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Lichen Flora of Pamukkale (Hierapolis), Turkey

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Abstract: A list of 82 lichen taxa is reported from Pamukkale (Hierapolis) in the province of Denizli. Sixty four taxa from the study area are new records for the province. Four taxa are new to Turkey: *Lecania sylvestris*, *Lecanora sambuci*, *Opegrapha herbarum*, *Peltula patellata*.

Key words: Lichen, calcareous, Denizli, flora, Turkey

INTRODUCTION

The floristic studies on the Turkish lichens have been carried out intensively in the recent decades although there are still many intact places. The following study is focused on the lichens of Pamukkale (Hierapolis) which is cited on the list of World Heritage of UNESCO being an antique city established in the second century (B.C.) and also known for its thermal springs and unique natural architecture of the travertine. Besides the historical values, the city has a rich biodiversity especially with higher plants, maquis vegetation and forests. So, it is also placed in a special status as Special Environment Protection Area by the Turkish Republic Ministry of Environment and Forestry. Pamukkale is densely subject to tourism throughout the year.

Pamukkale is situated 20 km NW from Denizli province. It is located in the central Aegean region of Southwestern Anatolia (37° 54' 57" N, 29°6' 46" E) (Fig. 1). The study area covers about 20 km^2, including antique Hierapolis city and the ruins, travertine region and surrounding villages. The elevation is between 250-490 m.

The geological structure has 4 different units; metamorphic rocks containing Neolithic marble and schist, sedimentary rocks containing pebble, sandstone and limestone, Quaternary alluviums and travertine. The region has 17 thermal areas with water temperature of 35 to 100°C. The water consists of excessive amount of calcium bicarbonate ($CaCO_3$) which causes white precipitation (calcium carbonate, $CaCO_3$) in the half-circle shaped travertine pool layers. The climate is generally Mediterranean with low values of humidity in the south. The average annual mean temperature is 15.7°C. The annual precipitation is about 554.5 mm (Koçman, 1993 a, b). Characteristic Mediterranean maquis elements are prevalent such as *Arbutus unedo*, *Phillyrea latifolia*, *Laurus nobilis*, *Nerium oleander*, *Vitex agnus castus*, *Quercus ilex* and *Myrtus communis*. The common trees are *Quercus coccifera*, *Pinus brutia*, *Pinus nigra* (Necdet *et al*., 1993).

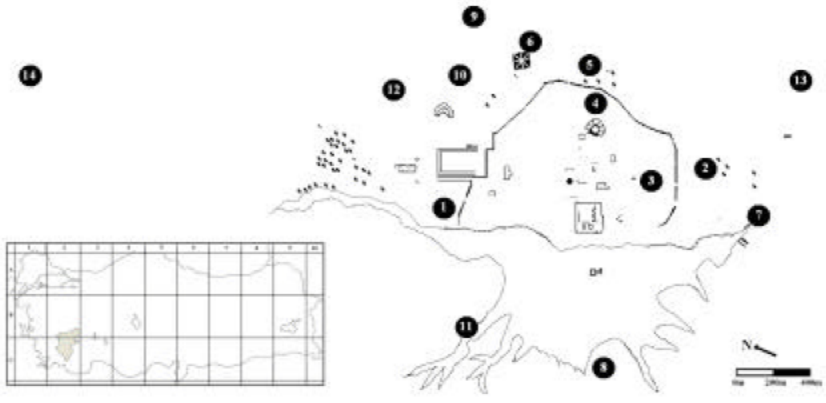


Fig. 1: Position of the study area in Turkey and collecting sites indicated with numbers in Pamukkale

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The lichen records from the area are very limited in literature (Schindler, 1998; John *et al*., 2000). There are only a few studies on the lichens of some other places in Denizli province (Pisut, 1970; John, 1992; Breuss and John, 2004).

List of collecting cites:

DENİZLİ-Pamukkale (Hierapolis):

01: North entrance of Bath-Basilica and through west side of North Necropolis, 350 m, 10.VIII.2002, 37°55' 47'' N - 29° 07' 17'' E.

02: South Roma Gate Travertine Reserve Hill, 360 m, 10.VIII. 2002, 37°55' 19'' N - 29° 07' 51'' E.

03: Southeastern parts of South Byzantines Walls, from City Baths, 360 m, 07.XII.2002, 37°55' 23'' N - 29° 07' 45'' E.

04: Between east of antic theatre and west side of city walls. 400 m, 07.IX.2003, 37°55' 38'' N - 29° 07' 46'' E.

05: North and east sides of cistern, 430 m, 07.IX.2003, 37° 55' 43'' N - 29°07' 55'' E.

06: East side of St. Philippe Martyrium 430 m, 07.IX.2003, 37°55' 53'' N - 29°07' 54'' E.

07: Bed of Kadı River, 290 m, 27.XI.2003, 37°55' 04'' N - 29°07' 31'' E.

08: Between Pamukkale city and Travertines, 250-290 m, 27.XI.2003, 37°55' 13'' N - 29°07' 05'' E.

09: Forest Area on the north side of St. Philippe Martyrium 440 m, 24.IV.2004, 37°56' 11'' N - 29° 07' 30'' E.

10: The hill on the east side of the old theatre, 470 m, 24.IV.2004, 37°56' 06'' N - 29°07' 38'' E.

11: The east face of the travertine slope on southwest side of Çukurbağ 320 m, 20.V.2004, 37°55' 34'' N - 29°07' 11'' E.

12: East Necropolis, the hill on the east side of North Baths, 440 m, 20.V.2004, N 37°56' 10'' - E 29°07' 29''.

13: The cross path of South Road and Kadı River, southeast slopes 370 m, 26.I.2005, 37°55' 20'' N - 29°08' 13'' E.

14: The fault zone between Pamukkale-Karahayıt, 390 m, 26.I.2005, 37°57' 10'' N - 29°07' 00'' E.

MATERIALS AND METHODS

The lichen materials were collected from 10.08.2002 to 26.01.2005 on different substrata from 14 cites in Pamukkale-antique Hierapolis city and its surroundings in the province of Denizli. The geographic coordinates and elevations were recorded as well as the substrate types. Determinations were made at least at species level by using standard identification techniques. The specimens are preserved in the Herbarium of the Faculty of Science and Arts, Marmara University, Istanbul (MUFE), with numbers 1314-1458. The herbarium numbers are belonging to Gülşah Çobanoğlu (G.Ç.) in MUFE.

RESULTS

The total lichen list includes 81 species (82 taxa) from 33 genera belonging to 19 families. The nomenclature follows the recent literature (Wirth, 1995; Blanco *et al*., 2004; Santesson *et al*., 2004). The abbreviations of the authors' names are according to Brummitt and Powell (1992).

A whole list of the 82 taxa is arranged in alphabetical order followed by the numbers of their collecting sites and the substratum data with the abbreviations given below. *Lecania sylvestris*, *Lecanora sambuci*, *Opegrapha herbarum*, *Peltula patellata* are new lichen records for the Turkish flora, indicated by an asterisk (*) in the list. A number sign (#) indicates new records (64) for the province of Denizli

Abbreviations of substrates used in the list:

E : Epiphytic on trees
C : $CaCO_3$ containing calcareous rock-limestone
CS : $CaCO_3$ containing calcareous soil
MH : Mossy habitat
L : Lichenicolous
M : Muscicolous
S : Siliceous rock
T : Terricolous

List of taxa:

Acarospora cervina A.Massal. 2, 4, 5, 6, 9; (C).

- *Acarospora macrospora* (Hepp.) A.Massal. ex Bagl. 2 (C).

Aspicilia calcarea (L.) Mudd. 1, 2, 3, 4, 5, 6, 8, 10, 11, 12, 14 (C).

- *Aspicilia contorta* (Hoffm.) Kremp. ssp. *contorta* 10, 12, 14 (C).
- *Aspicilia contorta* ssp. *hoffmanniana* S.Ekman and Fröberg 1, 4, 5, 8 (C).
- *Aspicilia recedens* (Taylor) Arnold 13 (S).
- *Buellia badia* (Fr.) A.Massal. 2 (C, L).
- *Caloplaca alociza* (A.Massal.) Mig. 2, 5, 12 (C).
- *Caloplaca aractina* (Fr.) Häyrén 13 (C).
- *Caloplaca cerina* (Ehrh. ex Hedw.) Th.Fr. *var. cerina* 5, 10, 13, 14 (E).
- *Caloplaca cerinelloides* (Erichsen) Poelt 13 (E).

Caloplaca chalybaea (Fr.) Müll.Arg. 12 (C).

- *Caloplaca citrina* (Hoffm.) Th.Fr. 2, 4 (C).
- *Caloplaca coronata* (Kremp. ex Körb.) J.Steiner 14 (C).
- *Caloplaca decipiens* (Arnold) Blomb. and Forssell 13 (C).

Caloplaca dolomiticola (Hue) Zahlbr. 12 (C).

Caloplaca erythrocarpa (Pers.) Zwackh 14 (C).

- *Caloplaca flavescens* (Huds.) J.R. Laundon 1, 4, 5, 6, 8, 14 (C).

- *Caloplaca holocarpa* (Hoffm. ex Ach.) A.E.Wade 1, 3, 5, 9, 10, 13, 14 (C).

Caloplaca inconnexa (Nyl.) Zahlbr. 2, 9, 10 (L).

- *Caloplaca lactea* (A.Massal.) Zahlbr. 2, 4, 8 (C).
- *Caloplaca luteoalba* (Turner) Th.Fr. 1, 2 (C).
- *Caloplaca saxicola* (Hoffm.) Nordin 9 (C).
- *Caloplaca teicholyta* (Ach.) J.Steiner 1, 3, 4, 5, 6, 8, 14 (C).
- *Caloplaca variabilis* (Pers.) Müll.Arg. 6, 8, 10, 12, 13, 14 (C).
- *Candelariella aurella* (Hoffm.) Zahlbr. 1, 4, 5, 6, 8, 9, 10, 12, 14 (C).
- *Candelariella medians* (Nyl.) A.L.Sm. 6, 14 (C).

Candelariella vitellina (Hoffm.) Müll.Arg. 13, 14 (C).

- *Candelariella xanthostigma* (Ach.) Lettau 10, 13 (E).
- *Catapyrenium squamulosum* (Ach.) Breuss 2, 3, 4, 7, 8, 11, 13 (CS - MH).
- *Cladonia foliacea* (Huds.) Willd. 2, 11 (T- MH).
- *Cladonia pocillum* (Ach.) Grognot 11 (T - MH).
- *Collema cristatum* (L.) Weber ex F.H.Wigg. *var. cristatum* 12, 13, 14 (C).
- *Collema tenax* (Sw.) Ach. em. Degel. 1, 2, 3, 4, 5, 6, 7, 8, 11, 13 (CS-MH)
- *Diploschistes muscorum* (Scop.) R.Sant. 11, 14 (C).

Diploschistes ocellatus (Vill.) Norman 2, 8, 11, 13 (C).

Diplotomma epipolium Arnold. 4, 5, 6, 8, 10, 12 (C).

- *Fulgensia fulgens* (Sw.) Elenkin 2, 7, 8, 11, 13 (C, CS - MH).

* • *Lecania sylvestris* (Arnold) Arnold 4, 14 (C).

- *Lecania turicensis* (Hepp) Müll.Arg. 4 (C).
- *Lecanora albescens* (Hoffm.) Branth and Rostrup 11 (C).
- *Lecanora campestris* (Schaer.) Hue 1, 5 (C, E).
- *Lecanora dispersa* (Pers.) Sommerf. 1, 10, 14 (C, E).

* • *Lecanora sambuci* (Pers.) Nyl. 14 (E).

- *Lecanora varia* (Hoffm.) Ach. 14 (E).

Lecidea lurida Ach. 13 (C).

- *Lecidella elaeochroma* (Ach.) M.Choisy 5, 13 (E).
- *Lichinella stipatula* Nyl. 13 (S).

Lobothallia radiosa (Hoffm.) Hafellner 4, 8, 13, 14 (C).

*• *Opegrapha herbarum* Mont. 2 (E).

- *Peltula euploca* (Ach.) Poelt 13 (S).

*• *Peltula patellata* (Bagl.) Swinsc. et Krog. 14 (C).

- *Phaeophyscia orbicularis* (Neck.) Moberg 5, 10 (E).
- *Physcia adscendens* (Fr.) H.Olivier 4, 10, 13 (E, C).
- *Physcia stellaris* (L.) Nyl. 10, 13, 14 (E).
- *Physcia tribacia* (Ach.) Nyl. 14 (C).
- *Physconia distorta* (With.) J.R.Laundon 5, 10 (E).
- *Physconia grisea* (Lam.) Poelt 13 (E).

Placocarpus schaereri (Fr.) Breuss 4, 8,,9, 10, 13, 14 (C).

- *Placynthium nigrum* (Huds.) Gray 2, 11 (C).

Protoparmeliopsis muralis (Schreb.) M.Choisy 2, 3, 4, 5, 6, 8, 9, 10, 13, 14 (C, S).

- *Psora decipiens* (Hedw.) Hoffm. 3, 7, 8, 13 (CS - MH).
- *Rinodina bischoffii* (Hepp) A.Massal. 2 (C).

Rinodina calcarea (Arnold) Arnold 2, 4, 5, 8 13, 14 (C).

- *Rinodina exigua* (Ach.) Gray 10, 13 (E).
- *Rinodina gennarii* Bagl. 10, 14 (C).
- *Sarcogyne privigna* var. *calcicola* H.Magn. 14 (C).
- *Sarcogyne regularis* Körb. 14 (C).

Squamarina cartilaginea (With.) P.James 1, 2, 4, 6, 7, 8, 11, 13, 14 (C, CS - MH).

- *Toninia candida* (Weber) Th. Fr. 13 (CS - MH).

Toninia cinereovirens (Schaer.) A.Massal. 5, 13 (C - MH).

Toninia diffracta (A.Massal.) Zahlbr. 2 (C).

- *Toninia physaroides* (Opiz) Zahlbr. 7 (CS - MH).
- *Toninia sedifolia* (Scop.) Timdal 2, 8, 11 (CS - MH).
- *Verrucaria fuscella* (Turner) Winch 4, 5, 6, 8, 12, 14 (C, L).
- *Verrucaria lecideoides* (A.Massal.) Trevisan 2, 3, 8 (C).
- *Verrucaria muralis* Ach. 1, 2, 3, 4, 5, 6, 8, 11, 12, 13, 14 (C).
- *Verrucaria nigrescens* Pers. 1, 2, 4, 5, 8, 10, 11, 12, 13, 14 (C).

Verrucaria viridula (Schrad.) Ach. 3 (C).

- *Xanthoparmelia pulla* (Ach.) O.Blanco, A.Crespo, Elix, D.Hawksw. and Lumbsch 13 (S).
- *Xanthoria parietina* (L.) Th.Fr. 3, 5, 10, 13, 14 (E).
- *Xanthoria polycarpa* (Hoffm.) Rieber 14 (E, M).

DISCUSSION

In the literature on the lichens of Denizli province including Pisut (1970), John (1992), Schindler (1998), John *et al.* (2000) and Breuss and John (2004), totally 34 lichen species have been recorded. Eighteen of these species were also recorded in this study. All the other 64 species are new to Pamukkale and Denizli. *Lecania sylvestris*, *Lecanora sambuci*, *Opegrapha herbarum*, *Peltula patellata* are new records for the Turkish lichen flora.

Majority of the species are calcicolous (63.7%), terricolous (16.8%) and epiphytic species follows (11.7%). Lichenicolous lichens are 3.9% of the whole taxa. Siliceous species have a lower proportion with 2.7% and muscicolous lichens with 0.8%. This densely distribution of the saxicolous species (66.4%) and lower proportion of the epiphytic species is related to the vegetation properties of the study area. The forest vegetation is very poor, not exceeding 2 or 3 trees, but mostly maquis in the area. The common culture forms of *Pinus* and *Cupressus* species, as being too young for lichen growth, have only a few lichens. As the only collection site with number 13 have some siliceous rocks in the study area, the saxicolous substrata are composed of mainly calcareous rocks.

Most of the substrate types of the lichens in the area generally correspond with the literature. *Buellia badia* and *Buellia epipolia* indicated lichenicolous development on the thallus of *Lecanora muralis*; also *Caloplaca inconnexa* on the thalli of *Acarospora cervina* and *Placocarpus schaereri.*

Morphological proportions of the whole taxa include 57.8% crustose taxa and 15.2% placodioid, 13.7% squamulose taxa, 12.9% foliose taxa and 0.4% fructicose taxa. The genus with the highest number in the area is *Caloplaca* represented by 18 taxa which is 21.95% in percentage, 15 of *Caloplaca* taxa are calcicolous, 2 epiphytic and 1 lichenicolous. Due to the natural calcareous properties of substrates in the area, calcicolous taxa of *Caloplaca* are dominant. The genus *Caloplaca* is widely distributed on calcareous substrate that corresponds with the literature about lichen records from Pamukkale (Hierapolis) district (Schindler, 1998; John and Seaward, 2000).

It has been very difficult to determinate some species because of morphological changes due to the high amount of $CaCO_3$ in travertine rocks precipitated from Thermal Spring water. Therefore some species such as *Fulgensia fulgens* and *Squamarina cartilaginea* has a whitish appearance, differing from their normal colours.

In this study, lichen flora of Pamukkale is reported and habitat - substrate data are also discussed. It includes the first detailed list of lichens from Pamukkale-Hierapolis district with historic and touristic values.

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