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Enhancing lichen inventories in Italy: new records of *Cladonia*, *Nephroma* and *Peltigera* from the mountains of Lombardia

Abstract

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We report 510 records of 58 species belonging to the three lichen genera *Cladonia* P. Browne, *Nephroma* Ach. and *Peltigera* Willd. from 57 sites in the Prealps and Alps of Lombardia (Northern Italy). Four mountain sectors were investigated: the Orobic Prealps and Alps (19 sites), the Brescia Prealps (9 sites), the Adamello massif (8 sites), and the Rhaetian Alps (22 sites). *Cladonia* was represented by 39 species (415 records), *Nephroma* by 2 species (7 records), *Peltigera* by 17 species (88 records). Some relevant records are reported for species from each genus. Albeit all of the recorded species have been already reported from Lombardia and most of them are common and widespread, some records refer to species of conservation concern, and all of the data reported here can contribute at improving the knowledge on the distribution of these genera, which is at the base of a better understanding of their ecology and of any eventual conservation strategy.

Key words: Alps, biodiversity, lichens, macrolichens, Prealps.

Introduction

Lombardia is the second richest administrative region of Italy in number of reported lichen taxa (Nimis 1993, 2016). However, most information dates back to works published between the 19th and the half of the 20th century. In the last decades, only a few field studies took place, and just in narrow areas of the region (e.g. Gheza 2018, 2019a, 2019b; Gheza & al. 2018, 2020a). Furthermore, the lichenological exploration of Lombardia has been geographically unbalanced: wide areas have been studied in the eastern and northern part of the region mainly by Anzi (1860, 1862, 1864, 1866, 1868), Garovaglio (1838, 1843, 1844, 1864) and Valcuvia Passadore & al. (2002a, 2002b, 2003), whereas many other areas have been left almost unexplored by lichenologists.

In recent years, lichen inventories returned on the foreground also in Lombardia. After the publication of several scattered records (Gheza 2015, 2017; Ravera & al. 2016a,

2017a, 2017b, 2018a, 2018b, 2019a, 2019b, 2020, 2021; Nascimbene & al. 2021a), recent work focused more deeply on the lichen biota of upland areas of Lombardia (Gheza 2019a, 2019b, 2019c; Gheza & al. 2020a). The thorough study of well-delimited geographic areas is one way to improve knowledge on lichen diversity of a region. Another way is focusing on critical or interesting taxonomic groups, e.g. understudied genera, critical species complexes, red-listed or biogeographically interesting groups. Data collected in this perspective can greatly improve knowledge on biogeography and ecology of such species (e.g. Gheza & al. 2020b), and help elucidate their responses to environmental stresses (e.g. Vallese & al. 2021).

This is a first contribution aimed at improving the knowledge on the distribution of selected lichen taxonomic groups in Lombardia based on new field explorations. We selected three well-known and widespread macrolichen genera including species characterized by well-recognizable and morphologically conspicuous thalli, i.e. *Cladonia* P.Browne, *Nephroma* Ach., and *Peltigera* Willd. In spite of being easily recognizable at the genus level, species belonging to these three genera require skilled taxonomic expertise to be correctly recognized, which was not always accomplished in previous works; therefore, new investigations can add relevant information.

Materials and Methods

Study area and study sites

Specimens of the selected genera were collected in several sites within four sectors of the Prealps and Alps of Lombardia. The sites are sorted below according to the main orographic units found in Lombardia (SOIUSA classification, see Marazzi 2005). They belong to the Orobic Prealps and Alps, the Brescia Prealps, the Adamello massif and the Rhaetian Alps. For each site, municipality, province (SO: Sondrio; BS: Brescia; BG: Bergamo), name of the locality, coordinates (UTM WGS84 system, zone 32T), altitude and a short description of the main habitat(s) are reported. Depending on the case, coordinates and altitude refer either to the central point of the surveyed area or to the starting and ending points of the trail along which specimens were sampled.

Orobic Prealps and Alps

01. Rasura (SO), pathway between Rifugio Bar Bianco and the hut above it, 541396.5104968-540767.5104458, 1511-1762 m, subalpine coniferous forest mixed with subalpine pastures.
02. Gerola Alta (SO), pathway between Nasoncio and Faggeta del Dosso dei Cavalli, 542999.5102702-544285.5101026, 1034-1313 m, mixed forest with schist outcrops.
03. Corteno Golgi (BS), Valle di Campovecchio, 591687.5109734-591588.5108066, 1385-1526 m, mixed coniferous forest mixed with pastures and siliceous rock outcrops and screes.
04. Corteno Golgi (BS), Valle di Campovecchio, 593049.5111433-591801.5109898, 1193-1375 m, moist spruce forest mixed with pastures and a small village, with siliceous rock outcrops and dry walls along the trail.

05. Corteno Golgi (BS), surroundings of the church of San Martino, 595121.5113047, 967-981 m, schist outcrops (Scisti di Edolo formation) colonized by xero-thermophilous vegetation.
06. Corteno Golgi (BS), Dossi di Santicolo along the road between Edolo and Santicolo, 599613.5113742, 804-815 m, schist outcrops (Scisti di Edolo formation) colonized by xero-thermophilous vegetation at the road edge.
07. Sonico (BS), road between Calzaferro and Edolo, 602964.5112978-601738.5114040, 1180-752 m, spruce forest with schist outcrops (Scisti di Edolo formation) at the road edge.
08. Malonno (BS), picnic area of Calzaferro, 602937.5112559, 1165-1173 m, meadow with *Calluna vulgaris* shrub above schist outcrops (Scisti di Edolo formation) on a thermophilous slope.
09. Malonno (BS), road between Loritto and Malonno, 601397.5108335-602413.5110602, 652-979 m, broadleaved forest with schist outcrops (Scisti di Edolo formation).
10. Paisco-Loveno (BS), edge of the Foresta ERSAF Legnoli, 595837.5100683-596537.5101134, 1212-1371 m, montane spruce forest with clearings and schist outcrops, near a stream.
11. Paisco-Loveno (BS), road between Forno di Loveno and the Vivione Pass, 595548.5100546-594677.5100029, 1323-1447 m, montane spruce forest with clearings and schist outcrops.
12. Paisco-Loveno (BS), road between Forno di Loveno and the Vivione Pass, 594677.5100029-594071.5100534, 1447-1549 m, subalpine larch forest with green alder and creeping pine shrub and schist outcrops.
13. Schilpario (BG), pathway between Malga Gaffione and Laghetti delle Valli, 592189.5098972-591352.5098200, 1830-1976 m, subalpine grasslands with siliceous rock outcrops.
14. Schilpario (BG), surroundings of the Laghetti delle Valli, 590935.5097785, 1978-1992 m, alpine grasslands with siliceous rock outcrops near small alpine lakes.
15. Schilpario (BG), Valle del Venerocolino, 589997.5098418, 1414-1457 m, subalpine pastures with siliceous rock outcrops.
16. Schilpario (BG), Valle del Venerocolino, 588845.5097298-589773.5098022, 1136-1351 m, moist montane spruce forest.
17. Vilminore di Scalve (BG), trail between the hamlet Bueggio and the Diga del Gleno, 583268.5094822-583172.5095269, 1067-1164 m, siliceous rock outcrops along a stream.
18. Vilminore di Scalve (BG), pathway between the hamlet Nona and the Diga del Gleno, 581923.5094932-583113.5096115, 1329-1465 m, mixed forest with siliceous rock outcrops.
19. Angolo Terme (BS), surroundings of the skilifts of Vareno on Monte Pora, 584491.5081396, 1597-1603 m, subalpine pastures on calcareous substrate.

Brescia Prealps

20. Gianico (BS), surroundings of Lago Rondeneto, 597651.5077933, 1697-1753 m, subalpine pasture with siliceous rock outcrops and small transition mires.
21. Bienno (BS), Val Grigna, Casera Val Gabbia, 602749.5082650-602056.5082547, 1430-1532 m, subalpine pasture with schist outcrops surrounded by a spruce forest.

22. Bienno (BS), Val Grigna, pathway between Valle delle Forme and Put de Berto, 603185.5083205-602749.5082650, 1259-1430 m, cool and moist spruce forest along a stream.
23. Bienno (BS), Val Grigna, muletrack between Prestine and Valle delle Forme, 601744.5085652-603185.5083205, 901-1259 m, broadleaved forest with siliceous rock outcrops (Verrucano Lombardo formation).
24. Breno (BS), Val Arcina, pathway between Malga Arcina and Casinone di Arcina, 606423.5083208-606764.5082193, 1609-1772 m, subalpine pasture with scattered larches and rhododendron shrubs.
25. Breno (BS), Val Arcina, pathway between Rifugio Davaione and Malga Arcina, 606053.5084229-606423.5083208, 1506- 1609 m, subalpine mixed coniferous forest.
26. Breno (BS), Campolaro, secular spruce forest of Malga Cogolo, 605894.5084603, 1496-1520 m, montane spruce forest.
27. Bagolino (BS), pathway between Piana del Gaver and Malga Bruffione, 613427.5085024-614628.5084821, 1414-1757 m, mixed montane forest.
28. Bagolino (BS), pathway between Malga Bruffione and Laghetti di Bruffione, 614628.5084821-615839.5084663, 1757-1895 m, mixed subalpine forest with siliceous rock (Verrucano Lombardo formation) outcrops.

Adamello massif

29. Berzo Demo (BS), Sentiero della Memoria, 602983.5105410-602545.5105423, 851-933 m, *Calluna vulgaris* shrub above schist outcrops (Scisti di Edolo formation) on a thermophilous slope.
30. Berzo Demo (BS), Dos de la Crus, 603051.5105828, 1123-1175 m, montane heathland surrounded by siliceous rock outcrops with military trenches.
31. Saviore dell'Adamello (BS), trail between Saviore and Fabrezza, 608485.5104066-611058.5105549, 1273-1423 m, spruce forest with clearings and dry walls along the trail.
32. Sonico (BS), secular chestnut orchard of Villincampo, 604968.5112388, 758-815 m, secular chestnut orchard now unmanaged with schist outcrops (Scisti di Edolo formation).
33. Sonico (BS), Val Malga, surroundings of Malga Boiana, 606548.5110329, 1144-1257 m, moist spruce forest with clearings.
34. Sonico (BS), Val Malga, surroundings of Malga Montoffo, 607768.5109865, 1398-1514 m, spruce forest with clearings.
35. Temù (BS), Val Vallaro, pathway between Paghera and Monte Pornina, 610814.5120354-610218.5120787, 1470-1609 m, subalpine spruce forest.
36. Temù (BS), Val Vallaro, pathway between Stadolina and Paghera, 610828.5121667-610814.5120354, 1103-1470 m, montane spruce forest.

Rhaetian Alps

37. Villa di Tirano (SO), pathway circumnavigating the Pian Gembro peat bog, UTM WGS84 32T 588900.5113129, 1365-1400 m, mixed forest with xero-thermophilous clearings hosting heath-like vegetation and siliceous rock outcrops.

38. Edolo (BS), road in the surroundings of Guspessa, 596429.5114447-595733.5115818, 1320-1734 m, spruce-larch forest with clearings, pastures and a small peat bog.
39. Vezza d'Oglio (BS), Pianaccio, 604568.5123493, 2100-2127 m, pastures and subalpine shrub surrounding a peat bog.
40. Vezza d'Oglio (BS), Lago Seroti Inferiore, 604519.5125308, 2175-2198 m, pastures and siliceous rock outcrops surrounding an alpine lake.
41. Monno (BS), road between Monno and the church of San Giacomo, 602258.5119155-601348.5122405, 1252-1753, spruce forest with clearings and a small peat bog.
42. Ponte di Legno (BS), lower part of the Valle delle Messi, 615814.5128498-614786.5129519, 1607-1677 m, meadows and pastures with scattered trees, siliceous rock outcrops and dry walls along the trail.
43. Ponte di Legno (BS), middle part of the Valle delle Messi, 614786.5129519-614206.5130437, 1677-1737 m, meadows and pastures with an open larch grove and siliceous rock outcrops and screes.
44. Valdidentro (SO), pathway between Isolaccia and Baite di Pezzel, 597780.5147560, 1370-1635 m, mixed coniferous forest.
45. Valdidentro (SO), pathway between Baite di Pezzel and Dosso Le Pone, 597653.5146181, 1635-2150 m, subalpine mixed coniferous forest.
46. Valdidentro (SO), Dosso Le Pone, 598790.5146354, 2150-2300 m, rhododendron and blueberry shrub with siliceous rock outcrops.
47. Valdidentro (SO), surroundings of the road to the Passo del Foscagno near the beginning of the pathway to the Val Viola Bormina, 595585.5145819, 1810-1823 m, subalpine mixed coniferous forest.
48. Valdidentro (SO), pathway to Val Verva and Val Viola Bormina, 595219.5145665-593288.5144107, 1861-1917 m, subalpine mixed coniferous forest.
49. Valdidentro (SO), pathway to Val Verva, 593288.5144107-594497.5143890, 1917-2007 m, subalpine mixed coniferous forest with siliceous rock outcrops.
50. Valdidentro (SO), Val Verva, 594497.5143890-595560.5141627, 2007-2200 m, alpine shrub and grasslands with siliceous rock outcrops.
51. Livigno (SO), Passo del Foscagno, 592741.5149738, 2296-2317 m, alpine grasslands with siliceous rock outcrops.
52. Livigno (SO), Lago di Livigno, 589565.5160342, 1820-1840 m, pine shrub on calcareous substrate.
53. Valmasino (SO), upper part of the Val di Mello, 551654.5123186-552358.5123904, 1148-1425 m, moist spruce forest with granite outcrops and clearings.
54. Valmasino (SO), lower part of the Val di Mello, 550011.5122314-551654.5123186, 1064-1148 m, spruce forest with granite outcrops, dry walls, clearings and a small village.
55. Valmasino (SO), road between San Martino and Bagni di Masino, 546867.5120973, 1046-1050 m, granite outcrops along the main road.
56. Valmasino (SO), Bagni di Masino, 546299.5121115, 1141-1152 m, cool and moist old-growth beech forest along a stream and clearings within it.
57. Valmasino (SO), Bagni di Masino, 546331.5121272, 1158-1170 m, clearing in a moist coniferous forest.

Sampling and identification of lichen specimens

Specimens of the three selected genera were collected in the explored sites on all the available substrates.

For the identification, we used the keys by Gheza & Nimis (2021) for *Cladonia*, Nimis (2021) for *Nephroma* and Nimis & Benesperi (2020) for *Peltigera*. Morphology was studied by means of a binocular microscope. Spot tests with the most commonly used regents, i.e. potassium hydroxide, sodium hypochlorite and para-phenylendiamine, were performed. When needed, also thin-layer chromatography (TLC) was carried out, using the reagents A, B' and C (cf. Orange & al. 2010).

The specimens are retained in Gabriele Gheza's personal herbarium.

Nomenclature follows Nimis & Martellos (2021).

Results

Overall, we collected 510 records referred to 58 species: 415 records of 39 *Cladonia* species, 7 records of 2 *Nephroma* species and 88 records of 17 *Peltigera* species. The list, reported hereinafter, includes references to the sites in which each species was collected, short indications of all the substrates on which each species was collected, and indications of the metabolites detected by TLC, when it was performed.

***Cladonia arbuscula* (Wallr.) Flot.** – Sites 03, 12, 13, 14, 24, 25, 39, 43, 44, 46, 47, 49, 50, 51, 54, 55, 56. – On organic soil, dead wood, plant debris.

***Cladonia bellidiflora* (Ach.) Schaer.** – Sites 13, 47, 50, 51. – On mosses and soil on siliceous rock.

***Cladonia caespiticia* (Pers.) Flörke** – Sites 02, 03, 04, 09, 10, 11, 12, 16, 17, 18, 19, 22, 25, 32, 37, 42. – On organic soil, conifer stumps, bark at the base of *Picea abies* and *Betula* sp.

***Cladonia cariosa* (Ach.) Spreng.** – Sites 01, 06, 19, 31, 37, 38, 53. – On both siliceous and calcareous soil.

***Cladonia cenotea* (Ach.) Schaer.** – Sites 24, 43, 45, 47, 48, 49, 50. – On conifer stumps.

***Cladonia cervicornis* (Ach.) Flot.** – Sites 18, 35, 37, 47, 55, 56. – On siliceous soil and soil above granite.

***Cladonia chlorophaea* (Sommerf.) Spreng.** – Sites 01, 06, 07, 08, 09, 10, 13, 16, 17, 19, 21, 22, 24, 25, 29, 30, 34, 35, 37, 39, 43, 47, 53, 54, 55, 59, 60. – On soil on schist and granite, stones of dry walls, siliceous soil, conifer stumps, bark at the base of *Betula* sp. With fumarprotocetraric acid.

***Cladonia coccifera* (L.) Willd.** – Sites 01, 04, 06, 07, 08, 14, 17, 19, 24, 25, 37, 38, 45, 46, 49, 50, 53, 54, 55, 56. – On organic soil, soil above siliceous rock, stones of dry walls. With usnic acid and zeorin.

***Cladonia coniocraea* (Flörke) Spreng.** – Sites 01, 03, 04, 10, 11, 12, 15, 16, 17, 22, 23, 24, 25, 26, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 41, 43, 44, 47, 48, 49, 53, 54, 56. – On conifer stumps, bark of *Larix decidua*, *Picea abies*, *Betula sp*., dead wood, soil above siliceous sandstone and granite, siliceous soil.

***Cladonia crispata* (Ach.) Flot.** – Sites 45, 49, 50, 55. – On acidic soil and soil above granite.

***Cladonia decorticata* (Flörke) Spreng.** – Sites 06, 24, 39. – On soil above schist.

***Cladonia deformis* (L.) Hoffm.** – Sites 25, 50. – On organic soil.

***Cladonia digitata* (L.) Hoffm.** – Sites 01, 03, 04, 10, 11, 12, 15, 24, 25, 26, 28, 35, 36, 43, 44, 45, 47, 48, 49, 50, 37. – On conifer stumps and bark at the base of *Larix decidua*.

***Cladonia ecmocyna* Leight.** – Site 14. – On organic soil.

***Cladonia fimbriata* (L.) Fr.** – Sites 01, 03, 04, 07, 09, 10, 11, 12, 22, 31, 33, 34, 35, 36, 37, 41, 43, 44, 47, 48, 49, 53, 54, 56. – On conifer stumps, dead wood, bark at the base of *Alnus incana*, *Castanea sativa*, *Fagus sylvatica*, *Larix decidua* and *Picea abies*, soil above limestone, schist and granite, stones of dry walls, siliceous soil.

***Cladonia floerkeana* (Fr.) Flörke** – Site 25. – On organic soil.

***Cladonia foliacea* (Huds.) Willd.** – Site 48. – On soil above siliceous rock. With fumarprotocetraric acid, usnic acid and zeorin.

Cladonia furcata* (Huds.) Schrad. ssp. *furcata – Sites 01, 02, 03, 04, 06, 08, 10, 11, 12, 13, 14, 16, 18, 20, 21, 22, 24, 25, 27, 28, 31, 33, 34, 35, 37, 39, 41, 42, 43, 44, 45, 47, 48, 49, 53, 54, 55, 56. – On organic soil, soil above schist and granite, on stones of dry walls, on conifer stumps.

***Cladonia gracilis* (L.) Willd.** – Sites 45, 49, 50. – On organic soil and plant debris.

***Cladonia macilenta* Hoffm.** – Sites 03, 10, 32, 35, 43, 56. – On stumps of *Castanea sativa*, *Laburnum* sp. and *Picea abies* and on dead wood.

***Cladonia macroceras* (Delise) Hav.** – Sites 04, 13, 14, 18, 24, 25, 40, 43, 45, 46, 49, 50, 51, 52. – On organic soil, conifer stumps and plant debris.

***Cladonia macrophyllodes* Nyl.** – Sites 13, 46, 48, 49, 50. – On soil above siliceous rock.

***Cladonia merochlorophaea* Asahina** – Sites 47. – On bark at the base of *Larix decidua*. With merochlorophaeic acid, 4-0-methylcryptochlorophaeic acid and small amounts of fumarprotocetraric acid.

***Cladonia parasitica* (Hoffm.) Hoffm.** – Sites 32. – On chestnut stumps.

***Cladonia phyllophora* Hoffm.** – Sites 03, 25, 45, 47, 48, 49. – On organic soil.

***Cladonia pleurota* (Flörke) Schaer.** – Sites 01, 02, 04, 05, 06, 12, 13, 14, 15, 17, 18, 20, 21, 24, 25, 27, 28, 29, 35, 38, 39, 40, 41, 42, 43. – On organic soil and on soil above siliceous rock.

***Cladonia polycarpoides* Nyl.** – Sites 05, 06, 08, 29. – On soil above schist.

***Cladonia polydactyla* (Flörke) Spreng.** – Sites 34, 53. – On conifer stumps and soil above granite.

***Cladonia pulvinata* (Sandst.) Herk & Aptroot** – Sites 06, 08, 37. – On soil above schist and on siliceous soil. With psoromic acid.

***Cladonia pyxidata* (L.) Hoffm.** – Sites 01, 04, 05, 06, 08, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 27, 28, 29, 30, 31, 33, 34, 35, 36, 37, 38, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56. – On siliceous, calcareous and organic soil, soil above schist, granite and siliceous sandstone, on stone of dry walls, on dead wood and stumps.

***Cladonia ramulosa* (With.) J.R.Laundon** – Site 54. – On soil above granite.

***Cladonia rangiferina* (L.) F.H.Wigg.** – Sites 03, 04, 06, 12, 14, 18, 24, 25, 28, 35, 37, 39, 40, 43, 45, 46, 49, 50, 51, 52. – On organic soil, soil above schist and conifer stumps.

***Cladonia rangiformis* Hoffm.** – Sites 05, 06, 29. – On soil above schist.

***Cladonia rei* Schaer.** – Sites 05, 06, 17, 19, 29, 41, 56. – On soil above schist and granite and on calcareous soil. With homosekikaic acid and fumarprotocetraric acid.

***Cladonia squamosa* Hoffm.** – Sites 04, 12, 18, 21, 22, 24, 25, 37, 45, 46, 53, 54, 56. – On soil above schist and granite, on mosses above siliceous rock and on conifer stumps.

***Cladonia strepsilis* (Ach.) Grognot** – Sites 06, 14, 40. – On soil above schist. With baeomycesic acid, squamatic acid and strepsilin.

***Cladonia sulphurina* (Michx.) Fr.** – Sites 03, 24, 28, 39, 43, 45, 47, 49, 50. – On conifer stumps.With usnic acid and squamatic acid.

***Cladonia symphycarpa* (Flörke) Fr.** – Site 18, 52. – On calcareous soil and on soil above siliceous sandstone.

***Cladonia uncialis* (L.) F.H.Wigg.** – Sites 13, 14, 39, 40, 47, 50, 51. – On acidic soil.

***Nephroma parile* (Ach.) Ach.** – Sites 15, 18, 43, 48, 53, 57. – On mossy schist and bark of *Fagus sylvatica*. It is worthy to notice that it was looked for in the historical locality reported by Giacomini (1937) (= site 35), without success.

***Nephroma resupinatum* (L.) Ach.** – Site 57. – On bark of *Fagus sylvatica*.

***Peltigera aphthosa* (L.) Willd.** – Sites 22, 24, 43. – On mossy soil.

***Peltigera canina* (L.) Willd.** – Sites 02, 03, 04, 35, 53, 56, 57. – On mossy soil, siliceous rock, stones of dry walls.

***Peltigera collina* (Ach.) Schrad.** – Sites 53, 56, 57. – On mossy bark of *Fagus sylvatica* and *Fraxinus excelsior*, on mossy granite.

***Peltigera degenii* Gyeln.** – Sites 04, 16. – On mossy soil, siliceous rock, stones of dry walls.

***Peltigera didactyla* (With.) J.R. Laundon** – Sites 05, 06, 11, 27, 35, 42, 53, 57. – On soil above siliceous rock, stones of dry walls.

***Peltigera elisabethae* Gyeln.** – Sites 03, 04, 05, 10, 11, 12, 15, 31, 33, 43. – On mossy soil, siliceous rock, stones of dry walls.

***Peltigera extenuata* (Vain.) Lojka** – Site 02. – On a mossy concrete wall.

***Peltigera horizontalis* (Huds.) Baumg.** – Sites 07, 11, 18, 21, 53, 54, 56. – On mossy soil, siliceous rock, stones of dry walls, on bark at the base of *Acer pseudoplatanus*, *Fagus sylvatica*, *Fraxinus excelsior*.

***Peltigera lepidophora* (Vain.) Bitter** – Sites 09, 15, 31. – On soil above schist and siliceous sandstone.

***Peltigera leucophlebia* (Nyl.) Gyeln.** – Sites 16, 53. – On mossy soil, siliceous rock.

***Peltigera malacea* (Ach.) Funck** – Site 43. – On mossy soil, siliceous rock.

***Peltigera membranacea* (Ach.) Nyl.** – Sites 01, 03, 04, 11, 16, 31. – On mossy soil, siliceous rock, stones of dry walls.

***Peltigera neckeri* Müll. Arg.** – Sites 03, 04, 28, 33, 36, 53. – On mossy soil, siliceous rock.

***Peltigera polydactylon* (Neck.) Hoffm.** – Sites 03, 10, 56. – On mossy soil, siliceous rock.

***Peltigera praetextata* (Sommerf.) Zopf** – Sites 02, 06, 07, 10, 11, 15, 20, 21, 22, 31, 35, 56, 57. – On mossy soil, siliceous rock, stones of dry walls.

***Peltigera rufescens* (Weiss) Humb.** – Sites 05, 06, 15, 17, 21, 22, 23, 27, 29, 31, 35, 38, 42, 43, 54. – On soil above siliceous rock, stones of dry walls.

***Peltigera venosa* (L.) Hoffm.** – Site 49. – On organic soil.

Discussion

Altogether, we recorded 48% of the *Cladonia* species, 29% of the *Nephroma* species and 74% of the *Peltigera* species hitherto reported from Italy. Considering that the sites were scattered in just few sectors of the region, this suggests a high potential diversity of these three genera in Lombardia.

Most species of *Cladonia*, including uncommon ones (e.g. *C. bellidiflora*, *C. cariosa*, *C. ecmocyna*, *C. floerkeana*, *C. pulvinata*, *C. polydactyla*, *C. strepsilis*), have already been reported from Lombardia in the last decade, mainly due to the research interest of the First Author, that is focused on this genus. Contrariwise, *Nephroma* and *Peltigera*, in spite of being conspicuous and well-known genera, have been reported only scatteredly in the past from the region. In particular, some species of *Peltigera* have not been reported for a long time: *P. collina* since Anzi (1860), *P. didactyla* since Anzi (1862, 1866), *P. malacea* since the late 19th century (see literature cited by Nimis 1993) and *P. membranacea* since Giacomini (1937).

The four mountain sectors in which lichens were sampled have been explored very heterogeneously in the past. The Rhaetian Alps and the northern side of the Orobic Alps have been surveyed extensively by Anzi (1860, 1862, 1864, 1866, 1868) and Garovaglio (1838, 1843), and the Adamello massif was studied scatteredly by Giacomini (1937), Dalle Vedove & al. (2002), Nascimbene (2006) and Gheza (2019b). Conversely, the southern sector of the Orobic Alps and Prealps is overlooked, with just two small valleys already surveyed (Gheza 2019a; Gheza & al. 2020a), and the Brescia Prealps are still virtually unexplored.

Several records represent an improvement for the knowledge of the lichen biota also at the level of administrative sectors. The species *C. caespiticia*, *C. chlorophaea*, *C. macrophyllodes*, *C. merochlorophaea* have never been reported before from Valtellina nor from the Province of Sondrio. The species *C. cariosa*, *C. parasitica*, *C. pulvinata*, *C. polycarpoides*, *C. rei*, *P. degenii*, *P. didactyla*, *P. lepidophora*, *P. malacea* have never been reported before from Val Camonica nor from the Province of Brescia. *C. cariosa*, *C. macrophyllodes*, *C. strepsilis*, *N. parile*, *P. degenii*, *P. didactyla*, *P. leucophlebia*, *P. membranacea* have never been reported before from Val di Scalve nor from the Province of Bergamo. Understudied administrative districts of the region, such as the Province of Bergamo (Gheza 2019a, 2019c), can particularly benefit of these new data to deepen the basic knowledge that is necessary to eventually achieve the conservation of the lichen biota through protection and/or management.

Three species are listed among the species of conservation concern. The species *C. arbuscula* and *C. rangiferina* are listed in the Habitats Directive (Annex V) and therefore protected in Lombardia under the regional law "*Legge Regionale n. 10/2008 ("disposizioni per la tutela e la conservazione della piccola fauna, della flora e della vegetazione spontanea")*". They are common and widespread in the Alps (Nimis & al. 2018), and have both been assessed as "least concern" in Italy according to the IUCN criteria (Ravera & al. 2016b). *Nephroma resupinatum* is listed as "near-threatened" in the Red List of epiphytic lichens of Italy (Nascimbene & al. 2013).

Finally, some considerations about ecological preferences of the genera can be derived from the records presented here. In the montane belt, the sites richest in *Cladonia* are those in which pioneer vegetation is developed on the thin soil layer above exposed siliceous rock outcrops (e.g. sites 05, 06, 29, 37, 55), which was observed also under different cli-

matic conditions (e.g. in Liguria, Gheza & al. 2020b). The *Cladonia*-dominated communities observed in such situations have a partly similar composition to the terricolous lichen communities found in lowland dry habitats in the western Po Plain (Gheza 2018, 2020), which is enriched here by further species with higher-altitude distribution patterns. In the subalpine and alpine belts, the sites richest in *Cladonia* are high-altitude heaths (e.g. sites 13, 14, 24, 39, 40, 43, 46, 49, 50). The sites richest in *Peltigera* are shadier and wetter, as typically found in moist forests at the bottom of narrow valleys (e.g. sites 03, 04, 11, 16, 35, 54, 56, 57). *Nephroma* species are much rarer, and the only site that hosted both the recorded species was the moist old-growth beech forest at Bagni di Masino (site 56), where also the rare *Peltigera collina* was found.

Conclusions

The new records reported here contribute to improve the knowledge on the current distribution and the ecology of several species of the genera *Cladonia*, *Nephroma* and *Peltigera* in the upland part of Lombardia.

A better knowledge on the distribution of overlooked organisms, such as lichens, is very needed, since it is at the base of any conservation action, from the planning of management to the establishment of legal protection. Albeit the lichen biota of Italy has been already well studied (Nimis & Martellos 2021), its knowledge is in constant development, and any new record can help in updating and improving it (Nascimbene & al. 2021a). Furthermore, the usefulness of lichen inventories has now entered a new era, in which its fundamental role in supporting phylogenetic and ecological research must be recognized and valorized (Nascimbene & al. 2021b); under this perspective, the exploration of lichenologically overlooked areas should be encouraged and supported.

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