situated in the southwestern part of the city located between 37°38' – 38°03' N and 30°22' – 30°45' E in the C3 square of grid system of Turkey. Isparta province and the study area indicated by a circle as well as Gölcük Nature Park (GNP) are shown in Fig. 1. The park and the study area are surrounded by mountains in south and hills in west and by Isparta city centre in north. Gölcük, which is a caldera lake formed in Early Pliocene, has an altitude of 1380 m and is surrounded by circles of volcanic cones ranging between 1480 m (in north) to 1630 m (in west). The climate of the study area has semi-arid

Mediterranean characters with total annual precipitation of 506 mm and average annual temperature of 12 °C (DEMİR, 2010). The drought period in the study area is between March and November as shown in the ombrothermic diagram given in Fig. 2.

The study area has a mixture of Irano-Turanian and Mediterranean phytogeographic elements with 28.2% endemism. The dominant taxa are *Pinus nigra* Arn. subsp. *pallasiana* (Lamb.) Holmboe, *Pinus sylvestris* L., *Cedrus libani* Carr., *Juniperus oxycedrus* L. subsp. *oxycedrus*, *Robinia pseudoacacia* L., *Juglans regia* L., *Castanea sativa* Miller, *Quercus robur* L., *Quercus coccifera* L., *Populus alba* L., *Populus nigra* subsp. *caudina* (Ten.) Bugala (FAKIR, 1998).

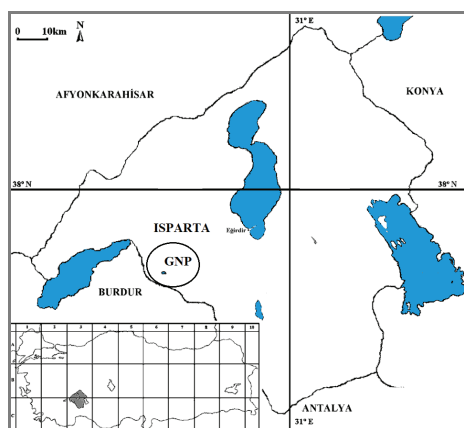


Figure 1. Isparta province and the study area (original).

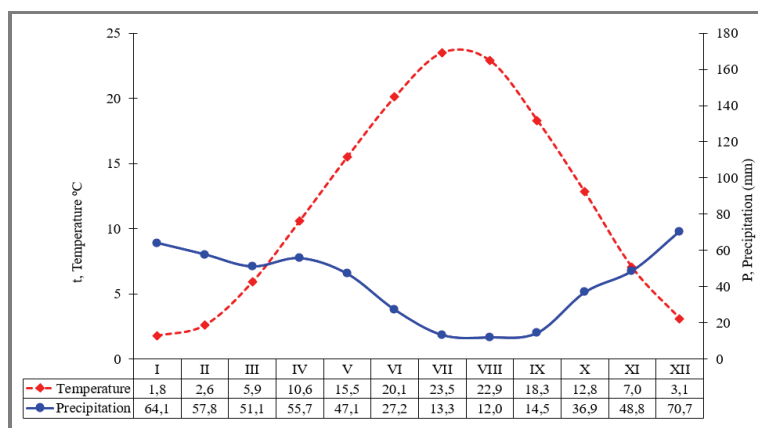


Figure 2. Ombrothermic diagram of Isparta (original).

The lichens were collected from 21 localities (Table 1; Fig. 3) in Gölcük Nature Park and its surroundings in Isparta between the dates April 11th, 2009 and July 22nd, 2010. The collected lichen samples were identified by using various identification keys and books (CLAUZADE & ROUX, 1985; PURVIS et al., 1992; WIRTH, 1995; BRODO et al., 2001; PURVIS, 2007; SMITH et al., 2009).

Microscopic observations were held through a stereomicroscope (Micros SZ45) and a light microscope (Olympus SZ40). The sections were examined in water, 10% KOH solution. Spot tests and UV Lamp (Merck Microbiology 4W 366 nm UV) test were applied to determine the lichen taxa according to identification keys when required.

Table 1. List of localities in the study area. (GNP: Gölcük Nature Park).

No	Locality	GPS Coordinates	Altitude (m)	Date
1	GNP, North-Western Slopes of Crater	37° 44' 08.80" N 30° 29' 09.90" E	1415	23.05.2009
2	GNP, North-Western Slopes of Crater	37° 44' 07.70" N 30° 28' 57.20" E	1460	23.05.2009
3	GNP, Western Slopes of Crater	37° 43' 53.74" N 30° 28' 47.32" E	1480	24.05.2009
4	GNP, Western Slopes of Crater	37° 43' 48.40" N 30° 28' 37.43" E	1632	24.05.2009
5	GNP, Western Slopes of Crater	37° 43' 58.38" N 30° 28' 35.48" E	1588	24.05.2009
6	Milas Promenade Area	37° 44' 28.42" N 30° 29' 14.80" E	1443	06.06.2009
7	GNP, South-Eastern Slopes of Crater	37° 42' 57.58" N 30° 30' 29.30" E	1577	07.06.2009
8	GNP, South-Eastern Slopes of Crater	37° 43' 13.30" N 30° 30' 13.70" E	1470	07.06.2009
9	GNP, Locust-Grove	37° 43' 28.88" N 30° 30' 17.82" E	1425	07.06.2009
10	Between Bezirgân and Hisartep Hill	37° 44' 26.65" N 30° 31' 30.33" E	1296	14.06.2009
11	Path to Ağlasun (Sagalassos)	37° 42' 48.30" N 30° 31' 38.10" E	1408	16.06.2009
12	GNP, Southern Border	37° 42' 16.00" N 30° 30' 15.50" E	1620	20.06.2009
13	Karatepe Hill Western Slope	37° 43' 53.00" N 30° 33' 00.00" E	1605	22.07.2009
14	Summit of Karatepe Hill	37° 43' 49.69" N 30° 33' 15.31" E	1724	22.07.2009
15	GNP, Picnic Area	37° 44' 04.70" N 30° 29' 25.40" E	1397	01.05.2010
16	GNP, South-Western Slopes of Crater	37° 43' 00.00" N 30° 29' 00.00" E	1501	01.05.2010
17	GNP, South of the Lake	37° 42' 53.00" N 30° 29' 42.80" E	1462	01.05.2010
18	GNP, East Slopes of Crater	37° 43' 43.27" N 30° 30' 26.28" E	1573	22.07.2010
19	GNP, East Slopes of Crater	37° 43' 49.60" N 30° 30' 16.30" E	1460	22.07.2010
20	Sidre Hill, East Slope	37° 44' 41.50" N 30° 34' 00.00" E	1190	11.04.2009
21	Halife Sultan Cemetery	37° 44' 44.13" N 30° 34' 23.82" E	1128	11.04.2009

Current online information systems “ITALIC 5.0” (<http://dryades.units.it/italic>) (NIMIS & MARTELLO, 2017) and “Mycobank Database” (<http://www.mycobank.org>) (ROBERT et al., 2015) were followed for the nomenclature of lichen taxa.

The specimens have been stored in the Herbarium of Marmara University (MUFE). At least one herbarium sample for every taxon has been recorded with a herbarium number between GÇ.2102-GÇ.2295.

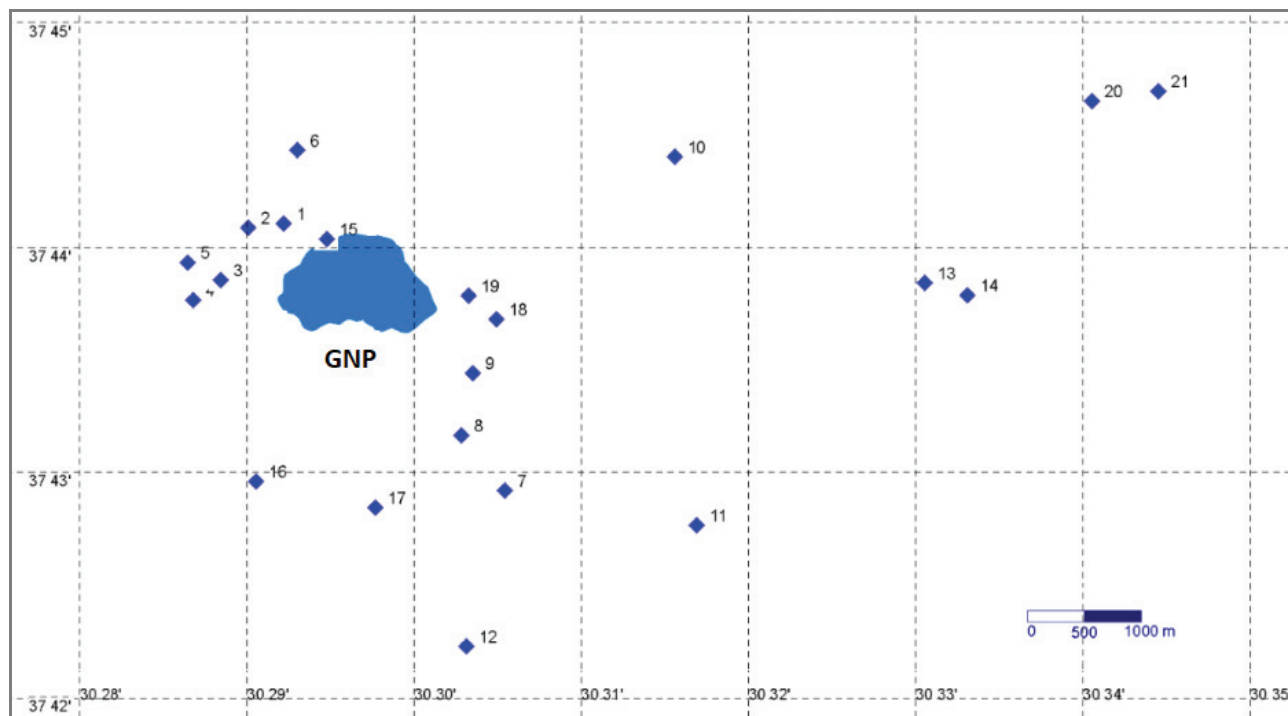


Figure 3. Localities (1-21) in the Study Area (original).

RESULTS

A total of 192 lichenized fungi taxa including 189 species, 3 subspecies and 3 varieties from Gölcük Nature Park and its surroundings are listed in alphabetical order. New records of taxa for Turkey are indicated by “*”, and for Isparta Province are indicated by “+”. The names of authors are abbreviated according to BRUMMITT & POWELL (1992). “Syn.” is used for the synonym names of some taxa. Substrate abbreviations follow the locality numbers of the lichen samples in the list.

Aa: *Aspicilia caesiocinerea*, Af: *Acarospora fuscata*, Ag: *Amygdalus communis*, Ai: *Aspicilia cinerea*, Cl: *Cedrus libani*, CR: Calcareous rock, Cs: *Catapyrenium squamulosum*, Cv: *Candelariella vitellina*, Lr: *Lecanora rupicola*, M: Moss, Pa: *Populus alba*, Pc: *Placocarpus schaeferi*, Pd: *Prunus domestica*, Pg: *Pinus nigra*, Pm: *Protoparmeliopsis muralis*, Pn: *Populus nigra*, Pr: *Peltigera rufescens*, Ps: *Physcia stellaris*, Qr: *Quercus* sp., Rp: *Robinia pseudacacia*, S: Soil, SR: Silicious rock, So: *Sorbus* sp., Ta: *Tephromela atra*.

Acarospora cervina (Ach.) A.Massal.: 3, 4, 11, 20 CR; 6, 9, 10, 13, 14, 16, 17 SR; 19 Ai. GÇ.2102

Acarospora fuscata (Schr.) Arnold: 5, 6, 10, 13, 14, 16 SR. GÇ.2103

Amandinea pelidna (Ach.) Fryday & Arcadia (Syn. *Amandinea lecideina* (H.Mayrhofer & Poelt) Scheid. & H. Mayrhofer): 6, 19 SR. GÇ.2106

Amandinea punctata (Hoffm.) Coppins & Scheid: 6 CR. GÇ.2107

+*Amygdalaria pelobotryon* (Wahlenb.) Norman: 10 S. GÇ.2108

Anaptychia ciliaris (L.) A.Massal.: 2, 7, 18 Pg; 4, 9, 12 Rp; 8 Qr; 10 S; 13 Cl; 15 Pn; 16, 17 SR; 20 Pd. GÇ.2109

Arthonia fusca (A.Massal.) Hepp (Syn. *Arthonia lapidicola* (Taylor) Branth & Rostr.): 20 CR. GÇ.2110

Aspicilia cinerea (L.) Körb.: 4 CR; 6, 7, 10, 13, 16, 17, 18, 19 SR. GÇ.2113

+*Athallia cerinella* (Nyl.) Arup, Frödén & Söchting (Syn. *Caloplaca cerinella* (Nyl.) Flagey): 7 Pg. GÇ.2124

Athallia cerinelloides (Erichsen) Arup, Frödén & Söchting (Syn. *Caloplaca cerinelloides* (Erichsen) Poelt): 7 Pg. GÇ.2125

Athallia holocarpa (Hoffm.) Arup, Frödén & Söchting (Syn. *Caloplaca holocarpa* (Hoffm.) A.E. Wade): 15 Pn; 18 Pg. GÇ.2140

+*Blastenia ammiospila* (Ach.) Arup, Söchting & Frödén (Syn. *Caloplaca cinnamomea* (Th.Fr.) H.Olivier): 5, 17 M. GÇ.2127

Blastenia crenularia (With.) Arup, Söchting & Frödén (Syn. *Caloplaca crenularia* (With.) J.R. Laundon): 4 CR; 13, 17, 18, 19 SR; 14 Aa, Pm. GÇ.2129

Blastenia herbidella (Arnold) Servit (Syn. *Caloplaca herbidella* (Hue) H.Magn.): 6, 7, 18 Pg; 14 Cl. GÇ.2139

Blennothallia crispa (Huds.) Otálora, P.M. Jørg. & Wedin (Syn. *Collema crispum* (Huds.) Weber ex F.H. Wigg.): 4, 11 SR; 20 CR. GÇ.2166

Buellia aethalea (Ach.) Th.Fr.: 4 CR; 8 SR. GÇ.2116

- +*Buellia schaeereri* De Not.: 8 Qr; 13 Cl; 15 Pn. GÇ.2117
 +*Buellia spuria* (Schaer.) Anzi: 17 SR. GÇ.2118
 +*Calogaya arnoldii* (Wedd.) Arup, Frödén & Söchting: 10, 16 SR. GÇ.2120
Calogaya decipiens (Arnold) Arup, Frödén & Söchting (Syn. *Caloplaca decipiens* (Arnold) Blomb. & Forssell): 3, 11 CR. GÇ.2132
Calogaya pusilla (A.Massal.) Arup, Frödén & Söchting (Syn. *Caloplaca saxicola* (Hoffm.) Nordin): 14 SR. GÇ.2145
 +*Caloplaca aractina* (Fr.) Häyrén: 6, 16 SR. GÇ.2119
Caloplaca cerina (Hedw.) Th.Fr. s.lat (Syn. *Caloplaca cerina* var. *cerina* (Ehrh. ex Hedw.) Th.Fr.): 7, 8, 18 Pg; 11 M; 12 Rp; 13 Cl; 15 Pn; 16 SR. GÇ.2121
 +*Caloplaca grimmiae* (Nyl.) H. Olivier: 13 Cv. GÇ.2137
Caloplaca haematites (Chaub.) Zwackh: 13 Cl; 14SR. GÇ.2138
 +*Caloplaca nivalis* (Körb.) Th. Fr.: 5 M; 14 S. GÇ.2144
 +*Caloplaca stillicidiorum* (Vahl) Lyngé var. *muscorum* (A.Massal.) (Syn. *Caloplaca cerina* var. *muscorum* (A.Massal.) Jatta): 5 M; 14 S; 16 SR. GÇ.2123
Caloplaca stillicidiorum (Vahl) Lyngé (Syn. *Caloplaca cerina* var. *chloroleuca* (Sm.) Th.Fr.): 5, 11 M; 5 Pr; 7 Pg; 14 SR; 15 Pn. GÇ.2122
 +*Calvitimela aglaea* (Sommerf.) Hafellner: 13, 14 SR. GÇ.2147
Candelariella aurella (Hoffm.) Zahlbr: 2 Pg; 3, 4, 5 CR; 7, 14, 17 SR. GÇ.2148
 +*Candelariella medians* (Nyl.) A.L. Sm.: 8, 14 SR; 20 CR. GÇ.2149
Candelariella vitellina (Hoffm.) Müll. Arg.: 4 Pc; 5, 8, 13, 16, 17, 18, 19 SR; 5, 10, 14 Pm; 5 Ta; 6 Pg; 11 Cs. GÇ.2150
Candelariella xanthostigma (Ach.) Lettau: 5 M; 6, 7, 8, 18, 21 Pg; 9, 12 Rp; 10 So; 13 Cl; 15 Pn. GÇ.2151
Carbonea vitellinaria (Nyl.) Hertel: 19 Cv. GÇ.2152
 +*Carbonea vorticosa* (Flörke) Hertel: 13 SR. GÇ.2153
Cerothallia luteoalba (Turner) Arup, Frödén & Söchting (Syn. *Caloplaca luteoalba* (Turner) Th.Fr.): 4 Rp. GÇ.2142
Chrysothrix chlorina (Ach.) J.R. Laundon: 8 SR. GÇ.2156
Circinaria caesiocinerea (Malbr.) A.Nordin, Savić & Tibell (Syn. *Aspicilia caesiocinerea* (Nyl. ex Malbr.) Arnold): 4, 11 CR; 5, 6, 8, 10, 14, 17 SR. GÇ.2111
Circinaria calcarea (L.) A. Nordin, Savić & Tibell (Syn. *Aspicilia calcarea* (L.) Körb.): 3, 4, 20 CR. GÇ.2112
Circinaria contorta (Hoffm.) A.Nordin, Savić & Tibell (Syn. *Aspicilia contorta* (Hoffm.) Körb. subsp. *contorta*): 3, 5, 11 CR; 13 SR. GÇ.2114
Circinaria contorta subsp. *hoffmanniana* (R.Sant.) I. Zhdanov (Syn. *Aspicilia contorta* (Hoffm.) Körb. subsp. *hoffmanniana*): 3, 5, 11 CR; 13 SR. GÇ.2114
 +*Cladonia chlorophaea* (Sommerf.) Spreng.: 10 S. GÇ.2157
Cladonia coniocraea (Flörke) Spreng: 5 S. GÇ.2158
Cladonia fimbriata (L.) Fr.: 1, 10 S. GÇ.2159
 +*Cladonia foliacea* (Huds.) Willd.: 10, 11, 14 S. GÇ.2160
Cladonia pocillum (Ach.) Grognot.: 10 S. GÇ.2161
Cladonia pyxidata (L.) Hoffm.: 1, 4, 5, 8, 10, 11, 14, 16, 17, 19 S. GÇ.2162
 +*Cladonia symphyocarpia* (Flörke) Fr.: 10 S. GÇ.2163
Collema subflaccidum Degel.: 4 S. GÇ.2168
 +*Diploschistes muscorum* (Scop.) R. Sant.: 5 M. GÇ.2170
 +*Diploschistes scruposus* (Schreb.) Norman: 17 SR. GÇ.2171
Diplotomma alboatrum (Hoffm.) Flot (Syn. *Diplotomma epopolium* (Ach.) Arnold): 5, 13 SR; 15 Pn; 20 CR. GÇ.2174
 +*Diplotomma chlorophaeum* (Leight.) Kr.P. Singh & S.R. Singh: 4 CR; 13 SR. GÇ.2173
 +*Diplotomma hedinii* (H.Magn.) P. Clerc & Cl. Roux: 3 CR. GÇ.2175
 **Diplotomma pharcidium* (Ach.) c: 15 Pn. GÇ.2176
 +*Enchylium conglomeratum* (Hoffm.) Otálora, P.M. Jørg. & Wedin (Syn. *Collema conglomeratum* Hoffm.): 8 M. GÇ.2165
 + *Enchylium tenax* (Sw.) Gray (Syn. *Collema tenax* (Sw.) Ach.): 3, 4 CR; 10, 11 S GÇ.2169
Evernia prunastri (L.) Ach.: 1, 2, 7, Pg; 8 Qr; 12 Rp; 20 Pd. GÇ.2177
 **Flavoplaca granulosa* (Müll.Arg.) Arup, Frödén & Söchting (Syn. *Caloplaca granulosa* (Müll.Arg.) J.Steiner): 13 SR; 20 CR. GÇ.2136
 +*Flavoplaca microthallina* (Wedd.) Arup, Frödén & Söchting (Syn. *Caloplaca microthallina* Wedd.): 4, 11 CR; 14 Pg. GÇ.2143
Gyalolechia flavorubescens (Huds.) Söchting, Frödén & Arup (Syn. *Caloplaca flavorubescens* (Huds.) J.R. Laundon): 1, 2, 7, 8, 18 Pg; 12 Rp; 13 Cl; 15 Pn. GÇ.2134
Gyalolechia flavovirescens (Wulfen) Söchting, Frödén & Arup (Syn. *Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth.): 4 Rp; 6, 10, 14 SR; 7 Pg. GÇ.2135
Gyalolechia fulgens (Sw.) Söchting, Frödén & Arup (Syn. *Fulgensia fulgens* (Sw.) Elenkin): 11, 20 S. GÇ.2178
Hypogymnia farinacea Zopf: 1, 7 Pg. GÇ.2179
 +*Hypogymnia physodes* (L.) Nyl.: 7 Pg. GÇ.2180

- Hypogymnia tubulosa* (Schaer.) Hav.: 2, 7, 18 Pg. GÇ.2181
Immersaria athroocarpa (Ach.) Rambold & Pietschm.: 6, 13, 19 SR. GÇ.2182
 +*Lambiella insularis* (Nyl.) T.Sprub. (Syn. *Rimularia insularis* (Nyl.) Rambold & Hertel): 6, 7, 8, Pg; 10 So; 12 Rp; 13 Cl. GÇ.2273
 +*Lathagrium auriforme* (With.) Otálora, P.M. Jørg. & Wedin (Syn. *Collema auriforme* (With.) Coppins & J.R. Laundon): 10 S. GÇ.2164
Lathagrium cristatum (L.) Otálora, P.M. Jørg. & Wedin (Syn. *Collema cristatum* (L.) Weber ex F.H. Wigg.): 4 S. GÇ.2167
Lecania naegelii (Hepp) Diederich & van den Boom: 15 Pn. GÇ.2183
 +*Lecania subfuscula* (Nyl.) S.Ekman: 14, 16, 17 SR; 17 S. GÇ.2184
Lecanora albellula (Nyl.) Th.Fr.: 15 Pn; 18 Pg. GÇ.2185
 +*Lecanora alpigena* (Ach.) Cl. Roux (Syn. *Lecanora polytropa* (Ehrh.) Rabenh.): 6, 8, 17 SR. GÇ.2198
Lecanora argentata (Ach.) Malme: 10 So; 18 Pg. GÇ.2187
 +*Lecanora campestris* (Schaer.) Hue: 1, 2, 7, 8 Pg; 3 CR; 4, 12 Rp. GÇ.2189
Lecanora carpinea (L.) Vain.: 6, 7, 14 Pg; 8 Qr; 9 Rp; 10 So. GÇ.2190
 +*Lecanora cenisia* Ach.: 4, 5, 8, 14, 17 SR. GÇ.2191
Lecanora chlarotera Nyl.: 7 Pg; 13 Cl. GÇ.2192
 +*Lecanora filamentosa* (Stirt.) Elix & Palice (Syn. *Lecanora symmicta* (Ach.) Ach.): 4, 13 S. GÇ.2203
Lecanora intumescens (Rebent.) Rabenh.: 15 Pn. GÇ.2196
Lecanora rupicola (L.) Zahlbr. (Syn. *Lecanora rupicola* var. *rupicola* (L.) Zahlbr.): 4, 5, 6, 8, 13, 14, 17 SR. GÇ.2199
Lecanora saligna (Schrad.) Zahlbr.: 6, 7, 10, 13, 14 SR. GÇ.2200
 +*Lecidea atrobrunnea* (DC.) Schaer.: 13, 14, 17 SR. GÇ.2205
 +*Lecidea confluens* (Weber) Ach.: 10 SR. GÇ.2206
 +*Lecidea fuscoatra* (L.) Ach.: 8, 17 SR. GÇ.2207
 +*Lecidella anomaloides* (A.Massal.) Hertel & H.Kilias: 5 SR. GÇ.2209
Lecidella carpathica Körb.: 4 CR; 5, 6, 14, 18 SR. GÇ.2210
Lecidella elaeochroma (Ach.) M.Choisy: 1, 2, 6, 7, 8, 18, 21 Pg; 4, 9, 12 Rp; 8 Qr; 10 So; 13 Cl; 15 Pn. GÇ.2211
 +*Lecidella scabra* (Taylor) Hertel & Leuckert: 13 SR. GÇ.2212
Lecidella stigmatea (Ach.) Hertel & Leuckert: 5, 17 SR. GÇ.2213
 +*Lecidella wulfenii* (Ach.) Körb.: 4 S; 14 M. GÇ.2214
 +*Lepra amara* (Ach.) Hafellner (Syn. *Pertusaria amara* (Ach.) Nyl.): 6 SR. GÇ.2237
 +*Lepra corallina* (L.) Hafellner (Syn. *Pertusaria corallina* (L.) Arnold): 13, 16, 17, 19 SR. GÇ.2238
 +*Lepra excludens* (Nyl.) Hafellner (Syn. *Pertusaria excludens* Nyl.): 8 SR. GÇ.2239
 +*Lepraria alpina* (B. de Lesd.) Tretiach & Baruffo: 5 S. GÇ.2215
 +*Lepraria caesioalba* (B. de Lesd.) J.R. Laundon: 5, 14, 17 S. GÇ.2216
 +*Lepraria eburnea* J.R. Laundon: 4, 10, 14 S. GÇ.2217
Leproplaca cirrochroa (Ach.) Arup, Frödén & Söchting (Syn. *Caloplaca cirrochroa* (Ach.) Th.Fr.): 10 CR. GÇ.2128
Lobothallia radiosa (Hoffm.) Hafellner: 4, 11, 20 CR; 6 SR. GÇ.2220
Lobothallia recedens (Taylor) A.Nordin, Savić & Tibell (Syn. *Aspicilia recedens* (Taylor) Arnold): 4 CR; 5 SR. GÇ.2115
Megaspora verrucosa (Ach.) Arcadia & A.Nordin: 11, 14 S; 17 M. GÇ.2221
Melanohalea exasperata (De Not.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch: 1, 2, 6, 7, 18, 21 Pg; 4, 12 Rp; 8 Qr; 10 So; 11 CR; 14, 16, 19 SR; 15 Pn. GÇ.2222
Melanohalea exasperatula (Nyl.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch: 2, 7 Pg; 8 Qr; 10 So; 13 Cl; 14 SR; 15 Pn. GÇ.2223
 **Miriquidica pycnocarpa* (Körb.) M.P. Andreev (Syn. *Lecidea pycnocarpa* (Körb.) Ohlert): 14 SR. GÇ.2208
 +*Myriolecis albescens* (Hoffm.) Šliwa, Zhao Xin & Lumbsch (Syn. *Lecanora albescens* (Hoffm.) Branth & Rostr.): 13 S. GÇ.2186
Myriolecis crenulata (Hook.) Šliwa, Zhao Xin & Lumbsch (Syn. *Lecanora crenulata* Hook.): 13 SR. GÇ.2193
Myriolecis dispersa (Pers.) Šliwa, Zhao Xin & Lumbsch (Syn. *Lecanora dispersa* (Pers.) Röhl.): 3, 4, 11, 20 CR; 6, 14 SR. GÇ.2194
Myriolecis hagenii (Ach.) Šliwa, Zhao Xin & Lumbsch. (Syn. *Lecanora umbrina* (Ach.) A.Massal.): 15 Pn; 18 Pg. GÇ.2204
Myriolecis sambuci (Pers.) Clem. (Syn. *Lecanora sambuci* (Pers.) Nyl.): 4, 7, 18 Pg. GÇ.2201
 +*Myriolecis semipallida* (H.Magn.) Šliwa, Zhao Xin & Lumbsch (Syn. *Lecanora semipallida* H.Magn.): 4 Rp; 13 Pg. GÇ.2202
Myriospora smaragdula (Ach.) Uloth (Syn. *Acarospora smaragdula* var. *lesdani* (Harm.) H.Magn.): 4 SR. GÇ.2105
 +*Nephromopsis chlorophylla* (Willd.) Divakar, A.Crespo & Lumbsch (Syn. *Tuckermanopsis chlorophylla* (Willd.) Hale): 1, 14 Pg. GÇ.2285
Parmelia saxatilis (L.) Ach.: 7 Pg; 10 S; 14 SR. GÇ.2226
Parmelia submontana Hale.: 18 Pg. GÇ.2227

- Parmelina pastillifera* (Harm.) Hale: 14 M. GÇ.2228
Parmelina tiliacea (Hoffm.) Hale: 2, 18 Pg; 10, 19 SR; 16 S. GÇ.2229
 +*Peltigera degenii* Gyeln.: 1 S. GÇ.2230
 +*Peltigera hymenina* (Ach.) Delise: 14 S. GÇ.2231
 +*Peltigera lepidophora* (Vain.) Bitter: 1 S. GÇ.2232
 +*Peltigera leucophlebia* (Nyl.) Gyeln.: 1, 14 S. GÇ.2233
 +*Peltigera neckeri* Hepp ex Müll.Arg.: 17 S. GÇ.2234
Peltigera praetextata (Flörke ex Sommerf.) Zopf: 1, 11 S. GÇ.2235
Peltigera rufescens (Weiss) Humb.: 5, 10, 11, 16, 19 S. GÇ.2236
Phaeophyscia nigricans (Flörke) Moberg: 3, 4 CR; 19 SR. GÇ.2240
Phaeophyscia orbicularis (Neck.) Moberg: 3, 4, 11 CR; 6 SR; 7 Pg; 10 So; 12 Rp; 15 Pn. GÇ.2241
Phaeophyscia sciastra (Ach.) Moberg: 4 CR; 6, 13 SR. GÇ.2242
Physcia adscendens (Fr.) H.Olivier: 4, 9 Rp; 7, 18, 21 Pg; 10 So; 15 Pn. GÇ.2243
Physcia aipolia (Ehrh. ex Humb.) Fürnr.: 12 Rp; 14 Pg; 20 Pa; 20 Pd. GÇ.2244
Physcia dubia (Hoffm.) Lettau: 1, 7, 21 Pg; 4 S; 6 SR; 10, 13 SR; 11 S; 20 CR. GÇ.2245
Physcia leptalea (Ach.) DC. (Syn. *Physcia semipinnata* (J.F. Gmel.) Moberg): 1, 2, 7 Pg; 4, 12 Rp; 8 Qr; 20 Pd. GÇ.2246
Physcia stellaris (L.) Nyl.: 1, 7, 21 Pg; 4, 9, 12 Rp; 8 Qr; 10 So; 15 Pn. GÇ.2247
Physcia tenella (Scop.) DC.: 1, 2 Pg; 8 Qr; 10 So; 11 S. GÇ.2248
Physcia tribacia (Ach.) Nyl.: 6 Pg; 10 SR. GÇ.2249
Physconia distorta (With.) J.R. Laundon: 12 Rp; 14 Pg; 16 SR. GÇ.2250
Physconia enteroxantha (Nyl.) Poelt: 10 S; 13, 16 SR; 20 CR. GÇ.2251
Physconia grisea (Lam.) Poelt: 2 Pg; 4 CR; 14 Pg. GÇ.2252
Physconia perisidiosa (Erichsen) Moberg: 5, 11 S. GÇ.2253
 +*Placidium rufescens* (Ach.) A.Massal. (Syn. *Catapyrenium rufescens* (Ach.) Breuss): 11, 14 S. GÇ.2154
 +*Placidium squamulosum* (Ach.) Breuss (Syn. *Catapyrenium squamulosum* (Ach.) Breuss): 11, 14 S. GÇ.2155
Placocarpus schaeferi (Fr.) Breuss: 4, 11, 12 CR. GÇ.2254
Pleurosticta acetabulum (Neck.) Elix & Lumbsch: 1, 2, 8, 14 Pg; 12 Rp; 15 Pn. GÇ.2255
 +*Polycauliona polycarpa* (Hoffm.) Frödén, Arup & Söchting (Syn. *Xanthoria polycarpa* (Hoffm.) Rieber): 4 Rp; 8 Qr. GÇ.2295
 +*Polychidium muscicola* (Sw.) Gray: 8, 17 S; 16 M. GÇ.2256
 +*Protoparmelia badia* (Hoffm.) Hafellner: 10 SR. GÇ.2257
Protoparmeliopsis bolcana (Pollini) Lumbsch (Syn. *Lecanora bolcana* (Pollich) Poelt): 11 CR; 13 SR. GÇ.2188
 +*Protoparmeliopsis garovaglii* (Körb.) Arup, Zhao Xin & Lumbsch. (Syn. *Lecanora garovaglioii* (Körb.) Zahlbr.): 5, 10, 14, 17 SR. GÇ.2195
Protoparmeliopsis laatokkaensis (Räsänen) Moberg & R.Sant. (Syn. *Lecanora laatokkensis* (Räsänen) Poelt): 3, 4, 11 CR; 5, 6, 10, 13, 14, 16, 17, 18, 19 SR. GÇ.2197
Protoparmeliopsis muralis (Schreb.) M.Choisy: 3, 4, 11 CR; 5, 6, 10, 13, 14, 16, 17, 18, 19 SR. GÇ.2258
Pseudevernia furfuracea (L.) Zopf var. *furfuracea*: 1, 2, 7, 18 Pg; 10 S 12 Rp. GÇ.2260
Pseudevernia furfuracea var. *ceratea* (Ach.) D.Hawksw.: 1, 2, 7, 8 Pg; 10 S; 12 Rp; 20 Pd. GÇ.2259
Psora decipiens (Hedw.) Hoffm.: 11, 14 S. GÇ.2261
 +*Psorotichia schaeferi* (A.Massal.) Arnold: 4 S. GÇ.2262
Pyrenodesmia chalybaea (Fr.) A.Massal. (Syn. *Caloplaca chalybaea* (Fr.) Müll.Arg.): 4 CR. GÇ.2126
Pyrenodesmia variabilis (Pers.) A.Massal. (Syn. *Caloplaca variabilis* (Pers.) Müll.Arg.): 4, 20 CR; 14, 16 SR. GÇ.2146
 +*Ramalina capitata* (Ach.) Nyl.: 14 SR. GÇ.2263
Ramalina farinacea (L.) Ach.: 1, 2, 7 Pg; 8 Qr; 9, 12 Rp; 13 Cl; 14 SR. GÇ.2264
Ramalina fraxinea (L.) Ach.: 12 Rp; 14 Pg; 15 Pn. GÇ.2265
 +*Ramalina pollinaria* (Westr.) Ach.: 6 SR. GÇ.2266
 +*Ramalina polymorpha* (Lilj.) Ach.: 1 Pg; 6 CR; 10, 14 SR. GÇ.2267
Rhizocarpon geminatum Körb.: 10, 13, 17 SR. GÇ.2268
Rhizocarpon geographicum (L.) DC.: 4, 5, 6, 7, 8, 10, 13, 16, 17, 18, 19, 20 SR. GÇ.2269
 +*Rhizocarpon lecanorinum* Anders: 5, 6, 8, 14, 16, 17, 19 SR. GÇ.2270
 +*Rhizocarpon simillimum* (Anzi) Lettau: 4, 6, 14 SR. GÇ.2271
 +*Rhizocarpon subgeminatum* Eitner: 4, 5, 8, 10, 14 SR. GÇ.2272
Rinodina exigua (Ach.) Gray: 13 Lr. GÇ.2274
 +*Rinodina interpolata* (Stirt.) Sheard: 5 SR. GÇ.2275
 +*Rinodina milvina* (Wahlenb.) Th.Fr.: 7, 13, 14 SR. GÇ.2276
Rinodina pyrina (Ach.) Arnold: 18 Pg. GÇ.2277
Rinodina sophodes (Ach.) A.Massal.: 15 Pn. GÇ.2278
Rusavskia elegans (Link) S.Y. Kondr. & Kärnefelt subsp. *elegans* (Syn. *Xanthoria elegans* (Link) Th.Fr.): 4, 20 CR. GÇ.2293

- +*Schaereria fuscocinerea* (Nyl.) Clauzade & Cl. Roux: 5 SR. GÇ.2279
Scytinium gelatinosum (With.) Otálora, P.M. Jørg. & Wedin (Syn. *Leptogium gelatinosum* (With.) J.R. Laundon): 10 SR; 11, 20 CR. GÇ.2218
Scytinium lichenoides (L.) Otálora, P.M. Jørg. & Wedin (Syn. *Leptogium lichenoides* (L.) Zahlbr.): 16 S. GÇ.2219
 +*Silobia rufescens* (Turner ex Ach.) M.Westb. & Wedin (Syn. *Acarospora rufescens* (Ach.) Kremp.): 16 S. GÇ.2104
Squamarina cartilaginea (With.) P.James: 5, 6, 7, 8, 10, 11, 13, 14 SR. GÇ.2280
 +*Tephromela atra* (Huds.) Hafellner: 4 CR; 5, 8, 13, 14 SR. GÇ.2281
Toninia sedifolia (Scop.) Timdal: 4, 10, 11 S 19 SR. GÇ.2282
 +*Toninia taurica* (Szatala) Oxner: 4, 10, 11, 16 S. GÇ.2283
 +*Toninia toniniana* (A.Massal.) Zahlbr.: 11, 14 S 20 CR. GÇ.2284
 +*Umbilicaria crustulosa* (Ach.) Lamy: 14 SR. GÇ.2286
Variospora dolomiticola (Hue) Arup, Söchting & Frödén (Syn. *Caloplaca dalmatica* (A.Massal.) H.Olivier): 20 CR. GÇ.2131
Variospora flavescens (Huds.) Arup, Frödén & Söchting (Syn. *Caloplaca flavescens* (Huds.) J.R. Laundon): 4 CR. GÇ.2133
Verrucaria muralis Ach.: 3, 4 CR. GÇ.2287
Verrucaria nigrescens Pers.: 4, 20 CR 13 SR. GÇ.2288
Xanthocarpia crenulatella (Nyl.) Frödén, Arup & Söchting (Syn. *Caloplaca crenulatella* (Nyl.) H.Olivier): 9 Ps; 10 So; 12 Rp; 15 Pn. GÇ.2130
Xanthocarpia lactea (A.Massal.) A.Massal. (Syn. *Caloplaca lactea* (A.Massal.) Zahlbr.): 13 SR. GÇ.2141
Xanthomendoza fulva (Hoffm.) Söchting, Kärnefelt & S.Y. Kondr.: 13, 16 SR; 19 S. GÇ.2289
 +*Xanthoparmelia loxodes* (Nyl.) O.Blanco, A.Crespo, Elix, D.Hawksw. & Lumbsch: 11 M. GÇ.2290
Xanthoparmelia pulla (Ach.) O.Blanco, A.Crespo, Elix, D.Hawksw. & Lumbsch: 6 CR; 10, 14, 16, 18, 19 SR. GÇ.2291
Xanthoparmelia verruculifera (Nyl.) O.Blanco, A.Crespo, Elix, D.Hawksw. & Lumbsch: 6, 10, 14 SR. GÇ.2292
Xanthoria parietina (L.) Beltr.: 1, 7, 21 Pg; 4, 9, 12 Rp; 8 Qr; 15 Pn. GÇ.2294

DISCUSSION

As a result of this study, 189 species, 3 subspecies and 3 varieties, a total of 192 taxa belonging to 79 genera, representing the lichen mycota of Gölcük Nature Park and surroundings of Isparta city were reported. Among these, 73 species were firstly recorded for the research area and the province of Isparta. *Diplotomma pharcidium* (Ach.) M.Choisy, *Flavoplaca granulosa* (Müll.Arg.) Arup, Frödén & Söchting, and *Miriquidica pycnocarpa* (Körb.) are 3 new records for Turkish Lichen Mycota.

According to the abundance of lichen species in 21 localities, epiphytic *Melanohalea exasperata* is the most frequent species (in 15 localities) while other epiphytics *Anaptychia ciliaris* and *Lecidella elaeochroma* (both in 13 localities) are the second frequent species together with crustose epilithic species *Acarospora cervina*, *Candelariella vitellina*, *Protoparmeliopsis muralis*, and *Rhizocarpon geographicum* (all in 12 localities) respectively have a prevalent abundance in the study area. These frequent-taxa have been well adapted to the climate, habitat and substrate conditions of the research area. Ecological compliance is the most effective factor in lichen diversity in a region (HAUCK et al., 2007; LÖHMUS et al., 2007). A comparison of these results in this study to those of Yukarı Gökdere region in Isparta by ORAN et al. (2007) shows that *Anaptychia ciliaris* is the common frequent species between two studies, while a comparison to Barla Mountain in Isparta by KOÇ et al. (2016) indicates that *Acarospora cervina* is the common frequent species between two studies. The difference between these two frequency-based comparison of taxa-lists are due to the difference in ecological factors like habitat and substrate types among these studies.

The distribution of species in the region according to substrate types is as follows: 155 (41.67%) of the recorded taxa are epiphytic where 136 (36.56%) are saxicolous, 54 (14.52%) are terricolous, 14 (3.76%) are muscicolous, and 13 (3.49%) are lichenicolous (Fig. 4). *Pinus nigra* is substrate of 51 (13.7%) of the total taxa where *Populus nigra* and *Robinia pseudacacia* are that of 26 (6.99%). Siliceous rocks are prevailing with 87 (23.39%) taxa over calcareous rocks with that of 49 (13.17%) as dominating saxicolous substrates in the study area.

The distribution of species in the study area by thallus morphology is shown in Fig. 5. Among the recorded taxa, 106 (55.50%) are crustose, 48 (25.13%) are foliose, 15 (7.85%) are squamulose, 10 (5.24%) are placodioid, 9 (4.71%) are fruticose and 3 (1.57%) are leprose.

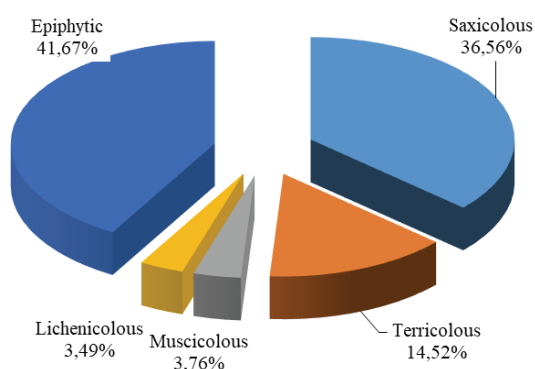


Figure 4. Taxon Distribution by Substrate Type.

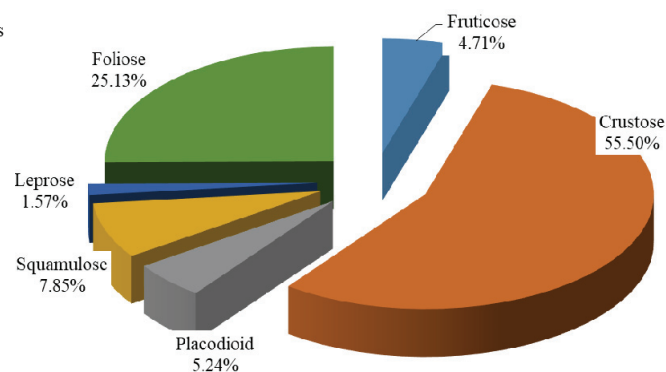


Figure 5. Taxon Distribution by Thallus Morphology.

The fruticose genera in the study area are *Evernia* (1 species), *Pseudevernia* (1 species), *Polychidium* (1 species), and *Ramalina* (5 species). The number and percentage of the fruticose taxa is lower compared to that of lichen records –which are mostly epiphytic as well- from *Quercus vulcanica* forests around Yukarı Gökdere in Isparta (ORAN et al., 2007). This is due to the fact that Gölcük Nature Park has a semi-arid climatic regime and inconvenient habitats for fruticose taxa.

The cyanolichens *Blennothallia crispa*, *Collema subflaccidum*, *Enchylium conglomeratum*, *Enchylium tenax*, *Lathagrium auriforme*, *Lathagrium cristatum* in the study are recorded only in moist microsites within the park area. Though the study area has a semi-arid Mediterranean climate, there are some habitats exposed to frequent dewfall in summer, as explained by HAUCK et al. (2007).

Altitude is an important factor besides climatic conditions on lichen diversity (ÇOBANOĞLU & SEVGI, 2009). In the present study, the altitude of the localities varies between 1128 m - 1724 m. Except for the localities II, III, IX and XII, there is an increase in the number of species recorded in every locality, directly proportional to the altitude of localities (Table 1). This proves that, with the increase of altitude, the lichen biodiversity increases as well. However, though visible in the above mentioned localities, the substrate type is a limiting factor. Localities over 1600 m are XIV, IV, X and XIII have higher number of lichen taxa compared to the rest of localities. Locality XIV which is the highest summit in the study area, has the maximum number of taxa (62) that is twice of the average specimen number, and one-third of the total taxa number in the given list. Since 640 lichen specimens have been collected from 21 localities in the study area, yields an average of 30.48 lichen taxa per locality. Besides locality XIV, there are 3 more localities that have higher number of taxa: locality IV (57 taxa), locality X (56 taxa) and locality XIII (47 taxa). Among these 3 localities, locality X (Between Bezirgân and Hisartep Hill) bears a number of diversity in habitats as well as substrates whereas, locality XIV (Summit of Karatepe Hill) and locality IV (GNP, Western Slopes of Crater) around the caldera, have maximum altitude compared to the rest of localities in the study area. The lichen diversity in locality IV is significantly correlated with the altitude and presence of old conifers in habitat variables that indicate occurrence of forest conditions (COPPINS & COPPINS, 2002). Moreover, locality XXI which is at the north-east boundary of Gölcük Nature Park next to Halife Sultan Cemetery has the minimum number of taxa (7) depending on its altitude (1128 m) and close proximity to the city centre which can cause a decrease in lichen diversity in the study area.

HAUCK et al. (2007) reported that the number of lichen taxa in a study area corresponds with the variety of ecosystems and habitats in the region. Considering the present study, it is visible that, the lichen biodiversity and the number of taxa are parallel to the diversity of ecological diversity of the localities, since the present study reports a relatively higher number of taxa from a this-size natural park. In ORAN et al. (2007) study, that of 92 taxa from a Rim-Oak Nature Protection Area, Isparta that has a surface area of 1,300 ha is given, which yields an average-biodiversity ratio of 14.13 ha per taxon. KOÇ et al. (2016) study, a list of 241 infrageneric taxa from Barla Mountain, Isparta that has a surface area of 89,000 ha is given, which yields an average-biodiversity ratio of 369.29 ha per taxon. ÇOBANOĞLU et al. (2009; 2010) study, a list of 115 taxa from Cozia National Park, Romania that has a surface area of 17,100 ha is given, which yields an average-biodiversity ratio of 148.70 ha per taxon. In the present study, a list of 192 taxa from Gölcük Nature Park, Isparta that has a surface area of 5,925 ha is given. This study yields an average-biodiversity ratio of 30.86 ha per taxon, in other words, this study reports a richer list of taxa compared to similar studies like KOÇ et al. (2016) and ÇOBANOĞLU et al. (2010) which can be explained by the variety of ecosystems and habitats in the study area of this study.

CONCLUSIONS

Natural habitat characteristics and substrate diversity (LÖHMUS et al., 2007) as well as anthropogenic activities influence the distribution of lichen species (KAPUSTA et al., 2004). The high proportion of lichen biodiversity of the study area is directly related to this. It was also concluded that increase in altitude was found to be a decisive factor in lichen diversity. The number of lichen species differs with changing habitat related to the elevation

(SEVGI et al., 2016) consequently, the highest number of lichen species occurs at the highest altitudinal zone as mentioned in a previous study by ÇOBANOĞLU & SEVGI (2009).

Concerning the research area and Isparta province, the study by SZATALA (1960) is historically the first recording of lichens from various localities in Isparta, with a list of 46 taxa. The studies by ORAN et al. (2007) and KOÇ et al. (2016) are the only studies aiming to report lichen diversity of a certain, limited and protected area in Isparta, the rest of the studies have either random records or records from some pathways. The present study is one of those targeting a protecting area. The lichen biodiversity of Gölcük Nature Park located in Isparta, a Mediterranean city of Turkey is reported with a list of 189 species (192 taxa). At the same time, the distribution of taxa has been evaluated ecologically.

Notwithstanding that, there is not a single collection of “Lichen Mycota of Turkey”, we can mention a recent work by JOHN & TÜRK (2017), a great attempt to compile a checklist of Turkey. However, it has many gaps to be filled. Wherefore, this study aims to make a contribution to taxonomic and mycotic studies on lichens in Turkey and provide a basis for further ecological, chemical and alike studies of lichenology that can be done in the region in the following years.

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