The lichen biota of the Special Area of Conservation Rio Pentemina (Ligurian Apennines, N Italy)

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Abstract - Despite its restricted geographical extent, Liguria hosts a very rich lichen biota. Nevertheless, the lichenological exploration of Liguria remains highly fragmented, both in space and time. Indeed, there are only a handful of comprehensive lichen biota lists for specific areas of Liguria. To address this gap of knowledge and support broader biodiversity, taxonomic, and ecological studies, we present a list of the lichen biota of the Pentemina Valley, which we consider to be one of the most interesting areas in the Ligurian Apennines from a lichenological point of view. The list includes 200 infrageneric taxa, fourteen of which are new to Liguria (e.g., *Loxospora elatina*). Additionally, fourteen other species of conservation interest have been collected (e.g., *Buellia hyperbolica*), while many others have been recorded after a century or more since the first and, in some cases, only report (e.g., *Ochrolechia szatalaensis* or *Verrucaria papillosa*).

Key words: biodiversity, epilithic, epiphytes, lichens, terricolous.

Riassunto - Il biota lichenico della Zona Speciale di Conservazione Rio Pentemina (Appennino Ligure, N Italia).

Nonostante la sua limitata estensione geografica, la Liguria ospita un biota lichenico molto ricco. Tuttavia, l'esplorazione lichenologica della Liguria rimane molto frammentata, sia nello spazio che nel tempo. Infatti, esistono soltanto poche liste dettagliate del biota lichenico per aree specifiche della Liguria. Per colmare questa lacuna di conoscenze e supportare studi più ampi sulla biodiversità, la tassonomia e l'ecologia, presentiamo un elenco del biota lichenico della Valle Pentemina, che consideriamo una delle aree più interessanti dell'Appennino ligure dal punto di vista lichenologico. L'elenco comprende 200 taxa infragenerici, quattordici dei quali nuovi per la Liguria (ad esempio *Loxospora elatina*). Inoltre, sono state raccolte altre quattordici specie di interesse conservazionistico (ad esempio *Buellia hyperbolica*), mentre molte altre sono state registrate dopo un secolo o più dalla prima e, in alcuni casi, unica segnalazione (ad esempio *Ochrolechia szatalaensis* o *Verrucaria papillosa*).

Parole chiave: biodiversità, epifite, epilitico, licheni, terricolo.

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INTRODUCTION

Despite an extension limited to just over 5000 km^2, Liguria hosts a very rich lichen biota. In fact, more than 1140 species are known to date, corresponding to biodiversity comparable to that of other, much larger Italian regions such as Lombardy, Piedmont, or Sardinia (Nimis & Martellos, 2023). The reason for such diversity is the considerable heterogeneity of habitats (Brunialti & Giordani, 2003; Mariotti, 2009): in just a few kilometers, the landscape changes from the rocky Mediterranean cliffs to the pastures and larch forests of the Ligurian Alps. Moreover, since the Roman times, the farming tradition has created and maintained unique cultural landscapes, such as olive and chestnut groves, and thousands of kilometers of dry-stone walls (Allegri, 2019). Thanks to their ecological continuity and favorable microclimatic characteristics, these landscapes ensure the establishment of both epiphytic and epilithic cryptogams (Nordén *et al.*, 2014).

Nevertheless, knowledge of Ligurian lichen biota is still extremely fragmented, both in space and time (Nimis, 2016; Valcuvia Passadore & Vittadini Zorzoli, 1982). An irreplaceable heritage is represented by the contributions of masters of 19th-century Lichenology, such as De Notaris (1846) and Baglietto (1857, 1861, 1862a, 1862b), and, between the 1920s and 1960s, by the feverish collecting and scientific networking activity conducted by the lichenologist poet Camillo Sbarbaro (1930, 1931, 1932, 1941, 1955, 1956). Inevitably, given the logistical possibilities of the time, these authors collected in limited areas. Furthermore, they concentrated their attention on only a few taxonomic groups (including some critical ones, such as the Verrucariaceae), while only sporadically collecting other taxa. Indeed, there are only a handful of truly exhaustive lists of the lichen biota for given Ligurian areas (e.g., Porcella, 1990). The compilation of species lists that are as exhaustive and detailed as possible for even small areas is not only of relevance in itself but is

the indispensable basis for supporting broader studies on biodiversity, taxonomy and ecology (Vondrák *et al.*, 2022; Nascimbene *et al.*, 2022), including those devoted to the conservation of the natural heritage under the increasing pressure of anthropogenic disturbance related to air pollution, climate change, and wildfires (Hobbs & Huenneke, 1992).

Several recent authors, in activity since the late 1980s, have unfortunately neglected the study of the lichen biota, limiting themselves to publishing partial local contributions and/or reports of interesting species (Giordani & Brunialti, 2000; Brunialti *et al.*, 2001).

In this paper, we present a list of the lichen biota of the Pentemina Valley, which we consider to be one of the most interesting areas in the Ligurian Apennines from a lichenological point of view (Nimis, 1993, 2023). In particular, the area included in the Rio Pentemina Special Area of Conservation (SAC) is a small territory of transition between the Apennine montane belt and the humid Mediterranean and sub-Mediterranean region of the Ligurian Rivieras. Apart from the more strictly thermophilic coastal aspects, it contains *in nuce* most of the ecological characteristics of suitable habitats for lichens in Liguria.

MATERIALS AND METHODS

The SAC Rio Pentemina (IT1330925) covers an area of 284 ha in the Ligurian Apennines, between the municipalities of Montoggio and Torriglia, in the hinterland of the Province of Genoa (Fig. 1).

The site is characterized by the confluence of a recessed, cool, and scarcely disturbed torrent (Fig. 2A) that favors the presence of well-preserved populations of amphibians and white-clawed Crayfish *Austropotamobius pallipes* (Lereboullet 1858). In addition, it hosts priority species and habitats according to 92/43 EEC. The most represented habitats include European dry heaths (code 4030); semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (6210); *Castanea sativa* Mill. woods (9260); alluvial forests with *Alnus glutinosa* (L.) Gaertn. and *Fraxinus excelsior* L. (Alno-Padion, Alnion incanae, Salicion albae – 91E0) (Fig. 2B), with several areas where the forest canopy reaches heights of 30 m (Fig. 2C).

The dominant geological structure is the formation of the Monte Antola limestone, consisting of calcareous-marly turbiditic deposits (flysch).

Several collection sessions were carried out in the spring of 2021 to investigate the main habitats of the SAC throughout its altitudinal extent. Extensive collections were carried out in the following 22 sampling sites (Fig. 2D).

1. Mulino delle Bande, 9.115003E, 44.526488N, 590 m, chestnut orchards and broadleaved forest along the river.
2. Rio Luvega, 9.100354, 44.541111, 780 m, broadleaved forest.
3. Along the ridge towards M. Liprando, 9.090325E, 44.541892N, 1040 m, limestone boulders and broadleaved mixed forest.
4. Above the village of Serre di Pentema, along the trail to Case Teglio, 9.106147E, 44.528428N, 740 m, boulders within a dry grassland.
5. Minaglia, near Case Teglio, 9.106569E, 44.535801N, 738 m, chestnut orchard.
6. Village of Costapianella, 9.102375E, 44.535253N, 740 m, isolated broadleaved trees.
7. Track from the village of Serre to Mulino delle Bande, 9.112528E, 44.527788N, 590 m, limestone drywalls and mixed broadleaved forest.
8. Rio Tigli, on the path towards Costapianella, 9.106012E, 44.536864N, 695 m, chestnut woodland and limestone boulders in open areas.
9. Along the path from Serre to Costapianella, near Case Teglio, 9.106439E, 44.532463N, 745 m, mixed broadleaved forest.
10. Monte Penzo, 9.109099E, 44.542197N, 1026 m, mixed broadleaved forest and grasslands.
11. Madonna della Guardia, 9.114714E, 44.539153N, 1030 m, chestnut woodland.
12. Monte di Pezza, 9.109099E, 44.542197N, 1020 m, chestnut woodland and broadleaved forest.
13. Serre di Pentema, 9.106285E, 44.526702N, 618 m, hazel grove under the village.
14. Rio Pentemina, 9.110125E, 44.526267N, 581 m, alder formations along the river.
15. At the confluence of Rio Pentemina and Rio Fallarosa, near Mulino delle Serre, 9.105173E, 44.525347N, 540 m, chestnut orchards.
16. Along the Rio Fallarosa, 9.106942E, 44.524350N, 576 m, broadleaved forest.
17. Mulino delle Serre, 9.106239E, 44.525545N, 567 m, broadleaved forest.
18. Along Rio Pentemina, between Mulino delle Serre and Mulino delle Bande, 9.111227E, 44.526366N, 570 m, chestnut orchard.
19. Carsegli, between Casevecchie and Poggio, 9.093399E, 44.536258N, 820 m, chestnut orchards.
20. Rio Corsegli, 9.092564E, 44.538537N, 768 m, chestnut woodland.
21. Track from Tinello to Mulino delle Bande, 9.115634E, 44.527948N, 598 m, broadleaved forest.
22. Track from Serre to Rio Pentemina, 9.104139E, 44.526445N, 603 m, broadleaved forest.

At each site, the collection was carried out by one or two experienced lichenologists. Although no time limit was set in advance, each site took a minimum of 30 minutes and a maximum of 3 hours to survey, depending on the ecological heterogeneity of the site. The search continued until no other taxa could be identified at the site under investigation. Samples were collected for all taxa for which it was not possible to make a sufficiently reliable identification in the field. Additionally, notes on the most common species were collected at some sites to supplement the total list of taxa. All substrates potentially colonizable by lichens at the sites were examined, including living trees, rock outcrops, soil, epilithic and epiphytic bryophytes, and various components of dead wood.

The specimens collected were identified in the laboratory using standard microscopic techniques adopted in Lichenology. Dichotomous keys available on ITALIC 7.0 (Nimis & Martellos, 2023) were used to identify the species. The identification of some specimens of critical genera was also verified by thin-layer chromatography to highlight the presence of lichen substances of taxonomic significance, following the protocols by Orange *et al.* (2001).

Lichen nomenclature follows ITALIC 7.0 (Nimis & Martellos, 2023), as well as the traits considered for the analysis of the lichen biota (i.e., growth forms, photobionts and reproductive strategies).

The specimens are kept in GE, FI and Herbarium Nascimbene, Herbarium Benesperi.

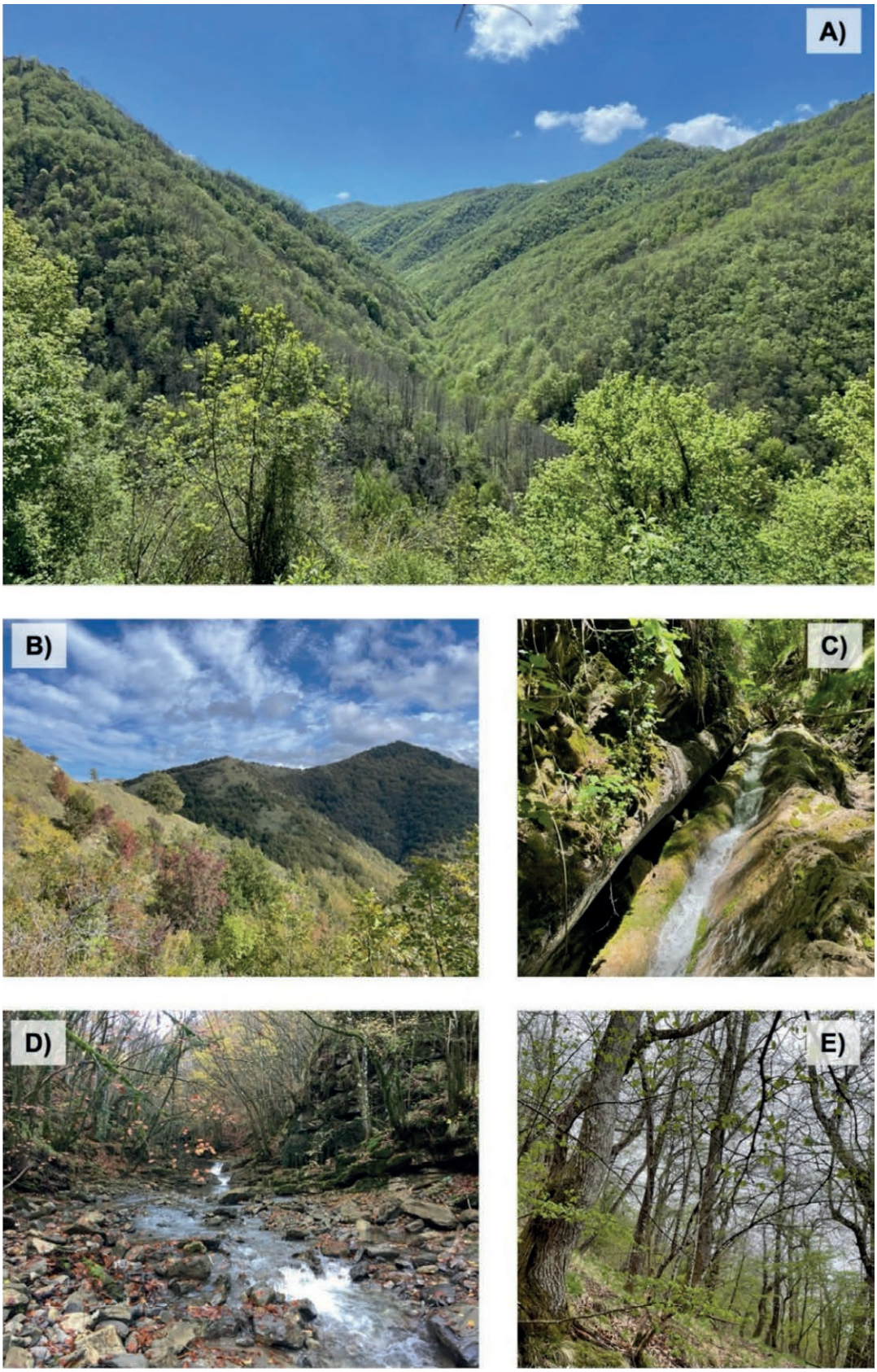

Fig. 1 – Landscapes and habitats of the Special Area of Conservation Rio Pentemina: A) valley floors and southern slopes with broadleaved forest; B) summit areas with wooded grasslands on the ridge towards Monte Liprando; C) stream on limestone outcrops in the Rio dei Tigli impluvium; D) riparian areas with alder and chestnut groves near Mulino delle Bande; E) abandoned chestnut groves on the slopes of Monte di Pezza. / Paesaggi e habitat della Zona Speciale di Conservazione Rio Pentemina: A) fondovalle e versanti meridionali con bosco di latifoglie; B) aree sommitali con praterie boscate sul crinale verso Monte Liprando; C) torrente su affioramenti calcarei nell'impluvio del Rio dei Tigli; D) aree ripariali con ontaneti e castagneti presso il Mulino delle Bande; E) Castagneti abbandonati sulle pendici del Monte di Pezza.

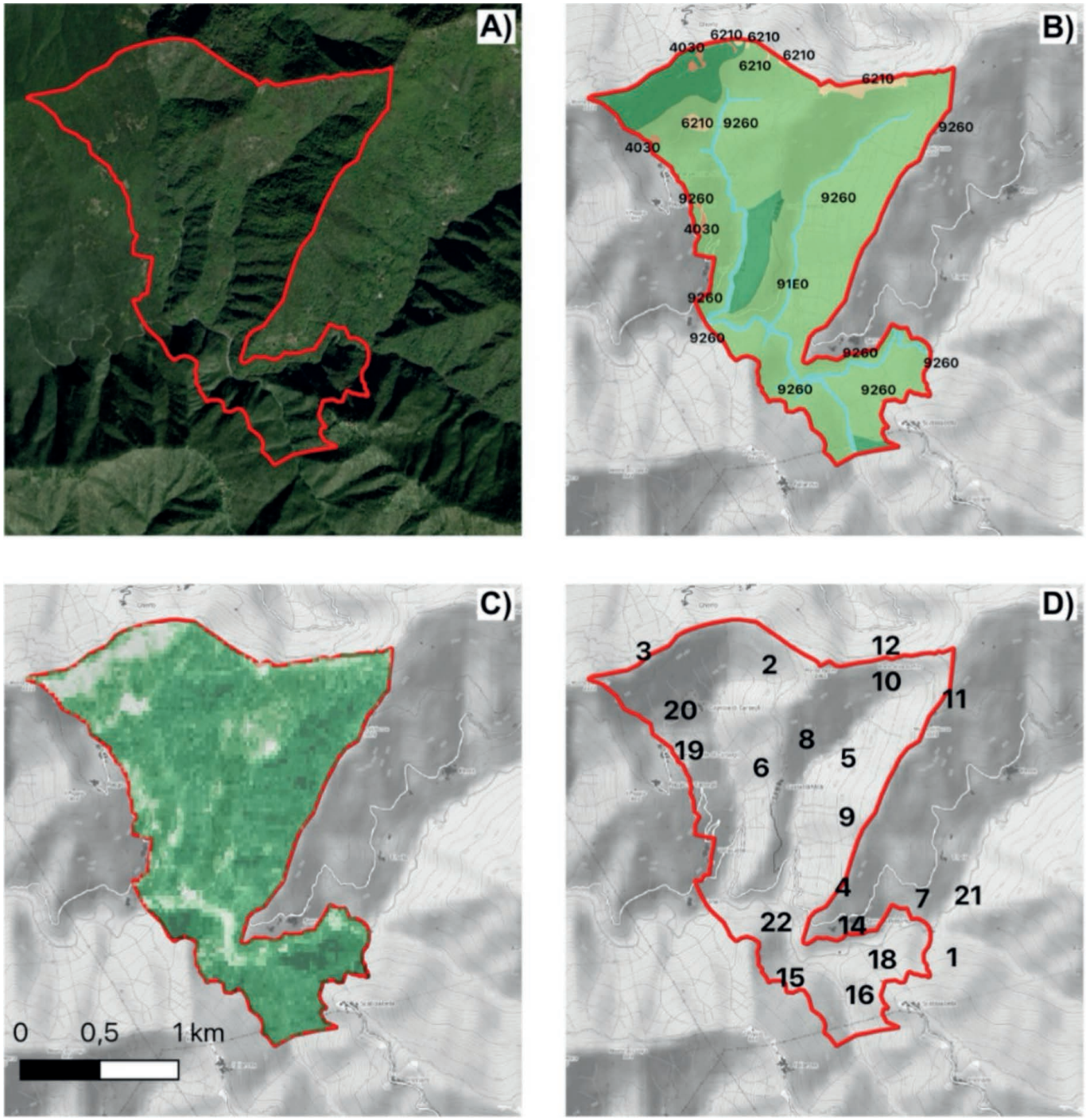

Fig. 2 – Characterization of the Special Area of Conservation (SAC) Rio Pentemina. A) Satellite image of the SAC area and surrounding Apennine valleys; B) habitat map in which the codes follow the classification of the Habitats Directive: 4030 - European dry heaths; 6210 - semi-natural dry grasslands and scrub facies on calcareous substrates (Festuco-Brometalia); 9260 - Castanea sativa Mill. woods; 91E0 - alluvial forests with *Alnus glutinosa* (L.) Gaertn. and *Fraxinus excelsior* L. (Alno-Padion, Alnion incanae, Salicion albae); C) forest height in the study area: white to dark green represents increasing tree heights with a range from 0 to 25 m; D) points sampled during the field surveys (see the methods section for a detailed description of the sampling sites). / Caratterizzazione della Zona Speciale di Conservazione (ZCS) del Rio Pentemina. A) Immagine satellitare dell'area ZCS e delle valli appenniniche circostanti; B) mappa degli habitat in cui i codici seguono la classificazione della Direttiva Habitat: 4030 - lande secche europee; 6210 - praterie secche seminaturali e facies di macchia su substrati calcarei (Festuco-Brometalia); 9260 - boschi di *Castanea sativa* Mill.; 91E0 - boschi alluvionali con Alnus glutinosa (L.) Gaertn. e *Fraxinus excelsior* L. (Alno-Padion, Alnion incanae, Salicion albae); C) altezza della foresta nell'area di studio: dal bianco al verde scuro rappresenta l'aumento dell'altezza degli alberi con un intervallo da 0 a 25 m; D) punti campionati durante i rilievi sul campo (si veda la sezione metodi per una descrizione dettagliata dei siti di campionamento).

RESULTS

The lichen checklist of the SAC Rio Pentemina consists of 200 infrageneric taxa, corresponding to 17.4% of the Ligurian lichen biota. Most taxa were exclusive to one substrate type, but 30 species were reported on two or more substrates. The bark of deciduous trees is the most represented substrate, hosting 122 species, followed by rocks with 63 species (57 from limestone and 6 from siliceous rock). Fifteen species were found on bryophytes (epiphytic, epilithic, or terricolous), while 7 species were reported from bare soil and 10 from dead wood. The crustose growth form is the most common (51%, plus 6 placodiomorphic, e.g., *Gyalolechia fulgida*, and 2 endolithic crustose species, e.g., *Bagliettoa parmigera*); however, broad-lobed (13%) and narrow-lobed (13%) foliose are well represented among epiphytic and epilithic species. Among other growth forms, 8.5% squamulose lichens, and 7% fruticose, 2.5% leprose, and 1% umbilicate foliose were found. Chlorococcoid photobionts were by far the most frequent (77%), followed by cyanobacteria (12%, e.g., *Fuscopannaria ignobilis* and *Scytinium plicatile*) and trentepohlioid (9.5%, e.g., *Gyalecta truncigena* and *G. jenensis*). Moreover, 3 species (1.5%) are only occasionally lichenized (e.g., *Arthopyrenia cerasi*). A 68.5% of the taxa had a sexual reproduction strategy, while the others propagated via vegetative structures (22% via soredia, 9.5% with isidia). Compared to the proportions in the Italian lichen biota as a whole, we recorded twice as many foliose lichens (and a correspondingly lower relevance of crustose species) and lichens with vegetative propagules in the study area. Similarly, compared to the national situation, cyanolichens and taxa with *Trentepohlia* as photobiont are more represented. 14 species (7% of the checklist) are red-listed as "near-threatened" (11 species), "vulnerable" (one species: *Parmotrema stuppeum*), and "endangered" (two species: *Buellia hyperbolica* and *Loxospora elatina*). 14 taxa are reported for the first time and 13 for the second time from Liguria. Below is the annotated checklist with references to colonized substrates and the locations where the taxa were found.

Checklist

In the following list, species new to Liguria are marked with *, while second reports are marked with #.

Acarospora macrospora (Hepp) Bagl.
On limestone (9).

Acrocordia conoidea (Fr.) Körb. var. ***conoidea***
On limestone (3).

Acrocordia gemmata (Ach.) A. Massal. var. ***gemmata***
On bark of *Castanea sativa* Mill. (1), *Acer pseudoplatanus* L. (3, 11, 12, 13).

Alyxoria culmigena (Lib.) Ertz
On bark of *Corylus avellana* L. (13).

Alyxoria mougeotii (A. Massal.) Ertz, Frisch & G. Thor
On limestone (1).
This is a poorly known taxon, related to *A. varia*, that deserves further study. It is very or extremely rare in several Italian regions below the montane belt (Nimis & Martellos, 2023).

Amandinea punctata (Hoffm.) Coppins & Scheid.
On bark of *Ostrya carpinifolia* Scop. (2, 3), *Castanea sativa* Mill. (12).

Arthonia atra (Pers.) A. Schneid.
On bark of *Corylus avellana* L. (13).

Arthonia radiata (Pers.) Ach.
On bark of *Corylus avellana* L. (13).

****Arthonia ruana*** A. Massal.
On bark of *Fraxinus* ornus L. (1).
A suboceanic species that colonizes several species of broad-leaved trees with smooth bark. Apparently very rare in Italy but probably overlooked.
New to Liguria.

****Arthonia vinosa*** Leight.
On bark of *Castanea sativa* Mill. (1).
A species found mostly in humid forests at the base of old trees with rough bark and sometimes on wood (Nimis & Martellos, 2023). The species is included in the Italian red list of epiphytic lichens as "near-threatened" (Nascimbene *et al.*, 2013).
New to Liguria.

Arthopyrenia analepta (Ach.) A. Massal.
On bark of *Fraxinus ornus* L. (10, 11, 12) and *Corylus avellana L.* (13).
An occasionally lichenized species that colonizes shrubs or trees with thin, smooth bark.

Arthopyrenia cerasi (Schrad.) A. Massal.
On bark of *Fraxinus ornus* L. (12).

Athallia pyracea (Ach.) Arup, Frödén & Søchting
On bark of *Ostrya carpinifolia* Scop. (2, 3, 4,11, 12).

****Bacidia fraxinea*** Lönnr.
On bark of *Corylus avellana* L. (13).
A species with a Mediterranean-Atlantic distribution, which usually colonizes various smooth-barked broad-leaved trees in open, humid forests.
New to Liguria.

Bacidia rubella (Hoffm.) A. Massal.
On bark of *Castanea sativa* Mill. (5).

Bagliettoa parmigera (J. Steiner) Vězda & Poelt
On limestone (1, 3, 17).

Bilimbia sabuletorum (Schreb.) Arnold
On terricolous bryophytes (4).

Blastenia ferruginea (Huds.) A. Massal.
On bark of *Castanea sativa* Mill. (1, 12), *Corylus avellana L.* (13).

Blastenia herbidella (Hue) Servít
On bark of *Acer pseudoplatanus* L. (3).
This species is found on bark, especially on basal parts of trunks, more rarely on wood, with optimum in the sub-Mediterranean and montane belts (Nimis & Martellos, 2023). The species is included in the Italian red list of epiphytic lichens as "near-threatened" (Nascimbene *et al.*, 2013). Already known from several locations in Liguria (Giordani, 2006; Giordani & Incerti, 2008).

Buellia disciformis (Fr.) Mudd
On bark of deciduous trees (11).
Found on smooth bark in humid woodlands, especially in open beech forests of the montane belt.
The species is included in the Italian red list of epiphytic lichens as "near threatened" (Nascimbene *et al.*, 2013).

Buellia griseovirens (Sm.) Almb.
On bark of deciduous trees (1, 2, 3, 11, 12).

Buellia hyperbolica Bagl.
On bark of *Castanea sativa* Mill. (19).
A species found on trunks of old trees, especially *Castanea*

and *Quercus*, and on wood. It is included in the Italian red list of epiphytic lichens as "endangered" (Nascimbene *et al.*, 2013). It was previously reported from Liguria in the Vara valley (Putortì *et al.*, 1999) and Fontanabuona valley (GE817).

Calicium abietinum Pers.
On bark of old *Castanea sativa* Mill. trees (11, 12).

****Calicium adspersum*** Pers.
On bark of old *Castanea sativa* Mill. trees (19).
A temperate species that colonizes bark crevices or wood of deciduous trees, such as oaks or chestnut trees.
New to Liguria.

#Calicium salicinum Pers**.**
On bark and on wood of old *Castanea sativa* Mill. trees (1).
The species had previously been reported from Liguria in chestnut groves in the Vara valley (Putortì *et al.*, 1999).

Candelaria concolor (Dicks.) Stein
On bark of *Ostrya carpinifolia* Scop. (10, 11).

****Candelariella boleana*** Etayo, Palice & T. Sprib.
On bark of *Ostrya carpinifolia* Scop. (11).
A rare species, whose presence in Italy may be underestimated, but that is widespread in Central and Southern Europe (Guttová & Palice, 2005; Etayo *et al.*, 2009).
New to Liguria. Second report for Italy (Ravera *et al.*, 2022).

Candelariella reflexa (Nyl.) Lettau
On bark of deciduous trees (2, 3, 11).

Candelariella xanthostigma (Ach.) Lettau
On bark of deciduous trees (3).

****Catillaria erysiboides*** (Nyl.) Th. Fr.
On bark of *Castanea sativa* Mill. (19)
New to Liguria.

Catillaria lenticularis (Ach.) Th. Fr.
On limestone (3, 7, 11, 12).

Catillaria nigroclavata (Nyl.) J. Steiner
On bark of *Ostrya carpinifolia* Scop. (11).

#Chaenotheca brunneola (Ach.) Müll. Arg.
On bark and on wood of old *Castanea sativa* Mill. trees (1).
On wood of old coniferous stumps in humid woodlands, more rarely on wood of deciduous trees. This is the second record from Liguria after the one from Ligurian Alps (TSB 33590). The species is included in the Italian red list of epiphytic lichens as "near-threatened" (Nascimbene *et al.*, 2013).

#Chaenotheca chrysocephala (Ach.) Th. Fr.
On bark of old *Castanea sativa* Mill. trees (19).
This is the second Ligurian report after the one near Upega in the Ligurian Alps (TSB33638).

Chaenotheca ferruginea (Sm.) Mig.
On bark of old *Castanea sativa* Mill. trees (1).

Chrysothrix candelaris (L.) J.R. Laundon
On bark of old *Castanea sativa* Mill. trees (1).

Circinaria calcarea (L.) A. Nordin, Savić & Tibell
On limestone (3).

Circinaria contorta (Hoffm.) A. Nordin, Savić & Tibell
On limestone (7).

Circinaria hoffmanniana (S. Ekman & Fröberg ex R. Sant.) A. Nordin
On limestone (7).

Cladonia coniocraea (Flörke) Spreng.
On bark and on wood of old *Castanea sativa* Mill. trees (1, 8, 11, 15, 19).

Cladonia digitata (L.) Hoffm.
On bark and on wood of old *Castanea sativa* Mill. trees (1, 5).

Cladonia fimbriata (L.) Fr.
On terricolous bryophytes (3), and on wood of old *Castanea sativa* Mill. trees (11).

****Cladonia floerkeana*** (Fr.) Flörke
On wood of old *Castanea sativa* Mill. trees (1, 19).
A circumboreal-mountain species found on soil or wood at the base of old trunks. It has an optimum in the sub-Alpine belt but is also known from Mediterranean locations such as the Tuscan Archipelago and Sardinia (Nimis & Martellos, 2023).
New to Liguria.

Cladonia parasitica (Hoffm.) Hoffm.
On bark and on wood of old *Castanea sativa* Mill. trees (1, 3).

Cladonia pyxidata (L.) Hoffm. **f.** ***pocillum*** (Ach.) Nyl**.**
On epilithic bryophytes (3).

Cladonia pyxidata (L.) Hoffm. **f.** ***pyxidata***
On epilithic bryophytes (1, 7, 12).

Cladonia rangiformis Hoffm**.**
On soil and epilithic bryophytes (3, 7, 12).

Cladonia squamosa Hoffm**. var.** ***squamosa***
On bark of old *Castanea sativa* Mill. (19).

Cladonia squamosa **var.** ***subsquamosa*** (Leight.) Vain.
On bark of old *Castanea sativa* Mill. (1, 5).
Compared to the typical variety, it is more hygrophytic and characterized by the presence of thamnolic acid. Already reported from a few locations in the Ligurian Apennines (Brunialti *et al.*, 1999; Gheza *et al.*, 2020; Watson, 2014).

Collema flaccidum (Ach.) Ach.
On bark of *Ostrya carpinifolia* Scop. (1, 3) and *Castanea sativa* Mill. (19).

Collema furfuraceum Du Rietz
On bark of *Castanea sativa* Mill. (12).

Collema nigrescens (Huds.) DC**.**
On bark of *Castanea sativa* Mill. (12).

Dendrographa decolorans (Sm.) Ertz & Tehler
On bark of *Castanea sativa* Mill. (1, 19).

Dermatocarpon miniatum (L.) W. Mann
On limestone (1, 5).

 # Dermatocarpon moulinsii (Mont.) Zahlbr.
On limestone (8).
It preferentially colonizes periodically wet siliceous rocks. The species was previously reported from Liguria in Val Bormida (Giordani & Brunialti, 2000).

Diploschistes gypsaceus (Ach.) Zahlbr.
On limestone (4).

Diploschistes muscorum (Scop.) R. Sant. **subsp.** ***muscorum***
On limestone (3).

Diplotomma chlorophaeum (Leight.) Kr.P. Singh & S.R. Singh
On limestone (7).

****Enchylium coccophorum*** (Tuck.) Otálora, P.M. Jørg. & Wedin
On soil (8).
This species colonizes calciferous soils in dry grasslands and is characterized by 1-septated ellipsoid spores. This is the third Italian report after those by Loppi *et al.* (1998) from Tuscany and Nascimbene *et al.* (2021) from Emilia-Romagna.

New to Liguria.
Enchylium tenax (Sw.) Gray
On limestone (7).
Evernia prunastri (L.) Ach.
On bark of deciduous trees and shrubs (1, 2, 3)
Flavoparmelia caperata (L.) Hale
On bark of deciduous trees (1, 2, 3).
Flavoparmelia soredians (Nyl.) Hale
On bark of deciduous trees (10,11).
Flavoplaca oasis (A. Massal.) Arup, Frödén & Søchting **f. *lithophila*** auct**.**
On limestone (3).
Fuscopannaria ignobilis (Anzi) P.M. Jørg.
On bark of *Castanea sativa* Mill. (11, 12, 18).
A Mediterranean-Atlantic species, rare but locally abundant in the study area in the crevices of large trees in humid chestnut groves.
 # *Fuscopannaria mediterranea* (Tav.) P.M. Jørg.
On bark of *Castanea sativa* Mill. (12).
Like the previous one but found only once in an old chestnut grove. Previously reported from Liguria (Giordani & Incerti, 2008).
**** Graphis pulverulenta*** (Pers.) Ach.
On bark of *Ostrya carpinifolia* Scop. (1), *Acer pseudoplatanus* L. (3) and *Castanea sativa* Mill. (13).
A species of the group of *G. scripta* with lirellae covered by an abundant white pruina.
New to Liguria.
Graphis scripta (L.) Ach.
On bark of *Ostrya carpinifolia* Scop. (1), *Acer pseudoplatanus* L. (3) and *Castanea sativa* Mill. (13).
 # *Gyalecta carneola* (Ach.) Hellb.
On bark of *Castanea sativa* Mill. (3, 15).
A species found in humid forests. It was already reported from Liguria in the Val d'Aveto (Nimis & Martellos, 2023), but it probably occurs also in other valleys of the Ligurian Apennines in old chestnut groves. It is included in the Italian red list of epiphytic lichens as "near-threatened" (Nascimbene *et al.*, 2013).
Gyalecta jenensis (Batsch) Zahlbr.
On limestone (3).
Gyalecta truncigena (Ach.) Hepp
On bark of *Castanea sativa* Mill. (1).
Gyalolechia flavovirescens (Wulfen) Søchting, Frödén & Arup
On limestone (3, 17).
Gyalolechia fulgida (Nyl.) Søchting, Frödén & Arup
On soil above limestone outcrops (3, 4, 9).
Hyperphyscia adglutinata (Flörke) H. Mayrhofer & Poelt
On bark of deciduous trees (11,12, 13).
Hypogymnia physodes (L.) Nyl.
On bark of deciduous trees (1, 2).
Imshaugia aleurites (Ach.) S.L.F. Mey.
On bark and wood of old *Castanea sativa* Mill. (1, 11).
In the Ligurian Apennines it is occasionally found on decorticated stumps, especially of old chestnut trees (Giordani *et al.*, 2009).
Lathagrium auriforme (With.) Otálora, P.M. Jørg. & Wedin
On epilithic bryophytes and periodically submerged limestone pavements (1).
Lathagrium cristatum (L.) Otálora, P.M. Jørg. & Wedin
On epilithic bryophytes and periodically submerged limestone pavements (1, 3, 20).
Lathagrium fuscovirens (With.) Otálora, P.M. Jørg. & Wedin
On limestone (1).
Lecania turicensis (Hepp) Müll. Arg.
On limestone (1,4).
Lecanora albella (Pers.) Ach.
On bark of *Castanea sativa* Mill. (1).
Lecanora argentata (Ach.) Malme
On bark of *Quercus cerris* L. (2).
Lecanora campestris (Schaer.) Hue
On limestone (4, 7, 9).
Lecanora carpinea (L.) Vain.
On bark of *Quercus cerris* L. (2), *Ostrya carpinifolia* Scop. and *Castanea sativa* Mill. (11).
Lecanora chlarotera Nyl.
On bark of deciduous trees (1, 2, 3, 4, 11,12).
Lecanora expallens Ach**.**
On bark of deciduous trees (3).
 # *Lecanora populicola* (DC.) Duby
On bark of *Ostrya carpinifolia* Scop. (1).
A cool-temperate to circumboreal-montane lichen found especially on *Populus tremula* and *Alnus* in the montane belt (Nimis & Martellos, 2023). The species is included in the Italian red list of epiphytic lichens as "data deficient" (Nascimbene *et al.*, 2013). This is the second Ligurian record after Baglietto's 19th century record from Voltri (TSB25865).
Lecanora pulicaris (Pers.) Ach.
On bark of *Quercus cerris* L. (2).
Lecanora strobilina (Spreng.) Kieff.
On bark of *Quercus cerris* L. (2).
Lecidella elaeochroma (Ach.) M.Choisy
On bark of deciduous trees (1, 2, 3, 4, 11, 12, 13).
Lepra albescens (Huds.) Hafellner
On bark of deciduous trees (1, 3, 11, 12, 13, 14).
Lepra albescens (Huds.) Haffelner **var**. ***corallina***
On bark of deciduous trees (3).
According to Nimis & Martellos (2023), it is a synonym of the nominal variety.
Lepra amara (Ach.) Hafellner
On bark of deciduous trees (1, 3, 13).
Lepraria eburnea J.R. Laundon
On limestone (1).
Lepraria nivalis J.R. Laundon
On limestone (17).
Leproplaca cirrochroa (Ach.) Arup, Frödén & Søchting
On limestone (9).
Leproplaca chrysodeta (Vain.) Ahti
On limestone (1).
A species found on steeply inclined surfaces of calciferous rocks. Rare, but likely overlooked.
Leproplaca xantholyta (Nyl.) Hue
On limestone (3).
A mild-temperate lichen of steeply inclined surfaces of limestone in shaded situations (Nimis & Martellos, 2023).
Lobothallia radiosa (Hoffm.) Hafellner
On limestone (1, 3, 4, 7).
**** Loxospora elatina*** (Ach.) A. Massal.
On bark of old *Castanea sativa* Mill. (1, 11).
This species has a predominantly boreal-mountainous distribution and is generally found on conifers (Nimis & Martellos, 2023). It is included in the Italian red list of

epiphytic lichens as "endangered" (Nascimbene *et al.*, 2013).
New to Liguria; first record outside the Alps in Italy.
Melanelixia glabratula (Lamy) Sandler & Arup
On bark of deciduous trees (1, 3, 12, 13).
Melanelixia subaurifera (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch
On bark of deciduous trees (1, 2, 3, 13).
 # *Melaspilea enteroleuca* (Ach.) Ertz & Diederich
On bark of *Castanea sativa* Mill. (3).
Following Ertz & Diederich (2015), Nimis & Martellos (2023) include the Italian specimens of *M. urceolata* in this taxon. According to this interpretation, the record from Rio Pentemina is the second one for Liguria after that of Giordani (2006) from the Ligurian Alps. On the other hand, the 19th-century record of Baglietto (sub *Buellia ricasolii*, 1857) cited by Nimis (1993) as from Liguria, being referred to Novi Ligure (in Piedmont), should be excluded. The species is included in the Italian red list of epiphytic lichens as "near-threatened" (Nascimbene *et al.*, 2013).
****Micarea elachista*** (Körb.) Coppins & R. Sant.
On bark and wood of old *Castanea sativa* Mill. (1, 15).
This species mainly colonizes deadwood stumps or the bark of old trees in chestnut groves; it is often associated with *Chaenotheca ferruginea*.
New to Liguria.
Mycobilimbia sphaeroides (Dicks.) S. Ekman & Printzen
On bark of *Castanea sativa* Mill. (1, 3, 13, 15).
It grows on epiphytic mosses in humid forests. Several old records are dubious and could refer to *Bilimbia sabuletorum*.
Naetrocymbe punctiformis (Pers.) R.C.Harris
On smooth bark of deciduous trees (1, 2, 3).
Nephroma laevigatum Ach.
On bark of *Castanea sativa* Mill. (12, 18).
Normandina pulchella (Borrer) Nyl.
On bark of deciduous trees (1, 3, 11, 18).
Ochrolechia pallescens (L.) A. Massal.
On limestone (3).
A temperate species resembling *O. parella*. In this checklist we maintain the distinction between the two species following the indications of Nimis (2023) according to whom, despite being morphologically similar, the two taxa have different ecology and distribution.
Ochrolechia parella (L.) A. Massal.
On limestone (3).
#*Ochrolechia szatalaensis* Verseghy
On bark of *Quercus cerris* L. (11). GE834
A cool-temperate to boreal-montane species with optimum in humid sites. The species is included in the Italian red list of epiphytic lichens as "least concern" (Nascimbene *et al.*, 2013).
Second Ligurian record after that of Baglietto, dated at least 130 years before (see sample S- F118654 'Ad fagos in Appennino Ligust. Olba', now Urbe, SV).
#*Ochrolechia turneri* (Sm.) Hasselrot
On bark of *Castanea sativa* Mill. (5).
In the humid sub-Mediterranean and montane belts it is very to extremely rare on isolated trees (Nimis and Martellos, 2023). Previously reported by Sbarbaro (1956) from Varazze (SV).
Opegrapha vulgata (Ach.) Ach.
On bark of *Castanea sativa* Mill. (11).
This species has an optimum in moist coniferous and deciduous forests. Although distributed in almost all of Italy, it is rather rare (Nimis & Martellos, 2023).
Pannaria conoplea (Ach.) Bory
On bark of *Castanea sativa* Mill. (12).
This rare species of the *Lobarion* community is sometimes found in the Apennines in old, preserved chestnut groves and other humid, open woodlands. It is included in the Italian red list of epiphytic lichens as "near-threatened" (Nascimbene *et al.*, 2013).
Parmelia saxatilis (L.) Ach.
On bark of deciduous trees (1, 2, 11, 12).
Parmelia sulcata Taylor
On bark of deciduous trees (1, 2, 3, 11, 12).
Parmeliella triptophylla (Ach.) Müll. Arg.
On bark of *Castanea sativa* Mill. (1, 11, 12, 18) and *Ostrya carpinifolia* Scop. (3).
A rare but widespread lichen found on old trees in humid forests, often in *Lobarion* communities. Locally common in preserved chestnut orchards of the study area. It is included in the Italian red list of epiphytic lichens as "near-threatened" (Nascimbene *et al.*, 2013).
Parmelina pastillifera (Harm.) Hale
On bark of deciduous trees (2, 3, 10, 11, 12, 19).
Parmelina quercina (Willd.) Hale
On bark of *Quercus cerris* L. (2), and *Castanea sativa* Mill. (19).
Parmelina tiliacea (Hoffm.) Hale
On bark of deciduous trees (10, 11, 12).
Parmeliopsis ambigua (Hoffm.) Nyl.
On bark of *Castanea sativa* Mill. (11, 19).
Parmotrema perlatum (Huds.) M. Choisy
On bark of *Castanea sativa* Mill. (1).
Parmotrema stuppeum (Taylor) Hale
On bark of *Castanea sativa* Mill. (1).
A temperate species that in Italy has a distribution limited to the best preserved and humid areas of the Tyrrhenian regions.
It is included in the Italian red list of epiphytic lichens as "vulnerable" (Nascimbene *et al.*, 2013).
Peltigera horizontalis (Huds.) Baumg.
On soil and terricolous bryophytes (1, 5, 19)
Peltigera neckeri Müll. Arg.
On soil and terricolous bryophytes (14, 22)
Peltigera praetextata (Sommerf.) Zopf
On epilithic and epiphytic mosses and on the bark of old *Castanea sativa* Mill. (1, 5, 11, 13, 18, 19).
Pertusaria coccodes (Ach.) Nyl.
On bark of *Acer pseudoplatanus L.* (3), *Quercus cerris* L. (11) and *Castanea sativa* Mill. (12).
Pertusaria flavida (DC.) J.R. Laundon
On bark of *Quercus cerris* L. (11).
Pertusaria hymenea (Ach.) Schaer.
On bark of *Castanea sativa* Mill. (11, 12).
Pertusaria leioplaca (Ach.) DC.
On bark of *Castanea sativa* Mill. (2, 12).
Pertusaria pertusa (L.) Tuck. **var. *pertusa***
On bark of deciduous trees (1, 3, 11).
Pertusaria pustulata (Ach.) Duby
On bark of *Castanea sativa* Mill. (11).

Phaeophyscia ciliata (Hoffm.) Moberg
On bark of *Fraxinus ornus* L. (11).
Phaeophyscia hirsuta (Mereschk.) Essl.
On limestone (4).
Phaeophyscia insignis (Mereschk.) Moberg
On bark of *Corylus avellana* L. (13).
Phaeophyscia pusilloides (Zahlbr.) Essl.
On bark of *Corylus avellana* L. (13).
Phlyctis agelaea (Ach.) Flot.
On bark of *Castanea sativa* Mill. (12), *Ostrya carpinifolia* Scop. (12) and *Corylus avellana* L. (13).
Phlyctis argena (Spreng.) Flot.
On bark of deciduous trees (1, 3, 12, 18).
Physcia adscendens H. Olivier
On bark of deciduous trees (1, 3).
Physcia aipolia (Humb.) Fürnr.
On bark of deciduous trees (10, 11).
Physcia leptalea (Ach.) DC.
On bark of deciduous trees (10, 11).
Physcia stellaris (L.) Nyl.
On bark of deciduous trees (2, 10).
Physcia tenella (Scop.) DC.
On bark of deciduous trees (2, 3, 10, 11, 12).
Physciella chloantha (Ach.) Essl.
On bark of *Corylus avellana L.* (13).
Physconia distorta (With.) J.R. Laundon
On bark of *Corylus avellana* L. (13) and *Castanea sativa* Mill. (19).
Physconia enteroxantha (Nyl.) Poelt
On bark of *Acer pseudoplatanus* L. (3).
Physconia grisea (Lam.) Poelt **subsp. *grisea***
On limestone (6).
Physconia perisidiosa (Erichsen) Moberg
On bark of *Fraxinus ornus* L. (11).
Placidium rufescens (Ach.) A. Massal.
On limestone (4, 7).
 # *Placopyrenium canellum* (Nyl.) Gueidan & Cl. Roux
Parasitic on *Circinaria* spp. (3).
A parasitic species of *Circinaria* in the first phase of its life cycle. Its presence in Italy is probably underestimated.
Second record from Liguria (Breuss, 2009).
Placynthium nigrum (Huds.) Gray
On limestone (3, 4).
Pleurosticta acetabulum (Neck.) Elix & Lumbsch
On bark of deciduous trees (6, 19).
****Porina aenea*** (Wallr.) Zahlbr.
On bark of *Corylus avellana L.* (13).
It has a Mediterranean-Atlantic distribution and colonizes various tree species with smooth bark, especially in humid and shady *Quercus* forests.
New to Liguria.
Protoblastenia rupestris (Scop.) J. Steiner **subsp. *rupestris***
On limestone (1, 3, 17).
Protoparmeliopsis versicolor (Pers.) M. Choisy
On limestone (3).
Pseudevernia f*urfuracea var. *ceratea (Ach.) D. Hawksw.
On bark of *Ostrya carpinifolia* Scop. (10).
It differs from the nominal variety due to the presence of olivetoric acid and a distribution more centered in dry continental areas (Martellos *et al.*, 2014).
Pseudoschismatomma rufescens (Pers.) Ertz & Tehler
On bark of *Castanea sativa* Mill. (1, 11, 12).
Psora testacea Hoffm.
On limestone (3).
Punctelia jeckeri (Roum.) Kalb
On bark of *Ostrya carpinifolia* Scop. (11).
It had previously been reported from Liguria in some locations in the Imperia area and the Eastern Riviera (Giordani *et al.*, 2009; Giordani & Incerti, 2008).
Punctelia subrudecta (Nyl.) Krog
On bark of deciduous trees (14).
Pyrenodesmia variabilis (Pers.) A. Massal.
On limestone (3).
Ramalina farinacea (L.) Ach.
On bark of *Corylus avellana* L. (13).
Ramalina fraxinea (L.) Ach.
On bark of deciduous trees (1).
Rhizocarpon distinctum Th. Fr.
On siliceous rock (3).
Rhizocarpon geographicum (L.) DC. **subsp. *geographicum***
On siliceous rock (3).
Rinodina sophodes (Ach.) A. Massal.
On bark of *Corylus avellana* L. (13).
Romjularia lurida (Ach.) Timdal
On limestone and soil (1, 3, 4).
****Scutula circumspecta*** (Vain.) Kistenich, Timdal, Bendiksby & S.Ekman
On bark of *Castanea sativa* Mill. (15).
This mild-temperate lichen is found on old trees in open, humid woodlands (Nimis & Martellos 2023).
New to Liguria.
Scytinium aragonii (Otálora) Otálora, P.M. Jørg. & Wedin
On epilithic bryophytes (1).
Scytinium gelatinosum (With.) Otálora, P.M. Jørg. & Wedin
On epilithic bryophytes (1).
Scytinium lichenoides (L.) Otálora, P.M. Jørg. & Wedin
On limestone and epilithic bryophytes (1, 3, 20, 22).
#*Scytinium plicatile* (Ach.) Otálora, P.M. Jørg. & Wedin
On limestone (1).
This species had previously been collected in Liguria in the 1920s by Sbarbaro in the Bisagno valley (Watson, 2014).
Scytinium pulvinatum (Hoffm.) Otálora, P.M. Jørg. & Wedin
On limestone (1, 4).
Scytinium teretiusculum (Wallr.) Otálora, P.M. Jørg. & Wedin
On bark of *Castanea sativa* Mill. (19).
Solenopsora candicans (Dicks.) J. Steiner
On limestone (1, 3).
Squamarina cartilaginea (With.) P. James **var. *cartilaginea***
On limestone (1, 3, 7).
Squamarina gypsacea (Sm.) Poelt
On limestone (1, 7, 9).
Staurothele immersa (A. Massal.) Dalla Torre & Sarnth.
On limestone (1).
Synalissa ramulosa (Bernh.) Fr.
On limestone (9).
****Tephromela atra* var. *calcarea*** (Jatta) Clauzade & Cl. Roux
On limestone (3).
New to Liguria.
Tephromela atra* var. *torulosa (Flot.) Hafellner
On bark of *Quercus cerris* L. (2).

Thalloidima opuntioides (Vill.) Kistenich, Timdal, Bendiksby & S.Ekman
On epilithic bryophytes (3) and on soil between limestone outcrops (8).
Thalloidima sedifolium (Scop.) Kistenich, Timdal, Bendiksby & S.Ekman
On limestone (4).
#*Thelidium olivaceum* auct.
On limestone (1).
A circumboreal-montane species of calcareous rocks. Previously collected by Sbarbaro on limestone in 1949 in Montallegro, Rapallo, province of Genova (F-1159746).
Thelidium papulare (Fr.) Arnold
On limestone (8, 17).
Thelopsis rubella Nyl.
On bark of *Castanea sativa* Mill. (12).
Found on old deciduous trees in areas with high rainfall. It is included in the Italian red list of epiphytic lichens as "least concern" (Nascimbene *et al.*, 2013).
Toniniopsis aromatica (Sm.) Kistenich, Timdal, Bendiksby & S.Ekman
On limestone (4).
Toniniopsis bagliettoana (A. Massal. & De Not.) Kistenich & Timdal
On terricolous bryophytes (3).
This species, which grows preferentially on terricolous bryophytes, in addition to the *locus typicus* in the Serino woodland (Lazzarin, 2000) in the Bisagno valley, has also been reported from Liguria in the Portofino park (GE498).
Trapeliopsis flexuosa (Fr.) Coppins & P. James
On lignum (1, 3).
Varicellaria hemisphaerica (Flörke) I. Schmitt & Lumbsch
On bark of *Quercus cerris* L. (11).
Variospora flavescens (Huds.) Arup, Frödén & Søchting
On limestone (3, 4).
#*Verrucaria dolosa* Hepp
On limestone (1).
It grows on small calcareous pebbles near the ground in sheltered situations. Recently reported from M. Fasce in the Eastern Riviera (Giordani *et al.*, 2016).
Verrucaria cfr hochstetteri Fr.
On limestone (17).
A poorly known taxon needing further studies. It is found on steeply inclined surfaces of compact limestone in sheltered situations.
Verrucaria nigrescens Pers**. f. *nigrescens***
On limestone (17). FI
#*Verrucaria papillosa* Ach**.**
On limestone (1).
This species, closely related to *V. viridula*, colonizes calciferous rocks in humid situations.
Second Ligurian record after Sbarbaro's from Spotorno in 1936 (F-47774514).
Xanthoparmelia conspersa (Ach.) Hale
On siliceous pebbles in limestone boulders (4).
Xanthoparmelia pulla (Ach.) O. Blanco, A. Crespo, Elix, D. Hawksw. & Lumbsch
On siliceous pebbles in limestone boulders (1).
Xanthoparmelia sublaevis (Cout.) Hale
On siliceous pebbles in limestone boulders (4).
A non-isidiate species similar to *X. stenophylla* but having sublinear lobes with subrotund to obtuse apices, an emaculate upper surface (Giordani *et al.*, 2002).
Xanthoparmelia verrucigera (Nyl.) Hale
On siliceous pebbles in limestone boulders (4, 8).
An isidiate species similar to *X. conspersa*, but containing lusitanic and verrucigeric acids (Giordani *et al.*, 2002; Rizzi & Giordani, 2013). Already reported from the Graveglia valley in the Eastern Riviera on jasper and serpentinite (Giordani *et al.*, 2009).
Xanthoria parietina (L.) Th. Fr.
On bark of deciduous trees (10, 13).

DISCUSSION AND CONCLUSIONS

The Rio Pentemina SAC hosts almost 1/5 of the Ligurian lichen diversity in less than 300 ha (i.e., 0.05% of the regional extension). There are many factors that determine the specific richness of a territory, first and foremost its area, based on the well-known Species Area Relationship (Gheza *et al.* 2023), but also environmental heterogeneity, which can be summarized by variables such as the width of the altitudinal gradient or the diversity of substrates (Bässler *et al.*, 2016; Lõhmus *et al.*, 2023). Comparing it with other geographically and environmentally equivalent areas, the lichen biota of Rio Pentemina is certainly rich (Gheza *et al.*, 2023), likely thanks to an altitudinal gradient of about 600 m and, above all, to its intermediate position between the Mediterranean and Continental biogeographic regions.

Chestnut groves, although often abandoned, and limestone outcrops in the sunniest and driest areas were among the most favorable habitats for lichens. The suitability of these habitats for lichens is well known (Kossowska, 2008; Matteucci *et al.*, 2012), and our observations highlight how a habitat-based approach, through the systematic identification and exploration of favorable sites in the area, facilitates the investigation of lichen biota (Nascimbene *et al.*, 2012; Vondrák *et al.*, 2018).

Although a small contribution to the knowledge of the lichen biota, this work supports the relevance of these studies, not only as a value per se, but also in broader ecological and conservation perspectives. Some data from our work confirm that the exploration of the Ligurian lichen biota (but this is probably true elsewhere) is still incomplete. For example, we found 14 species new to Liguria. These findings highlight several instances where the investigation of lichens is particularly challenging: i) taxa belonging to critical groups recently revised (or in need of revision), such as *Graphis pulverulenta* (in the *G. scripta* complex: Neuwirth & Aptroot, 2011) or *Verrucaria hochstetteri* (in the *V. hochstetteri* complex: Pykälä *et al.*, 2020); ii) taxa that were previously overlooked because they could only be identified by more in-depth methods, such as the analysis of secondary metabolites (as in the case of *Cladonia floerkeana*) or only recently reported from Italy (as *Candelariella boleana* (Ravera *et al.*, 2022); iii) overlooked species relegated to extremely localized microhabitats, such as the crevices of old trunks, as in the case of *Calicium adspersum*, or soil pockets in limestone outcrops, as in the case of *Enchylium coccophorum*.

Only partially superimposed on the contingent of species new to Liguria, i.e., just in the cases of *Arthonia vinosa* and *Loxospora elatina*, is the significant presence of 14 species

of conservation interest, included in the red list of Italian epiphytic lichens (Nascimbene *et al.*, 2013); in our case, these are mostly taxa of small size and/or difficult identification, such as *Melaspilea enteroleuca* or *Loxospora elatina*. No less important are the second reports from Liguria of several species after a century or more since the first, and in some cases only, report, as in the cases of *Ochrolechia szatalaensis* or *Verrucaria papillosa*. Among the taxa here reported, there are also two species recently described, *Scytinium aragonii* and *Candelariella boleana*, for which our observations represent a contribution to the knowledge of their distribution.

In conclusion, by enhancing the knowledge of the distribution of lichens, comprehensive species lists such as that of the Rio Pentemina represent a fundamental basis for planning proper conservation of endangered lichens (cf. Vondrák *et al.*, 2022; Nascimbene *et al.*, 2022).

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