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Investigations on the bark pH and epiphytic lichen diversity of *Quercus* taxa found in Marmara Region

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Abstract

Epiphytic lichen diversity were investigated on 11 *Quercus* taxa in Marmara Region and effect of bark pH was evaluated on the lichen diversity. Overall 88 lichen taxa were recorded. Q. *petraea* was determined the richest oak with 47 lichen taxa while *Q. hartwissiana* was determined the most poor oak with 7 lichen taxa. The highest average bark pH (6,16) was recorded from *Q. frainetto* and the lowest average bark pH (4,76) was recorded from *Q. cerris.* Since bark pH values of the investigated *Quercus* taxa are usually high, nitrophytic species were more observed than acidophytic species on barks. In this study, we observed that bark pH values were varied among *Quercus* taxa and localities. Heavy fertilization practises in Marmara Region were observed effect of bark pH of *Quercus* taxa in the several localities which near the agricultural areas.

Key words: Bark pH, biodiversity, epiphytic lichens, *Quercus,* Turkey

INTRODUCTION

Lichens which are grown on natural habitats such as tree, rock, soil and also on artificial substrates like concrete, tile, metal; have wide ecological amplitude. Different tree species in foresty regions are suitable substrates for epiphytic lichens.

Turkey has a very important area in terms of oak forests and oak species. This genera are represented by 18 natural species in Turkey [1].

Quercus has an acidic bark and a good phorophyte for epiphytic lichen species [2]. Acidity is a natural phenomenon. It affects species composition and is probably the most important factor determining the natural lichen floras of tree species [3]. According to this study results, the pH of tree bark and the susceptibility to toxic substances appear to be two major primary factors affecting epiphytic lichen composition. These factors have independent effects on the lichen composition. Most of the so-called nitrophytic species appear to have a low sensivity to toxic effects of SO_2; their only requirement being a high bark pH. An increased bark pH appears to be primary cause of the enormous increase in nitrophytic species and the disappearence of acidophytic species. There is a nearly linear relationship between the ambient NH_3 concentration in air and the abundance of nitrophytes on *Quercus*.

Tree bark is continually exposed to the environment over a period of several years. Therefore, it can give precise information about changes that occur in the air conditions of ecosystem. This and other characteristics make a suitable material to tree bark for the evaluation of air pollution. It is frequently used in the analysis of heavy metal deposition, sulphur (SO_2) and acid pollutants [4].

Lichenological studies in Turkey are based mostly on taxonomic works. Recent years, there are numerous articles on lichens concern with Marmara Region. Most of them are focused on general lichen flora [6-9], and some of them are related to air pollution and monitoring [10-12]. Also, there are various studies related with antimicrobial, genotoxic and antigenotoxic potentials of lichens [13-14]. Tufan Cetin & Sumbul [15], were studied lichens of Duzlercamı region (Antalya) after the 1997 fire as an ecological evaluation. However, there are no detailed studies about epiphytic lichens and substrate features, in Turkey.

The aim of the present study has been to investigate the relationship between epiphytic lichen diversity and bark pH of oak species in Marmara Region.

MATERIALS AND METHODS

The bark and lichen samples were collected from 31 different localities in Marmara Region (Balikesir, Bursa, Canakkale, Edirne, Istanbul, Kirklareli and Tekirdag provinces) between the year of 2005 and 2007 (Table 1). The lichen samples were identified to species level using standart microscopic techniques and spot tests. The names of authors were abbreviated according to Brummitt and Powell [16]. The specimens are kept in the herbarium of Uludag University (BULU) in Bursa.

Bark samples were dried for one week at room temperature in the laboratory. To determine bark pH, method recommended by Kricke [17] was used with a following changes. Bryophyte and lichen remnants were removed from tree bark to avoid their effect on pH value. Then, 2 g for each tree barks was weighed, ground by aid of knife and muller and suspended in 20 ml distilled water. The suspensions were shaken for one hour and stored for one day. Later supernatant was filtered from filter paper in test tubes. The pH values of the supernatant was measured by pH meter (Hanna HI 8314).

Table 1. Collecting localities

No	Date	Locality / Substrate	Altitude	Coordinates
1	23.07.2006	Kirklareli: Centre; in the vicinity of Kavakdere / *Q. cerris*	160 m	41°35'11"N, 27°17'26"E
2	25.07.2006	Canakkale: Can; in the vicinity of Uvezdere, oak and pine forest / *Q. cerris*	345 m	40°03'26"N, 26°51'00"E
3	14.06.2006	Kirklareli: Vize; between Kömürköy and Vize, 11 km from Kömürköy, oak woodland / Q. cerris	275 m	41°37'26"N, 27°51'50"E
4	19.06.2006	Canakkale: Gelibolu; in the vicinity of Fındıklı, meadow / *Q. coccifera*	138 m	40°26'07"N, 26°33'22"E
5	25.07.2006	Canakkale: Centre; in the vicinity of Serceler, roadside / *Q. coccifera*	164 m	40°03'37"N, 26°35'35"E
6	16.09.2007	Bursa: Mudanya; in the vicinity of Mesudiye / *Q. coccifera*	85 m	40°21'39"N, 28°35'34"E
7	24.07.2006	Kirklareli: Pınarhisar; between Akören and İslambeyli, 2 km from Akören / *Q. frainetto*	400 m	41°42'20"N, 27°35'26"E
8	06.07.2005	Canakkale: Centre; between Can and Canakkale, road junction of Kocalar, oak woodland / *Q. frainetto*	469 m	40°02'03"N, 26°46'57"E
9	15.06.2006	Kirklareli: Demirköy; in the vicinity of Igneada, oak woodland / Q. frainetto	28 m	41°52'32"N, 27°58'02"E
10	20.10.2007	Kirklareli: Demirköy; between Karacadag and Yigitbası, 1km from Yigitbası / *Q. hartiwissiana*	205 m	41°56'55"N, 27°40'18"E
11	05.07.2005	Canakkale: Bayramic; between Yeniköy and Uvecik, 3 km from Yeniköy, oak woodland alan / *Q. infectoria*	29 m	39°54'30"N, 26°10'40"E
12	28.07.2006	Balikesir: Centre; in the vicinity of Türkali / *Q. infectoria*	275 m	39°29'16"N, 27°51'14"E
13	06.05.2007	Bursa: Yenişehir; between Subası and Yazılı, exit of Subası, oak woodland / *Q. infectoria*	385 m	40°12'42"N, 29°39'06"E
14	13.06.2006	Istanbul: Catalca; between Canakcı and Dagyenice, oak woodland / *Q. ithaburensis* subsp. *macrolepis*	69 m	41°15'35"N, 28°29'19"E
15	05.07.2005	Canakkale: Bayramic; between Bayramic and Ezine, 15 km from Bayramic, agricultural field / *Q. ithaburensis* subsp. *macrolepis*	76 m	39°46'22"N, 26°27'54"E
16	05.07.2005	Canakkale: Centre; between Truva and Kumkale, entrance of Kumkale, agricultural field / *Q. ithaburensis* subsp. *macrolepis*	24 m	39°58'35"N, 26°14'17"E
17	24.07.2006	Kirklareli: Demirköy; between Yenice and Demirköy, Kadınkule / *Q. petraea*	682 m	41°44'58"N, 27°40'03"E
18	17.06.2005	Bursa: Nilüfer; in the vicinity of Ucpınar, oak woodland / *Q. petraea*	660 m	40°06'17"N, 28°50'41"E
19	16.06.2006	Kirklareli: Kofcaz; between Kula and Kocayazı, before 9 km from Kocayazı, beech and oak forest / *Q. petraea*	492 m	41°59'42"N, 27°16'30"E
20	16.06.2006	Kirklareli: Centre; between Karahamza and Yoguntas, 2 km from Karahamza, oak woodland / *Q. pubescens*	337 m	41°51'34"N, 27°01'10"E
21	25.07.2006	Canakkale: Centre; in the vicinity of Musaköy / *Q. pubescens*	90 m	40°11'19"N, 26°32'29"E
22	18.06.2006	Tekirdag: Hayrabolu; in the vicinity of Karabürcek, oak woodland / *Q. pubescens*	205 m	41°13'43"N, 27°00'04"E
23	17.06.2006	Edirne: Uzunköprü; in the vicinity of Cakmak, agricultural field / *Q. robur*	103 m	41°21'33"N, 26°40'39"E
24	12.06.2006	Istanbul: Sarıyer; Belgrad Forests, Topkoru, oak forest / *Q. robur*	138 m	41°11'05"N, 28°59'07"E
25	16.09.2007	Bursa: Nilüfer; in the vicinity of Alaaddinbey, roadside / *Q. robur*	78 m	40°12'10"N, 28°53'45"E
26	27.07.2006	Balikesir: Balya; in the vicinity of Kadıköy, oak woodland / *Q. trojana*	163 m	39°47'37"N, 27°37'32"E
27	27.07.2006	Balikesir: Centre; between Gökköy and Coraklık, 2 km from Gökköy, agricultural area / *Q. trojana*	222 m	39°34'56"N, 27°47'36"E
28	26.07.2006	Balikesir: Balya; in the vicinity of Pınaroba, roadside / *Q. trojana*	463 m	39°46'25"N, 27°29'16"E
29	23.07.2006	Tekirdag: Centre; in the vicinity of Hüsnülü, agricultural field / *Q. virgiliana*	146 m	41°01'41"N, 27°35'41"E
30	14.06.2006	Kirklareli: Pınarhisar; in the vicinity of Cevizköy, agricultural field / *Q. virgiliana*	241 m	41°33'24"N, 27°35'19"E
31	18.06.2006	Edirne: Kesan; between Sabanmera and Yayla, before 3 km fromYayla, oak woodland / *Q. virgiliana*	118 m	40°39'04"N, 26°23'43"E

Study area

Marmara Region is located in the northwest of Turkey and surrounds Marmara Sea (Fig. 1). This region is consist of two parts: Anatolian and Thrace peninsula. Mount of Uludag (Olympos), which the highest peak is 2543 m, is the highest point of study area and it is located from south of Bursa in Anatolian peninsula. Another important mounts are Yıldız (Istranca) Mountains, which the highest peak is 1031 m, lying along the coast of Black Sea of Thrace peninsula.

Due to the geographical position, Marmara Region has different climate. Mediterranean and Oceanic climate have seen in this region. Oceanic climate occurs in the coast of Black Sea while Mediteranean climate is present on the coast of Marmara Sea, Aegean Sea and the inland areas. Climate has become hard steadily inland area at Thrace peninsula. The mean annual precipitation is 500-1000 mm and temperature is 14-16 ^{o}C [18].

Quercus species are a suitable phorophyte for lichen settlement. Therefore, various lichen species was found on oak trees at this study.

Bark pH is influenced by many factors [3]. In this study, we observed that bark pH value was varied among *Quercus* taxa and localities (Table 3). The highest bark pH (6,6) was recorded from *Q. frainetto* at 9th locality and the lowest pH (4,35) was recorded from *Q. cerris* at 1st locality. The highest average pH (6,16) was found for *Q. frainetto* and the lowest average pH (4,76) was found for *Q. cerris.*

Characteristically, acidic bark of oak was considered as an excellent substrate, as nitrophytic lichen species are rare on oak trunks in non-eutrophicated conditions [3]. Besides, eutrophication which connected with ecological factors, was conducive to lichen colonization. A high occurence of nitrophytic lichens corresponded with the intensity of farming [21]. In this study, nitrophytic species were more than the acidophytic species. Due to heavy fertilization in Marmara Region, bark pH of *Quercus* taxa in the several localities were measured high. For this reason, nitrophytes such as *Caloplaca holocarpa, Candelariella vitellina, C. xanthostigma, Lecanora hagenii, Parmelina tiliacea, Phaeophyscia orbicularis, Physcia adscendens, Protoparmeliopsis muralis and Xanthoria parietina* [3, 4, 21] were found frequently in these localities. *Candelaria concolor,* a nutrient-tolerant lichen species [21], was observed 27th localities, which was near the agricultural field, on the trunks of *Q. trojana.*

In addition, *Cladonia* spp., *Lepraria incana, Platismata glauca* and *Pseudevernia furfuracea var. furfuracea* which is determined acidophytic species [3, 4] were found in some localities (9, 17, 18, 19, 20) of the research area. These lichen species were recorded only one or two times from the trunks of *Q. petraea, Q. frainetto and Q. pubescens.* At these localities, except the locality of 9th, pH value were not very high (4,83-5,33). *Cladonia rangiformis* were found one time on *Q. frainetto* trunks where the pH value 6,6.

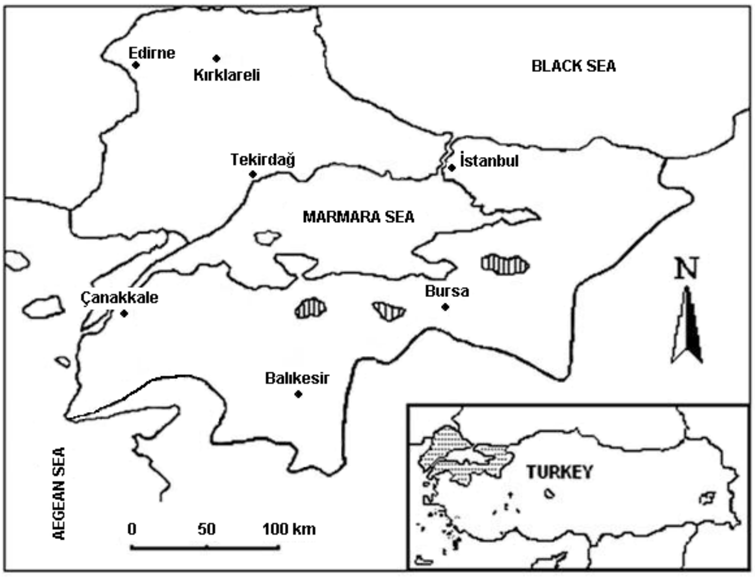

Figure 1. Map of the Marmara Region

RESULTS

In this investigation, a total of 88 lichen taxa were identified from oak trees. Of these, 31 taxa were found on *Q. cerris,* 14 taxa on *Q. coccifera,* 33 taxa on *Q. frainetto,* 7 taxa on *Q. hartwissiana,* 16 taxa on *Q. infectoria*, 12 taxa on *Q. ithaburensis* subsp. macrolepis, 47 taxa on *Q. petraea,* 27 taxa on *Q. pubescens,* 14 taxa on *Q. robur,* 32 taxa on *Q. trojana* and 22 taxa on *Q. virgiliana.*

The lichen taxa were listed alphabetically with locality numbers and substrates at the Table 2.

DISCUSSION

The floristic composition of epiphytic lichen communities is determined by substrate qualities such as age of tree, bark texture, bark chemistry and habitat conditions such as age and history of the woodland, forest productivity, aspect, and climate [19].

Tree species are one of the most important factors explaining distribution of epiphytic lichen species [20].

Table 2. Lichen taxa and phorophyte species with locality numbers

Taxa	A	B	C	D	E	F	G	H	I	J	K	T
Acrocordia gemmata			9							28		**2**
Amandinea punctata	1, 2						18	22			29	**4**
Anaptychia ciliaris			7, 9	10	12		17, 18, 19	20, 22			30, 31	**6**
Bacidia fraxinea			9								31	**2**
Bacidia globulosa					12							**1**
Bacidia laurocerasi									24			**1**
Bacidia rubella							17					**1**
Buellia disciformis	2		8				19					**3**
Caloplaca cerina var. *cerina*						16						**1**
Caloplaca ferruginea	2	5	7, 8				17, 18			28		**5**
Caloplaca flavorubescens		5					17					**2**
Caloplaca haematites		5										**5**
Caloplaca herbidella							19					**1**
Caloplaca holocarpa		5			11, 12, 13							**2**
Candelaria concolor										27		**1**
Candelariella vitellina		5									30	**2**
Candelariella xanthostigma	1							20				**2**
Cladonia coniocraea								20				**1**
Cladonia fimbriata							17					**1**
Cladonia pyxidata							17, 19					**1**
Cladonia rangiformis			9									**9**
Collema flaccidum										28		**1**
Collema nigrescens										28		**1**
Collema subflaccidum										28	31	**2**
Diplotomma alboatrum						15, 16						**1**
Evernia prunastri	3		7, 8	10			17, 18, 19	22		26		**6**
Hyperphyscia adglutinata					11			22				**2**
Lecanora argentata			8			15						**2**
Lecanora carpinea	1, 2, 3		7, 8		13		17, 18, 19	21, 22	23	27	30	**8**
Lecanora chlarotera	2	4, 5	7, 8		13	16	17, 19	21, 22	23	26, 27, 28	30	**10**
Lecanora expallens											31	**1**
Lecanora glabrata		5			12		17				31	**4**
Lecanora hagenii					13							**1**
Lecanora intumescens							17, 19					**1**
Lecanora meridionalis					13							**1**
Lecidella elaeochroma	2, 3	4, 5, 6	7, 8	10	12, 13	14	17, 18	21, 22	23	26, 27, 28	30, 31	**11**
Lepraria incana							19					**1**
Lobaria pulmonaria							19					**1**
Melanelia fuliginosa subsp. *glabratula*							17, 19					**1**
Melanelixia subargentifera	1						19	20				**3**
Melanelixia subaurifera	2, 3	4	8				19			26		**5**
Melanohalea elegantula	1					15						**2**
Nephroma laevigatum							18					**1**
Ochrolechia arborea	1									28		**2**
Ochrolechia turneri	3		7				17,18		24			**4**

A: ***Q. cerris***; B: ***Q. coccifera***; C: ***Q. frainetto***; D: ***Q. hartwissiana***; E: ***Q. infectoria***; F: ***Q. ithaburensis*** subsp. ***macrolepis***; G: ***Q. petraea***; H: ***Q. pubescens***; I: ***Q. robur***; J: ***Q. trojana***; K: ***Q. virgiliana***; T: Total number of substrate

Table 2. Lichen taxa and phorophyte species with locality numbers

Taxa	A	B	C	D	E	F	G	H	I	J	K	T
Parmelia sulcata	2, 3	4	7, 8, 9	10			17,18,19	20,22		26	31	**8**
Parmelina carporrhizans			8									**1**
Parmelina quercina	2							21				**2**
Parmelina tiliacea	1,2		7, 8, 9			15	17,18,19	20,21,22		28	29,31	**7**
Peltigera praetextata							19					**1**
Peltigera rufescens							17					**1**
Pertusaria albescens			7, 8				17, 18, 19			28		**3**
Pertusaria amara				10			17, 18					**2**
Pertusaria flavida							19			28		**2**
Pertusaria hymenea										28		**1**
Pertusaria leioplaca										26		**1**
Pertusaria pertusa							17, 18, 19			28		**2**
Phaeophyscia ciliata							19					**1**
Phaeophyscia orbicularis	1, 3				12, 13		19		25	28	29, 30	**6**
Phlyctis agelaea									24		31	**2**
Phlyctis argena	1, 3		7, 8				17, 18, 19			26		**4**
Physcia adscendens	3		8		13	14	19	20, 22	23		29, 30, 31	**8**
Physcia aipolia			7				17, 19	20			31	**4**
Physcia dimidiata										27		**1**
Physcia leptalea	2											**1**
Physcia stellaris		5	8		11, 12	15, 16		21, 22	23	27	29, 30	**8**
Physconia distorta			7, 8		13		17, 18					**3**
Physconia enteroxantha	1, 3		8, 9	10			17, 18, 19	20			29	**6**
Physconia grisea	1		7			15		20, 22	23	27	30, 31	**7**
Physconia perisidiosa			7, 8, 9				18, 19	20		28		**4**
Physconia servitii	2		7					21				**3**
Platismatia glauca							18					**1**
Pleurosticta acetabulum	2		7, 8				17, 18, 19	20, 21, 22	23	26, 27	30, 31	**7**
Protoparmeliopsis muralis								22				**1**
Pseudevernia furfuracea var. *furfuracea*							18					**1**
Ramalina calicaris										26		**1**
Ramalina farinacea	2, 3		7, 9	10			17, 18, 19	22	24	26		**7**
Ramalina fastigiata	2		7, 8				17, 18, 19	22		26		**5**
Ramalina fraxinea	2							22				**2**
Ramalina pollinaria			9				18, 19				31	**3**
Rinodina capensis	2											**1**
Rinodina exigua		5						21				**2**
Rinodina pyrina		5	8			16						**3**
Rinodina sophodes	2						18		23			**3**
Scoliciosporum umbrinum	2		8							28		**3**
Tephromela atra							17			26		**2**
Tornabea scutellifera					12							**1**
Xanthoria parietina	1, 2, 3	4, 5, 6	7, 8, 9		11, 12, 13	14, 15, 16	17, 18, 19	20, 21, 22	23, 25	26, 27	29, 30, 31	**10**
Total taxa	31	14	33	7	16	12	47	27	14	32	22	

A: ***Q. cerris***; B: ***Q. coccifera***; C: ***Q. frainetto***; D: ***Q. hartwissiana***; E: ***Q. infectoria***; F: ***Q. ithaburensis*** subsp. ***macrolepis***; G: ***Q. petraea***; H: ***Q. pubescens***; I: ***Q. robur***; J: ***Q. trojana***; K: ***Q. virgiliana***; T: Total number of substrate

Rinodina, which is described as eutrophic genus [22], had 4 taxa from different oak species and localities. At these localities pH value was rather high and varies from 4,70 to 6,47. *R. pyrina* is a photophytic and nitrophytic species [23, 24]. This species was observed nutrient-enriched smooth or rough bark which pH value is more than five (5,15-6,47). Besides, photophytic and not nitrophytic to moderately nitrophytic species *R. sophodes* [23, 24] was recorded from the bark which is the pH value up to 5,04 (4,7-5,04).

Acrocordia gemmata was recorded from two localities which has the high bark pH value, on *Q. frainetto* (pH 6,60) and *Q. trojana* (6,55) trunks.

Lecanora chlarotera, L. carpinea, Lecidella elaeochroma, Parmelia sulcata, Physcia adscendens, P. stellaris and Xanthoria parietina were found on several substrates. It is known that these remaining species are very common and they have wide ecological amplitude [23, 24, 25].

Q. hartwissiana had the least numbers of lichen species in this study. In Marmara Region, this species is not common and found rarely in limited areas. It was observed only in one locality at this study and 7 lichen species were recorded from the trunk of *Q. hartwissiana.* On the contrary, the most abundant lichen samples (47 taxa) was found on *Q. petraea.* These three localities, which was found *Q. petraea,* have high altitude, rather moist and woodland areas. Due to these features, the number of lichen species was recorded rather high at these localities (see Table 3).

The factors such as bark texture, moisture-holding capacity and chemistry of bark influence lichen settlement on trees [26]. Moisture availability of tree trunks affects the diversity and distribution of corticolous lichen communities on tree. For example, *Lobaria pulmonaria* (19th locality) and *Nephroma laevigatum* (18th locality) which are growing on mossy, humid woodland areas, were recorded on trunks of *Q. petraea*. This result showed that moisture-holding capacity of tree bark is important as bark pH value.

The 6th (2 taxa, *Q. coccifera*) and the 17th localities (28 taxa, *Q. petraea*) had the least and the highest numbers of lichen taxa, respectively. This two locality were differ from some features. *Q. coccifera* was found at 85 m while *Q. petraea* was found at 682 m. Besides, *Q. coccifera* form on semigreen shrub whereas *Q. petraea* has deciduous tree. On the other hand, 17th locality is very protected woodland area while 6th locality cover with maquis

Table 3. Locality numbers, pH value and a total lichen taxa according to substrate species

Substrate name	Locality number	pH	Mean pH	Total number of lichen species
Q. cerris	1	4,35	4,76	12
	2	4,7		20
	3	5,25		12
Q. coccifera	4	5,05	5,33	5
	5	5,15		12
	6	5,8		2
Q. frainetto	7	5,41	6,16	20
	8	6,47		23
	9	6,6		11
Q. hartwissiana	10	5,48	5,48	7
Q. infectoria	11	5,39	5,57	4
	12	5,52		9
	13	5,8		10
Q. ithaburensis subsp. *macrolepis*	14	5,16	5,66	3
	15	5,8		8
	16	6,03		4
Q. petraea	17	4,83	5,19	28
	18	5,04		25
	19	5,70		20
Q. pubescens	20	5,33	5,43	13
	21	5,48		10
	22	5,5		18
Q. robur	23	4,97	5,31	9
	24	5,42		4
	25	5,54		2
Q. trojana	26	4,91	5,49	13
	27	5,03		9
	28	6,55		16
Q. virgiliana	29	4,9	5,1	7
	30	4,97		11
	31	5,45		15

elements. As well as differences altitude and locality, in terms of lichen settlement, the trunks of *Q. petraea* has a wider surface area. For this reason, it has much lichen specimens to host. Substrate factors and habitat features are very effective to determine the species richness on trees [20, 27].

The results showed that the bark pH is affect the settlement of epiphytic lichen species but is not the only factor effecting distribution of epiphytic lichen. Further, studies need to determine other factors influencing species diversity and composition of epiphytic lichens, especially bark properties (pH, texture, age), habitat features, agricultural practices, air pollution and other environmental effects.

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REFERENCES

[1] Gunal N. 1997. Türkiye'de başlıca ağaç türlerinin coğrafi yayılışları, ekolojik ve floristik özellikleri. Çantay Kitabevi, İstanbul.

[2] Larsen RS, Bell JNB, James PW, Chimonides PJ, Rumsey FJ, Tremper A, Purvis OW. 2007. Lichen and bryophyte distribution on oak in London in relation to air pollution and bark acidity. Environmental Pollution 146:332-340.

[3] Van Herk CM. 2001. Bark pH and suspectibility to toxic air pollutants as independent causes of changes in epiphytic lichen composition in space and time. Lichenologist 33(5):419-441.

[4] Santamaria JM and Martin A. 1997. Tree bark as a bioindicator of air pollution in Navara, Spain. Water, Air and Soil Pollution 98:381-387.

[5] Cicek A, Ozdemir-Türk A (1998) Lichen Flora of Sakarya Province. Tr. J. of Botany 22:99-119.

[6] Ozdemir-Turk A, Guner H. 1996. The Lichens of the Yıldız Mountain in Turkey. In: IV th. Plant Life Symposium (ed. Ozturk M, Secmen O, Gork G), pp. 455-471, Izmir.

[7] Ozdemir-Turk A, Guner H. 1998. Lichens of the Thrace Region of Turkey. Turkish Journal of Botany 22:397-407.

[8] Ozturk S. 1992. Uludağ'ın kabuksu ve dalsı likenleri üzerinde bir araştırma. Turkish Journal of Botany 16:405-409.

[9] Cobanoglu G, Sevgi O. 2006. Contribution to the lichen flora of Gurgen Dagı (Canakkale). Turkish Journal of Botany 30:47-54.

[10] Ozdemir A. 1992. Bilecik şehri epifitik likenlerinin kükürtdioksit (SO_2) kirliliğine bağlı olarak dağılışı. Turkish Journal of Botany 16:177-185.

[11] Ozturk S, Guvenc G, Aslan A. 1997. Distribution of epiphytic lichens and sulphur dioxide (SO_2) pollution in the city of Bursa. Turkish Journal of Botany 21:211-215.

[12] Karabulut SN, Ozdemir-Turk A, John V. 2004. Lichens to monitor afforestation effects in Canakkale, Turkey. Cryptogamie Mycologie 25(4):33-346.

[13] Turk H, Yılmaz M, Tay T, Ozdemir Turk A, Kıvanc M. 2006. Antimicrobial activity of extracts of chemical races of the lichen *Pseudevernia furfuracea* and physodic acid, choloroatranorin, atranorin, and olivetoric acid constituents. Zeitschrift für Naturforschung 61C:499-507.

[14] Zeytinoglu H, Incesu Z, Ayaz Tuylu B, Ozdemir Turk A, Barutca B. 2007. Determination of genotoxic, antigenotoxic and cytotoxic potential of the extract from lichen *Cetraria aculeata* (Schreb.) Fr. in vitro. Phytoterapy Research 2(1):118-123.

[15] Tufan Cetin O, Sumbul H. 2008. 21 Temmuz 1997 yangınında zarar gören Düzlerçamı bölgesinin (Antalya) likenleri. Ekoloji 17(67):31-36.

[16] Brummitt RK, Powel CE. 1992. Authors of plant names. Royal Botanical Gardens, Kew.

[17] Kricke R. 2002. Measuring bark pH. In: Monitoring with Lichens-Monitoring Lichens (ed. Nimis PL, Scheidegger C, Wolseley PA), pp. 333-336. Kluwer Academic, Dordrecht.

[18] Akman Y. 1990. İklim ve Biyoiklim (Biyoiklim Metodları ve Türkiye İklimleri). Palme Yayın Dağıtım, Ankara.

[19] Ihlen PG, Gjerde I, Sætersdal M. 2001. Structural indicators of richness and rarity of epiphytic lichens on *Corylus avellana* in two different forest types within a nature reserve in South-western Norway. Lichenologist 33(3):215-229.

[20] Mežaka A, Brūmelis G, Piterans A. 2008. The distribution of epiphytic bryophyte and lichen species in relation to phorophyte characters in Latvian natural old-growth broad leaved forests. Folia Cryptog. Estonica 44:89-99.

[21] Ruoss E. 1999. How agriculture affects lichen vegetation in central Switzerland. Lichenologist 31(1):63-73.

[22] Aragón G, Sarrión FJ and Martínez I. 2004 Epiphytic lichens on *Juniperus oxycedrus* L. in the Iberian Peninsula. Nova Hedwigia 78(1-2):45-56.

[23] Wirth V. 1995. Die Flechten Baden-Württembergs. Teil 1-2. Ulmer, Stuttgart.

[24] Zedda L. 2002. The epiphytic lichens on *Quercus* in Sardinia (Italy) and their value as ecological indicators. Botanic Garden and Botanical Museum, Berlin.

[25] Purvis OW, Coppins BJ, Hawksworth DL, James PV, Moore M. 1992. The Lichen Flora of Great Britain and Ireland. Natural History Museum Publications, London.

[26] Brodo IM, Sharnoff SD, Sharnoff S. 2001. Lichens of North America. Yale University Press, New Haven and London.

[27] Friedel A, Oheimb G, Dengler J, Hardtle W. 2006. Species deversity and species composition of epiphytic bryophytes and lichens-a comparision of managed and unmanaged beech forests in NE Germany. Feddes Repertorium 117(1-2):172-185.