

Checklist of lichenized and lichenicolous fungi from the Penyagolosa Massif and nearby areas (Castelló, eastern Iberian Peninsula)

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Abstract. The Penyagolosa Massif (Castelló, Valencian Community), which includes the Penyagolosa Natural Park, is one of the most emblematic natural landscapes of the eastern Iberian Peninsula. It hosts a wide variety of Mediterranean habitats, including groves of several *Quercus* species and extensive *Pinus* spp. forests. The present checklist represents the first compilation of lichenized and lichenicolous fungi for the protected as well as nearby areas and is mostly based on species records available at the Biodiversity Data Bank of the Generalitat Valenciana (BDBCv). We report 221 and 12 infrageneric taxa of lichenized and lichenicolous fungi, respectively. *Punctelia caseana* is reported for the first time for the European continent. Six lichenicolous fungi are newly reported for the Valencian Community. The study area includes the red-listed lichen *Xanthoparmelia camtschadalis*. The families *Parmeliaceae* and *Teloschistaceae* were the most represented. By evaluating the functional traits, we found that the most abundant are those having (1) crustose thalli, (2) with sexual reproduction, mainly through the formation of apothecia, and (3) that are associated with trebouxoid green microalgae. Furthermore, the most frequent lichen community in the study area is formed by xerophytic lichens that can tolerate very high direct solar irradiation and grow under weak eutrophication conditions. Finally, we emphasize the need to accelerate the compilation of the diversity of lichenized and lichenicolous fungi in the park through DNA sequencing and molecular phylogenetic studies.

Keywords. biodiversity, conservation, lichens, literature review, plant micro-reserve, natural park, Valencian Community.

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Introduction

Lichenization has been a prominent force in fungal evolution that explains why lichen-forming fungi account for at least one fifth of all known fungi (Kirk *et al.*, 2008; Lücking *et al.*, 2017). In the Iberian Peninsula and Balearic Islands, the first formal checklist of lichenized fungi compiled by Llimona & Hladun (2001) encompassed ca. 12% of the total lichen diversity known globally, i.e., 2426 out of 19000 species (Lücking *et al.*, 2017). Llimona & Hladun (2001) also included 368 lichenicolous fungi, which, according to Lücking *et al.* (2021), may be divided into mycoparasites, when they attack the lichen mycobiont causing a considerable damage to the thallus, gall-formers, and other fungi that share the algal partner without causing any visible symptoms on thalli. Lichen and lichenicolous fungal checklists have been assembled at a more regional scales in the Iberian Peninsula coinciding with administrative boundaries (e.g., autonomous communities, provinces, and districts) or with emblematic natural

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landscapes, either protected by law or not (e.g., Boqueras *et al.*, 1989; Fos, 2000; Martínez *et al.*, 2000; Sarrión, 2001; Aragón, 2002; Pérez-Ortega & Álvarez-Lafuente, 2006a,b; Etayo, 2010; Burgaz, 2014; Burgaz *et al.*, 2017; Blázquez, 2022). The lichen and lichenicolous fungal checklist of the Valencian Community, an administrative area encompassing ca. 23×10^3 km² in the eastern Iberian Peninsula, was first compiled in 1999 based on a bibliographic review including more than 3700 specimen records and hosted 569 infrageneric taxa (Atienza & Segarra, 1999). A recent revision raised the number of infrageneric taxa to 836 lichenized and 94 lichenicolous fungi (reviewed by Fos, 2023; BDBCv, 2023). Local lichenologists have also focused their attention on the diversity of lichens occurring in areas of this region often hosting protected natural landscapes: Els Ports and El Baix Maestrat, including La Tinença de Benifassà Natural Park (Atienza, 1990), the Font Roja Natural Park (Barreno *et al.*, 1990; Calvo & Sanz, 2000; Fos & Atienza, 2009), the Illes Columbretes Natural Park (Calatayud, 1998), the plant micro-reserve Las Hoyuelas (Fos, 2001), and more recently, the Albufera of Valencia Natural Park (Atienza & Fos, 2011; García Alonso *et al.*, 2018). The diversity of lichens has also been compiled from areas with high anthropogenic use (l’Horta Sud; Fos, 2022), and specific habitats, such as siliceous rocks in the Serra Calderona and Serra d’Espadà natural parks (Calatayud & Barreno, 1994; Calatayud *et al.*, 1995; Calatayud, 1998) and epiphytic lichens on cork and holm oaks (Fos, 1998; Fos *et al.*, 2001; Garrido-Benavent *et al.*, 2013). However, other emblematic areas in the Valencian Community completely lack checklists about lichens and lichenicolous fungi.

A major geographical landmark in the north-western Valencian Community lacking one such checklist is the Penyalgosa Massif, which is located between the municipalities of Vistabella del Maestrat, Xodos and Villahermosa del Río in the province of Castelló. It is a cultural reference point deeply rooted in local tradition that host the second highest peak in the Valencian Community (1814 m asl) and encompasses the Penyalgosa Natural Park, with 1094.45 protected hectares (ha). The vegetation of the Penyalgosa Massif and nearby areas is composed of holm oak groves (*Quercus rotundifolia* Lam.) enriched with maples (*Acer opalus* subsp. *granatense* (Boiss.) Font Quer & Rothm.) and some gall oaks (*Q. faginea* Lam.) that are replaced at higher altitudes by extensive pine forests of black pine (*Pinus nigra* Arnold subsp. *salzmannii* (Dunal) Franco) and Scots pine (*P. sylvestris* L.) with a diverse understorey that includes populations of holly (*Ilex aquifolium* L.) and yew (*Taxus baccata* L.), the rare wild apple tree (*Malus sylvestris* Mill.), linden (*Tilia platyphyllos* Scop.), and mountain elms (*Ulmus glabra* Huds.). In the areas with acidic (siliceous) soils, groves of *Quercus pyrenaica* Willd. and mature forests of maritime pine (*Pinus pinaster* Aiton) occur, and these are accompanied by several species of rockroses (*Cistus populifolius* L., *C. laurifolius* L.) and heather (*Erica* L. spp. and *Calluna vulgaris* (L.) Hull). The bioclimatic characterization indicates that this area includes the meso- and oromediterranean thermoclimatic belts, and a subhumid ombroclimate (Rivas-Martínez *et al.*, 2017). In the Valencian Community, the typical vegetation from the oromediterranean belt is only present in this area, around the Penyalgosa peak, and in the highest areas of the Rincón de Ademuz (Valencia), in the surroundings of Alto del las Barracas or Cerro Calderón (1836 m asl), where the maximum regional altitude is reached.

From an historical perspective, Cavanilles (1795) highlighted the remarkable diversity of plants that grew in the municipality of Vistabella del Maestrat, but without any mention of the presence of cryptogams (i.e., fungi and fungi-like organisms, algae, ferns, and mosses). Later, numerous botanists visited the region and contributed data on its flora and vegetation: E. Reverchon, P. Font i Quer, A. de Bolòs, O. de Bolòs, C. Pau, S. Rivas Goday, J. Borja and, especially, J. Vigo (1968). None of them, however, provided any reference to the Penyalgosa’s cryptogams. The first documented observations of lichens in this natural park corresponded to collections of *Cladonia pyxidata* (L.) Hoffm. and *Lasallia pustulata* (L.) Mérat made in the 1970’s and 80’s (Burgaz, 2015; BDBCv, 2023), and the last were made in the 90s, in a study on lichen phytochemistry by Miguel & Villa (1990). Other references to lichens from that decade were referred to areas surrounding Villafranca del Cid, a municipality located further north of the study area.

The present work assembles the first checklist of lichenized and lichenicolous fungi of the Penyalgosa Massif, including the natural park as well as nearby areas, mostly based on species records available at the Biodiversity Data Bank of the Valencian Community (BDBCv, 2023). Various functional traits like thallus growth form, reproduction type, and associated photobiont were considered to characterize the suite of compiled lichens. The preferences of the listed taxa for different environmental factors, such as aridity, substrate pH, solar irradiation, and eutrophication, were also

considered. By compiling this checklist, we aim at providing a basis for developing conservation studies in the Penyagolosa Natural Park that take lichens into consideration, and to adopt management measures that deal with anthropogenic threats as well as climate disruption, given that lichens are excellent biomonitors of environmental change (Nash III, 2008; Abas, 2021).

Methods

The checklist has been compiled using two data sources. First, 2418 lichen and lichenicolous fungal records available at the Biodiversity Data Bank of the Valencian Community (BDBCv, 2023) that were incorporated into this database after intense surveys conducted by one of the authors (SF) from 1996 to 2022. Most identifications were done *de visu*, whereas material was collected to identify doubtful species or tiny lichens in the laboratory. We downloaded species records for nine 10×10 km UTM grids (900 km² or 9×10⁴ ha), including the grid 30TYK25 that contains the Penyagolosa Natural Park (1094.45 ha, Figure 1; Table 1). Within these grids, lichens were recorded in eighty-six 1×1 km grids (86 km² or 8600 ha; Supplementary Material S1), which can be accessed virtually at <https://bdb.gva.es/es/>.

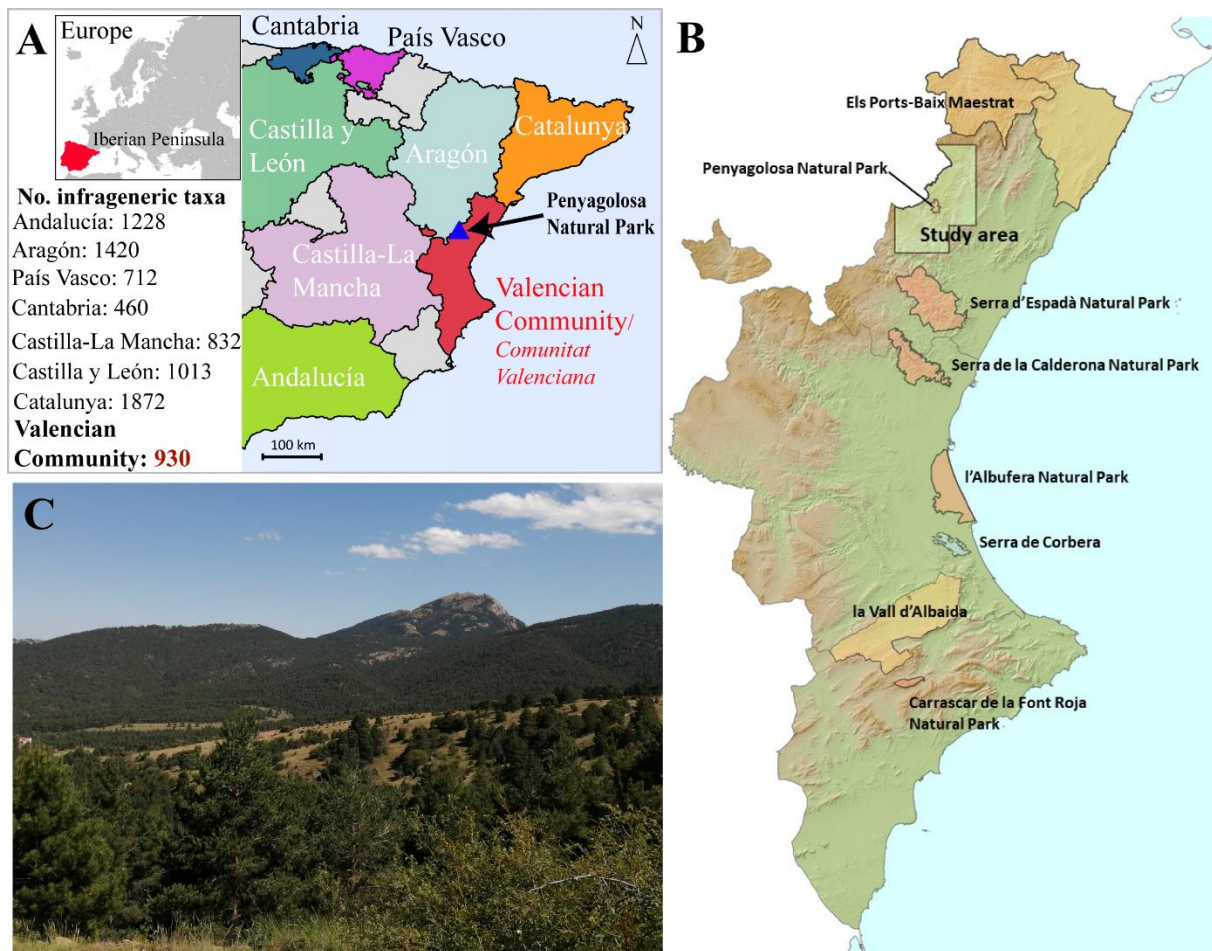


Figure 1. A, Location of the Penyagolosa Massif in the Iberian Peninsula, with data on total number of lichen and lichenicolous infrageneric taxa for several administrative Spanish regions [Aragón: Etayo (2010); Andalucía: Burgaz (2014); País Vasco: Ihobe (2010); Cantabria and Castilla y León: Pérez-Ortega & Álvarez-Lafuente (2006a,b); Castilla-La Mancha: Blázquez (2022); Catalunya: Hladun (2023); Valencian Community/Comunitat Valenciana: Fos (2023), BDBCv (2023)]; B, Map of the Valencian Community depicting the location of the Penyagolosa Natural Park and the whole study area, with the placement of other studied areas with available checklists on lichenized and/or lichenicolous fungi (Table 1); C, view of Penyagolosa summit; Maps and photograph: IGB & SF.

Table 1. Studied localities (10×10 km grids, datum ETRS89) comprising lichen and lichenicolous fungal occurrence data.

Locality code	UTM 10×10 km grid	Included municipalities
1	30TYK14	Zucaina
2	30TYK15	Villahermosa del Río
3	30TYK24	Villahermosa del Río and Castillo de Villamalefa
4	30TYK25	Vistabella del Maestrat, Villahermosa del Río and Xodos
5	30TYK26	Vistabella del Maestrat and Xodos
6	30TYK27	Vistabella del Maestrat and Villafranca del Cid
7	30TYK35	Xodos
8	30TYK36	Vistabella del Maestrat and Benafigos
9	30TYK37	Villafranca del Cid and Benassal

Second, lichen and lichenicolous fungi were collected during a field trip organized by the XXIII International Symposium of Cryptogamic Botany that was held in Valencia in July 2022. Material was collected in three localities: Mas Roig and El Rebollar, both located in the UTM 1×1 km grid 30TYK2359, and a protected plant micro-reserve named Barranc de la Pegunta (30TYK2557). Collections were deposited in the herbarium of the Faculty of Biological Sciences of the University of Valencia (acronym VAL_Lich).

Specimens were identified in the laboratory based on general lichen guides and identification keys: Clauzade & Roux (1985), Giralt (1996), Boqueras (2000) and Smith *et al.* (2009). The identification of the material included the analysis of microscopic characters and chemical reactions (K, C, P). Thin layer chromatography (TLC) was conducted to identify the lichen substances of *Cladonia*, *Ochrolechia*, *Usnea*, *Punctelia* and *Xanthoparmelia* specimens according to standardised protocols (Orange *et al.*, 2001). The nomenclature and species authorities were retrieved from MycoBank (2023). All information is available for consultation in the BDBC (2023) and in the GBIF biodiversity data platform (GBIF, 2023).

Percentages of the following functional traits were also calculated based on categories proposed by Nimis (2023): 1) growth form (crustose, foliose, fruticose, and squamulose; we considered species in the genus *Cladonia* to have mixed or composite thalli, following Burgaz & Ahti (2009)); 2) photobiont type (three categories: trebouxoid or chlorococcoid algae other than *Trentepohlia*, cyanobacteria, and others); 3) reproductive strategy (sexual vs. asexual); 4) type of reproductive structures (apothecia, perithecia, isidia, soredia, thallus fragments); and 5) habitat (epiphytic, saxicolous and terricolous). Regarding the response to different environmental factors, we considered eutrophication, solar irradiation, aridity (water requirement) and pH of substratum. Additionally, we classified the species in terms of poleotolerance, which is a parameter indicating the tendency of a lichen to occur in areas with different degrees of human disturbance Nimis (2023).

Results and Discussion

The assembled checklist includes 221 lichenized and 12 lichenicolous fungi at the infrageneric level (Appendix 1). These numbers are relevant for the studied ecosystem given that lichens, together with bryophytes, contribute significantly to carbon and nitrogen fixation (Elbert *et al.*, 2012). Lichens also show a remarkable ability to uptake and retain atmospheric water and provide shelter and food for a multitude of microbial and microarthropod communities (Cornelissen *et al.*, 2007; Asplund & Wardle 2017). Furthermore, the diversity of lichenized fungi in the Penyagolosa Massif and nearby areas represents ca. 26% of all known lichens from the Valencian Community (Fos, 2023; BDBC, 2023). Compared to similar surveys in and out of the Valencian Community, the diversity of lichens in the studied area is moderately high (Table 2). For example, another emblematic protected area at the south of the Valencian Community, the Font Roja Natural Park (Alicante province), encompasses 128 lichenized and two lichenicolous fungi so far (Fos & Atienza, 2009). The lichen biota of the Albufera Natural Park includes 140 lichenized and 6 lichenicolous fungi (Atienza & Fos, 2011; García Alonso *et al.*, 2018). However, comparisons based on Table 2 data must be done with caution as either the lichen groups or the total area surveyed differs between studies. In general, many checklists lack data from saxicolous species (Figure 2A-C), especially those occurring on calcareous rocks. In the study area,

saxicolous species are clearly underrepresented. The use of molecular phylogenetic studies would speed up the rate at which additional lichen taxa are added to the checklist.

Table 2. Number of lichens and lichenicolous fungi recorded for various areas in the Iberian Peninsula with special emphasis on studies conducted in the Valencian Community (see also Figure 1).

Studied area	Administrative region	Lichens	Lichenicolous	Studied lichen groups	Work
Penyagolosa Natural Park and nearby areas	Valencian Community	221	12	Epiphytic, terricolous, and saxicolous	Present study
Els Ports & Baix Maestrat (incl. La Tinença de Benifassà Natural Park)	Valencian Community	210	5	Epiphytic	Atienza (1990)
Sierra de Corbera	Valencian Community	66	n/a	Epiphytic	Atienza & Crespo (1984)
Sierra de Espadán Natural Park	Valencian Community	126	n/a	Saxicolous (silicolous)	Calatayud (1991); Calatayud & Barreno (1994)
Font Roja Natural Park	Valencian Community	128	2	Epiphytic, terricolous, and saxicolous	Barreno <i>et al.</i> (1990); Fos & Atienza (2009)
Vall d'Albaida	Valencian Community	55	2	Epiphytic (<i>Quercus rotundifolia</i>)	Garrido-Benavent <i>et al.</i> (2013)
Albufera of Valencia Natural Park	Valencian Community	140	6	Epiphytic, terricolous, and saxicolous	García Alonso <i>et al.</i> (2018)
Montserrat Natural Park	Catalunya	202	n/a	Saxicolous (silicolous)	Hladun (1982)
Sierra del Moncayo	Aragón	122	n/a	Epiphytic	Boqueras <i>et al.</i> (1989)
Sierra del Tremedal	Aragón	127	n/a	Epiphytic	Aragón <i>et al.</i> (1999)
Sierra de Javalambre	Aragón	124	n/a	Epiphytic	Fos (2000)
Sierra de Gúdar	Aragón	101	n/a	Epiphytic	Martínez <i>et al.</i> (2000)
Sierra Madrona-Valle de Alcudia	Castilla-La Mancha	235	13	Epiphytic	Sarrión (2001)
Cazorla, Segura and Las Villas Natural Park	Andalucía	465	3	Epiphytic, terricolous, and saxicolous	Aragón (2002)
Serranía de Ronda	Andalucía	336	24	Epiphytic, terricolous, and saxicolous	Burgaz <i>et al.</i> (2017)

The number of lichenized and lichenicolous taxa above the species level in the Penyagolosa Massif and nearby areas were 115 genera, 41 families, 27 orders, and 8 classes (Supplementary Material S2). The most diverse genera were *Xanthoparmelia*, with nine species, and *Cladonia*, *Lecanora* and *Physcia*, with eight species each, followed by *Ramalina* with six species. *Cladonia* and *Lecanora* have often been found to be two of the most diverse genera in other mountain ecosystems in the Iberian Peninsula (Boqueras *et al.*, 1989; Fos, 2000; Fos & Atienza, 2009; Burgaz *et al.*, 2017). Regarded in a wide sense, the genus *Caloplaca* would have been the most species-rich genera in the study area, with almost 30 species; however, the taxonomy of the family *Teloschistaceae*, to which this genus belongs, has undergone dramatic changes at the genus level in the last decade, and *Caloplaca* has been split into several new genera (e.g., Arup *et al.*, 2013; Frolov *et al.*, 2021). Nowadays, *Caloplaca sensu lato* in the Penyagolosa Massif and nearby areas is divided into sixteen different genera. At the family level, *Parmeliaceae* (44), *Teloschistaceae* (35), *Physciaceae* (22) and *Lecanoraceae* (20) were the ones that included the highest number of species. Finally, the *Lecanorales*, with 98 species and *Teloschistales*, with 35, were the orders that showed the highest diversity of lichenized fungi.

Lichens with crustose and foliose thalli were the most abundant, with 47% and 34% of the total species diversity, respectively (Figure 3A; Supplementary Material S2). On the opposite, fruticose and composite lichens were the rarest (12 and 10 species, respectively). Percentages of abundance ranging from nearly 50 to 60% of crustose lichens and 30 to 40% of foliose lichens have also been calculated for epiphytic lichens from Sierra del Tremedal (Aragón *et al.*, 1999), Sierra de Javalambre (Atienza *et al.*, 1992; Fos, 2000), Sierra de Gúdar (Martínez *et al.*, 2000), the Vall d'Albaida region, and the Font Roja Natural Park (Fos & Atienza, 2009; Garrido-Benavent *et al.*, 2013). These coincidences should not be interpreted as a pattern for all Mediterranean ecosystems, as Burgaz *et al.* (2017) found opposite values (i.e., higher percentages of foliose than crustose lichens) in their assessment of the lichen diversity of the Serranía de Ronda (southern Iberian Peninsula). In the Penyagolosa Massif and nearby areas, crustose lichens of the genera *Lecanora*, *Lecidella* and *Caloplaca* s.l. generally dominate epiphytic

communities on the nutrient-rich bark of young deciduous and evergreen trees (e.g., holm and gall oaks, maples, and lime and apple trees), often in exposed areas, roadsides, and tracks, as well as areas disturbed by livestock and agricultural use, as observed in Sierra del Tremedal and Javalambre (Aragón *et al.*, 1999; Fos, 2000). The crustose growth form is often the most frequent on either acidic or calcareous rocks as well. Foliose lichens, however, develop profusely on the bark of older oaks as well as pines; in the studied area, species in the genera *Hypogymnia*, *Flavoparmelia*, *Melanelixia*, *Parmelia*, and *Parmelina*, all belonging to *Parmeliaceae*, and *Anaptychia* and *Physconia* (*Physciaceae*) showed the highest cover on tree trunks. The foliose species *Pseudevernia furfuracea* (Figure 2D) is nowadays the most abundant species on *Pinus* bark in the study area. Regarding the fruticose lichens, species of the genus *Ramalina* are frequently found in oak trunks and branches, whereas *Bryoria fuscescens* and *Usnea hirta* are often found on *Pinus* bark. The phorophytes supporting the highest number of different lichen taxa were *Quercus rotundifolia*, with more than 50 species, followed by *Pinus sylvestris* (40) and the broadleaved *Acer opalus* subsp. *granatense* (>30; Figure 3H). Regarding other functional lichen traits, the 64% of all listed taxa in the Penyagolosa Massif and nearby areas displayed sexual reproduction (Figure 3B; Supplementary Material S2), mostly through the production of apothecia (137 species), whereas the remaining taxa reproduced asexually, with 58 sorediate and 17 isidiate species (Figure 3B). Regarding the photobiont choice, most lichens (ca. 94%) associated with a trebouxoid green microalga, whereas only a few (12 species, ca. 5%) partnered with cyanobacteria. Previous studies have shown that the abundance of fertile lichens with *Trebouxia* s.l. as primary photobiont increases linearly with intensification of land use, whereas asexually reproducing lichens are more common in well-preserved forests (Stofer *et al.*, 2006; Lundström *et al.*, 2013). The almost lack of old forests in the study area might explain at least partially the absence of some asexually reproducing taxa (Stofer *et al.*, 2006; Zarabska-Bozejewicz & Kujawa, 2018).

The most frequent lichen community in the Penyagolosa Massif and nearby areas was formed by xerophytic lichens (44% of total lichen taxa; Figure 3C; Supplementary Material S2) that can stand a very high direct solar irradiation (65%; Figure 3D), usually grow on subacid to subneutral substrata (38%; Figure 3E) and develop under weak eutrophication conditions (43%; Figure 3F). Hygrophytic species that occur on very shaded habitats and that develop under no eutrophication conditions were the least frequent (Figure 3C). Similar percentages for eutrophication and aridity tolerance categories were calculated in the evaluation of the lichen diversity of the Vall d'Albaida region and the Font Roja Natural Park (Garrido-Benavent *et al.*, 2013), thus suggesting that both the Mediterranean macroclimate, with a marked aridity period during summer, and land use (especially agriculture and livestock) might be driving the lichen community assembly in the study area (Aragón *et al.*, 2010; Matos *et al.*, 2015). However, other forest variables like patch size or stand variability, as well as the altitude and slope might be playing a role in lichen community composition (e.g., de Gea *et al.*, 2023). Finally, the 39% of the compiled lichens are from typical of moderately perturbed areas (Figure 3G), according to the different poleotolerance categories proposed by Nimis (2023); the percentages of species occurring in the study area that typically inhabit natural or seminatural areas and very perturbed areas were also noticeable (35 and 26%, respectively; Figure 3G). These results should be re-evaluated once species groups still poorly studied in the area are included, such as the calcareous saxicolous species.

During the field trip of 2022, a specimen of *Punctelia caseana* (Figure 2E) was collected on the trunk of *Prunus mahaleb* in the plant micro-reserve Barranc de la Pegunta (1×1 km UTM grid 30TYK2557). This corticolous lichen is characterized by producing foliose thalli with a grey-blue upper surface with epruinose lobe tips, and with frequent soralia, which are primarily marginal along the secondary lobes, or laminal when they develop from pseudocypbellae in the older portions of the thallus; conidia are filiform and on average 9–10 µm long (Lendemer & Hodkinson, 2010). *Punctelia caseana* was described from North America and, so far, it has been only recorded from USA, Canada, and Mexico (Lendemer & Hodkinson, 2010); to the best of our knowledge, our collection represents the first record outside the American continent. Corroboration of the identity of this species has been done estimating a phylogeny with data from the fungal barcode marker nuclear ribosomal Internal Transcribed Spacer (results not shown; GenBank accession number for the obtained nrITS sequence of *P. caseana*: PP760193). Regarding its chemistry, we have also detected atranorin and lecanoric acid (Lendemer & Hodkinson, 2010). The 2022 field trip made it also possible to add the following six lichenicolous fungi to the Valencian Community checklist for the first time: *Bryostigma parietinarium*, *Clypeococcum hypocenomyces*, *Heterocephalacria physciacearum*, *Muellerella erratica*, *Protousnea*

huuskonenii, and *Tremella hypogymniae*. Furthermore, the lichen *Xanthoparmelia camtschadalis* (Figure 2F) is the only red-listed species included in the checklist as endangered (Atienza & Segarra, 1999, 2002). We determined that it produces usnic, salazinic and consalazinic acids, in agreement with Hale (1990). In the study area, this lichen grows in cold grassy plains soils, and it is distributed in the grids 30TYK2155, 30TYK2359, 30TYK2879, 30TYK3069, 30TYK3174, 30TYK3177, and 30TYK3275.

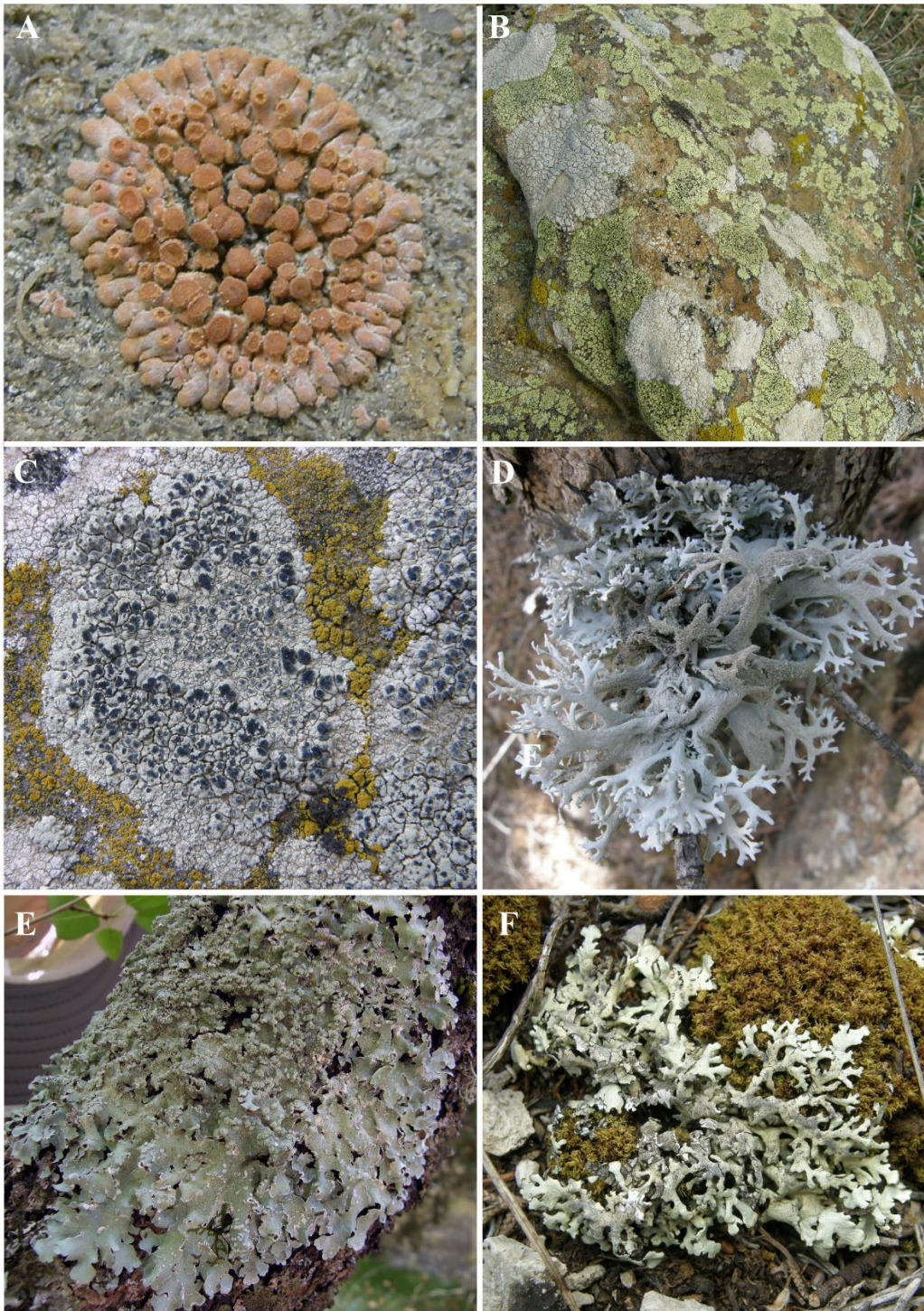


Figure 2. Diversity of lichenized fungi in the Penyagolosa Massif. A, *Lecanora sulphurea*; B, Community of lichenized fungi on an acidic rock; C, *Calogaya pusilla*; D, *Pseudevernia furfuracea*; E, *Punctelia caseana*; F, *Xanthoparmelia camtschadalis*. Photographs: IGB.

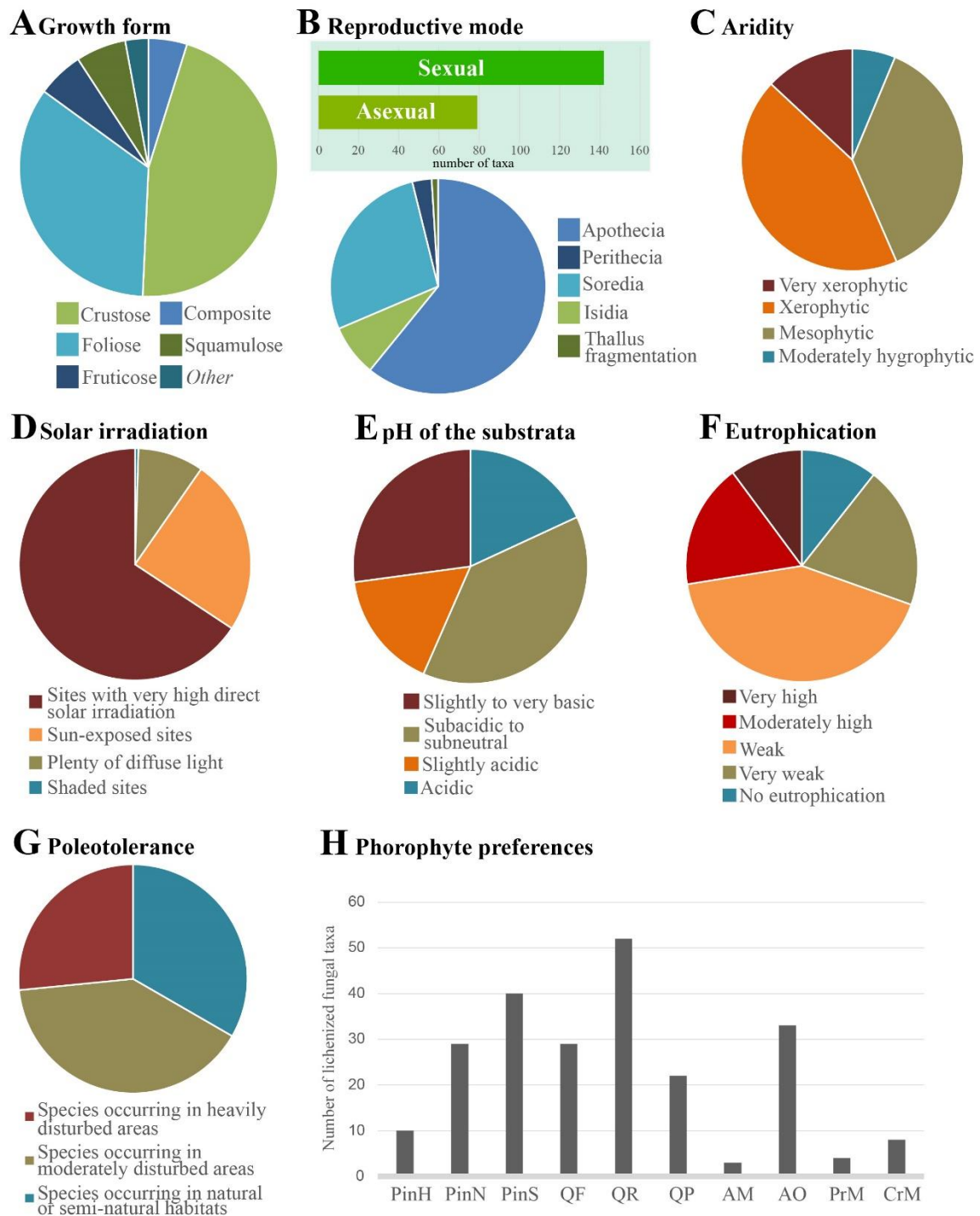


Figure 3. Characterization of functional and ecological traits in the checklist taxa. A, Prevalence of thallus growth forms; B, Abundance of reproductive modes and relative frequencies of dispersal strategies; C, Prevalence of different tolerances to aridity; D, Prevalence of different tolerances to several levels of solar irradiation; E, Prevalence of different tolerances to substratum pH; F, Prevalence of different tolerances to eutrophication; G, Prevalence of different poleotolerances; H, Preference for particular phorophytes (PinH: *Pinus halepensis*; PinN: *P. nigra* subsp. *salzmannii*; PinS: *P. sylvestris*; QF: *Quercus faginea*; QR: *Q. rotundifolia*; QP: *Q. pyrenaica*; AM: *Acer monspessulanum*; AO: *A. opalus* subsp. *granatense*; PrM: *Prunus mahaleb*; CrM: *Crataegus monogyna*).

Taxonomically, *Cladonia subrangiformis* was assumed to conform a subspecies of *C. furcata* in the compiled checklist given that the phenotypic traits that have often been used to distinguish these two species were found to be highly homoplastic (Pino-Bodas *et al.*, 2015). The unclear boundaries revealed by phylogenetic analyses between the morphologically similar putative species *Cladonia convoluta* and *C. foliacea* (Pino-Bodas *et al.*, 2010), and *C. pocillum* and *C. pyxidata* (Kotelko & Piercey-Normore, 2010; Stenroos *et al.*, 2019), led us to consider them as conspecific. However, *C. pocillum* and *C. pyxidata* were kept as different forms of *Cladonia pyxidata*. Additionally, it must be noted that the identity of some listed species, in particular those belonging to the genera *Blastenia*, *Flavoplaca*, *Parmelia* s.l. or *Pyrenodesmia*, is in need for further corroboration using molecular phylogenetic analyses, as species circumscriptions in these genera based solely on morphological characters are often imprecise (Molina *et al.*, 2004; Divakar *et al.*, 2005; Vondrák *et al.*, 2020; Frolov *et al.*, 2021; Garrido-Benavent *et al.*, 2023).

Conclusions

The Penyagolosa Massif and nearby areas support a moderately rich community of lichenized and lichenicolous fungi. Climatic and geographic factors, as well as different intensities of land use (agriculture, livestock, and forest management) are probably shaping species composition of lichen communities in the study area. In fact, a more comprehensive study considering the different areas of the Penyagolosa Massif is needed to evaluate the impact of different intensities of land use on lichen diversity. Furthermore, there is a pressing need to adopt more straightforward techniques to accelerate the compilation of species diversity. DNA sequencing and molecular phylogenetic studies are expected to contribute to this end. This combined approach would also allow for unravelling the taxonomic identity of the associated photobionts (either eukaryotic microalgae or cyanobacteria), thus generating knowledge for a neglected fraction of the biodiversity hosted in the protected area. It would also allow for elucidating mycobiont-photobiont interaction patterns, which often remain unknown for most Mediterranean ecosystems.

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Authorship contribution

IGB: conceptualization, data curation, formal analysis, fundraising, research, methodology, management of the project, resources, writing (first draft, review, and editing); LE: data curation, formal analysis, methodology, supervision writing (review); VA, LV, JCZ: formal analysis, research, resources, supervision writing (review); MJC, LF: research; SF: data curation, research, methodology, supervision writing (review).

Conflict of interest

None.

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Supplementary Material

S1. Functional and ecological traits in the checklist taxa.

S2. List of 1×1 km UTM grids (datum ETRS89) from which lichen and lichenicolous fungal records were retrieved based on the Biodiversity Data Bank of the Comunitat Valenciana (BDBCv, 2023).

Appendix 1. Checklist of lichenized and lichenicolous fungi from the Penyagolosa Massif and nearby areas. The taxa are listed alphabetically, indicating for each species the locality of collection (see list in Table 1), the habitat and ecology, and the availability of specimens at VAL_Lich. For taxa that have recently been combined into other genera, the most widely used synonyms are also given. The symbol * denotes that the species is novel for the checklist of lichens and lichenicolous fungi of the Valencian Community. Abbreviations for phorophyte species are AM (*Acer monspessulanum* L.), AO (*A. opalus* subsp. *granatense*), CoA (*Corylus avellana* L.), CrM (*Crataegus monogyna* Jacq.), Er (*Erica* sp.), JugR (*Juglans regia* L.), JunO (*Juniperus oxycedrus* L.), OE (*Olea europaea* L.), PinH (*Pinus halepensis* Mill.), PinS (*P. sylvestris*), PinN (*P. nigra* subsp. *salzmannii*), PisL (*Pistacia lentiscus* L.), PoN (*Populus nigra* L.), PrA (*Prunus avium* (L.) L.), PrD (*P. dulcis* (Mill.) D. A. Webb), PrM (*P. mahaleb* L.), PrS (*P. spinosa* L.), QF (*Quercus faginea*), QR (*Q. rotundifolia*), QP (*Q. pyrenaica*), RP (*Robinia pseudoacacia* L.) and SA (*Salix atrocinerea* Brot.). Lack of data is denoted by “n/a”.

Scientific name	Localities	Habitat	Voucher
<i>Abrothallus parmeliarum</i> (Sommerf.) I. Kotte	4	Lichenicolous; parasitic on <i>Parmelia saxatilis</i>	VAL_Lich 33255
<i>Acarospora cervina</i> (Ach.) A. Massal.	4, 5, 6 & 9	Saxicolous on calcareous rocks.	n/a
<i>Amandinea punctata</i> (Hoffm.) Coppins & Scheid.	4	Epiphytic on AO	VAL_Lich 26525 & 29748
<i>Anaptychia ciliaris</i> (L.) Flot	4, 5 & 6	Epiphytic on AO, QF and QR	VAL_Lich 33232
<i>Athallia alnetorum</i> (Giralt, Nimis & Poelt) Arup, Frödén & Søchting (≡ <i>Caloplaca alnetorum</i> Giralt, Nimis & Poelt)	4	Epiphytic on AO and PinS	VAL_Lich 26530, 26537 & 29749
<i>Athallia cerinella</i> (Nyl.) Arup, Frödén & Søchting (≡ <i>Caloplaca cerinella</i> (Nyl.) Flagey)	4	Epiphytic on AO	VAL_Lich 29750
<i>Athallia cerinelloides</i> (Erichsen) Arup, Frödén & Søchting (≡ <i>Caloplaca cerinelloides</i> (Erichsen) Poelt)	4	n/a	n/a
<i>Athallia holocarpa</i> (Hoffm.) Arup, Frödén & Søchting (≡ <i>Caloplaca holocarpa</i> (Hoffm.) A.E. Wade)	4 & 6	Epiphytic on QR	n/a
<i>Bagliettoa marmorea</i> (Scop.) Gueidan & Cl. Roux (≡ <i>Verrucaria marmorea</i> (Scop.) Arnold)	2, 3, 4, 5 & 9	Saxicolous on calcareous rocks	n/a
<i>Bagliettoa parmigerella</i> (Zahlbr.) Vězda & Poelt (≡ <i>Verrucaria parmigerella</i> Zahlbr.)	4	Saxicolous on calcareous rock	VAL_Lich 29734
<i>Bilimbia sabuletorum</i> (Schreb.) Arnold	6	On mosses	n/a
<i>Blastenia crenularia</i> (With.) Arup, Søchting & Frödén (≡ <i>Caloplaca crenularia</i> (With.) J.R. Laundon)	4	n/a	VAL_Lich 33859
<i>Blastenia ferruginea</i> (Huds.) A. Massal. (≡ <i>Caloplaca ferruginea</i> (Huds.) Th. Fr.)	4, 5, 6 & 9	Epiphytic on AO, QF, QR, and QP	n/a
<i>Blastenia hungarica</i> (H. Magn.) Arup, Søchting & Frödén (≡ <i>Caloplaca hungarica</i> H. Magn.)	4, 5 & 6	Epiphytic on PinS and PinN	VAL_Lich 26533, 26538 & 29727
<i>Bryoria fuscescens</i> (Gyeln.) Brodo & D. Hawksw.	4 & 6	Epiphytic on QR and PinS	VAL_Lich 29240, 33213 & 33243

Scientific name	Localities	Habitat	Voucher
* <i>Bryostigma parietinarium</i> (Hafellner & A. Fleischhacker) S.Y. Kondr. & Hur (≡ <i>Arthonia parietinaria</i> Hafellner & A. Fleischhacker)	4	Lichenicolous; parasitic on <i>Xanthoria parietina</i>	VAL_Lich 33244
<i>Buellia disciformis</i> (Fr.) Mudd	6	Epiphytic on PinN	n/a
<i>Calogaya decipiens</i> (Arnold) Arup, Frödén & Søchting (≡ <i>Caloplaca decipiens</i> (Arnold) J. Steiner)	4, 5, 7 & 9	Mainly saxicolous on calcareous rocks and mortar, rarely terricolous	n/a
<i>Calogaya pusilla</i> (A. Massal.) Arup, Frödén & Søchting (≡ <i>Caloplaca pusilla</i> (A. Massal.) Zahlbr.)	2, 7 & 9	Saxicolous on calcareous rocks and mortar	n/a
<i>Calogaya schistidii</i> (Anzi) Arup, Frödén & Søchting (≡ <i>Fulgensia schistidii</i> (Anzi) Poelt)	4	On mosses over calcareous substrata	n/a
<i>Caloplaca aegatica</i> Giralt, Nimis & Poelt	4	Epiphytic on AO	VAL_Lich. 29745
<i>Caloplaca agardhiana</i> (Flot.) Clauzade & Cl. Roux	4	Saxicolous on calcareous sandstone	VAL_Lich 29731_3
<i>Caloplaca cerina</i> (Hedw.) Th. Fr.	4, 5, 6 & 9	Epiphytic on several phorophytes: AO, QR, and QP	VAL_Lich 26534 & 29751
<i>Candelaria concolor</i> (Dicks.) Stein	8	Epiphytic on <i>Pinus</i> sp.	n/a
<i>Candelariella aurella</i> (Hoffm.) Zahlbr.	4, 5, 7, 8 & 9	Saxicolous on calcareous rocks and mortar	n/a
<i>Candelariella coralliza</i> (Nyl.) H. Magn.	5	Saxicolous on acidic sandstone	VAL_Lich 33717
<i>Candelariella vitellina</i> (Hoffm.) Müll. Arg.	4 & 5	Epiphytic on PinS and saxicolous on orthoquartzitic sandstone	n/a
<i>Candelariella xanthostigma</i> (Pers. ex Ach.) Lettau	4, 5 & 6	Epiphytic on several phorophytes: JunO, PinS and QR	n/a
<i>Carbonea latypizodes</i> (Nyl.) Knoph & Rambold	4	Saxicolous on sandstone	VAL_Lich 28203
<i>Catillaria chalybeia</i> (Borrer) A. Massal.	8	Saxicolous on acidic sandstone	VAL_Lich 33464
<i>Catillaria nigroclavata</i> (Nyl.) J. Steiner	4	n/a	n/a
<i>Cetraria aculeata</i> (Schreb.) Fr.	4, 6, 8 & 9	Terricolous	VAL_Lich 24765, 29677, 33240 & 33865
<i>Cetraria islandica</i> (L.) Ach.	4	Terricolous	n/a
<i>Circinaria calcarea</i> (L.) A. Nordin, Savić & Tibell (≡ <i>Aspicilia calcarea</i> (L.) Bagl.)	2, 3, 4, 5, 6, 7, 8 & 9	Saxicolous on calcareous rocks	n/a
<i>Circinaria contorta</i> (Hoffm.) A. Nordin, Savić & Tibell (≡ <i>Aspicilia contorta</i> subsp. <i>contorta</i> (Hoffm.) Körb.)	3, 4, 6 & 9	Saxicolous on calcareous rocks	VAL_Lich 29731_2
<i>Circinaria hoffmanniana</i> (S. Ekman & Fröberg ex R. Sant.) A. Nordin (≡ <i>Aspicilia</i>	2, 3, 4, 5 & 9	Saxicolous on calcareous rocks	Preserved specimen: VAL_Lich 26527

Scientific name	Localities	Habitat	Voucher
<i>contorta</i> subsp. <i>hoffmanniana</i> S. Ekman & Fröberg)			
<i>Cladonia cervicornis</i> (Ach.) Flot.	4	n/a	n/a
<i>Cladonia chlorophaea</i> (Flörke ex Sommerf.) Spreng.	4	On mosses	VAL_Lich 29721
<i>Cladonia coniocraea</i> (Flörke) Spreng.	4, 5 & 6	Terricolous or at the base of <i>Pinus sylvestris</i> trunks	VAL_Lich 24747, 27282a, 32857 & 33230
<i>Cladonia fimbriata</i> (L.) Fr.	4, 5 & 6	Terricolous or muscicolous	VAL_Lich 24748, 27282, 28032, 28033, 28202, 29722 & 33246
<i>Cladonia foliacea</i> (Huds.) Willd.	4, 5, 6, 8 & 9	Terricolous, especially in areas with plant debris, or muscicolous	VAL_Lich 28030, 29246, 29604, 29676, 29742, 32747, 32751 & 33631 (TLC: fumarprotocetraric and usnic acids).
<i>Cladonia furcata</i> (Huds.) Schrad. subsp. <i>furcata</i>	4	On mosses	n/a
<i>Cladonia furcata</i> (Huds.) Schrad. subsp. <i>subrangiformis</i> (L. Scriba ex Sandst.) Pišút	4, 5, 6, 8 & 9	n/a	VAL_Lich 29611, 29678, 32752 & 33864
<i>Cladonia pyxidata</i> (L.) Hoffm. f. <i>pocillum</i> (Ach.) Nyl.	2, 4, 5, 6 & 8	Terricolous, muscicolous, or in calcareous rock cracks	n/a
<i>Cladonia pyxidata</i> (L.) Hoffm. f. <i>pyxidata</i>	3, 4, 5 & 6	Terricolous, muscicolous, or at the base of <i>Pinus</i> spp.	VAL_Lich 24692, 29247, 29741 & 33250
<i>Cladonia rangiformis</i> Hoffm.	4, 5, 6, 8 & 9	Terricolous and muscicolous	VAL_Lich 28031, 29611_2, 29723, 29741_2, 32697 & 32748
* <i>Clypeococcum hypocenomyces</i> D. Hawksw.	4	Lichenicolous; parasitic on <i>Hypocenomyce scalaris</i>	VAL_Lich 33257
<i>Collema furfuraceum</i> (Arnold) Du Rietz	4	Saxicolous on calcareous rocks	VAL_Lich 33866
<i>Dermatocarpon miniatum</i> (L.) W. Mann	4	Saxicolous on calcareous rocks	VAL_Lich 27193, 33219 & 33245
<i>Diploschistes muscorum</i> (Scop.) R. Sant.	4	Parasitic on terricolous <i>Cladonia pyxidata</i>	VAL_Lich 27192
<i>Diploschistes scruposus</i> (Schreb.) Norman	4	n/a	n/a
<i>Diplotomma alboatrum</i> (Hoffm.) Flot.	4 & 5	Saxicolous on calcareous rocks	n/a
<i>Diplotomma venustum</i> (Körb.) Körb.	3, 4, 5, 8 & 9	Saxicolous on calcareous rocks	n/a
<i>Enchylium tenax</i> (Sw.) Gray (= <i>Collema tenax</i> Sommerf.)	8	Terricolous, on clayish soil	n/a

Scientific name	Localities	Habitat	Voucher
<i>Evernia prunastri</i> (L.) Ach.	4, 5, 6 & 9	Epiphytic on several phorophytes: AM, Er, PinH, PinN, PinS, QF, QR and QP	VAL_Lich 33458
<i>Flavoparmelia caperata</i> (L.) Hale	4, 5, 6, 8 & 9	Epiphytic on several phorophytes: OE, PinH, PinN, PinS, PrD, QF, QR and QP	VAL_Lich 25178, 27194 & 33459
<i>Flavoparmelia soledians</i> (Nyl.) Hale	3, 4, 5 & 6	Epiphytic on several phorophytes: PinN, PinS, PisL, and QR	VAL_Lich 26532
<i>Flavoplaca citrina</i> (Hoffm.) Arup, Frödén & Søchting (≡ <i>Caloplaca citrina</i> (Hoffm.) Th. Fr.)	2, 4, 5, 6, 7 & 9	Saxicolous on either calcareous or acidic rocks (e.g., sandstone) and mortar	n/a
<i>Glaucumarina carpineae</i> (L.) S.Y. Kondr., Lökös & Farkas (≡ <i>Lecanora carpineae</i> (L.) Vain.)	3, 4, 5, 6 & 9	Epiphytic on several phorophytes: PrA, PrD, QF, QR and QP	n/a
<i>Glaucumarina leptyrodes</i> (G.B.F. Nilsson) S.Y. Kondr., Lökös & Farkas (≡ <i>Lecanora leptyrodes</i> G.B.F. Nilsson)	4, 6 & 8	Epiphytic on QR	n/a
<i>Gyalolechia flavorubescens</i> (Huds.) Søchting, Frödén & Arup var. <i>flavorubescens</i> (≡ <i>Caloplaca flavorubescens</i> (Huds.) J.R. Laundon)	4	n/a	n/a
* <i>Heterocephalacria physciacearum</i> (Diederich) Millanes & Wedin	4	Lichenicolous	n/a
<i>Huneckia pollinii</i> (A. Massal.) S.Y. Kondr., Elix, Kärnefelt, A. Thell, J. Kim, A.S. Kondratyuk & J.-S. Hur (≡ <i>Caloplaca pollinii</i> (A. Massal.) Jatta)	3, 4 & 6	Epiphytic on PisL and QR	n/a
<i>Huriopsis plana</i> (H. Magn.) S.Y. Kondr. & Lökös (≡ <i>Rinodina plana</i> H. Magn.)	4	Epiphytic on AO	VAL_Lich 29753
<i>Hyperphyscia adglutinata</i> (Flörke) H. Mayrhofer & Poelt	1, 2, 3, 4, 5, 6 & 9	Epiphytic on several phorophytes: AO, CoA, JugR, PinH, PisL, PoN, PrA, PrD, PrM, QR, QP and SA	n/a
<i>Hypocnomyce scalaris</i> (Ach. ex Lilj.) M. Choisy	4 & 6	Lignicolous on PinN and PinS	VAL_Lich 29238, 29609, 33216 & 33218
<i>Hypogymnia farinacea</i> Zopf	3, 4, 5, 6 & 9	Epiphytic on several phorophytes: AO, Er, PinH, PinN,	VAL_Lich 29237 & 33262

Scientific name	Localities	Habitat	Voucher
		PinS, PrA, PrD, QF, QR and QP	
<i>Hypogymnia physodes</i> (L.) Nyl.	4, 5 & 6	Epiphytic on several phorophytes: On PinN, PinS and, more rarely, on QF and QR	VAL_Lich 29239, 29603, 29740, 33217 & 33226
<i>Hypogymnia tubulosa</i> (Schaer.) Hav.	4, 6 & 7	Epiphytic on PinN and PinS, and, more rarely, QR	VAL_Lich 29242, 33223, 33225 & 33268
<i>Imshaugia aleurites</i> (Ach.) S.L.F. Mey.	4, 5 & 6	Epiphytic on PinN and PinS	VAL_Lich 25180, 26540, 26674, 29607 & 33263
<i>Kuettlingeria erythrocarpa</i> (Pers.) I.V. Frolov, Vondrák & Arup (≡ <i>Caloplaca erythrocarpa</i> (Pers.) Zwackh)	4, 5, 6, 8 & 9	Saxicolous on calcareous rocks	VAL_Lich 33860
<i>Kuettlingeria teicholyta</i> (Ach.) Trevis. (≡ <i>Caloplaca teicholyta</i> (Ach.) J. Steiner)	7 & 9	Saxicolous on calcareous rocks and mortar	n/a
<i>Lasallia pustulata</i> (L.) Mérat	4	Saxicolous on acidic sandstone	VAL_Lich 24861
<i>Lathagrium cristatum</i> (L.) Otálora, P.M. Jörg. & Wedin (≡ <i>Collema cristatum</i> (L.) Weber ex F.H. Wigg.)	2, 3, 4, 5, 6, 7, 8 & 9	Saxicolous on calcareous rocks and mortar	VAL_Lich 26529, 26560, 33248 & 33861
<i>Lathagrium undulatum</i> (Flot.) Poetsch (≡ <i>Collema undulatum</i> Laurer ex Flot.)	4	Terricolous or on calcareous rocks	VAL_Lich 26528 & 26562
<i>Lecania naegeli</i> (Hepp) Diederich & van den Boom	4	Epiphytic on AO	VAL_Lich 29745_2
<i>Lecanora argentata</i> (Ach.) Malme	6	Epiphytic on QR	n/a
<i>Lecanora campestris</i> (Schaer.) Hue	4, 5, 6 & 9	Saxicolous either on calcareous rocks or acidic sandstones	n/a
<i>Lecanora chlarotera</i> Nyl. subsp. <i>chlarotera</i>	3, 4, 5 & 6	Epiphytic on AO, PisL and QR	VAL_Lich 29753_2
<i>Lecanora expallens</i> Ach.	4	Epiphytic on PinS	n/a
<i>Lecanora horiza</i> (Ach.) Röhl.	4, 5, 6, 8 & 9	Epiphytic on PoN, PrD, PrM, QR and QP	VAL_Lich 29752
<i>Lecanora hybocarpa</i> (Tuck.) Brodo	3 & 4	Epiphytic on PrD and QR	n/a
<i>Lecanora strobilina</i> (Spreng.) Kieff.	3, 4, 5, 6 & 8	Epiphytic on several phorophytes: PinN, PinS, PrA and QR	n/a
<i>Lecanora sulphurea</i> (Hoffm.) Ach.	4	Saxicolous on acidic sandstones	VAL_Lich 33127
<i>Lecidella carpathica</i> Körb.	4	Saxicolous on acidic sandstone	VAL_Lich 33719
<i>Lecidella elaeochroma</i> (Ach.) M. Choisy	3, 4, 5, 6, 8 & 9	Epiphytic on several phorophytes: AO, PinN, PoN, PrA,	VAL_Lich 26531, 29744 & 29747

Scientific name	Localities	Habitat	Voucher
		PrD, PrS, QR and QP	
<i>Lecidella stigmatea</i> (Ach.) Hertel & Leuckert	4	Saxicolous on calcareous sandstone	VAL_Lich 29731_4
<i>Lendemeriella lucifuga</i> (G. Thor) S.Y. Kondr. (\equiv <i>Caloplaca lucifuga</i> G. Thor)	4 & 9	Epiphytic on JunO	n/a
<i>Lepra albescens</i> (Huds.) Hafellner (\equiv <i>Pertusaria albescens</i> (Huds.) M. Choisy & Werner)	4 & 5	Epiphytic on CrM and <i>Quercus</i> sp.	n/a
<i>Lepra amara</i> (Ach.) Hafellner (\equiv <i>Pertusaria amara</i> (Ach.) Nyl.)	4 & 6	Epiphytic on AO and PinN	VAL_Lich 29235 & 29608
<i>Lepra aspergilla</i> (Ach.) Hafellner (\equiv <i>Pertusaria aspergilla</i> (Ach.) J.R. Laundon)	4	n/a	n/a
<i>Lepra leucosora</i> (Nyl.) Hafellner (\equiv <i>Pertusaria leucosora</i> Nyl.)	4	Saxicolous on acidic sandstone	VAL_Lich 33857
<i>Lepraria crassissima</i> (Hue) Lettau	3, 4, 5 & 6	Either terricolous (e.g., on clayish slopes) or within cracks of calcareous rocks	VAL_Lich 28034
<i>Lepraria lobificans</i> Nyl.	2, 3 & 4	Terricolous or saxicolous on calcareous rocks (also in rock cracks)	n/a
<i>Leprocaulon quisquiliare</i> (Leers) M. Choisy (= <i>L. microscopicum</i> (Vill.) Gams)	4	Saxicolous on acidic soil	VAL_Lich 27189
<i>Leproplaca chrysodeta</i> (Vain.) J.R. Laundon ex Ahti	4	n/a	n/a
<i>Leproplaca xantholyta</i> (Nyl.) Nyl.	2, 3, 4, 6 & 9	Saxicolous on calcareous rocks	n/a
<i>Lichenocodium erodens</i> M.S. Christ. & D. Hawksw.	4	Lichenicolous	n/a
<i>Lichenodiplis lecanorae</i> (Vouaux) Dyko & D. Hawksw.	4	Lichenicolous	n/a
<i>Lobothallia radiosa</i> (Hoffm.) Hafellner	2, 3, 4, 5, 6 & 9	Saxicolous on either calcareous rocks or orthoquartzitic sandstone	n/a
<i>Marchandiomyces corallinus</i> (Roberge) Diederich & D. Hawksw.	4	Lichenicolous	n/a
<i>Megaspora verrucosa</i> (Ach.) Arcadia & A. Nordin	4	n/a	n/a
<i>Melanelixia glabra</i> (Schaer.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	4, 5 & 6	Epiphytic on AO, <i>Pinus</i> sp., QF and QR	n/a
<i>Melanelixia glabrata</i> (Lamy) Sandler & Arup	4 & 6	Epiphytic on QR	n/a
<i>Melanelixia subargentifera</i> (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	6	Epiphytic on AO	n/a

Scientific name	Localities	Habitat	Voucher
<i>Melanelixia subaurifera</i> (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	4, 5, 6 & 8	Epiphytic on several phorophytes: AO, CrM, <i>Pinus</i> sp., QF, QR and QP	VAL_Lich 33463
<i>Melanohalea elegantula</i> (Zahlbr.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	4, 5 & 6	Epiphytic on PinN, PinS and PrM	VAL_Lich 33294
<i>Melanohalea exasperata</i> (De Not.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	4, 5 & 6	Epiphytic on AO, PinN, QF, QR and QP	VAL_Lich 33241
<i>Melanohalea exasperatula</i> (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	4, 5 & 6	Epiphytic on PinN, PinS and QR	n/a
<i>Melaspilea bagliettoana</i> Zahlbr.	6	Muscicolous	n/a
<i>Micarea peliocarpa</i> (Anzi) Coppins & R. Sant.	4	n/a	n/a
* <i>Muellerella erratica</i> (A. Massal.) Hafellner & Volk. John (\equiv <i>Muellerella pygmaea</i> var. <i>athallina</i> (Müll. Arg.) Triebel)	4	Lichenicolous; parasitic on <i>Kuettlingeria erythrocarpa</i>	VAL_Lich 33636
<i>Mycocalicium subtile</i> (Pers.) Szatala	4	On lignum of a fallen trunk of <i>Pinus</i> sp.	VAL_Lich 33634
<i>Myriolecis albescens</i> (Hoffm.) Śliwa, Zhao Xin & Lumbsch (\equiv <i>Lecanora albescens</i> (Hoffm.) Branth & Rostr.)	9	Saxicolous on mortar	n/a
<i>Myriolecis dispersa</i> (Pers.) Śliwa, Zhao Xin & Lumbsch (\equiv <i>Lecanora dispersa</i> (Pers.) Röhl.)	6	Saxicolous on calcareous rock	n/a
<i>Myriolecis hagenii</i> (Ach.) Śliwa, Zhao Xin & Lumbsch (= <i>Lecanora umbrina</i> (Ach.) A. Massal.)	4	Epiphytic on AO	VAL_Lich 29751_2
<i>Nephromopsis chlorophylla</i> (Willd.) Divakar, A. Crespo & Lumbsch (\equiv <i>Cetraria chlorophylla</i> (Willd.) Vain.)	4	n/a	n/a
<i>Niorma chrysophthalma</i> (L.) S.Y. Kondr., Kärnefelt, Elix, A. Thell, N.H. Jeong & Hur (\equiv <i>Teloschistes chrysophthalmus</i> (L.) Th. Fr.)	1, 3, 4, 5, 6, 8 & 9	Epiphytic on several phorophytes: AO, CoA, CrM, PisL, PrD, PrS, QF and QR	VAL_Lich 29243
<i>Ochrolechia arborea</i> (Kreyer) Almb.	4 & 9	Epiphytic on PinN	VAL_Lich 29726
<i>Ochrolechia pallescens</i> (L.) A. Massal.	4	n/a	VAL_Lich 33247
<i>Ochrolechia subviridis</i> (Høeg) Erichsen	6	Epiphytic on PinS	n/a
<i>Ochrolechia szatalaensis</i> Versegly	4 & 9	Epiphytic on PinN and PinS	VAL_Lich 26673, 29725 & 33126 (TLC: variolaric acid)
<i>Ochrolechia turneri</i> (Sm.) Hasselrot	4	Epiphytic on PinS	VAL_Lich 26536
<i>Parmelia barrenoae</i> Divakar, M.C. Molina & A. Crespo	4 & 6	Epiphytic on PinS and PrM	VAL_Lich 33295
<i>Parmelia saxatilis</i> (L.) Ach.	4, 5 & 6	Epiphytic on several phorophytes: PinN, PinS, QF and QR	VAL_Lich 25179, 29730, 33224, 33265 & 33267

Scientific name	Localities	Habitat	Voucher
<i>Parmelia serrana</i> A. Crespo, M.C. Molina & D. Hawksw.	4	Epiphytic on PinS	VAL_Lich 33457
<i>Parmelia sulcata</i> Taylor	4, 5 & 6	Epiphytic on several phorophytes: PinN, PinS, QR and QP	VAL_Lich 33461
<i>Parmelina carporrhizans</i> (Taylor) Poelt & Vězda	4	Epiphytic on bark of an unknown phorophyte	VAL_Lich 33237
<i>Parmelina quercina</i> (Willd.) Hale	4, 5, 6 & 9	Epiphytic on AM, AO, OE, <i>Pinus</i> sp., <i>Populus</i> sp., PrD, QF, QR and QP	n/a
<i>Parmelina tiliacea</i> (Hoffm.) Hale	4, 5, 6, 8 & 9	Epiphytic on several phorophytes: AM, AO, OE, PinS, PrD, PrM QF, QR and QP	VAL_Lich 33228
<i>Parmeliopsis ambigua</i> (Wulfen) Nyl.	4, 5 & 6	Epiphytic on PinN and PinS	VAL_Lich 11055 & 26671
<i>Parmeliopsis hyperopta</i> (Ach.) Vain.	4, 5 & 6	Epiphytic on PinN and PinS	VAL_Lich 33212
<i>Parmotrema perlatum</i> (Huds.) M. Choisy	4 & 6	Epiphytic on QF and QR	VAL_Lich 33456
<i>Peltigera elisabethae</i> Gyeln.	4	Terricolous or in cracks of calcareous rocks	VAL_Lich 29724 & 33293
<i>Peltigera horizontalis</i> (Huds.) Baumg.	5	Terricolous and muscicolous	VAL_Lich 32749
<i>Peltigera membranacea</i> (Ach.) Nyl.	4 & 5	Terricolous and muscicolous	VAL_Lich 28177 & 28178
<i>Peltigera praetextata</i> (Flörke ex Sommerf.) Zopf	4 & 5	Terricolous and muscicolous	VAL_Lich 29720, 32750 & 33251
<i>Peltigera rufescens</i> (Weiss) Humb.	4	Terricolous and muscicolous	
<i>Pertusaria paramerae</i> A. Crespo & Vězda	4 & 8	Epiphytic on PinS	VAL_Lich 29728
<i>Pertusaria pertusa</i> (L.) Tuck. var. <i>pertusa</i>	4	n/a	VAL_Lich 33718
<i>Pertusaria pseudocorallina</i> (Sw.) Arnold	4	n/a	n/a
<i>Pertusaria rupicola</i> (Fr.) Harm.	4	On acidic sandstone	n/a
<i>Phaeophyscia cernohorskyi</i> (Nádv.) Essl.	2 & 9	Epiphytic on JugR and PrD	n/a
<i>Phaeophyscia hirsuta</i> (Mereschk.) Essl.	2	Epiphytic on JugR	n/a
<i>Phaeophyscia orbicularis</i> (Neck.) Moberg	3, 4, 5, 6 & 9	Epiphytic on OE, PoN, PrA, PrD, and saxicolous on calcareous rocks	n/a
<i>Phlyctis argena</i> (Ach.) Flot.	6	Epiphytic on QF and QR	n/a
<i>Physcia adscendens</i> H. Olivier	1, 2, 3, 4, 5, 6, 8 & 9	Epiphytic on several phorophytes: AM, AO, CoA, CrM,	VAL_Lich 29729, 29746 & 33221

Scientific name	Localities	Habitat	Voucher
		Er, JugR, OE, PinH, PinN, PinS, PisL, PoN, PrA, PrD, PrM, PrS, RP, QF, QR, QP and saxicolous on orthoquartzite and calcareous rocks	
<i>Physcia aipolia</i> (Ehrh. Ex Humb.) Fűrnr.	4, 5, 6 & 9	Epiphytic on several phorophytes: AO, CrM, PinH, PinN, PrD, QF and QR	VAL_Lich 29234 & 33233
<i>Physcia biziana</i> (A. Massal.) Zahlbr. var. <i>biziana</i> .	4	Epiphytic on bark of an unknown phorophyte	VAL_Lich 33242
<i>Physcia caesia</i> (Hoffm.) Hampe ex Fűrnr.	4	Saxicolous on acidic sandstone	VAL_Lich 33858
<i>Physcia dubia</i> (Hoffm.) Lettau	4	n/a	n/a
<i>Physcia leptalea</i> (Ach.) DC.	1, 3, 4, 5, 6 & 9	Epiphytic on several phorophytes: AM, AO, CoA, CrM, OE, PinS, PisL, PrD, PrS, QF, QR and QP	VAL_Lich 26561, 29244 & 33859
<i>Physcia stellaris</i> (L.) Nyl.	4, 5 & 6	Epiphytic on AO, JunO, PinS and QR	n/a
<i>Physcia tenella</i> (Scop.) DC.	3, 4, 5 & 6	Epiphytic on AO, OE, PrA, PisL, QF and QR	VAL_Lich 33231
<i>Physconia distorta</i> (With.) J.R. Laundon	4 & 6	Epiphytic on QF and QR	n/a
<i>Physconia enteroxantha</i> (Nyl.) Poelt	4 & 6	Epiphytic on QF and QR	VAL_Lich 33252 & 33462
<i>Physconia grisea</i> (Lam.) Poelt subsp. <i>grisea</i>	4	Epiphytic on PinH	VAL_Lich 27191
<i>Physconia perisidiosa</i> (Erichsen) Moberg	4, 5 & 6	Epiphytic on QF and QR	n/a
<i>Physconia venusta</i> (Ach.) Poelt	5 & 6	Epiphytic on QF and QR	n/a
<i>Placocarpus schaeereri</i> (Fr.) Breuss	4 & 5	Saxicolous on calcareous rocks	n/a
<i>Placynthium nigrum</i> (Huds) Gray	4, 5, 6 & 8	Saxicolous on calcareous rocks	n/a
<i>Platismatia glauca</i> (L.) W.L. Culb. & C.F. Culb.	4, 5 & 6	Epiphytic on PinN and PinS	VAL_Lich 33260
<i>Pleurosticta acetabulum</i> (Neck.) Elix & Lumbsch	4, 5, 6 & 9	Epiphytic on several phorophytes: AM, AO, PrD, QF, QR and QP	VAL_Lich 33261
<i>Polycauliona phlogina</i> (Ach.) Arup, Frödén & Söchting (≡ <i>Caloplaca phlogina</i> (Ach.) Flagey)	6	Epiphytic on <i>Juniperus</i> sp.	n/a

Scientific name	Localities	Habitat	Voucher
<i>Porpidinia tumidula</i> (Sm.) Timdal (≡ <i>Toninia tumidula</i> (Sm.) Zahlbr.)	2, 4, 5, 6 & 9	Saxicolous on calcareous rocks	n/a
<i>Protoparmeliopsis muralis</i> (Schreb.) M. Choisy var. <i>muralis</i>	3, 4, 5, 6, 7, 8 & 9	Saxicolous on calcareous and acidic rocks, also on mortar	VAL_Lich 33719
* <i>Protousnea huuskonenii</i> (Räsänen) Divakar, Crespo & Lumbsch (≡ <i>Raesaenenia huuskonenii</i> (Räsänen) D. Hawksw., Boluda & H. Lindgr.)	4	Lichenicolous	n/a
<i>Pseudevernia furfuracea</i> (L.) Zopf	4, 5 & 6	Epiphytic on PinN, PinS, QR and QP	VAL_Lich 25355, 26604, 29241, 29602, 29739, 33238, 33256, 33264 & 33269.
<i>Psora decipiens</i> (Hedw.) Hoffm.	4, 5, 7 & 9	Terricolous and saxicolous on calcareous rocks and mortar	n/a
<i>Psora testacea</i> Hoffm.	4 & 6	Saxicolous on calcareous rocks	VAL_Lich 11087 & 32820
<i>Psora vallesiaca</i> (Schaer.) Timdal	4, 5, 6 & 9	Saxicolous on calcareous rocks and in cracks	n/a
* <i>Punctelia caseana</i> Lendemer & Hodgkinson	4	Epiphytic on PrM	VAL_Lich 33124 (TLC: atranorin and lecanoric acid)
<i>Punctelia subrudecta</i> (Nyl.) Krog	4, 5, 6 & 9	Epiphytic on CrM, OE, PinH, PrD, QR and QP	VAL_Lich 33455 & 33460
<i>Pyrenodesmia alociza</i> (A. Massal.) Arnold (≡ <i>Caloplaca alociza</i> (A. Massal.) Mig.)	9	Saxicolous on calcareous rocks	n/a
<i>Pyrenodesmia variabilis</i> (Pers.) A. Massal. (≡ <i>Caloplaca variabilis</i> (Pers.) Müll. Arg.)	3	Saxicolous on calcareous sandstone	n/a
<i>Ramalina calicaris</i> (L.) Röhl.	6	Epiphytic on AO	n/a
<i>Ramalina canariensis</i> J. Steiner	6	Epiphytic on QR	n/a
<i>Ramalina farinacea</i> (L.) Ach.	3, 4, 5, 6 & 9	Epiphytic on several phorophytes: AM, AO, Er, PinH, PinN, PinS, PrD, QF, QR and QP	VAL_Lich 29237 & 33254
<i>Ramalina fastigiata</i> (Pers.) Ach.	4, 5, 6 & 9	Epiphytic on several phorophytes: AO, <i>Pinus</i> sp., PrD, QF and QR	VAL_Lich 33222
<i>Ramalina fraxinea</i> (L.) Ach.	3, 4, 5, 6 & 9	Epiphytic on several phorophytes: AO, PrA, QF, QR and QP	n/a
<i>Ramalina requienii</i> (De Not.) Jatta	4	n/a	n/a
<i>Rhizocarpon disporum</i> (Hepp) Müll. Arg.	4	Saxicolous on acidic sandstone	VAL_Lich 33717

Scientific name	Localities	Habitat	Voucher
<i>Rhizocarpon geographicum</i> (L.) DC.	4	Saxicolous on acidic sandstone	VAL_Lich 33717 & 33719
<i>Rinodina confragosa</i> (Ach.) Körb.	4	Saxicolous on acidic sandstone	VAL_Lich 33718
<i>Rinodina pyrina</i> (Ach.) Arnold	4	Epiphytic on AO	VAL_Lich 26554 & 29750_2
<i>Rinodina sophodes</i> (Ach.) A. Massal.	4	Epiphytic on bark of an unknown phorophyte	VAL_Lich 33235
<i>Romularia lurida</i> (Ach.) Timdal	4, 5, 6 & 9	Saxicolous on calcareous rocks and in cracks	n/a
<i>Rufoplaca arenaria</i> (Pers.) Arup, Søchting & Frödén (≡ <i>Caloplaca arenaria</i> (Pers.) Müll. Arg.)	4	Saxicolous on siliceous sandstone	VAL_Lich 26526 & 26539
<i>Rusavskia elegans</i> (Link) S.Y. Kondr. & Kärnefelt subsp. <i>elegans</i> (≡ <i>Xanthoria elegans</i> (Link) Th. Fr.)	4 & 7	Saxicolous on calcareous rocks and mortar	VAL_Lich 33227, 33234, 33236 & 33249
<i>Sanguineodiscus haematites</i> (Chaub. ex St.-Amans) I.V. Frolov & Vondrák (≡ <i>Caloplaca haematites</i> (Chaub. ex St.-Amans) Zwackh)	4 & 6	Epiphytic on QR	n/a
<i>Sarcogyne clavus</i> (DC.) Kremp.	4	Saxicolous on acidic sandstone	VAL_Lich 33607
<i>Sarcogyne pruinosa</i> (Schaer.) A. Massal. (≡ <i>Sarcogyne regularis</i> Körb.)	4	Saxicolous on calcareous rocks	VAL_Lich 29737
<i>Scytinium lichenoides</i> (L.) Otálora, P.M. Jørg. & Wedin (≡ <i>Leptogium lichenoides</i> (L.) Zahlbr.)	4 & 8	Terricolous and muscicolous	n/a
<i>Solenopsora candicans</i> (Dicks.) J. Steiner	4	Saxicolous on calcareous rocks	n/a
<i>Solorina saccata</i> (L.) Ach.	4 & 6	Terricolous and in cracks of calcareous rocks	VAL_Lich 11054
<i>Squamarina cartilaginea</i> (With.) P. James	3, 4, 5, 6, 8 & 9	Terricolous and saxicolous on calcareous rocks and in cracks	VAL_Lich 29245, 29738 & 29743
<i>Squamarina concrescens</i> (Müll. Arg.) Poelt	3, 4 & 5	Saxicolous on calcareous rocks and in clayish slopes	n/a
<i>Squamarina lentigera</i> (Weber) Poelt	4	n/a	n/a
<i>Squamarina stella-petraea</i> Poelt	4	n/a	n/a
<i>Straminella conizaeoides</i> (Nyl. ex Cromb.) S.Y. Kondr., Lökös & Farkas (≡ <i>Lecanora conizaeoides</i> Nyl. ex Cromb.)	4	n/a	n/a
<i>Synalissa symphorea</i> (Ach.) Nyl. (= <i>Synalissa ramulosa</i> (Bernh.) Fr.)	4	n/a	n/a
<i>Tephromela atra</i> (Huds.) Hafellner	4, 5 & 6	Saxicolous on acidic rocks, siliceous sandstones and orthoquartzitic	VAL_Lich 33717 & 33862

Scientific name	Localities	Habitat	Voucher
		rocks; rarely epiphytic on QR	
<i>Thalloidima candidum</i> (Weber) A. Massal. (= <i>Toninia candida</i> (Weber) Th. Fr.)	2, 4, 5, 6, 8 & 9	Saxicolous on calcareous rocks	VAL_Lich 26535 & 33215
<i>Thalloidima opuntioides</i> (Vill.) Kistenich, Timdal, Bendiksby & S. Ekman (= <i>Toninia opuntioides</i> (Vill.) Timdal)	4	Saxicolous on calcareous rocks and in cracks	VAL_Lich 33292
<i>Thalloidima sedifolium</i> (Scop.) Kistenich, Timdal, Bendiksby & S. Ekman (= <i>Toninia sedifolia</i> (Scop.) Timdal)	4 & 9	Terricolous and saxicolous on calcareous rocks and in cracks	VAL_Lich 33214
<i>Trapeliopsis flexuosa</i> (Fr.) Coppins & P. James	4, 5 & 6	Epiphytic on PinN and PinS	VAL_Lich 27195
<i>Trapeliopsis granulosa</i> (Hoffm.) Lumbsch	5	Epiphytic on PinS	VAL_Lich 26675
* <i>Tremella hypogymniae</i> Diederich & M.S. Christ.	4	Lichenicolous; parasitic on <i>Hypogymnia physodes</i>	VAL_Lich 33253
<i>Umbilicaria polyphylla</i> (L.) Baumg.	4	Saxicolous on sandstone rocks	n/a
<i>Usnea hirta</i> (L.) Weber ex F.H. Wigg.	4, 5 & 6	Epiphytic on PinN and PinS	VAL_Lich 26672, 29236, 29605, 33220 (TLC: usnic acid), 33239 & 33259
<i>Varicellaria hemisphaerica</i> (Flörke) I. Schmitt & Lumbsch (= <i>Pertusaria hemisphaerica</i> (Flörke) Erichsen)	4 & 5	Epiphytic on PinS	VAL_Lich 26676
<i>Varicellaria lactea</i> (L.) I. Schmitt & Lumbsch (= <i>Pertusaria lactea</i> (L.) Arnold)	4, 5 & 9	Saxicolous on calcareous and acidic rocks, also on orthoquartzite and mortar	VAL_Lich 29736
<i>Variospora aurantia</i> (Pers.) Arup, Frödén & Søchting (= <i>Caloplaca aurantia</i> (Pers.) Hellb.)	2, 3, 4, 5, 8 & 9	Saxicolous on calcareous rocks	n/a
<i>Variospora dolomiticola</i> (Hue) Arup, Søchting & Frödén (= <i>Caloplaca dolomiticola</i> (Hue) Zahlbr.)	4, 6 & 9	Saxicolous on calcareous rocks	n/a
<i>Variospora flavescens</i> (Huds.) Arup, Frödén & Søchting (= <i>Caloplaca flavescens</i> (Huds.) J.R. Laundon)	3, 4, 6 & 9	Saxicolous on calcareous rocks and mortar	VAL_Lich 29733
<i>Variospora velana</i> (A. Massal.) Arup, Søchting & Frödén (= <i>Caloplaca velana</i> (A. Massal.) Du Rietz)	4 & 5	Saxicolous on calcareous rocks	VAL_Lich 29735
<i>Verrucaria macrostoma</i> Dufour ex DC.	4 & 9	Saxicolous on calcareous rocks	n/a
<i>Verrucaria nigrescens</i> Pers.	2, 3, 4, 5, 6, 8 & 9	Saxicolous on calcareous, sandstone and orthoquartzite rocks; rarely epiphytic on OE	VAL_Lich 29731_5 & 29732
<i>Xalocoa ocellata</i> (Fr.) Kraichak, Lücking & Lumbsch (= <i>Diploschistes ocellatus</i> (Fr.) Norman)	4 & 9	Saxicolous on calcareous rocks	n/a

Scientific name	Localities	Habitat	Voucher
<i>Xanthocarpia lactea</i> (A. Massal.) A. Massal. (≡ <i>Caloplaca lactea</i> (A. Massal.) Zahlbr.)	4, 5 & 9	Saxicolous on calcareous and acidic rocks, also on orthoquartzite and mortar	VAL_Lich 29736
<i>Xanthoparmelia camtschadalis</i> (Ach.) Hale	4, 6 & 9	Terricolous	VAL_Lich 27190, 33229 & 33867 (TLC: usnic, salazinic and consalazinic acids)
<i>Xanthoparmelia conspersa</i> (Ehrh. ex Ach.) Hale	4	Saxicolous on acidic rocks	n/a
<i>Xanthoparmelia loxodes</i> (Nyl.) O. Blanco, A. Crespo, Elix, D. Hawksw. & Lumbsch	4	n/a	n/a
<i>Xanthoparmelia mougeotii</i> (Schaer.) Hale	4	Saxicolous on acidic sandstone	n/a
<i>Xanthoparmelia protomatrae</i> (Gyeln.) Hale	4	Saxicolous on acidic sandstone	VAL_Lich 33719 (TLC: usnic, fumarprotocetraric and protocetraric acids)
<i>Xanthoparmelia pulla</i> (Ach.) O. Blanco, A. Crespo, Elix, D. Hawksw. & Lumbsch	4	Saxicolous on orthoquartzite sandstone	n/a
<i>Xanthoparmelia stenophylla</i> (Ach.) Ahti & D. Hawksw. (= <i>Parmelia somloensis</i> Gyeln.)	5	Saxicolous on orthoquartzite sandstone	n/a
<i>Xanthoparmelia tinctina</i> (Maheu & A. Gillet) Hale	4	Saxicolous on acidic rocks	n/a
<i>Xanthoparmelia verruculifera</i> (Nyl.) O. Blanco, A. Crespo, Elix, D. Hawksw. & Lumbsch	4	Saxicolous on acidic rocks	VAL_Lich 33862
<i>Xanthoria calcicola</i> Oxner	3, 4, 5 & 9	Saxicolous on calcareous rocks	n/a
<i>Xanthoria parietina</i> (L.) Beltr.	1, 2, 3, 4, 5, 6, 8 & 9	Epiphytic on several phorophytes: AM, AO, CoA, CrM, JugR, JunO, OE, PinH, PinS, PisL, PoN, PrA, PrD, PrM, PrS, RP, QF, QR and QP	n/a
<i>Xanthoriicola physciae</i> (Kalchbr.) D. Hawksw.	9	Lichenicolous; parasitic on <i>Xanthoria parietina</i> growing on <i>Prunus dulcis</i>	n/a
<i>Zwackhiomyces cervinae</i> Calat., Triebel & Pérez-Ortega	4	Lichenicolous; parasitic on <i>Acarospora cervina</i> growing on calcareous rocks	Holotype deposited in Herbarium M with code 0044788