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The Lichen Flora on *Quercus* in the Tamentout Forest of Algeria

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Abstract

Lichens are major components of forest ecosystems. However, their accurate identification at species level is often difficult, especially in poorly investigated areas. The objective of this study is an inventory of epiphytic lichens in the Tamentout Forest on three types of phorophytes, *Quercus faginea*, *Q. suber* and *Q. ilex*. In this region, 68 epiphytic lichen species have been identified, belonging to 23 families and 36 genera. The specific richness on the three phorophytes was different. *Quercus suber*, the dominant phorophyte, supports the highest number of species compared to *Q. faginea*, and *Q. ilex*. An analysis of growth forms shows that all are represented in the study area. However, crustose and foliose lichens are the most common ones. As a result of our inventory, we report *Parmeliella testacea* new to Algeria, and list 20 lichen species now protected by Algerian legislation.

Keywords: Algeria, Lichens, Biodiversity, Epiphytes, *Quercus*, Tamentout Forest

Introduction

Lichens are major components of forest ecosystems (Petersson *et al.* 2021). Environmental and ecological factors significantly influence their growth, richness and distribution (Van Herk 2001, Rascale & Hugonnot 2020, Belguidoum *et al.* 2021).

Accurate identification of biodiversity at species level is fundamental for ecology, evolution, conservation biology and assessing the impact of global changes on ecosystems (Nascimbene *et al.* 2010, Morellato *et al.* 2016, Rubio-Salcedo *et al.* 2017, Belguidoum *et al.* 2022). However, the assessment of biodiversity remains difficult, especially for geographic regions that receive little attention (Leavitt *et al.* 2021).

Until now, the lichen biota of Algeria has hardly been explored; several taxonomic groups remain poorly known. Only few studies with fragmentary records have been devoted to investigating lichen diversity in the country (Amrani *et al.* 2018). Nylander (1853, 1858) published a catalog of lichens as "*Prodromus lichenophiae Gallioe Algeria*". Another important contribution was Flagey (1896), with his catalog of lichens increasing the number of lichens reported from the country to 650 species.

Maheu (1906) subsequently published a list of 28 species collected in the Oran region. Maire & Senvet (1928) reported the presence of 10 lichen species in the Tipaza region. A team of botanists from Algiers University also carried out surveys in Algeria (Faurel *et al.* 1954). Djellil (1989) identified 147 lichen species from the Akfadou region (Bejaia). Van Haluwyn *et al.* (1994) studied the epiphytic vegetation of the Annaba region.

Recently, an inventory was carried out and the list of Algerian lichens was updated: Rebbas *et al.* (2011) identified 50 species from Gouraya National Park (Bejaia). Ait Hammou *et al.* (2011) surveyed lichens on Aleppo pine and cypress from the Guezoul forest (Tiaret). Boutabia *et al.* (2015) identified 117 species in the Elkala region. In the region of Megres (Setif), Lograda *et al.* (2015) identified 52 species. Amrani *et al.* (2015, 2018) carried out a bibliographical review of the lichenological literature pertaining to Algeria. Khedim *et al.* (2018) reported 20 macrolichens from the Theniet-El-Had National Park. Belguidoum *et al.* (2021) were able to identify 66 lichen species by studying the diversity and distribution of epiphytic lichens on *Cedrus atlantica* and *Quercus faginea* in the Mont Babor forest. Belguidoum *et al.* (2022) recorded 54 lichen species in urban areas of Setif, Algeria. Following the publication of

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Algeria's lichenology exploration (1798-2013), 1051 lichen taxa are now listed in the latest checklist of Algerian lichens (Amrani *et al.* 2018).

The aim of this work is to study the diversity and distribution of epiphytic lichens on three species of phorophytes (host trees), *Quercus faginea* (faginate oak), *Q. suber* (cork oak) and *Q. ilex* (holm oak) in the Tamentout Forest (studied here for the first time). The results of this study contribute to our knowledge of lichen diversity and distribution in Algeria, and in the Mediterranean region generally.

Materials and methods

Study area

The study was conducted in the Tamentout Forest from March to November 2021. The study area extends over the northern part of the province of Setif (Ain Sebt), over part of Jijel and Mila provinces in Algeria. It is located between latitudes 36° 29' 18"–36° 19' 05" N and longitudes 5° 24' 56"–5° 30' 46' E (Fig. 1).

The Tamentout Forest, located in a mountainous region, occupies the massifs of Sidi Mimoun, Es-Settara, Boukemmous and Ain Settah. The forest covers an area of 6366 ha and extends across the three provinces Jijel, Mila and Setif. The highest point in the forest is the peak of Tameguida, at 1626 m above sea level (asl).

This forest is located in a semi-arid bioclimatic area, with average monthly temperature of 20.2°C recorded for August. The average temperature for the coldest month of January is 5.9°C. Rainfall is very variable; December is the wettest month, with a monthly average of 273.7 mm. The driest month is July, with a monthly average of 5.6 mm. The average duration of snowfall is 26 days/year, with a thickness exceptionally reaching up to 80 cm (RWS 2022).

The dominant natural trees in the Tamentout Forest are Cork oak (*Quercus suber*), Zeen oak (*Q. faginea*), and Afares oak (*Q. afares*). The regeneration of these species has previously been abundant (Boudy 1955), but currently the forest is threatened, because these tree species are no longer regenerating. The cork from *Q. suber* is an important economic resource, but the forests dominated by this species are strongly impacted by forestry practices, such as the removal of under-story vegetation to facilitate harvesting, or even worse than that opening the forest by clearing parts. In addition, the selective cutting of trees, overgrazing, and, above all, frequent and repeated fires contribute to the decline of lichen diversity.

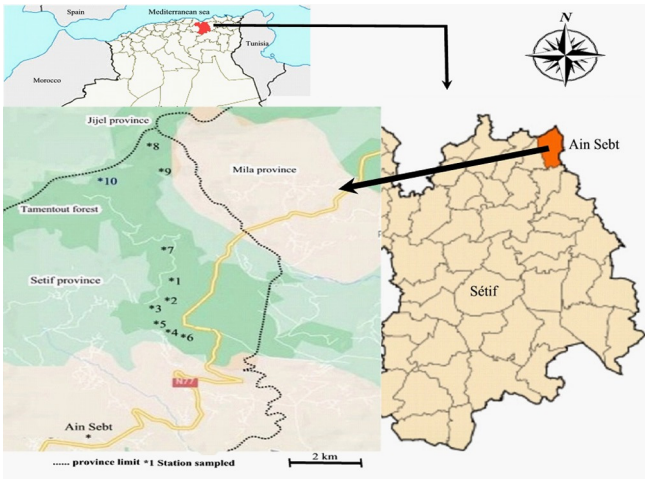

FIGURE 1. Sample stations in the Tamentout Forest of the Ain Sebt Region.

Lichen sampling

Specimens of epiphytic lichens growing on *Quercus faginea, Q. suber*, and *Q. ilex* were collected from 10 sites in the Tamentout Forest (Table 1). Lichen samples were collected at different tree heights and in all cardinal directions.

Species identification

Lichens specimens were examined in detail using a dissecting (Optika) and a compound microscope (Zeiss Axioscop 40, at 100×, 400×, and 1000× magnification,). Because morphological characteristics of lichens are not always

sufficient for identification, chemical spot tests were also carried out using commonly used spot test reagents (C, K, KC, and P).

Identification was facilitated by several keys (Ozenda & Clauzade 1970, Boistel 1986, Tiévant 2001, Jans 2011, Van Haluwyn *et al.* 2013) as well as website resources like the French Association of Lichenology (http://www.afl-lichenologie.fr/), LIAS light (http://liaslight.lias.net/), the information system on Italian lichens ITALIC (http://italic.units.it/?procedure=idkeys), and the British Lichen Society (https://www.britishlichensociety.org.uk/). The nomenclature follows Index Fungorum (http://www.indexfungorum.org/). All identifications were also verified by Mohammad Sohrab (Iran). Specimens are deposited in ABHCH, the herbarium of the Valorization of Natural Biological Resources Laboratory of the Faculty of Nature and Life Sciences, Ferhat Abbas University, under the code number of: N° FSN-CL92.

TABLE 1. Geographic coordinates and phorophytes of the sampled stations.

Site	**Geographic coordinates**	**Elevation** (m.s.n.m)	**Phorophyte (*Quercus*)**
1	36°31'12"N, 5°44'17"E	976	*Q. suber*
2	36°30'53"N, 5°44'05"E	997	Q. suber
3	36°31'11"N, 5°44'16"E	1013	*Q. suber, Q. faginea,*
4	36°30'35"N, 5°44'16"E	971	*Q. suber, Q. faginea, Q. ilex*
5	36°30'52"N, 5°44'05"E	961	*Q. suber, Q. faginea, Q. ilex*
6	36°30' 28"N, 5°44'30"E	1080	Q. suber, Q. ilex
7	36°31'28"N, 5°44'25"E	1102	Q. faginea, Q. ilex
8	36°33'09"N, 5°44'09"E	1186	Q. suber
9	36°33'11"N, 5°45'35"E	1010	Q. suber
10	36°33'11"N, 5°45'30"E	985	Q. suber

Results

The investigation of the lichen species from the three phorophytes (*Quercus suber, Q. faginea* and *Q. ilex*) in the Tamentout Forest revealed 68 epiphytic species (Table 2).

Species richness on the three phorophytes was different. *Quercus suber*, the dominant tree species, supports the highest number of lichen species compared to the other trees. All sixty-eight species of lichenized fungi identified from the Tamentout Forest were found on *Q. suber*, 28 species on *Q. faginea*, and only 19 on *Quercus ilex* (Fig. 2).

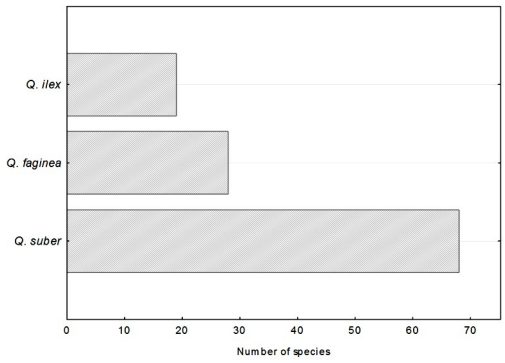

FIGURE 2: Number of lichen species on the different phorophytes in the Tamentout Forest.

The lichen family *Parmeliaceae,* is best represented, with 12 species, followed by *Physciaceae*, with nine species, and *Ramalinaceae* and *Lecanoraceae*, with six species (Fig. 3). *Teloschistaceae is* represented by five species, followed by *Caliciaceae* with four species, and *Cladoniaceae*, *Collemataceae*, *Pannariaceae*, and *Pertusariaceae* are represented by three species, while the rest of the families are represented by one or two lichen species only.

Our analysis of the biological spectrum of lichen growth forms in the Tamentout Forest showed that all the physiognomic types were present in the study area (Fig. 5). With 46% crustose lichens (excluding leprose and squamulose ones) are clearly most abundant, followed by 31% foliose, 10% fruticose, and 6% species of lichens with dimorphic thalli (e.g, *Cladonia*). 4% of the lichen thalli are gelatinous. In the study area, leprose and squamulose thalli were the least represented, with only 1% each.

As part of the survey *Parmeliella testacea* PM Jorg. (*Pannariaceae*) is reported new to Algeria (identification confirmed by Dr. Mohammad Sohrabi, Iran). A description of the species is included below, based on the literature and updated according to our observations.

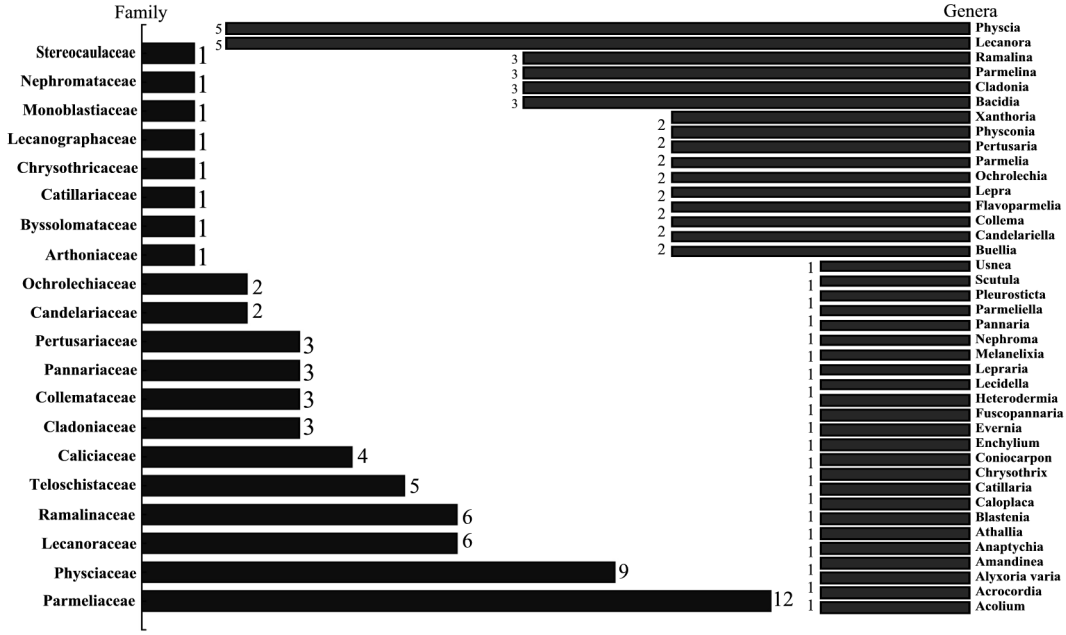

FIGURE 3. Number of species recorded for each family and genus at the Tamentout Forest.

TABLE 2. The lichens identified in Tamentout Forest

Species Current name	**Thalli**	***Family***	***Quercus***		
			suber	***ilex***	***faginea***
Acolium inquinans (Sm.) A. Massal. 1853	Cr	Caliciaceae	+	-	-
Acrocordia gemmata (Ach.) A. Massal. 1854	Cr	Monoblastiaceae	+	+	+
Alyxoria varia (Pers.) Ertz & Tehler. 2011	Cr	Lecanographaceae	+	-	-
Amandinea punctata (Hoffm.) Coppins & Scheid. 1993	Cr	Caliciaceae	+	-	+
Anaptychia ciliaris (L.) Körb. ex A. Massal. 1853	Fr	Physiaceae	+	+	+
Athallia pyracea (Ach.) Arup, Frödén & Søchting. 2013	Cr	Teloschistaceae	+	-	-
Bacidia rosella (Pers.) De Not. 1846	Cr	Ramalinaceae	+	+	+
Bacidia rubella (Hoffm.) A. Massal. 1852	Cr	Ramalinaceae	+	-	+
Bacidina phacodes (Körb.) Vězda 1991	Cr	Ramalinaceae	+	-	-
Blastenia ferruginea (Huds.) A. Massal. 1852	Cr	Teloschistaceae	+	+	+
Buellia disciformis (Fr.) Mudd. 1861	Cr	Caliciaceae	+	+	+
Buellia griseovirens (Turner & Borrer ex Sm.) Almb. 1952	Cr	Caliciaceae	+	-	+
Caloplaca cerina (Hedw.) Th. Fr. 1861	Cr	Teloschistaceae	+	-	-
Candelariella reflexa (Nyl.) Lettau 1912	Cr	Candelariaceae	+	-	-
Candelariella xanthostigma (Pers. ex Ach.) Lettau 1912	Cr	Candelariaceae	+	-	-
Catillaria nigroclavata (Nyl.) J.Steiner 1898	Cr	Catillariaceae	+	-	-
Chrysothrix candelaris (L.) J. R. Laundon 1981	Cr	Chrysothricaceae	+	-	-
Cladonia chlorophaea (Flörke ex Sommerf) Spreng. 1827	Co	Cladoniaceae	+	-	-
Cladonia coniocraea (Flörke) Spreng. 1827	Co	Cladoniaceae	+	-	-
Cladonia fimbriata (L.) Fr. 1831	Co	Cladoniaceae	+	-	-
Collema furfuraceum (Arnold) Du Rietz. 1929	Ge	Collemataceae	+	+	+
Collema nigrescens (Huds.) DC. 1805	Ge	Collemataceae	+	-	-
Coniocarpon cinnabarinum DC. 1805	Cr	Arthoniaceae	+	-	-
Enchylium conglomeratum (Hoffm.) Otálora, P.M. Jørg. & Wedin. 2014	Ge	Collemataceae	+	-	-
Evernia prunastri (L.) Ach. 1810	Fr	Parmeliaceae	+	-	-
Flavoparmelia caperata (L.) Hale.1986	Fo	Parmeliaceae	+	-	-
Flavoparmelia soredians (Nyl.) Hale 1986	Fo	Parmeliaceae	+	-	-
Fuscopannaria mediterranea (Tav.) P.M. Jørg. 1994	Co	Pannariaceae	+	-	-

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TABLE 2. (Continued)

Species Current name	**Thalli**	*Family*	*Quercus*		
			suber	*ilex*	*faginea*
Heterodermia obscurata (Nyl.)Trevis. 1869	Fo	Physciaceae	+	-	-
Lecanora albella (Pers.) Ach. 1810	Cr	Lecanoraceae	+	+	+
Lecanora carpinea (L.) Vain. 1888	Cr	Lecanoraceae	+	-	+
Lecanora chlarotera Nyl. 1872	Cr	Lecanoraceae	+	-	-
Lecanora expallens Ach. 1810	Cr	Lecanoraceae	+	-	+
Lecanora glabrata (Ach.) Malme 1932	Cr	Lecanoraceae	+	-	+
Lecidella elaeochroma (Ach.) M. Choisy 1950	Cr	Lecanoraceae	+	+	+
Lepra albescens (Huds.) Hafellner. 2016	Cr	Pertusariaceae	+	+	+
Lepra amara (Ach.) Hafellner 2016	Cr	Pertusariaceae	+	-	-
Lepraria incana (L.) Ach. 1803	Le	Stereocaulaceae	+	+	+
Melanelixia subargentifera (Nyl.) O. Blanco, A. Crespo, Divakar, Essl. D. Hawksw & Lumbsch. 2004	Fo	Parmeliaceae	+	-	-
Nephroma parile (Ach.) Ach. 1810	Fo	Nephromataceae	+	+	+
Ochrolechia balcanica Verseghy 1962	Cr	Ochrolechiaceae	+	-	-
Ochrolechia turneri (Sm.) Zopf 1896	Cr	Ochrolechiaceae	+	-	-
Pannaria conoplea (Pers.) Bory. 1828	Fo	Pannariaceae	+	-	-
Parmelia saxatilis (L.) Ach. 1803	Fo	Parmeliaceae	+	+	+
Parmelia sulcata Taylor 1836	Fo	Parmeliaceae	+	+	+
Parmeliella testacea P. M. Jørg. 1978	Sq	Pannariaceae	+	-	-
Parmelina carporrhizans (Taylor) Hale 1974	Fo	Parmeliaceae	+	-	-
Parmelina pastillifera (Harm.) Hale 1976	Fo	Parmeliaceae	+	+	+
Parmelina tiliacea (Hoffm.) Hale 1974	Fo	Parmeliaceae	+	+	+
Pertusaria coccodes (Ach.) Nyl. 1858	Cr	Pertusariaceae	+	-	-
Pertusaria flavida (DC.) J.R. Laudon 1963	Cr	Pertusariaceae	+	-	-
Physcia adscendens H. Olivier 1882	Fo	Physciaceae	+	-	-
Physcia aipolia (Ehrh. ex Humb.) Fürnr. 1839	Fo	Physciaceae	+	-	-
Physcia leptalea (Ach.) DC. 1805	Fo	Physciaceae	+	-	-
Physcia stellaris (L.) Nyl. 1853	Fo	Physciaceae	+	-	-
Physcia tenella (Scop.) DC. 1805	Fo	Physciaceae	+	-	-
Physconia grisea (Lam.) Poelt 1865	Fo	Physciaceae	+	-	+
Physconia venusta (Ach.) Poelt 1966	Fo	Physciaceae	+	+	+
Pleurosticta acetabulum (Neck.) Elix & Lumbsch 1988	Fo	Parmeliaceae	+	+	+
Ramalina calicaris (L.) Röhl. 1813	Fr	Ramalinaceae	+	-	-
Ramalina farinacea (L.) Ach. 1810	Fr	Ramalinaceae	+	-	-
Ramalina fastigiata (Pers.) Ach. 1810	Fr	Ramalinaceae	+	-	-
Scutula igniarii (Nyl.) S. Ekman. 2021	Cr	Byssolomataceae	+	-	+
Usnea rubicunda Stirt. 1881	Fr	Parmeliaceae	+	-	-
Xanthoria parietina (L.) Th. Fr. 1860	Fo	Teloschistaceae	+	+	+
Xanthoria polycarpa (Hoffm.) Rieber 1891	Fo	Teloschistaceae	+	+	+

Cr : Crustose, Fr: Fruticose, Co: Complex, Fo: Foliose, Le: Leprose, Sq: Squamulose, Ge: Gelatinous); (+) Present, (-) Absent.

Description of *Parmeliella testacea* from the Tamentout Forest:

The species has a squamulose to minutely foliose thallus composed of pale chestnut-brown to gray-brown lobes, forming a rosette. It tightly adheres to its substrate with distinct peripheral lobes and its upper surface is fragile (Fig. 4). When wet, the thallus turns dark blue-gray. The thallus is sorediate with dark gray, coarsely granular soredia formed in predominantly marginal, sometimes also laminar, button-shaped soralia. These soralia are initially concolorous with the thallus surface, their soredia sometimes brittle, on a ± uniform surface, which may become coarsely cracked along the margin. The thallus resides on an arachnoid hypothallus, blue-black in color. In the specimens collected in Algeria, apothecia were not observed; the photobiont is *Nostoc*.

Notes: Only a single corticolous specimen of *Parmeliella testacea* was found in the Tamentout Forest, growing on *Q. suber.* The species generally appears to be quite rare, and in France its threat status has been assessed according to IUCN red-list criteria as Vulnerable (VU) by Roux *et al.* (2017). In the past, the species had been reported from England, but it is considered extinct (Cannon *et al.* 2021).

Specimen examined. ALGERIA. Setif Province: Tamentout Forest, Collection Site 5 (36° 30' 52"N, 5° 44' 05"E), 961 m altitude, 2021, *Belguidoum, A. no. Cl92* (ABHCH).

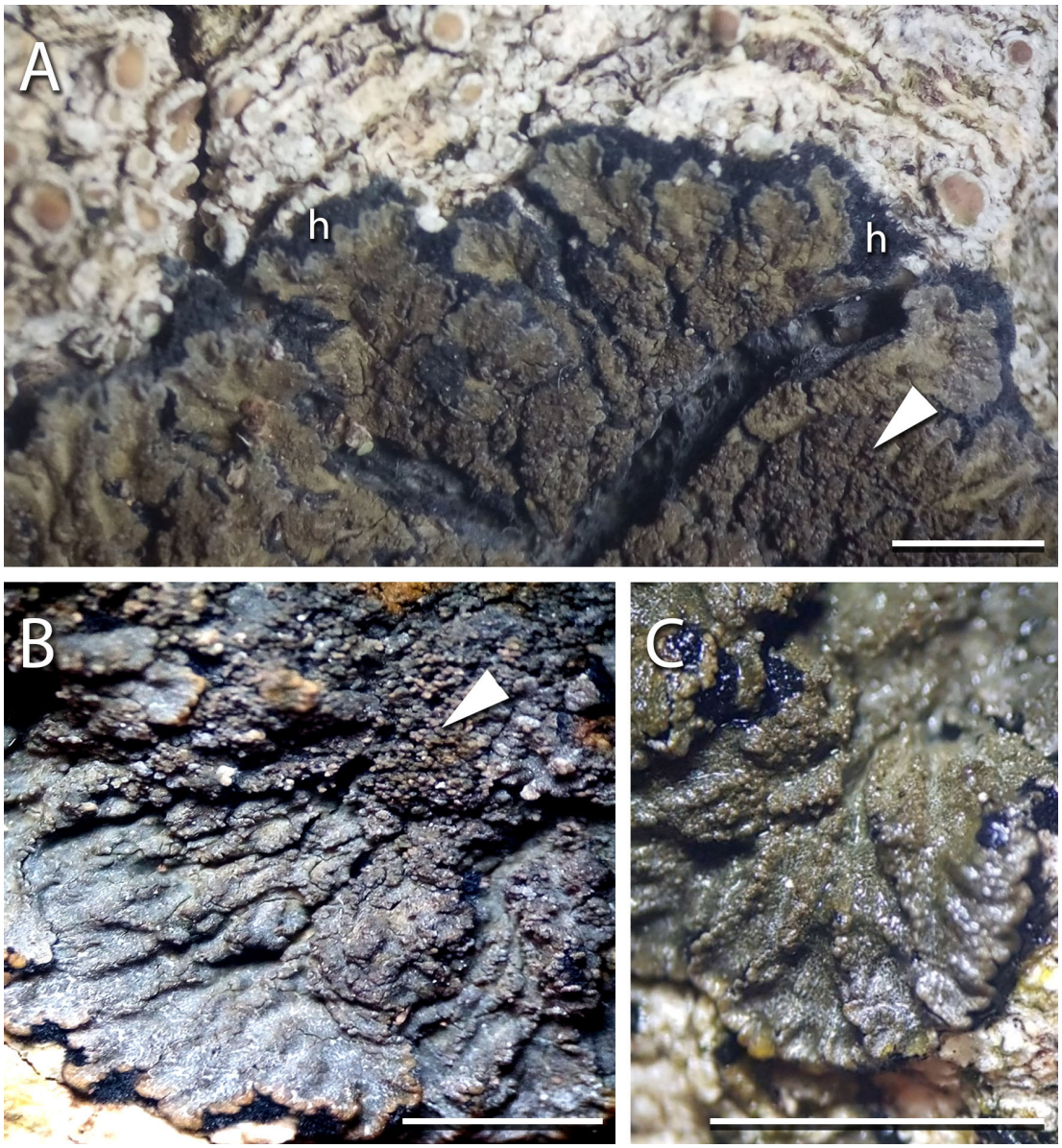

FIGURE 4: *Parmeliella testacea* from the Tamentout Forest (Belguidoum, A. no. Cl92, ABHCH) A. Thallus overview (h: black hypothallus; arrow: button-shaped soralia). B. close-up of humid, bluish green thallus (arrow: button shaped soralia). C. close-up of wet, olive thallus. Scale bars: 5 mm.

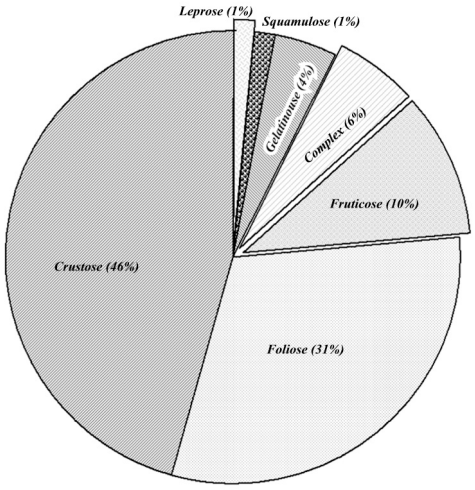

FIGURE 5. Growth forms of lichens in the Tamentout Forest.

Discussion

The number of lichen taxa recorded here on *Quercus suber* is generally higher than previously recorded on other species of *Quercus* in Algeria (Nylander 1878, Flagey 1896, Van Haluwyn *et al.* 1994), or even in Tunisia (El Mokni *et al.* 2015). In El Kala National Park (Algeria), Boutabia *et al.* (2015) mentioned the presence of 135 species. Studies carried out in Sardinia reported 40 lichen species (Camarda & Zedda 1995); From the Iberian Peninsula, Fos & Barreno (1994) listed 173 lichen species. This difference in diversity is possibly related to climatic parameters, such as humidity, temperature, and precipitation (Bässler *et al.* 2016, Di Nuzzo *et al.* 2021, Saiz *et al.* 2021).

Our inventory of lichens on the three phorophytes (*Quercus suber, Q. ilex* and *Q. faginea*) shows that Q. *suber* supports the greatest number of species. This was previously also observed by a survey of the El Kala region (northeastern Algeria) (Boutabia 2016). Several studies in France (Bricaud 2010; Van Den Boom & Etayo 2014), Italy (Zedda 2002, Incerti & Nimis 2006,) and Portugal (Paz-Bermudez *et al.* 2009) have all reported that, at least in the Mediterranean region, cork oak is a substrate, which, among different species of oak, supports the greatest species diversity of lichens.

Amrani *et al.* (2018), summarizing all previous species inventories from Algeria, have reported a total of 1051 species of lichenized fungi, but have not mentioned the presence of *Parmeliella testacea* PM Jorg.. Thus, our report of this species from the Tamentout Forest is also the first report of this species from Algeria.

All growth-forms of lichens are well-represented in the study area; with crustose and foliose thalli predominate. Belguidoum *et al.* (2021) reported similar results from the Monts of Babor Forest in Algeria. Fruticose species represent only 10%, being limited to *Ramalina*, *Evernia*, *Flavoparmelia*, and *Usnea*; generally, these species are most commonly found at higher altitudes. In Algeria, the most diverse populations of fruticose lichens are found on top of the highest mountains, which might be explained by increased humidity at these altitudes (Monge-Nájera 2019).

Among lichens reported from the Tamentout Forest, nineteen species are now protected by Algerian legislation: *Anaptychia ciliaris*, *Cladonia chlorophaea*, *Cladonia coniocraea*, *Cladonia fimbriata*, *Evernia prunastri*, *Nephroma parile*, *Parmelia saxatilis*, *Parmelia sulcata*, *Physcia adscendens*, *Physcia aipolia*, *Physcia leptalea*, *Physcia stellaris*, *Physcia tenella*, *Physconia grisea*, *Physconia venusta*, *Ramalina calicaris*, *Ramalina farinacea*, *Ramalina fastigiata* and *Usnea rubicunda* (J.O.R.A.D.; 2012).

Despite the development of lichenological studies around the world, an updated Checklist of Lichens from Algeria still awaits publication. Our study is a first approximation of the epiphytic diversity on oak in a forest now heavily exploited for economic resources and subject to repeated fires. We hope that it will serve as a basis for the elaboration of future catalogs of lichen biodiversity, the preparation of management and conservation plans, and the development of studies assessing environmental quality, based on these symbiotic bioindicator organisms. We plan to continue this study, not only at the level of Setif (Algeria) but also extending into adjoining regions, thus contributing to a better understanding of lichen diversity across the Mediterranean region.

Our results indicate that more than a quarter of Algeria's epiphytic lichens are likely to be threatened. Further research and effort is needed to include lichens in major national conservation plans in understudied regions. These results also highlight the lack of information that still hinders the rigorous inventory of lichens in Algeria.

Acknowledgments

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