

Mediterranean Cladoniaceae

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Cladoniaceae

INTRODUCTION

The Old World Mediterranean Region lies in Southern Europe, Southeast Asia and Northern Africa, surrounding the Mediterranean Sea basin (Fig. 1). Although it represents only 1.6% of the land area of the planet, 10% of all known vascular plants grow in this region, 50% of which being endemic (Cowling *et al.* 1996). The dominant vegetation in this region is of sclerophyllous type, characterized by perennial, often small-sized leaves, usually covered with waxes. These woodlands have been managed for centuries to obtain pastures, resulting in agroforestry ecosystems characterized by scattered trees (21-40% of canopy) and an annual grass layer, with a savannah-like landscape. The successional stages of these forests are dominated by shrubs of *Fagaceae*, *Lamiaceae* and *Cistaceae* or *Pinus halepensis* formations (San-Miguel-Ayanz *et al.* 2016), with different designations, depending on the country. Species of genera with a paleotropical origin, such as *Myrtus*, *Phillyrea* and *Pistacea*, are also frequent. A transition to main nemoral European broadleaved forests occurs in the mountains and is constituted by warm-temperate deciduous trees (*Quercus* spp., *Fraxinus ornus*, *Ostrya carpinifolia* or *Acer* spp.) which occupy sub-mediterranean locations (Box & Fujiwara 2015). The region is considered one of the world biodiversity hotspots (Blondel & Aronson 1999) and the study of its flora has appealed many researchers (Maya *et al.* 2017). The paleogeologic and climatic events that have succeeded each other through time, along with the great orographical heterogeneity and the soil variety are responsible for the region's high floristic wealth. The dominant climate of the countries in this region is the so-called Mediterranean climate, characterized by the aridity of the summer season, often a prolonged absence of rainfall. Summer temperatures tend to exceed 35 °C, while winters are usually mild, although the continental areas may be subject to severe frosts. The western areas are more humid through the influence of the Atlantic Ocean. Nevertheless, a narrow strip with Atlantic climate is located in the Northern Iberian Peninsula and much of France. The Alps in Northern Italy and the Apennines in

Central Italy have a temperate climate in the lower levels, while above the treeline the climate is alpine (for more information see Nimis 2016). Most of Morocco, Algeria, Tunisia and Libya present desert climates.

The Mediterranean lichens have been more intensely studied in some countries for which a complete lichen flora or checklist exist. These countries are France (Ozenda & Clauzade 1970; Roux *et al.* 2014, 2017), Italy (Nimis 1993, 2016; Nimis & Martellos 2017; Nimis *et al.* 2018), Greece (Abbott 2009; Linda 2019), Spain and Portugal (Llimona & Hladun 2001). An important contribution to the Western European lichen flora was published by Clauzade & Roux (1985). The origin of many of these studies was an international project to prepare a checklist of the Mediterranean lichens (Nimis 1996). The cited works were forerunners of the study of the family *Cladoniaceae* in this region. Subsequently, monographic studies of the family, or of the genus *Cladonia*, as well as new records, have been published for the Iberian Peninsula (Burgaz & Ahti 2009; Pino-Bodas *et al.* 2013b, 2014), Greece (Sipman & Ahti 2011), Bosnia-Herzegovina and Croatia (Burgaz & Pino-Bodas 2012), Italy (Gheza *et al.* 2018), Turkey (Kocakoya *et al.* 2018), etc. However, still now the knowledge on the *Cladoniaceae* in the Mediterranean basin is much less complete than in Central and Northern Europe, where the distribution of most of the species is well known (Ahti & Stenroos 2013). This is the reason why we decided to carry out the study of the family *Cladoniaceae* for the countries surrounding the Mediterranean Sea, in order to compile a catalogue as complete as possible of the species present in the region, adding distribution maps of the species and data about their chemical variation.

The area under active study embraced the following countries or regions: Portugal, Spain, Andorra, Italy, Southern France, Malta, Croatia, Bosnia-Herzegovina, Montenegro, Albania, Greece, Cyprus, Turkey, Morocco, Algeria, Tunisia and Libya. All the authors have performed extensive field work in Spain and Portugal, but in order to carry out the present survey field work new



Fig. 1. Countries surrounding the Mediterranean basin. Modify from <https://d-maps.com/>.

Alb: Albania; B&H: Bosnia-Herzegovina; Kos: Kosovo; Mol: Moldova; Mon: Montenegro; N.Ma: North Macedonia; Slov: Slovenia; TRNC: Turkish Republic North Cyprus.

collections were made by the author Burgaz in some of the less surveyed countries: Albania, Greece, Malta, Croatia, Montenegro and Cyprus. In addition, new collections were made in Southern France, Southern Italy and Sardinia. The author Ahti has independently collected *Cladonia* in Sardinia, NE Italy, Greece and Turkey (there with Pino-Bodas). From the herbaria or literature we also added the presence of each species in San Marino, Egypt, Lebanon, Syria and Israel (including all Palestine).

Besides many Spanish and Portuguese herbaria, several other herbaria have been visited to achieve a more complete sampling: Florence (FI), Helsinki (H), Budapest (BP), Tbilisi (TBI). In addition, the author Ahti

has examined material in numerous other herbaria in course of many years, especially Paris (PC), London (BM), Stockholm (S), Uppsala (UPS), Vienna (W, WU), Berlin (B), Geneva (G) and Copenhagen (C). The species distribution maps have been drawn main using the material studied by Burgaz along with some bibliographic quotations; the sources are distinguished on the maps by means of different symbols, (▲) for the specimens studied and (●) for literature reports. This study is meant as a compendium of the knowledge on *Cladonia* in the countries that border the Mediterranean for a world monograph. It provides new records for several countries and extends the distribution of a number of species.

CLADONIACEAE

The family *Cladoniaceae* comprises about 500 species distributed in 18 genera (Stenroos *et al.* 2019), only three of them present in Europe, *Cladonia*, *Pilophorus* and *Pycnothelia*. Most of the species (ca. 475) belong to the genus *Cladonia* (Ahti 2000; Wijayawardene *et al.* 2018). The first stage of development begins with the formation of a prothallus, constituted by the hyphae from the germination of an ascospore. Almost immediately the prothallus contacts the alga, starting the lichenization and developing small squamules of dorsiventral structure which constitute the primary thallus. Most of the taxa have a mixed thallus, consisting of two parts, one basal, parallel to the substrate, called primary thallus and other erect, the secondary thallus. The secondary thallus consists of vertical structures, fruticulose, hollow, exceptionally solid, called podetia (when it is constituted by generative tissue) or pseudopodetia (when it is constituted by vegetative tissue). The taxonomy of the family is mostly based on the morphology of these structures, which can range from simple to very complex branching patterns.

The tips of the podetia may be linear, attenuated, then called subulate, or flaring on scyphi. The scyphi can be closed or perforated in the center, in which case are called funnels. The vegetative reproduction is dominant by means of soredia or frequently by dispersion of thallus fragments, while the true isidia are very rarely present in the *Cladoniaceae*. Numerous species have the podetia covered by squamules that also act as vegetative propagules. Most taxa form conidiomata or pycnidia, flask-shaped structures which act as spermogonia. They can be located on the primary thallus or at the apex of the podetia. The shape of the pycnidia varies from cylindrical to globose or pyriform, and the size is also variable. The conidia or pycnidiospores are simple, hyalines, from straight to falcate, contained on a hyaline or reddish slime which facilitate the release of the pycnidiospores. It can be observed in fresh specimens and has certain taxonomic value.

The ascomata are biatorine apothecia, a special type of lecideine apothecia without thalline exciple, while the true exciple disappears quickly. The apothecia are formed

at the apex of the podetia, more rarely they are sessile on the squamules or on a short stipe. The colour of the hymenium varies from dark, brown to almost black to light brown, but red colour hymenia also appear. The asci show an apical amyloid thickening (I+), with a clearer central channel, and are surrounded by a strongly amyloid tube of *Porpidia*-type. They contain 8 ascospores, which are simple, rarely with 1-3 septa, hyaline, from fusiform to ovoid. The paraphyses are simple and septate. The characters associated with the apothecia lack taxonomic value in most of the genera.

Anatomically, the thallus have a compact ectal layer called cortex, lacking in many species, made up of hyphae with short cells, with thickened walls and vertical orientation. The surface of the cortex is variable and has taxonomic value. Sometimes an epinecral layer outside the cortex exists. Under the cortex the algal layer appears, which can be continuous or discontinued by photobiont glomerules. Immediately below the algal layer the medulla is located, formed by lax hyphae. In many species, the boundary between the algal layer and the medulla is not clear. In the podetia, an additional layer, the stereome or inner medulla, is present under the medulla. It is constituted by cartilaginous hyphae with thickened walls. The inner surface of the stereome can be smooth to fibrous, hyaline or whitish. Longitudinal sections of the podetia are necessary to observe these characters. The photobionts found in symbiosis with *Cladoniaceae* belong to the genera *Asterochloris* (Tschermak-Woess 1989; Yahr *et al.* 2006; Moya *et al.* 2015), or rarely *Chlorella* (Peršoh *et al.* 2004), both unicellular green algae. Up to now eleven different species of *Asterochloris* have been found associated with the genus *Cladonia* (Škaloud *et al.* 2015; Kim *et al.* 2017), however a greater biodiversity is expected (Škaloud & Peksa 2010; Řídká *et al.* 2014; Moya *et al.* 2015). The *Pilophorus* species have regularly cyanobacterial symbionts in special structures called cephalodia, in addition to green algae.

Chemistry.- More than 70 different substances have been reported in *Cladoniaceae*, most of which are polyphenols. Ultraviolet (UV) light shed directly on the specimens is used to observe the fluorescence of some depsides and

depsidones. Traditional colour spot tests with reagents (such as KOH) used to detect lichen substances can fail when the concentration is low. Therefore, it is important to use thin layer chromatography (TLC) technique to identify the major secondary metabolites present in the specimens, since these compounds are very useful in species identifications of *Cladoniaceae*.

Habitat and distribution.- Most taxa of *Cladoniaceae* are terricolous, though several *Cladonia* species live on trees, shrubs or wood, and all *Pilophorus* species are saxicolous. They need enough light and humidity to develop. Some man-made environments are very favorable habitats for *Cladoniaceae*, such as roadsides or roads, as long as the traffic is not excessive. The family has a subcosmopolitan distribution, and *Cladonia* is the genus with the widest distribution. Many taxa have wide distribution (embracing several continents) although there are some species with restricted distributions, even local endemics. Only *Cladonia corsicana* and *C. graeca* are endemic for the Mediterranean region. Some other taxa, *C. foliacea*, *C. rangiformis* or *C. subturgida*, though not restricted to Mediterranean region are most abundant in it.

Phylogeny.- The *Cladoniaceae* family belongs to the order Lecanorales, Lecanoromycetes, Ascomycotina (Miadlikowska *et al.* 2014; Lücking *et al.* 2016). Based on a temporal scale, some authors have proposed to include under *Cladoniaceae* the families *Stereocaulaceae* and *Squamarinaceae* (Kraichak *et al.* 2018). In this study, however, we keep the traditional concept of *Cladoniaceae*, following Stenroos *et al.* (2019) and Lücking (2019). This is a monophyletic family closely related to *Stereocaulaceae* (Wedin *et al.* 2000; Stenroos *et al.* 2002; Miadlikowska *et al.* 2014). The genus *Cladonia* is closely related to a clade formed by *Pycnotbelia*, *Carassea* and *Metus*. The phylogenetic relationships of *Pilophorus* within the family *Cladoniaceae* are still unclear (Stenroos *et al.* 2019).

Remarks.- The *Cladoniaceae* is a family well studied in many regions of the world. But additional sampling is necessary in many regions (for instance Asia, Africa or South America). In the Mediterranean basin, the countries of North Africa have been poorly studied and new records are expected for the future. Most taxa are conspicuous and easily recognizable as belonging to *Cladoniaceae* due to their characteristic colour and thallus shape.

KEY OF THE GENERA PRESENT IN THE MEDITERRANEAN COUNTRIES

1. Primary thallus squamulose persistent or evanescent, or crustose evanescent *Cladonia*
1. Primary thallus crustose, always persistent 2
2. Podetia hollow, swollen, cephalodia no present *Pycnotbelia*
2. Podetia solid, no swollen, cephalodia always present *Pilophorus*

Cladonia P.Browne

Civ. Nat. Hist. Jamaica: 81, 1756, nom. cons.

Cladina Nyl., Not. Sällsk. Fauna Fl. Fenn. Förh. 8: 110, 1866.

Type species: (= *Lichen subulatus* L., Sp. Pl. 1148, 1753)

Cladonia subulata (L.) F.H.Wigg.

Prothallus black, brown or orange, subterranean. The main thallus is dimorphic. The primary thallus is squamulose, rarely subcrustose, persistent or evanescent, sometimes dominant. It has fruticulose podetia, 0.5-15 cm long, rarely shorter, generally hollow, very rarely solid, from simple to very branched. The branching pattern can be regular or more frequently irregular, isotomic or anisotomic, from dichotomous to polytomous. The podetial surface can be ecorticate, smoothly corticate, partially corticate, densely squamulose or sorediate. The wall of the podetia commonly has a cortex, algal layer, medulla and stereome, although the cortex and stereome may be absent. The surface of the stereome can be smooth, papillose, striated, reticulated or tomentose. Pycnidia are frequent and appear on the primary thallus or at the apex of the podetia, in a varied way, sometimes shortly pedunculated, dolioliform, pyriform or ampullaceous, with red or hyaline pycnidial slime, which has taxonomic value. Pycnidiospores are hyaline, in general, falciform or more rarely straight, $3-14 \times 0.5-1 \mu\text{m}$. The apothecia are brown, ochraceous, pink or red, usually formed at the apex of the podetia, very rarely sessile on the squamules of the primary thallus. The spores are simple, fusiform, ovoid or oblong, colourless, $6-24 \times 2-6 \mu\text{m}$, 8 per ascus. The spores have not taxonomic value because the sizes for the different species overlap.

Chemistry.- The *Cladonia* species produce numerous phenolic compounds of secondary metabolism, depsides, depsidones, dibenzofurans, terpenes and aliphatic acids.

Habitat and distribution.- *Cladonia* contains a set of epigeous, epiphytic and epilithic taxa, being most abundant on acidic substrates, although they also appear in basic soils. In the Mediterranean countries the common habitats for *Cladonia* are: heathlands and other shrub formations, open *Pinus* and *Quercus* forests or road banks. The genus has a cosmopolitan distribution, especially in humid areas, from the low tropical areas to the maritime Antarctic and Arctic areas, avoiding arid and semi-arid deserts. Several distributional patterns can be distinguished in the Mediterranean species. Many of them have wide distributions; others are restricted to Europe; Europe and Northern Africa; or Europe and Macaronesia.

Remarks.- Most of the traditional sections of *Cladonia* (Ahti 2000) are polyphyletic and a new infrageneric though informal classification, has tentatively been established based on phylogenetic results (Stenroos *et al.* 2019). It divides the genus *Cladonia* in eleven major clades. Species of nine of them are present in the countries that surround the Mediterranean Sea. The species identification within the genus *Cladonia* is one of the most intricate among the macrolichens. Several molecular studies have been carried out in order to establish the species boundaries in groups of closely related species (Pino-Bodas *et al.* 2013a; Steinová *et al.* 2013; Stenroos *et al.* 2015). However, numerous species complexes still need detailed studies, e.g. the *C. pyxidata* and *C. chlorophaea* groups.

GENERAL KEY OF THE MEDITERRANEAN SPECIES OF THE GENUS CLADONIA

1. Primary thallus developed, secondary thallus absent or very poorly developed 2
1. Primary thallus under developed or absent, secondary thallus with dominant development or equal development of the two parts of the thallus 34
2. Thallus forming a rosette with squamules firmly attached to the substrate 3
2. Thallus not forming a rosette of squamules firmly attached to the substrate 6
3. Squamules Pd+ red 4
3. Squamules Pd+ yellow or Pd- 5

4. Rosettes with squamules rounded, isolated at the beginning, convex, usually with granular edges
 *C. peziziformis*
4. Rosettes flat, with squamules thick, contiguous, and usually cracked *C. pyxidata* (morph *pocillum*)
5. Rosettes forming pulvinules, Pd+ yellow, C+ green, K-, UV+ white *C. strepsilis*
5. Rosettes flat, Pd-, C-, K+ yellow, UV- *C. galindezii*
6. Squamules small (< 1 cm), fragile, with irregular edges 7
6. Squamules bigger, not fragile 9
7. Squamules Pd+ yellow, C-, with split edge and coralloid appearance *C. parasitica*
7. Squamules Pd+ red or Pd- 8
8. Squamules Pd-, with margin soredate, small podetia with red apothecia *C. incrassata*
8. Squamules Pd+ red, with margin not soredate, small podetia (≤ 3 mm long) with brown or pale brown apothecia *C. caespiticia*
9. Squamules of the primary thallus with yellow or yellowish underside 10
9. Squamules of the primary thallus with underside of different colour 13
10. Squamules large (9-38 mm), intensely yellow 11
10. Squamules smaller (< 10 mm), pale yellow with darkened bases 12
11. Squamules rounded, underside cottony, Pd- *C. luteoalba*
11. Squamules elongate, with narrow lobes and deep lobulations, Pd+ red *C. foliacea*
12. Squamules white, underside yellowish grey *C. pulvinata*
12. Squamules brown, underside bluish grey *C. polycarpoides*
13. Squamules of primary thallus with soredate margins, base generally orange 14
13. Squamules of primary thallus esoredate, base not orange 16
14. Squamules rounded, with shallow lobulations, below and margins with fine soredia, 30-50 μm diam
 *C. digitata*
14. Squamules elongate, with deep lobulations, margin with granular soredia, 30-70 μm diam 15
15. Thallus Pd-, squamules up to 2 mm *C. unbricola*
15. Thallus Pd+ yellow, squamules 2-8 mm long *C. polydactyla*
16. Squamules brownish to dark brown on the underside 17
16. Squamules white below, bases can be white, blackened or yellowish 19
17. Squamules dark brown to brownish below, Pd+ red 18
17. Squamules brownish below, Pd- *C. deschatresii*

18. Squamules pruinose above, dark brown below, K+ yellow *C. firma*
 18. Squamules not pruinose, brownish to greyish blue below, usually K- *C. cervicornis*
19. Squamules Pd+ red or Pd- 20
 19. Squamules Pd+ yellow 31
20. Squamules Pd- 21
 20. Squamules Pd+ red 25
21. Squamules Pd-, K- 22
 21. Squamules Pd-, K+ yellow 23
22. Squamules small (0.5-3 mm), underside white, UV+ white *C. imbricarica*
 22. Squamules elongate (3-10 mm), incised, UV+ bluish white *C. callosa*
23. Squamules not fragile, < 10 mm long 24
 23. Squamules fragile, 12-25 mm long *C. subturgida* (chemotypes I and II)
24. Squamules 2-4 mm long, thin, not brownish at the tips *C. cariosa* (chemotypes I, IV)
 24. Squamules 4-6 mm long, thick, brownish at the tips, often pruinose *C. symphycarpa* (chemotype IV)
25. K-, squamules fragile *C. subturgida* (chemotypes V, VI)
 25. K+ yellow, squamules not fragile 26
26. Squamules elongate or rounded, with blackened base or whitish at lower side 27
 26. Squamules rounded, with base yellowish at lower side *C. macrophyllodes*
27. Base at lower side blackened 28
 27. Base at lower side whitish 29
28. Squamules elongate (6-10 mm), erect *C. subcervicornis*
 28. Squamules rounded (5-25 mm), with incurved apices *C. turgida*
29. Squamules fragile *C. subturgida* (chemotypes III, IV)
 29. Squamules not fragile 30
30. Squamules thin, not brownish at the tips *C. cariosa* (chemotypes III, V)
 30. Squamules thick, brownish at the tips, often pruinose *C. symphycarpa* (chemotype V)
31. Squamules elongate, K+ yellow or K+ yellow after red 32
 31. Squamules more or less rounded, K- *C. macrophylla*
32. Squamules K+ yellow *C. symphycarpa* (chemotype III)
 32. Squamules K+ yellow, slowly turning red 33

33. Squamules thin, not brownish at the tips *C. cariota* (chemotype II)
 33. Squamules thick, brownish at the tips, often pruinose *C. symphyarpa* (chemotypes I, II)
34. Primary thallus absent or very reduced, podetia developed, narrow, generally branched, ascyphose 35
 34. Primary and secondary thallus present, podetia scyphose or not, simple or little branched 81
35. Podetia without cortex, surface arachnoid (use hand lens!), without soredia, richly branched 36
 35. Podetia with cortex, smooth, sorediate or squamulose, simple, little branched or richly branched 44
36. Podetia Pd+ red 37
 36. Podetia Pd- 41
37. Podetia greyish white, K+ yellow 38
 37. Podetia grey or yellowish green, K- 39
38. Podetia with black stereome and white areolae at the base *C. stygia*
 38. Podetia without black stereome *C. rangiferina*
39. Podetia greyish, with apical ramifications dichotomous, deflexed in several directions *C. ciliata*
 39. Podetia yellowish green, with apical ramifications generally tri-, tetra- or pentachotomous 40
40. Podetia with ultimate branchlets tri-, rarely di- or tetrachotomous, generally unilaterally deflexed
 *C. arbuscula*
 40. Podetia with ultimate branchlets tri-, tetra- or pentachotomous, generally erect or very little deflexed
 *C. portentosa*
41. Podetial surface with continuous algal layer, thallus forming characteristic subglobose heads 42
 41. Podetial surface without continuous algal layer, thallus not forming characteristic subglobose heads ... 43
42. Podetia with ultimate branchlets uniformly dichotomous *C. mediterranea*
 42. Podetia with ultimate branchlets uniformly tetra- or pentachotomous *C. stellaris*
43. Podetia with ultimate branchlets di- or trichotomous, erect or slightly unilaterally oriented *C. mitis*
 43. Podetia with ultimate branchlets tri-, tetra- or pentachotomous, somewhat curved and podetia with curly appearance in general *C. portentosa*
- 44 (35). Podetia yellowish 45
 44 (35). Podetia not yellowish 51
45. Podetia not sorediate 46
 45. Podetia sorediate 49
46. Podetia with darkened apices, no crystals at surface 47
 46. Podetia without darkened apices, surface not shiny, in herbarium developing towards the tips abundant fine crystals on surface *C. zopfii*

47. Podetia with strongly darkened tips, frequently with narrow scyphi *C. amaurocraea*
 47. Podetia with darkened tips but never forming scyphi 48
48. Podetia with axils perforated, ultimate ramifications (di-), tri- or tetrachotomous ... *C. uncialis* subsp. *uncialis*
 48. Podetia with axils closed, ultimate ramifications dichotomous *C. uncialis* subsp. *biuncialis*
49. Apothecia brownish, on decaying wood or on soil 50
 49. Apothecia ochraceous, on rotting wood *C. bacilliformis*
50. On decaying wood *C. norvegica*
 50. On mosses or siliceous humous soil *C. cyanipes*
51. Podetia corticate over the entire surface, with few squamules, not soresiate 52
 51. Podetia corticate at the base or in the lower half, with numerous squamules or with soresia 62
52. Podetia Pd- 53
 52. Podetia Pd+ red or Pd+ yellow 56
53. Podetia with algal layer discontinuous, richly branched, sometimes with squamules, tips closed, UV-
 *C. rangiformis* (chemotype I)
 53. Podetia with algal layer continuous, simple or branched, axils open or closed, UV+ or UV- 54
54. Podetia less than 2 cm tall, yellowish green, always with ochraceous apothecia, axils closed, UV-
 *C. botrytes*
 54. Podetia taller, brown or whitish grey, apothecia uncommon, tips open, UV+ white 55
55. Podetia dark or pale brown, shiny, base strongly melanotic *C. subfurcata*
 55. Podetia yellowish brown to brownish olive, opaque, base not melanotic *C. crispata*
56. Podetia large (> 20 mm), closed or only tips longitudinally open in fertile specimens 57
 56. Podetia small (4-24 mm long), tips open but when dry they seem closed *C. corsicana*
57. Podetia with thick medulla, which breaks the cortex at the base and produces characteristic white spots . 58
 57. Podetia with thin medulla, that does not break the cortex at the base 59
58. Podetia with uniform dark brown colour, richly branched, occurs on basic soil
 *C. furcata* (morph *subrangiformis*)
 58. Podetia brownish green, darkened or fulvous at the base, simple or little branched, only appears altitudes
 above 1500 m, on acid or basic soil *C. macroceras*
59. Podetial base not darkened, fertile specimens sometimes with open tips 60
 59. Podetial base darkened or yellowish, tips never open 61
60. Podetia K-, with uniform colour, with continuous algal layer *C. furcata*
 60. Podetia K+ yellow, usually appearing pale or variegated in part, areolate, with discontinuous algal layer ..
 *C. rangiformis* (chemotypes II, III)

61. Podetia K+ yellow, glaucous, base yellowish, tips subulate, occasionally with wide (to 8 mm) scyphi
 *C. ecmocyna*
61. Podetia K-, brown to greenish, base not yellowish, tips subulate or with narrow scyphi (< 5 mm) .. *C. gracilis*
- 62 (51). Podetia squamulose, with a variable number of squamules, but distributed throughout the podetia ... 63
- 62 (51). Podetia with squamules only in the lower half, or without squamules or sorediate 68
63. Podetia Pd-, UV+ white 64
63. Podetia Pd+ red or Pd+ yellow, UV- 65
64. Apothecia red, tips not open *C. bellidiflora*
64. Apothecia brown, tips open *C. squamosa* (chemotype I)
65. Pd+ yellow *C. squamosa* (chemotype II)
65. Pd+ red 66
66. Podetial squamules small, < 1 mm long, axils closed or slightly perforated 67
66. Podetial squamules > 1 mm long, podetial tips always dichotomously branched, axils generally open
 *C. furcata*
67. Squamules largely fragments of the cortex that peel off, towards tips surface granulose not truly sorediate ..
 *C. scabriuscula*
67. Squamules bullate, base strongly melanotic inside podetia *C. islandica*
68. Podetia Pd+ red, Pd+ yellow or yellow later red 69
68. Podetia Pd- 76
69. Podetia Pd+ yellow, with red apothecia 70
69. Podetia Pd+ red or Pd+ yellow later red, without red apothecia 71
70. Podetia finely sorediate, with whitish appearance *C. macilenta* (chemotype I)
70. Podetia not finely sorediate, usually granular, without whitish appearance *C. floerkeana* (chemotype II)
71. Podetia Pd+ red 72
71. Podetia Pd+ yellow later red *C. acuminata*
72. Podetia totally sorediate 73
72. Podetia only sorediate in the upper half *C. cornuta*
73. Podetia brownish, UV+ white *C. rei*
73. Podetia greenish, UV- 74
74. Podetia simple or dichotomously branched, or forming scyphi 1-3 mm wide, frequently with long marginal
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1. *Cladonia acuminata* (Ach.) Norrl.
 in Norrlin & Nyl., Herb. Lich. Fenn. Index.: 3,
 no. 57a, 1875.

Cenomyce pityrea f. *acuminata* Ach., Syn. Meth. Lich.: 254, 1814.

TYPE: Switzerland, Schleicher 57-2 (H-ACH 1712E lectotype, Stenroos & Ahti, Ann. Bot. Fenn. 27: 318, 1991 '1990').

Cladonia acuminata subsp. *foliata* (Arnold) Vain., Acta Soc. Fauna Flora Fenn. 10: 79, 1894. - *Cladonia norrlinii* Vain. nom. illegit., Acta Soc. Fauna Flora Fenn. 53(1): 18, 1922.

ILLUSTRATIONS: Ahti & Stenroos (2013: 93); Stenroos *et al.* (2016: 155); Valcuvia Passadore & Gheza (2017: 103).

Primary thallus squamulose, persistent or evanescent, squamules 2-7 mm long × 1.4-3 mm wide, margin crenate. Podetia whitish-grey with the base darkened, 15-20 mm high × 1-2 mm wide, usually not widened, simple or and rarely branched near the tips, subulate. Surface partially corticate, sorediate in the apex and with squamules at the base. Apothecia uncommon, brown. Pycnidia at the

apex of the podetia or on the basal squamules, pycnidial slime hyaline.

Chemistry.- Pd+ yellow later red, K+ yellow later red, UV-. Atranorin, norstictic and connorstictic acids. Up to five chemotypes have been described in other regions of the world (Stenroos *et al.* 1992; Ahti 2000; Ahti & Stenroos 2013) but in Mediterranean countries only this chemotype is present.

Habitat and distribution.- It is a terricolous species that grows on basic substrates. It has a very irregular distribution in the Mediterranean countries growing from montane belt to the subalpine in the Eurosiberian region, being more frequent in Northern Italy (Nimis & Martellos 2017, Nimis *et al.* 2018) and in France where it is a rather rare species (Roux *et al.* 2017), only one record in Spain (Pino-Bodas *et al.* 2012a) and very scarce in Turkey (Osyczka *et al.* 2011; Yacizi *et al.* 2013). It is probably more frequent but overlooked. This species has a bipolar distribution it is most abundant in arctic to temperate and boreal montane regions with some outliers in South America (Ahti & Stenroos 2013).

Mediterranean countries.- France, Italy, Spain and Turkey.

Remarks.- In absence of podetia it can be mistaken for *C. cariosa* because the squamules of primary thallus are indistinguishable.

2. *Cladonia amaurocraea* (Flörke) Schaer. Lich. Helv. Spic. 1(1): 34, 1823.

Capitularia amaurocraea Flörke, Beitr. Naturk. 2: 334, 1810.

TYPE: Austria, Salzburg, Flörke 58 (BM lectotype, Ahti, Regnum Veg. 128: 66, 1993).

ILLUSTRATIONS: Ahti & Stenroos (2013: 93); Stenroos *et al.* (2016: 155); Valcuvia Passadore & Gheza (2017: 73).

Primary thallus evanescent. Podetia up to 50 mm long × 1 mm wide, internode length 4–6 mm, slender, anisotomous to dichotomous, occasionally scyphose with proliferations in the margin of the scyphi, light yellow, brownish apices, axils closed or slightly open. Surface not shiny, smoothly corticate. Internal surface of the podetia striated. Apothecia very rare, brown. Pycnidia at the apex of the podetia, with hyaline slime.

Chemistry.- Pd–, K–, KC+ yellow, UV–. Usnic, barbatic and 4-*O*-demethylbarbatic acids.

Habitat and distribution.- A terricolous species growing among rocks in open forested areas and shrublands of the Eurosiberian region. Very rare in Mediterranean countries only few records in the Eurosiberian region of Bosnia-Herzegovina (Kušan 1953), France (Roux *et al.* 2017) and Italy (Nimis *et al.* 2018) growing in montane, subalpine and alpine belts with long periods covered by snow and near the treeline. It has a circumpolar distribution (Europe, Asia and North America) in Arctic and Boreal zones with continental tendencies (Litterski & Ahti 2004; Ahti & Stenroos 2013).

Mediterranean countries.- Bosnia-Herzegovina, France and Italy.

Remarks.- Earlier this species was regarded as closely related to *C. uncialis* but molecular studies showed that both species are not phylogenetically related (Stenroos *et al.* 2019). At the moment is the only species included in the Clade *Amaurocraeae*. It can be mistaken for *C. uncialis* subsp. *biuncialis* because of the sometimes dichotomous apices, but the latter taxon never contains barbatic acid.

3. *Cladonia arbuscula* (Wallr.) Flot. subsp. *arbuscula* in Wendt, Thermen Warmbrunn: 94, 1839.

Patellaria foliacea var. *arbuscula* Wallr., Naturgesch. Sülchen-Flecht.: 169, 1829.

TYPE: Germany, Thuringia, Nordhausen, Wallroth, Tafel 261 (STR lectotype, Ruoss & Ahti, Nova Hedwigia 41: 151, 1985).

Cladonia arbuscula subsp. *squarrosa* (Wallr.) Ruoss, Bot. Helv. 97: 260, 1987. - *Cladina arbuscula* (Wallr.) Hale & W.L.Culb., Bryologist 73: 510, 1970. - *Cladina arbuscula* subsp. *squarrosa* (Wallr.) Burgaz, Nova Hedwigia 55: 38, 1992.

ILLUSTRATIONS: Wirth (1995: 294); Barreno & Pérez-Ortega (2003: lam. 32); Wirth *et al.* (2004: 71); Burgaz & Ahti (2009: 19); van Haluwyn *et al.* (2012: 179); Ahti & Stenroos (2013: 94); Wirth *et al.* (2013: 390); Stenroos *et al.* (2016: 156); Valcuvia Passadore & Gheza (2017: 31).

Primary thallus evanescent, difficult to observe. Podetia 45–75 mm long, the length of the longest internode is 4–12 mm, with anisotomous branching, rarely subisotomous, main axes 1.1–2 mm wide, richly branched, more densely near the apex, usually oriented to the same side or not curved, and open in all directions, branching predominantly trichotomous and tetrachotomous, although sometimes also dichotomous, axils perforated, grey-green, whitish grey to yellowish grey. Surface decorticate, generally felty, mainly with discontinuous algal layer, rarely continuous. Apothecia not found in our area. Pycnidia dark, with hyaline slime, located at the apex of the podetia.

Chemistry.- There are three major chemotypes. Chemotype I: Pd+ yellow, K–, C–, UV–. Usnic and psoromic acids. Chemotype II: Pd+ red, K–, C–, UV–. Usnic and fumarprotocetraric acid complex. Chemotype III: Pd–, K–, C–, UV–. Usnic acid only. The most common in Southern European specimens is chemotype II. The chemotype I has a restricted distribution to the Alps in Italy (Nimis *et al.* 2018).

Habitat and distribution.- It grows on acidic and mineral soils among the mosses in heathland and open beech forests or pine formations. It is rare and local in the Mediterranean countries being more frequent in the Eurosiberian region than in the Mediterranean region, from colline to alpine belts and supramediterranean belt. According to Ravera *et al.* (2016) its populations are

declining but this species is not considered endangered in Italy. It has a bipolar distribution, from temperate to Arctic and Antarctic regions (Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, Algeria, Bosnia-Herzegovina, Croatia, France, Italy, Montenegro, Portugal, Slovenia, Spain, Tunisia and Turkey.

Remarks.- Several subspecies have been described. Ruoss (1987) considered that only specimens with psoromic acid belong to *C. arbuscula* s. str., while those containing fumarprotocetraric acid (rarely only usnic acid) should be considered as a different taxon, *C. arbuscula* subsp. *squarrosa*. The chemical differences are not clearly correlated with morphological characters (Ahti 2000) and genetic differences have not been found at the moment (fresh material of *C. arbuscula* never caught for phylogenetic studies; Piercey-Normore *et al.* 2010). The molecular variation within this group is still poorly understood and there are probably cryptic species present (Piercey-Normore *et al.* 2010; Athukorala *et al.* 2016). Morphologically it is very similar to *C. mitis* (see the discussion under this species). The reports from Algeria and Tunisia need confirmation.

4. *Cladonia asahinae* J.W.Thomson J. Jap. Bot. 51: 361, '1976' 1977.

TYPE: United States of America, Washington, Skagit Co., Fidalgo Island, Mt. Erie S of Anacortes, 1969 Thomson 16296 (WIS holotype).

ILLUSTRATIONS: Brodo *et al.* (2001: 238); Burgaz & Ahti (2009: 33); Ahti & Stenroos (2013: 94); Osyczka (2013: 62); Stenroos *et al.* (2016: 157).

Primary thallus squamulose, persistent, small squamules with crenulate margin, 2-3 mm long × 3-4 mm wide, olive green on upper surface, white below. Podetia scyphose, 6-10 mm long × 2-3 mm wide, greyish green. Surface corticate at the base, granulose or slightly soresiate. Apothecia not found. Pycnidia dark brown, almost black, located on the margin of the podetia.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. In the Mediterranean countries, only one chemotype was found, containing fumarprotocetraric acid complex and rangiformic acid. However, this species is chemically very variable and other three chemotypes have been described (Brodo & Ahti 1996).

Habitat and distribution.- It grows on small steps of acidic rocks and on slopes. In the Mediterranean countries it was only found in the Iberian Peninsula and even there is very rare, usually growing above 1500 m altitude in the mountains of Northern sub-plateau. It probably is more common but overlooked and reported as *C. chlorophaea* in absence of chemical studies. There are very few reports of this taxon in Europe, more common in Western Europe probably because it has oceanic preferences (Holien & Tønsberg 1985). It is known from Asia, Western North America, Southern South America and Antarctica (Stenroos *et al.* 1992; Hammer 1995; Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, Portugal and Spain.

Remarks.- It belongs to the group of *C. chlorophaea* s. lat. and some authors considered it as a mere chemotype (James 2009). However, we believe that some morphological differences such as the presence of podetia with granules or thick soresia, confer it a species rank.

5. *Cladonia bacilliformis* (Nyl.) Sarnth. Österr. Bot. Z., 46: 264, 1896.

Cladonia carneola var. *bacilliformis* Nyl., Syn. Meth. Lich., 1(2): 201, 1860.

TYPE: Finland, Uusimaa, Helsingfors (Helsinki), 1858 Nylander (H holotype).

ILLUSTRATIONS: Ahti & Stenroos (2013: 94); Stenroos *et al.* (2016: 158).

Primary thallus squamulose, usually evanescent. Podetia 5-25 mm long × 1 mm wide, yellowish green, apiculate and later with narrow scyphus, simple or branched near the apex. Surface soresiate, with soresia farinose. Apothecia not frequent, at the scyphus margin, ochraceous. Pycnidia common, at the apex of the podetia, hyaline pycnidial slime.

Chemistry.- Pd-, K-, KC-, C-, UV-. Usnic, barbatic and 4-O-demethylbarbatic.

Habitat and distribution.- It grows on rotten woods and stumps of coniferous trees. This is a very rare species in the Mediterranean countries only reported of Croatia (Kušan 1953), Montenegro (Strasser *et al.* 2015), Italy (Nimis *et al.* 2018) and Spain (Etayo 2010) growing in montane to subalpine belts of the Eurosiberian region.

It has a bipolar distribution with continental tendencies, common in Scandinavia and some outposts in Southern South America (Stenroos 1995; Litterski & Ahti 2004; Ahti & Stenroos 2013).

Mediterranean countries.- Croatia, France, Italy, Montenegro and Spain.

Remarks.- It can be mistaken for *C. macilenta*, both species have subulate podetia with sorediate surface, but the presence of ochraceous apothecia and usnic acid are good characters to identify the present species. The podetia of *C. bacilliformis* are more yellowish.

6. *Cladonia bellidiflora* (Ach.) Schaer.

Lich. Helv. Spic. 1(1): 21, 1823.

Lichen bellidiflorus Ach., Lichenogr. Suec. Prodr.: 194, 1799 '1798'.

TYPE: Sweden (H-ACH 1569A, lectotype, Ahti, Regnum Veg. 78: 68, 1993).

ILLUSTRATIONS: Wirth (1995: 316); Brodo *et al.* (2001: 240); Burgaz & Ahti (2009: 55); van Haluwyn *et al.* (2012: 153); Ahti & Stenroos (2013: 94); Wirth *et al.* (2013: 391); Stenroos *et al.* (2016: 159).

Primary thallus squamulose. Squamules elongate and ascending, 9-22 mm long \times 2-4 mm wide, deeply toothed (4-6 mm), greenish yellow in upper part, yellowish brown (K+ brown-purple) towards the base and in the lower side. Podetia 20-30 mm long \times 3 mm wide, greenish-grey to greenish-yellow, straight or somewhat twisted, thinned at apex, unbranched, granulose corticate at the base, often densely covered with squamules, 2-3 \times 1-2 mm, easily detached from the podetia, given a decorticate look once they have fallen, never sorediate. Apothecia very common, up 0.8 mm diameter, red, sessile or in short prominences, sometimes clustered at the apex of the podetia. Pycnidia very rare, with red slime.

Chemistry.- Pd-, K-, KC+ yellow, C-, UV+ white. Usnic and squamatic acids. Other chemotypes have been described from South America (Stenroos *et al.* 1992).

Habitat and distribution.- It grows on acidic bare soils, high mountain heathlands, mossy rocks or pine forests. Rare species in the Mediterranean countries but common in the Pyrenees and the Alps (Burgaz & Ahti 2009; Roux *et al.* 2017; Nimis *et al.* 2018). It is distributed in the alpine, montane and supramediterranean belts. It has a wide distribution in the Arctic and Boreal regions

of the North Hemisphere but is scarcer in the Southern Hemisphere (Litterski & Ahti 2004).

Mediterranean countries.- France, Italy, Portugal, Slovenia, Spain and Turkey.

Remarks.- In absence of apothecia it can be mistaken for *C. squamosa*, both species having podetia covered with numerous squamules. But *C. bellidiflora* is distinguished from *C. squamosa* by the closed podetia and the yellowish colour of the thallus.

7. *Cladonia borealis* S.Stenroos

Ann. Bot. Fenn. 26: 160, 1989.

TYPE: Finland, Etelä-Häme, Ylöjärvi, Pengonpohja, 1905, Sola (H holotype).

ILLUSTRATIONS: Wirth (1995: 299); Brodo *et al.* (2001: 241); Burgaz & Ahti (2009: 22); Ahti & Stenroos (2013: 94); Stenroos *et al.* (2016: 159).

Primary thallus squamulose. Squamules crenulated and ascending, 2-4 mm long \times 2-3 mm wide, scarce divided (1-1.5 mm) and forming rounded lobes, greyish green on upper surface, white below. Podetia scyphose, greenish yellow to greyish green, 6-11 mm long \times 4-9 mm wide, rarely with proliferations in the margin, gradually flaring, podetia with corticate and areolate base, 0.8-1.5 mm wide, top with flattened plates of 0.2-0.8 mm, detached as vegetative propagules. Apothecia red, very rare. Pycnidia at the margin of the podetia.

Chemistry.- Pd-, K-, KC+ yellow, C-, UV-. Usnic, barbatic and 4-O-demethylbarbatic acids.

Habitat and distribution.- It is a rare species in the Mediterranean countries being more frequent in the Northern Iberian System, Pyrenees and Alps (Roux *et al.* 2017; Nimis *et al.* 2018) growing on acidic bare soils, in high mountain heathlands, *Fagus*, *Abies* or *Pinus* forests near treeline. It is distributed in the alpine, montane and supramediterranean belts. It has a bipolar distribution with scattered populations on mountains of temperate regions in both hemispheres, particularly abundant in Boreal and Arctic regions (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Andorra, France, Greece, Italy, Montenegro, Spain and Turkey.

Remarks.- This species can be mistaken for other scyphose species with red apothecia, such as *C. coccifera*, *C. diversa* or *C. pleurota*. For long time it was considered as

a chemotype of *C. coccifera* but the chemical differences were correlated with morphological features (Stenroos 1989). *Cladonia borealis* has mostly smooth corticate podetia with flat plates, while the podetia of *C. coccifera* are areolate corticate with bullate to globose granules. *Cladonia pleurota* can be distinguished by the sorediate podetia and *C. diversa* by the presence of microsquamules.

8. *Cladonia botrytes* (K.G.Hagen) Willd.
Fl. Berol. Prodr.: 365, 1787.

Lichen botrytes K.G.Hagen, Tent. Hist. Lich.: 121, t. 2, fig.9, 1782.
TYPE: [Poland], in silva Wilky et prope Tieffensee, icon in Hagen, Tent. Hist. Lich. t. 2, fig. 9 (first specimen from left), 1782 (lectotype, Ahti, Regnum Veg. 128: 69, 1993); Poland, Bory Tucholskie, 1990 Faltynowicz & Miadlikowska, Lich. Polon. Exs. no. 6 (H epitype, Ahti & Stenroos, Nordic Lich. Fl. 5: 91, 2013).
ILLUSTRATIONS: Wirth (1995: 317); Brodo *et al.* (2001: 241); Ahti & Stenroos (2013: 94); Stenroos *et al.* (2016: 160); Valcuvia Passadore & Gheza (2017: 205).

Primary thallus squamulose, persistent but inconspicuous. Podetia no scyphose, unbranched or dichotomous branched near the apices, axils closed, 20-30 mm long × 0.3-1.5 mm wide, greyish yellow. Surface corticate, areolate or verruculose. Apothecia ochraceous to pale brown, frequent, up 1.5 mm diameter, at the apex of the podetia usually grouped. Pycnidia dark almost black, on the primary thallus, sessile but prominent, cylindrical, constricted at the base, with hyaline slime.

Chemistry.- Pd-, K-, KC+ yellow or KC-, UV-. Usnic, barbatic and 4-O-demethylbarbatic acids.

Habitat and distribution.- This is a lignicolous species growing on coniferous stumps, usually on horizontal surfaces. It is very rare in the Mediterranean countries only found in the Italian Alps (Nimis *et al.* 2018), Montenegro (Žukovec 2005) and Slovenia (Grube *et al.* 1998). It has a circumpolar boreal and northern temperate distribution (Ahti & Stenroos 2013).

Mediterranean countries.- Italy, Montenegro and Slovenia.

Remarks.- It is a species easily recognizable by its often present ochraceous apothecia. In addition, it is the only lignicolous species with ochraceous apothecia present in the Mediterranean countries.

9. *Cladonia caespiticia* (Pers.) Flörke
De Cladon.: 8, 1828.

Baeomyces caespiticus Pers., Ann. Bot. (Usteri) 7: 155, 1794 '1793'.

TYPE: No locality, Persoon (H-ACH 1722A lectotype, Ahti, Regnum Veg. 146: 69, 1993).

ILLUSTRATIONS: Wirth (1995: 318); Brodo *et al.* (2001: 242); Burgaz & Ahti (2009: 67); van Haluwyn *et al.* (2012: 73); Ahti & Stenroos (2013: 95); Wirth *et al.* (2013: 382, 392); Stenroos *et al.* (2016: 160); Valcuvia Passadore & Gheza (2017: 105).

Primary thallus squamulose, persistent. Squamules small, 1-10 mm long × 2-5 mm wide, with crenulate margin, sometimes finger like, yellowish green in the upper surface, very finely arachnoid white on the underside. Podetia not very often encountered, generally not visible due to its small size, 1-5 mm long × 0.4-1.5 mm wide, simple, cylindrical or clavate, decorticate, slightly striated, very rarely with squamules, almost translucent, because they do not present algal layer. Apothecia frequent, at the tip of the podetia, 0.7-1.5 mm diameter, light brown to dark, peltate, generally solitary. Pycnidia in the primary thallus, ovoid to conical, constricted at the base, with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex.

Habitat and distribution.- It grows at the base of mossy trees, freshly cut wood, especially of deciduous trees and in the interior of little altered forests, less frequently it can be found on road slopes. It is common in the Eurosiberian region, being very rare in the Mediterranean region, where only grows in subhumid and humid environments. It is a widespread species, present in temperate regions of Europe, North America, Asia and Macaronesia, with few records in Brazil (Ahti 2000; Litterski & Ahti 2004)

Mediterranean countries.- Albania, Algeria, Croatia, France, Greece, Italy, Morocco, Portugal, Slovenia, Spain and Turkey.

Remarks.- It form large mats at the base of mossy trees, on road slopes or wood remains. It is difficult to identify if the apothecia are absent, and can be mistaken for *C. parasitica*, another lignicolous species. However the squamules of *C. parasitica* have the margin with coraloid granular appearance and contain thamnolic acid (Pd+ yellow).

10. *Cladonia callosa* Delise ex Harm.

Lich. France 3: 326, 1907.

TYPE: France, Calvados, Nord-Falaise, Noron-L'Abaye, Bruyères, Brébisson in Malbranche, Lich. Normandie no. 355 (AUT lectotype, Deschâtres & Boissière, Bull. Soc. Linn. Provence 45: 287, 1994).

Cladonia fragilissima Østh. & P.James, Norw. J. Bot. 24: 123, 1977.

ILLUSTRATIONS: Deschâtres & Boissière (1994: 17); Krog *et al.* (1994: 157); Paus (1994: 8); van Herk & Aptroot (2003: 131); van Haluwyn *et al.* (2012: 81).

Primary thallus squamulose, persistent, forming pulvinular cushions. Squamules 5-10 mm long × 2-3 mm wide, rounded, very delicate and break easily, green to brownish green in the upper surface, white below. Podetia very rare, up to 1.5 cm high, narrowly scyphose and perforate in the center, branched near the apex. Surface corticate with fissures. Apothecia dark brown, at the apex, pruinose, forming small cluster. Pycnidia dark, frequent, on basal squamules, with hyaline slime.

Chemistry:- Pd-, K-, C-, UV+ ice blue. Grayanic acid.

Habitat and distribution.- It grows on acidic soils, on peat in heathlands and pastures. It is a very rare species in the Mediterranean countries that has only been reported in the Eurosiberian region of France in the colline and montane belts (Deschâtres & Boissière 1994). This species is restricted to West-northern Europe, growing in very oceanic habitats. It probably has been unnoticed because its small size and the frequent absence of podetia (Litterski & Ahti 2004; Ahti & Stenroos 2013).

Mediterranean countries.- France.

Remarks.- It can be mistaken for other species with well developed primary thallus, such as *C. strepsilis* but this has C+ green reaction, *C. cervicornis* Pd+ red, *C. pulvinata* Pd+ yellow, *C. subcervicornis* K+ yellow and Pd+ red, but all the spot tests reactions in *C. callosa* specimens are negative and UV+. It can be mistaken for *C. cariosa*, both with small primary thallus and fissurate podetia, but it grows on basic soils and never contains grayanic acid. The phylogenetic relationships of this species are unknown. In the recent phylogeny of *Cladoniaceae* it forms a subclade in the base of the Clade *Cladonia* (Stenroos *et al.* 2019).

11. *Cladonia cariosa* (Ach.) Spreng.

Syst. Veg. 4(1): 272, 1827.

Lichen cariosus Ach., Lichenogr. Succ. Prodr.: 198, 1799 '1798'.

TYPE: Sweden (H-ACH 1577A lectotype, Stenroos *et al.*, Fl. Criptog. Tierra del Fuego 13(7): 22, 1992).

ILLUSTRATIONS: Brodo *et al.* (2001: 243); Burgaz & Ahti (2009: 77); van Haluwyn *et al.* (2013: 190-191); Ahti & Stenroos (2013: 95); Wirth *et al.* (2013: 385); Stenroos *et al.* (2016: 161); Valcuvia Passadore & Gheza (2017: 107).

Primary thallus squamulose, persistent. Squamules small, 2-4 mm long × 1-2 mm wide, entire margins to incise, greenish-grey on the upper surface, white on the underside that is finely fibrillose. Podetia scarce, 7-20 mm long × 3-5 mm wide, no scyphose, with numerous longitudinal cracks that sometimes have the appearance fibrose, striate, digitately branched near the apices. Surface partially corticate and covered with granules or scattered squamules. Apothecia dark brown, up 3 mm diameter at the apex of the podetia, usually grouped with corymbose appearance. Pycnidia dark almost black, on the primary thallus, sessile but prominent, ovoid to conical, constricted at the base, with hyaline slime.

Chemistry.- Several chemotypes have been found. Chemotype I: Pd-, K+ yellow, KC-, C-, UV-. Atranorin. Chemotype II: Pd+ yellow, K+ yellow, KC-, C-, UV-. Atranorin, norstictic and connorstictic acids. Chemotype III: Pd+ red, K+ yellow, KC-, C-, UV-. Atranorin and fumarprotocetraric acid. Chemotype IV: Pd-, K+ yellow, KC-, C-, UV-. Atranorin and rangiformic acid. Chemotype V: Pd+ red, K+ yellow, KC-, C-, UV-. Atranorin, fumarprotocetraric and rangiformic acids. The most frequent in Mediterranean countries is the chemotype I. Up to nine chemotypes has been identified over the world (Osyczka & Skuba 2011).

Habitat and distribution.- It grows on bare soil, rocky steps or slopes, on basic or moderately acidic substrates. It is relatively frequent in the Mediterranean countries although it has a dispersed distribution and is probably unnoticed when the specimens are not fertile. It is a Holarctic species with outliers in Southern South America (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Andorra, Algeria, Bosnia-Herzegovina, Croatia, Cyprus, France, Greece,

Italy, Montenegro, Morocco, Portugal, Slovenia, Spain and Turkey.

Remarks.- It is easily distinguished by the presence of podetia with large longitudinal fissures and the large terminal apothecia. It can be confused with *C. peziziformis* but it has smaller podetia and the squamules of the primary thallus are very rounded, with a small ear appearance. In absence of podetia it is difficult to separate from *C. symphyocarpa*, although the primary thallus is thinner in *C. cariosa*. A molecular study of the *C. cariosa* group has pointed out the existence of four independent lineages morphologically and chemically variable (Pino-Bodas *et al.* 2012a). However more studies, including material from other regions, are necessary in order to clarify the taxonomy of this group.

12. *Cladonia carneola* (Fr.) Fr. Lichenogr. Eur. Reform.: 233, 1831.

Cenomyce carneola Fr., Sched. Crit. Lich. Succ. 3-4: 23, 1825.

TYPE: Sweden, Fries, Lich. Succ. Exs. no. 115 (UPS lectotype, Stenroos *et al.*, Fl. Criptog. Tierra del Fuego 13(7): 44, 1992).

ILLUSTRATIONS: Brodo *et al.* (2001: 244); Barreno & Pérez-Ortega (2003: lam. 33); Burgaz & Ahti (2009: 25); Ahti & Stenroos (2013: 95); Stenroos *et al.* (2016: 162); Valcuvia Passadore & Gheza (2017: 109).

Primary thallus squamulose. Squamules small, ascending, 1-3 mm long × 1-4 mm wide, sparsely divided, in general with rounded lobes, pale yellowish green. Podetia pale greenish yellow, 6-25 mm long × 2.5-6 mm wide, at base 0.5-2 mm wide, abruptly flaring, with margin dentate or proliferating. Surface finely sorediate, soredia farinose, 20-40 µm diameter, basal part somewhat corticate, sometimes with squamules. Apothecia ochraceous to light brown, infrequent. Pycnidia light brown on the apex of podetia with hyaline slime.

Chemistry.- Pd-, K-, KC+ yellow, C-, UV-. Usnic acid and zeorin, occasionally may present barbatic acid.

Habitat and distribution.- It grows on stumps and decaying wood, in pine, beech and other deciduous forests, exceptionally in decaying heath wood. It is distributed in the subalpine, montane, supra- and oromediterranean belts in the Mediterranean countries. It has a Holarctic distribution with small outlier in South America (Stenroos *et al.* 1992; Ahti & Stenroos 2013).

Mediterranean countries.- Algeria, Bosnia-Herzegovina, Croatia, France, Italy, Montenegro, Portugal, Slovenia, Spain and Turkey. The reports from Algeria and Turkey need confirmation.

Remarks.- It is morphologically and chemically similar to *C. pleurota*, although *C. carneola* has a thallus more intensely yellow, due to higher concentration of usnic acid. It differs from *C. pleurota* by having wider scyphi (up to 6 mm), with clearly irregular margin and finely sorediate surface (soredia 20-40 µm). Occasionally, *C. pleurota* has narrow podetia (up to 5 mm), with irregular margin, granulate sorediate surface (soredia 30-120 µm), and corticate base. It can also be mistaken for *C. fimbriata*, but it is easily recognized by the Pd+ red reaction (indicating the presence of fumarprotocetraric acid).

13. *Cladonia cenotea* (Ach.) Schaer. Lich. Helv. Spic.: 35, 1823.

Baeomyces cenoteus Ach., Methodus: 345, 1803.

TYPE: Sweden (H-ACH 1572C lectotype, Ahti, Regnum Veg. 128: 71, 1993).

ILLUSTRATIONS: Wirth (1995: 319); Brodo *et al.* (2001: 245); Burgaz & Ahti (2009: 30); van Haluwyn *et al.* (2012: 193); Ahti & Stenroos (2013: 95); Stenroos *et al.* (2016: 163); Valcuvia Passadore & Gheza (2017: 95).

Primary thallus squamulose. Squamules 1-2 mm long × 0.6-1.5 mm wide, undivided margin, crenulated to slightly divided, sometimes very little visible, upper side greyish green, white below. Podetia grey or greyish brown, 10-31 mm long × 2-5 mm wide, with narrow scyphi, perforated in the center, forming funnels, curved edges inward, 1 or 2 times marginally proliferating. The upper half of the podetia covered by farinose soredia (17-50 µm diameter) while small crenulate squamules (0.6-0.8 mm long) are usually present in the basal part. Apothecia very rare, at the apex of the podetia, brown. Pycnidia very rare, at the apex of the podetia, dark brown, with hyaline slime.

Chemistry.- Pd-, K-, C-, UV+ white. Squamatic acid. In other regions a chemotype containing thamnolic acid is rarely found.

Habitat and distribution.- It grows on stumps and decaying wood specially of coniferous trees. It can be considered a rare species in the Mediterranean countries, only frequent in the subalpine, montane, colline and

supramediterranean belts. Mainly a Holarctic species with some outposts in Argentina and Chile (Stenroos *et al.* 1992; Ahti & Stenroos 2013).

Mediterranean countries.- Algeria, Bosnia-Herzegovina, Croatia, France, Italy, Montenegro, Portugal, Slovenia, Spain and Turkey.

Remarks.- It can be mistaken for other sorediate scyphose species with brown apothecia such as *C. fimbriata* or *C. chlorophaea*, but it is distinguished by the narrow podetia that frequently proliferate at the edges, clearly perforated. *Cladonia cenotea* resembles to *C. squamosa*, both with funnels. But the podetia of *C. squamosa* are usually densely squamulose and unbranched. According to the last phylogeny of *Cladoniaceae*, it is a polyphyletic species (Stenroos *et al.* 2019).

14. *Cladonia cervicornis* (Ach.) Flot. Jahresber. Schles. Ges. Vaterl. Cult. 27: 105, 1849.

Lichen cervicornis Ach., Lichenogr. Succ. Prodr.: 198, 1799 '1798'.
TYPE: Sweden (H-ACH 1672B-C lectotype, Ahti, Regnum Veg. 121: 71, 1993).
ILLUSTRATIONS: Burgaz & Ahti (2009: 37); van Haluwyn *et al.* (2012: 75); Ahti & Stenroos (2013: 95); Stenroos *et al.* (2016: 163).

Primary thallus squamulose, persistent, frequently pulvinular, forming mats up to 2-10 cm. Squamules 5-24 mm long × 1-4 mm wide, with undivided to slightly crenulate margin, or irregularly digitately lobulate, upper part dark brownish green, brownish white to grey below, very finely arachnoid. Podetia frequent, scyphose, 7-19 mm long × 2-4.5 mm wide, 1-2 mm wide at the base, forming 1-4 tiers with central proliferations, or sometimes with lateral proliferations, with 1-12 per scyphi. Surface smoothly corticate to slightly arachnoid in the young parts, rarely present squamules, dark brownish green. Apothecia uncommon, on the scyphi margin, up to 3 mm diameter, dark brown and usually isolated. Pycnidia at the scyphi margin or on the squamules of the primary thallus, not stalked, subglobose to ovoid, with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex, occasionally with atranorin.

Habitat and distribution.- It grows on bare soil, humus or mossy rocks, with preference for acid substrates, in a wide variety of open woodlands, shrubs, garrigues and pastures from sea level to 1860 m altitude. It is very common in the

Mediterranean region, from thermo- to supramediterranean belts. It has Euroasiatic distribution, being more frequent in West and South territories of the Mediterranean countries. Some records from North America need to be confirmed (Ahti 2007; Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Algeria, Bosnia-Herzegovina, Croatia, Cyprus, France, Greece, Italy, Montenegro, Portugal, Spain, Tunisia and Turkey.

Remarks.- In absence of podetia it can be mistaken for several taxa, such as *C. firma*, *C. corsicana* or *C. subturgida*, but it differs by having bigger and strongly recurved squamules of the primary thallus with brownish green on the upper side and pinkish brown on the lower side. At higher altitudes it can be confused with *C. macrophyllodes*, which has a blackish base. Other species with central proliferating scyphi in the Mediterranean region are: *C. verticillata* and *C. pubvinata*. Van Herk & Aptroot (2003) established differences among them, based on the morphology of the primary thallus and the number of tiers, and suggested to give them the species rank (up to this date, they are considered as subspecies of *C. cervicornis*). However, the best character to distinguish *C. cervicornis* from *C. pubvinata* is the presence of psoromic acid (Pd+ yellow) in the latter. This species is morphologically very variable and several authors (Ahti 2000, 2007; Ahti & Stenroos 2013) have indicated that molecular studies are necessary to clarify its taxonomy.

15. *Cladonia chlorophaea* (Flörke ex Sommerf.) Spreng. Syst. Veg. 4(1): 273, 1827.

Cenomyce chlorophaea Flörke ex Sommerf., Suppl. Fl. Lapp.: 130, 1826.

TYPE: Not typified in the present sense, needs nomenclatural conservation.

ILLUSTRATIONS: Wirth (1995: 307); Brodo *et al.* (2001: 248); Burgaz & Ahti (2009: 33); van Haluwyn *et al.* (2012: 203, lower); Ahti & Stenroos (2013: 96); Stenroos *et al.* (2016: 164).

Primary thallus squamulose, persistent. Squamules small, 2-4 mm long × 4 mm wide, with entire margin, slightly crenulate or something lobed, somewhat with margin granulose-soradiate, grey-green to greenish brown in the upper part, white below. Podetia scyphose, 8-20 mm long × 4-7 mm wide, greyish green to greenish brown, generally simple, but occasionally proliferating from the

margin forming a new scyphi. Upper parts and inside of scyphi covered with granulose to gross soredia (60–170 µm diameter). Base of podetia usually corticate, in young specimens the cortex reaches the scyphal margin. Old parts frequently esorediate, scattered microsquamules appear. Apothecia in the podetial margin, on stalks up to 5 mm long, uncommon, brown, that can form structures up to 5 mm diameter. Pycnidia ovoid, in the denticulate scyphal margin, with hyaline slime.

Chemistry.- Pd+ red, K–, KC–, C–, UV–. Fumarprotocetraric acid complex, sometimes quaesitic acid.

Habitat and distribution.- It grows on decaying wood, humus, tree base or bare soil generally on acid substrates and in a wide diversity of forests and shrubs from sea level to 2900 m altitude in all the bioclimatic belts. It is a cosmopolite species (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Algeria, Andorra, Bosnia-Herzegovina, Croatia, Cyprus, France, Greece, Italy, Montenegro, Morocco, Portugal, Slovenia, Spain and Turkey.

Remarks.- We follow the species concept of *C. chlorophaea* s. str. accepted by Ahti (1966), Kristinsson (1971) and Ahti & Stenroos (2013) since there are morphological characters associated with the chemical variation. Other authors (Purvis *et al.* 1992; James 2009) considered *C. asabinae*, *C. cryptochlorophaea*, *C. grayi*, *C. homosekikaica*, *C. merochlorophaea* and *C. norochlorophaea* as chemotypes of *C. chlorophaea* s. lat. The taxonomy of this group of species is unsolved. In the phylogeny of *Cladoniaceae* these species formed two different clades in the Subclade *Graciles* (Stenroos *et al.* 2019). It can be mistaken for some specimens of *C. pyxidata*, *C. fimbriata* or *C. humilis*. However, the granular scyphus is a good character to distinguish it from *C. pyxidata*, whose scyphi are covered with numerous peltate squamules and flare gradually. *Cladonia fimbriata* and *C. humilis*, that occasionally grow together with *C. chlorophaea*, can be distinguished from it by the presence of farinose soredia.

16. *Cladonia ciliata* Stirt.

Scott. Naturalist (Perth) 9 (n.s. 3): 308, 1888.

TYPE: Scotland, Kirkcudbright, New Galloway, Knocknalling Wood, 1884, McAndrew 64 (GLAM holotype).

Cladonia ciliata var. *tenuis* (Flörke) Ahti, Biblioth. Lichenol. 9: 48, 1977. - *Cladonia tenuis* (Flörke) Harm., Lich. France: 228, 1908 '1907'. - *Cladina ciliata* (Stirt.) Trass, Folia Cryptog. Eston. 11: 6,

1979. - *Cladina tenuis* (Flörke) de Lesd., Bull. Soc. Bot. France 54: 680, 1908 '1908'.

ILLUSTRATIONS: Wirth (1995: 297); Pérez-Valcárcel *et al.* (2003: 157); Wirth *et al.* (2004: 72); Burgaz & Ahti (2009: 19); van Haluwyn *et al.* (2012: 181); Wirth *et al.* (2013: 395); Ahti & Stenroos (2013: 96); Stenroos *et al.* (2016: 165); Valcuvia Passadore & Gheza (2017: 33).

Primary thallus evanescent. Podetia 20–70 mm long × 0.7–1.2 mm wide, with a clearly defined main axis, anisotomic or subisotomous branching and internode length 2–5 mm, podetial tips attenuate and deflexed, or divergent in all directions in fertile specimens, branching pattern clearly dichotomous, rarely trichotomous, podetia greenish yellow to greenish grey, darkened at tips. Apothecia brown, infrequent. Pycnidia at the apex of the podetia with red slime.

Chemistry.- Chemotype I: Pd+ red, K–, KC–, C–, UV–. Fumarprotocetraric acid complex, usnic acid. Chemotype II: Pd+ red, K–, KC–, C–, UV–. Fumarprotocetraric acid complex. These two chemotypes are recognized at the form or varietal level: chemotype I corresponds to f. *flavicans* (Flörke) Ahti & DePriest and chemotype II to f. *ciliata*. The podetia of both forms are morphologically indistinguishable, but the colour is useful to identify them, greenish yellow in the former and greenish grey in the latter. However, it is advisable to confirm the identifications by TLC because the colour varies in shaded habitats.

Habitat and distribution.- The chemotype greenish yellow (f. *flavicans*) is more abundant in the Mediterranean countries than the greenish grey chemotype (f. *ciliata*), more sparse. The f. *flavicans* is more frequent in thermic and humid shrublands, maquis and open woodlands of *Quercus suber* while f. *ciliata* grows in more continental areas in Spain, but elsewhere the latter is more frequent in highly oceanic areas. The general distribution of *C. ciliata* is clearly oceanic (Litterski & Ahti 2004). According to Ravera *et al.* (2016) this species is endangered in Italy because of the reduction of its habitats.

Mediterranean countries.- Croatia, France, Greece, Italy, Portugal, Spain, Tunisia and Turkey.

Remarks.- *Cladonia ciliata* can be mistaken for *C. arbuscula*, both with Pd+ red reaction, but the diameter of the main axis is smaller in *C. ciliata* (0.7–1 mm) than in *C. arbuscula* (1.2–1.8 mm) (Burgaz & Martínez 2008). The records from Tunisia need confirmation.

17. *Cladonia coccifera* (L.) Willd.

Fl. Berol. Prodr.: 361, 1787.

Lichen cocciferus L., Sp. Pl.: 1151, 1753.

TYPE: Sine loco (LINN 1273.215 lectotype, Ahti, Regnum Veg. 128: 72, 1993, second-step lectotype, Jørgensen *et al.*, Bot. J. Linn. Soc. 115: 374, 1994).

ILLUSTRATIONS: Barreno & Pérez-Ortega (2003: lam. 34); Pérez-Valcárcel *et al.* (2003: 157); Wirth *et al.* (2004: 88); Burgaz & Ahti (2009: 22); van Haluwyn *et al.* (2012: 145); Ahti & Stenroos (2013: 96); Stenroos *et al.* (2016: 165).

Primary thallus squamulose. Squamules scattered or forming compact cushions, 2-4 mm long × 3-4 mm wide, ascendent, from rounded to moderately lobed up to 2 mm, greenish yellow underside, brownish towards the base. Podetia 8-20 mm long × 3-15 mm wide, base 1-2 mm wide, greyish yellow to greenish yellow. Podetia morphologically very variable gradually attenuate towards the base, *pyxidata*-type or flaring abruptly, sometimes with marginal proliferations. Surface covered by convex corticate granules (they detach and act as vegetative propagules), more abundant in the upper part of the podetia. Base of podetia corticate, sometimes with big squamules. Apothecia red on the margin of the scyphi, up to 3 mm diameter. Pycnidia red, with red slime.

Chemistry.- Pd-, K-, KC+ yellow, C-, UV-. Usnic acid and zeorin, sometimes porphyritic and rhodocladonic acids. Needle crystals of zeorin can be observed at podetial tips in old specimens from herbaria.

Habitat and distribution.- It is frequently found in heathland and acid soils, occasionally on mossy rocks and decaying wood. More frequent in the Eurosiberian region, at the colline, montane and subalpine belts, but rare in the Mediterranean region, growing mainly in the supramediterranean belt. It is a subcosmopolitan species (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, France, Greece, Italy, Montenegro, Portugal, Slovenia, Spain, Tunisia and Turkey.

Remarks.- It is a species morphologically and chemically very variable. The similar species *C. diversa*, containing the same secondary metabolites, has podetia covered with numerous microsquamules. *Cladonia borealis* can be distinguished from *C. coccifera* by the podetia covered with flat plates and the presence of barbatic acid. The

phylogenetic study carried out by Steinová *et al.* (2013) indicated that it is a polyphyletic species.

18. *Cladonia coniocraea* (Flörke) Spreng.

Syst. Veg. 4(1): 272, 1827.

Cenomyce coniocraea Flörke, Deutsche Lich. 7: 14, 1821, nom. cons.

TYPE: Sweden, Närke, Svennevad, Korsmon, 1950 Kjellmert in Magnusson, Lich. Sel. Scand. Exs. no. 388 (UPS typ. cons.).

Cladonia ochrochlora Flörke, De Cladon.: 75, 1828, nom. cons.

ILLUSTRATIONS: Wirth (1995: 303); Brodo *et al.* (2001: 247); Pérez-Valcárcel *et al.* (2003: 159); Wirth *et al.* (2004: 80); Burgaz & Ahti (2009: 35); van Haluwyn & Asta (2013: 215); Ahti & Stenroos (2013: 96); Wirth *et al.* (2013: 396); Stenroos *et al.* (2016: 166); Valcuvia Passadore & Gheza (2017: 111, 133).

Primary thallus squamulose, persistent. Squamules 1-5 mm long × 1-4 mm wide, with margin crenulate to lobate-palmate to scattered or abundant sorediate on lower side, green to greyish green on the upper side, white on the lower side. Podetia subulate or slightly scyphose, 7-25 mm long × 0.8-1 mm wide, green to greyish green, usually simple, but sometimes dichotomously divided at the apex, podetia corticate only in the lower part, without reaching the top, small squamules may appear in the cortex, surface sorediate at the upper part and inside the scyphi, soredia farinose 20-50 µm diameter. Apothecia not frequent, located at the apex of the podetia, brown, up to 1 mm diameter. Pycnidia uncommon, at the apex of the podetia, ovoid, with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex, the presence of quaesitic acid is inconstant.

Habitat and distribution.- It grows on decaying wood, stumps and tree base of deciduous and coniferous forests, especially in mossy areas and where humidity is persistent, also grows on bare soil. It is more frequent in the Eurosiberian region and in further north locations of the Mediterranean region. It is widely distributed in both hemispheres from boreal areas to temperate zones (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Andorra, Algeria, Bosnia-Herzegovina, Croatia, France, Greece, Italy, Montenegro, Morocco, Portugal, Slovenia, Spain, Tunisia and Turkey.

Remarks.- Here, in the species concept of *C. coniocraea* we include *C. ochrochlora*, a species morphologically very

similar, because the phylogenetic results did not support them as different species (Pino-Bodas *et al.* 2011), supporting the hypothesis proposed by Wirth (1995) and Thomson (2003). The features used to distinguish them are as follows: 1) the podetium basal cortex is longer and thicker in *C. ochrochlora*; 2) the presence of discrete soralia in *C. ochrochlora*, while *C. coniocraea* has diffuse soralia; 3) larger soredia in *C. ochrochlora*; 4) broader scyphi in *C. ochrochlora*. Most of the Mediterranean material corresponds to the concept of *C. ochrochlora*. Other taxa of similar morphology are *C. macilenta* and *C. subulata*. In the first case, the podetia reacts Pd– or Pd+ yellow, never red, and in the second species, the primary thallus is very small and evanescent, well developed podetia have antler-like branching pattern, and the habitat is different, since *C. subulata* grows preferably on bare soil, very rarely on decaying wood, the apex are apiculate and the podetia dichotomically divided. Another possible mistake is with *C. rei*, which may have subulate podetia, but this one differs in brown colour and the thallus being UV+ whitish grey, due to the presence of homosekikaic acid.

19. *Cladonia conista* (Nyl.) Robbins in Allen, *Rhodora* 32: 92, 1930.

Cladonia fimbriata f. *conista* Nyl., *Ann. Sci. Nat., Bot., Sér.* 4: 15: 370, 1861.

TYPE: Germany, 'a Flörke 1' (H-ACH 1705a lectotype, Ahti, *Ann. Bot. Fenn.* 3: 387, 1966).

ILLUSTRATIONS: Pino-Bodas *et al.* (2012c: 167); Ahti & Stenroos (2013: 96); Stenroos *et al.* (2016: 166).

Primary thallus squamulose, persistent. Squamules large, 1.5–4 mm long × 3–4 mm wide, more or less rounded, margin entire, somewhat lobed or sometimes slightly sorediate, light green on the upper side, lower side white, sometimes slightly veined. Podetia scyphose, 4–18.6 mm long × 2–9 mm wide, with a stalk 2–9 mm long, longer than the scyphus wide, scyphi abruptly flaring, light greenish grey, simple, generally very regular, rarely with proliferations from the margin. Surface of the podetia smoothly corticate from the base to near the scyphal margin, inside and outside surface of scyphi covered by farinose soredia, 20–45 µm diameter. Apothecia uncommon, on marginal proliferations, dark brown.

Pycnidia not frequent, at the scyphus margin, sessile or constricted at base, with hyaline slime.

Chemistry.– Pd+ red, K–, C–, UV–. Bourgeanic and fumarprotocetraric acids.

Habitat and distribution.– It grows on bare acidic or sub-neutral soils and road banks. It is a frequent species in the Mediterranean countries from sea level to 1400 m altitude, although its distribution is not well known because chemical data are necessary to distinguish it from *C. humilis* but many references lack this kind of data. It is a subcosmopolitan species, mainly distributed in temperate regions (Pino-Bodas *et al.* 2012c; Ahti & Stenroos 2013).

Mediterranean countries.– Albania, Algeria, Bosnia-Herzegovina, Croatia, Cyprus, France, Greece, Italy, Montenegro, Portugal, Spain and Turkey.

Remarks.– This species was traditionally considered a chemotype of *C. humilis* since both are morphologically very similar, but the molecular studies (Dolnik *et al.* 2010; Pino-Bodas *et al.* 2012c, 2013c) showed that they are different species. Sometimes difficult to differentiate from other species of the *C. humilis* group, but it is easy to recognize by the presence of a long stalk in the podetia, farinose soredia and bourgeanic acid.

20. *Cladonia cornuta* (L.) Hoffm. *Descr. Pl. Cl. Crypt.* 2(1): t. 25(1), 1791.

Lichen cornutus L., *Sp. Pl.*: 1152, 1753.

TYPE: Sine loco, (LINN 1273.223, lectotype, Ahti, *Regnum Veg.* 128: 73, 1993).

ILLUSTRATIONS: Brodo *et al.* (2001: 249); Burgaz & Ahti (2009: 51); van Haluwyn *et al.* (2012: 195); Ahti & Stenroos (2013: 97); Stenroos *et al.* (2016: 167); Valcuvia Passadore & Gheza (2017: 113).

Primary thallus squamulose, evanescent, rarely persistent. Squamules scattered, 3–4 mm long × 2–3 mm wide, margin crenulate, greenish brown to yellowish brown on the upper side, white below. Podetia dispersed or forming mats, 25–35 mm long × 1–2 mm wide, bright brown, greenish brown or greenish yellow, straight, simple or rarely branched once or twice, generally attenuated at the apex, fertile specimens forming small shallow, narrow and corticate scyphi. Surface mostly corticate, sorediate at tips, rarely with squamules at the base of the podetia; cortex smooth to verrucose, shiny, areolate patches of cortex also in the upper parts; farinose

soredia. Apothecia very rare, brown, at the apex of the podetia. Pycnidia very rare, at the apex of podetia, with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex.

Habitat and distribution.- It grows on humus and decaying wood, rarely on bare soil. More frequent in the montane to subalpine belts of the Eurosiberian region but very rare in the Mediterranean region, restricted to supra- and oromediterranean belts. It has a subcosmopolitan distribution, been more abundant in circumpolar regions (Arctic, Antarctic and Boreal zones), with continental tendency (Brodo & Ahti 1996).

Mediterranean countries.- France, Italy, Portugal, Slovenia and Spain.

Remarks.- It can be confused with *C. coniocraea* that differs in its surface almost completely covered by soredia and greyish green, while in *C. cornuta* the soredia cover only the upper half of the podetia, that is greenish brown. It can also be confused with *C. gracilis*, whose podetia are mainly corticate and only occasionally develop some granular soredia at the apex of the podetia. Additionally, the podetial wall is thicker in *C. cornuta* than in *C. gracilis*. Also the medulla in *C. cornuta* is much thicker than the stereome, while in *C. gracilis* the medulla is thinner than the stereome. The molecular results of Pino-Bodas *et al.* (2011) support that this taxon is monophyletic and not closely related to *C. coniocraea*.

21. *Cladonia corsicana* (Rondon & Vězda) Pino-Bodas, Burgaz & Martín Mycol. Prog. 11: 269-278, 2012.

Cladonia turgida (Ehrh.) Hoffm. var. *corsicana* Rondon & Vězda, Lichenes Sel. Exs. Fasc. 36: 2 (no. 881), 1970.

TYPE: Gallia, Corsica. Dist. Ste-Marie-Sicche: Coti-Chiavari, alt. 100 m, ad terrum macram graniticam in fossis viae vetustae, 1969 Rondon & Vězda (PRA-V 06481 holotype).

ILLUSTRATIONS: Pino-Bodas *et al.* (2012b: 277).

Primary thallus squamulose, persistent. Squamules 6-14 mm long × 1-4 mm wide, erect, undivided or irregularly lobate. Upper surface light-green, lower surface arachnoid, white to greyish or pinkish toward the tips. Podetia frequent, 4-24 mm long × 2-10 mm wide, without scyphi, branched at the apices, enterely open, flattened, sheet-shaped,

occasionally the podetium walls twist and join at the base, often with oval perforations. Podetium surface smoothly corticate, light-green. Apothecia common, dark brown. Pycnidia on upper surface of squamules and sometimes on podetia, globose, with hyaline slime.

Chemistry.- Pd+ red, K- or K+ dark brownish, KC-, C-, UV-. Fumarprotocetraric acid complex.

Habitat and distribution.- It grows on acid soils, steps and rock fissures, in locations with a dominant vegetation of cork tree (*Quercus suber*), *Cistus* sp. shrubland and heathlands, from thermo- to mesomediterranean belts, not observed in the Eurosiberian region. This species was described for Corsica but its distribution is extended to Sardinia, Crete and the southwest of the Iberian Peninsula (Poelt & Vězda 1977; Pino-Bodas *et al.* 2012b).

Mediterranean countries.- France, Greece, Italy, Portugal and Spain.

Remarks.- Not common, easily overlooked due to small size of squamules and podetia. When podetia are desiccated they twist, giving the impression that their walls are joined, what makes easy to mistake this species for specimens of *C. subturgida* but the paler greenish colour of the upper side and the squamules that break very easily in *C. subturgida* are characteristics not observable in *C. corsicana*.

22. *Cladonia crispata* (Ach.) Flot. in Wendt, Thermen Warmbrunn: 93, 1839.

Baeomyces turbinatus var. *crispatus* Ach., Methodus: 341, 1803.

TYPE: Sweden (H-ACH 1411B lectotype, Stenroos, Ann. Bot. Fenn. 25: 124, 1988).

Cenomyce gracilis var. *ctetrariiformis* Delise in Duby, Bot. Gall.: 625, 1830. - *Cladonia gracilis* var. *ctetrariiformis* (Delise) Vain., Acta Soc. Fauna Flora Fenn. 4(1): 392, 1887.

ILLUSTRATIONS: Burgaz & Ahti (2009: 30); van Haluwyn *et al.* (2012: 193); Ahti & Stenroos (2013: 97); Stenroos *et al.* (2016: 169); Valcuvia Passadore & Gheza (2017: 75).

Primary thallus squamulose, soon disappearing. Squamules simple, 1-2 mm long, greyish green upper side and white below. Podetia slender, irregularly branched, with lateral perforations, axils and scyphi open, forming funnels, with spiny marginal proliferations that bear pycnidia, 20-25 mm long × 1.5-3 mm wide, greyish brown to greenish grey in the shadow morphotypes. Surface corticate,

smooth or slightly areolated, sometimes with scattered squamules. Apothecia very rare, 0.2-0.8 mm diameter, dark brown, generally grouped on the terminal proliferations of the podetia. Pycnidia very frequent, dark, on extensions at the apex of the podetia with red slime.

Chemistry.- Pd⁻, K⁻, C⁻, UV⁺ white. Squamatic acid. Outside the Mediterranean countries this species is chemically more variable, containing squamatic and barbatic acids or thamnolic acid (Huovinen & Ahti 1988).

Habitat and distribution.- It is a frequent taxon in heathlands, but quite scarce in other habitats of the Eurosiberian region from montane to subalpine belts, with very few records of the Mediterranean region. It has subcosmopolitan distribution (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Andorra, Croatia, France, Greece, Italy, Montenegro, Portugal, Slovenia and Spain.

Remarks.- The var. *crispata* has clearly scyphose podetia, shorter than var. *ctrariiformis*, the scyphus have numerous proliferations, while in var. *ctrariiformis* the podetia are only, sometimes, slightly widened. The var. *crispata* is widely distributed by the Arctic and Boreal regions, but apparently it does not reach Southern Europe, while var. *ctrariiformis* has a more oceanic distribution. It can be mistaken for *C. gracilis*, although in the latter the podetia are more delicate and longer, with the axils and scyphi closed and are also Pd⁺ red (fumarprotocetraric acid) and UV⁻ (without squamatic acid). According to phylogenetic study carried out by Stenroos *et al.* (2019) *C. crispata* is polyphyletic and more studies are necessary.

23. *Cladonia cryptochlorophaea* Asahina J. Jap. Bot. 16: 711, 1940.

TYPE: Japan, Honshu, prov. Shinano (Pref. Nagano), Mt. Nyugasa, 1937 Yoshioka in Herb. Asahina 37031 as '37013' (TNS holotype).

ILLUSTRATIONS: Burgaz & Ahti (2009: 33); Ahti & Stenroos (2013: 97); Stenroos *et al.* (2016: 170).

Primary thallus squamulose, persistent. Squamules small, 1-3 mm long × 1-3 mm wide, with the margin entire or slightly crenulate, greyish green on the upper side, white below. Podetia scyphose, 4-9 mm long × 2.5-4 mm wide, greyish green. Surface from granulose to sorediate, soredia 30-80 µm diameter. Apothecia rare, brown, at the

scyphus margin. Pycnidia ovoid, at the scyphal margin, with hyaline slime.

Chemistry.- Pd⁺ orange, K⁺ wine red, KC⁺ red, C⁻ or C⁺ red disappearing quickly, UV⁺ yellowish. Cryptochlorophaeic and paludosic acids, fumarprotocetraric acid complex (inconstant but in Europe normally present), plus trace of amounts of inconstant 4'-*O*-methylcryptochlorophaeic and subpaludosic acids.

Habitat and distribution.- This species grows on decaying wood, bases of deciduous trees, humus or exceptionally on bare soil. It is a rather rare with scattered records in the Mediterranean countries, more frequent in the Eurosiberian region from colline to subalpine belts.

Mediterranean countries.- Andorra, Albania, Croatia, France, Greece, Italy, Portugal, Slovenia and Spain.

Remarks.- It belongs to the group of *C. chlorophaea* s. lat. and for some authors it is a chemotype (Purvis *et al.* 1992; James 2009; Wirth *et al.* 2013; Nimis & Martellos 2017). However, we consider that there are enough morphological differences to recognize it as species level. The podetia are covered by granules or thick soredia and have light greyish green thallus. However, TLC analysis is absolutely necessary to identify it. It can also be confused with *C. subulata* or *C. fimbriata*, but these have finely farinose soredia and are UV⁻.

24. *Cladonia cyanipes* (Sommerf.) Nyl. Mém. Soc. Sci. Nat. Cherbourg 5: 95, 1858 '1857'.

Enomyce carneopallida var. *cyanipes* Sommerf., Suppl. Fl. Lapp. 129, 1826.

TYPE: Norway, Nord-Nordland, Saltdalen, Sommerfelt (BG L-4009 lectotype, Ahti, Regnum Veg. 128: 74, 1993).

ILLUSTRATIONS: Ahti & Stenroos (2013: 97); Stenroos *et al.* (2016: 171); Valcuvia Passadore & Gheza (2017: 115).

Primary thallus squamulose, evanescent. Podetia pale greenish yellow, 4-10 cm long × 0.5-6 mm wide, usually with blackish base, dichotomous branching, tips subulate or narrowly scyphose, axils closed. Surface finely sorediate, but the soredia disappear, exposing a scabrous surface, basal parts somewhat corticate. Apothecia uncommon, brownish, at apex. Pycnidia common, light brown, with hyaline slime.

Chemistry.- Pd⁻, K⁻, C⁻, UV⁺ whitish. Barbatic, 4-*O*-demethylbarbatic and usnic acids, sometimes zeorin.

Habitat and distribution.- It grows on siliceous soils, near the treeline. This is a very rare species in the Mediterranean countries, only growing in the Alps and the Pyrenees mountains in the montane to alpine belts of the Eurosiberian region and not found in the Mediterranean region (Roux *et al.* 2017; Nimis *et al.* 2018). It has a circumpolar distribution (Ahti & Stenroos 2013).

Mediterranean countries.- France, Italy and Slovenia.

Remarks.- It can be mistaken for *C. bacilliformis* but it has shorter and less branched podetia. It generally grows on rotting wood.

25. *Cladonia cyathomorpha* Stirt. ex Walt. Watson J. Bot. 73: 156, 1935.

TYPE: Scotland, Kirkcudbright, New Galloway, near Loch Dungeon, 1881, McAndrew (E lectotype, as 'holotype', Jølle, *Blyttia* 40: 60, 1982).

ILLUSTRATIONS: Jølle (1977: 164); Burgaz & Ahti (2009: 39); Ahti & Stenroos (2013: 98); Valcuvia Passadore & Gheza (2017: 117).

Primary thallus squamulose, persistent. Squamules large, 4-7 mm long \times 5-8 mm wide, rounded, with the margin sometimes granular to sorediate, sometimes with deep lobes up to 2-4 mm, upper side smooth and green, lower side white, with pink to yellowish brown veins usually visible, in some squamules the veins are extending, given a corticate aspect to the lower side. Podetia scyphose, 4-15 mm long \times 3-7 mm wide, simple, flaring gradually, scyphal margin with small proliferations. Surface corticate, with convex and dispersed granules above and especially inside the scyphi. Apothecia very rare, on the scyphal margin, brown, generally remain isolated. Pycnidia pyriform, dark, frequent, on the scyphal margin, with hyaline slime.

Chemistry:- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex. An unknown substance called Cyat has been detected in North European specimens (Jølle 1977) but it has not been found in the material studied.

Habitat and distribution.- Frequent on slopes, bare soil and mossy rocks, has a wide altitudinal range, from sea level to 2000 m altitude growing in the colline, montane, meso- and supramediterranean belts. It has a fairly restricted distribution in Western Europe, Macaronesia and Southern Argentina (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Andorra, Croatia, Cyprus, France, Greece, Italy, Montenegro, Morocco, Portugal, Spain and Turkey.

Remarks.- This species is poorly known, probably overlooked. It can be mistaken for *C. pyxidata* for having podetia with granules, but it differs in the large and rounded squamules of primary thallus with veined lower side. It also looks like *C. bumilis*, which also has rounded, but shorter squamules, without veins or less marked and often farinose soredia. The identity of Mediterranean specimens was confirmed using molecular data by Pino-Bodas *et al.* (2013c).

26. *Cladonia dactylota* Tuck. Amer. J. Sci. Arts, ser. 2, 28: 201, 1859.

TYPE: Cuba, Santiago de Cuba, Nimanina, 1857, Wright (FH-Tuck lectotype, Ahti, *Regnum Veg.* 128: 74, 1993).

ILLUSTRATIONS: Ahti (2000: 18).

Primary thallus squamulose, persistent. Squamules ascendant, 2-8 mm long \times 1-3 mm wide, slightly pruinose in the upper side, esorediate to granulose or sorediate below. Podetia scyphose, regular, 8-20 mm long \times 2-4 mm wide, scyphal margin with short proliferations. Surface areolate to verruculose, no shine, pruinose, with longitudinal ridges, sometimes with tuberculose soralia under the scyphi and mixed with cottony hyphae. Apothecia uncommon, brown, at the podetial margin. Pycnidia at scyphal margin, with hyaline slime.

Chemistry: Pd+ yellow, K-, C-, UV-. Psoromic and 2'-O-demethylpsoromic acids.

Mediterranean countries.- France.

Habitat and distribution.- It grows on humid acid bare soil and wet slope road banks being a pioneer species. Only one record from southwestern Pyrenees mountains growing in the colline belt, is known in the Mediterranean countries. It has a subtropical to warm temperate distribution (Ahti 2000), present in Central America, with very few outliers in Southeast North America and South America mountains and the Azores, reported from Santa Maria and Flores Islands (Pino-Bodas *et al.* 2017; Roux *et al.* 2019).

Remarks.- This species is easily recognized by the scyphose podetia with tuberculose soralia together with the presence of psoromic acid (Pd+ yellow).

27. *Cladonia decorticata* (Flörke) Spreng.
Syst. Veg. 4(1): 271, 1827.

Capitularia decorticata Flörke, Beitr. Naturk. 2: 297, 1810.

TYPE: Germany, Berlin, Flörke, Deutsche Lich. no. 75 (UPS neotype, Ahti, Regnum Veg. 128: 75, 1993).

ILLUSTRATIONS: Stenroos *et al.* (1992: 15); Burgaz & Ahti (2009: 77); Ahti & Stenroos (2013: 98); Stenroos *et al.* (2016: 171); Valcuvia Passadore & Gheza (2017: 119).

Primary thallus squamulose, persistent or evanescent, greyish green upper side, white below. Squamules rounded, small, with a slightly crenulated edge, 1.5-2 mm long × 1-2 mm wide. Podetia frequent, 4-9 mm long × 0.5-1 mm wide, cylindrical, unbranched or branched, tips subulate. Surface corticate, partly sorediate or with scattered areoles to almost decorticate, which gives it a characteristic whitish appearance, central canal of the podetia very narrow, <10 µm diameter. Apothecia very rare, terminal, at the apex of the podetia. Pycnidia uncommon, on primary thallus, ovoid, with hyaline slime.

Chemistry.- Pd-, K-, UV+ pale blue. Perlatolic acid.

Habitat and distribution.- On sandy, bare soils, rarely on rotting wood. It is very rare in the Mediterranean countries, restricted to the montane and subalpine belts of the Pyrenees and the Alps (Burgaz & Ahti 2009; Roux *et al.* 2017; Nimis *et al.* 2018). It is mainly a Holarctic species with some outposts in Southern South America (Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, Croatia, France, Italy, Slovenia and Spain.

Remarks.- In general, it is unnoticed because of its small size and reduced presence. It can be mistaken for *C. ramulosa*, from which it basically differs in the absence of fumarprotocetraric acid. It can be confused with *C. acuminata*, which has subulate and partially decorticate podetia, but it contains different secondary metabolites and is always UV-.

28. *Cladonia deformis* (L.) Hoffm.
Deutschl. Fl. 2: 120, 1796.

Lichen deformis L., Sp. Pl.: 1152, 1753.

TYPE: Icon in Linnaeus, Fl. Lapp.: tab. 11, fig. 5, 1737, right-hand podetium (lectotype, Jørgensen *et al.*, Bot. J. Linn. Soc. 115: 375, 1994), Sweden, Uppland, Värmdön, Hasseludden, 1915, Malme in

Malme, Lich. Suec. Exs. no. 533 (S epitype, Jørgensen *et al.*, Bot. J. Linn. Soc. 115: 383, 1994).

ILLUSTRATIONS: Wirth (1995: 301); Brodo *et al.* (2001: 251); Burgaz & Ahti (2009: 25); van Haluwyn *et al.* (2012: 147); Ahti & Stenroos (2013: 98); Stenroos *et al.* (2016: 172); Valcuvia Passadore & Gheza (2017: 53).

Primary thallus squamulose. Squamules parallel or erect, often large, 5 mm long × 3 mm wide, more or less rounded, sometimes with incisions up to 0.5 mm, lower side occasionally sorediate, greenish yellow in the upper part and white below. Podetia common, 7-25 mm long × 3.5-7 mm wide, base 1-3 mm wide, greenish yellow to greyish green, slightly cupped and with even margin, sometimes it has small longitudinal fissures. Surface finely sorediate, soredia farinose 30-60 µm diameter, old herbaria specimens covered by numerous crystals similar to fine needles. Apothecia red, very rare. Pycnidia red containing red slime.

Chemistry.- Pd-, K-, KC+ yellow, C-, UV-. Usnic, isousnic acids and zeorin.

Habitat and distribution.- It grows on decaying wood in acidic soils. It is a very rare taxon, only found in the subalpine and alpine belts of the Eurosiberian region. It has a temperate to Arctic and Antarctic distribution (Stenroos 1993; Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, Bosnia-Herzegovina, Croatia, France, Italy, Montenegro, Slovenia and Spain.

Remarks.- Similar to *C. sulphurina* but it has no long longitudinal fissures in the podetia, which are slightly widened at the apex as well as develops fine crystals on surface in herbarium. Also the presence of squamatic acid and a more intense yellow colour in *C. sulphurina* are good characters to differentiate the two species.

29. *Cladonia deschatresii* Boissière
Bull. Ass. fr. Lichénologie 39: 328, 2014, nom.
inval. (to be validated later in 2020).

TYPE: France, Allier, Cusset, Les Grivats, rive droite du Sichon, côteau à *Genista purgens*, station ensoleillée, alt. 350 m, 1964 Deschâtres (REN-Abb 50 holotype).

ILLUSTRATIONS: Boissière (2013: 330, 331).

Primary thallus squamulose, persistent, forming cushions. Squamules 5-10 mm long × 1-4 mm wide, usually dichotomic to digitately divided at the apex, often convex,

upper side brownish, lower side white, blackish at the base in both sides. Podetia very rare, up to 10 mm high, cylindrical to 2-3 times branched and enlarged at the top, not scyphose. Surface continuously corticate, cortex smooth to verrucose with small squamules. Apothecia brown, at the apex of podetia, usually clustering. Pycnidia not frequent, black, on the primary thallus.

Chemistry.- Pd-, K-, C-, UV+ blue. Barbatic acid.

Habitat and distribution.- It is a very rare species only known from the Central Massif, France, growing on sandy and very acid soils in heathlands and shrubs with *Calluna vulgaris*, *Juniperus* and *Genista*. Restricted to the colline and montane belts in the Eurosiberian region.

Mediterranean countries.- France.

Remarks.- It grows along with species with dominant primary thallus and rare podetia, such as *C. callosa*, *C. peziziformis* or rarely *C. cervicornis*. It is easily recognized by the colour of the primary thallus and the negative reactions to reagents. However due to its small size it has probably passed unnoticed.

30. *Cladonia digitata* (L.) Hoffm. Deutschl. Fl. 2: 124, 1796.

Lichen digitatus L., Sp. Pl.: 1152, 1753, nom. cons.

TYPE CONS.: Sweden, Östergötland (Ostrogothia), Stenhammar in Stenhammar, Lich. Succ. Exs., ed. 2, no. 195 (UPS).

ILLUSTRATIONS: Wirth (1995: 325); Brodo *et al.* (2001: 251); Wirth *et al.* (2004: 87); Burgaz & Ahti (2009: 43); van Haluwyn & Asta (2013: 217); Ahti & Stenroos (2013: 98); Wirth *et al.* (2013: 374, 388); Stenroos *et al.* (2016: 173); Valcuvia Passadore & Gheza (2017: 55).

Primary thallus squamulose. Squamules big and dominant, 6-12 mm long × 4-7 mm wide, in general, with rounded appearance, undivided or slightly dentate, underside densely sorediate at the margins, soredia 25-30 µm diameter, margin involute, greenish yellow on the upper part, white below, often with an orange colouration towards the base. Podetia 8-26 mm long × 0.7-4 mm wide, infrequent, subulate or with narrow scyphi, in general curved and decumbent, proliferating at the margins. Surface finely sorediate, soredia 30-50 µm diameter, although the presence of some corticate areas towards the base are frequent, inside part of scyphi corticate. Apothecia and pycnidia red, located at the end of the apices or in short prominences at the margin of the podetia, pycnidia on scyphal margin with red slime.

Chemistry.- Pd+ yellow, K+ yellow, KC-, C-, UV-. Thamnolic and rhodocladonic acids.

Habitat and distribution.- It grows on decaying wood and bases of deciduous and coniferous trees. This taxon has preference for humid forests of long ecological stability. It is not frequent, although in some sites it can be locally abundant. It has been collected in the colline, montane and subalpine belts, and in few humid localities of the supramediterranean belt. Apparently it is very rare in Portugal. Its distribution is mainly restricted to the Holarctic, with some outposts in East Africa (Litterski & Ahti 2004; Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Algeria, Bosnia-Herzegovina, Croatia, France, Greece, Italy, Montenegro, Portugal, Slovenia, Spain and Turkey.

Remarks.- It is easily recognized by the rounded and big squamules of the primary thallus, with the lower side almost completely sorediate. However, it can be confused with *C. polydactyla*, but this one has squamules with deep incisions, less sorediate. Other taxa with sorediate squamules are *C. incrassata* and *C. parasitica*, but their squamules are much smaller and the soredia are thicker.

31. *Cladonia diversa* Asperges ex S. Stenroos in Ahti & Stenroos, Bot. Complut. 35: 326, 2012.

TYPE: Belgium, Kempisch District, Kalmthout, Van Ganzenven, 1974 Asperges 2498 (BR holotype).

ILLUSTRATIONS: Wirth (1995: 323, sub *C. coccifera*); Barreno & Pérez-Ortega (2003: lam. 35); Burgaz & Ahti (2009: 22); Ahti & Stenroos (2013: 98); Stenroos *et al.* (2016: 174); Valcuvia Passadore & Gheza (2017: 57).

Primary thallus squamulose. Squamules ascendent 2-4 mm long × 2-4 mm wide, generally rounded, sometimes moderately divided and forming rounded lobes, greenish yellow on the upper side and white below. Podetia slender, scyphose, 5-20 mm long × 2-9 mm wide, base 1-2 mm wide, unbranched or proliferating from scyphal margin, gradually or abruptly flaring. Surface densely squamulose at the base, upper parts covered by numerous flattened granules or microsquamules. Apothecia red on scyphal margin, pycnidia red to black with red slime.

Chemistry.- Pd-, K-, KC+ yellow, C-, UV-. Usnic, rhodocladonic acids and zeorin, often also porphyritic

and isousnic acids. Needle crystals of zeorin can be observed in old herbaria specimens.

Habitat and distribution.- This is the taxon with red apothecia (old Section *Cocciferae*, Clade *Erythrocarpae*) most frequent and abundant in oceanic areas of the Western Mediterranean countries. It grows in acid soils of heathlands, coniferous, deciduous and sclerophyllous woodlands. A widespread species (Europe, Macaronesia, Asia and North America) although its distribution is not well known (Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, France, Greece, Italy, Montenegro, Portugal and Spain.

Remarks.- Morphologically it is very variable and difficult to identify. It can be mistaken for *C. coccifera*, which is distinguished by the numerous flattened granules and microsquamules that cover the podetia, while *C. coccifera* has prominent and convex squamules. A recent molecular study indicated that *C. diversa* is polyphyletic (Steinová *et al.* 2013) and it still needs additional research.

32. *Cladonia ecmocyna* Leight.

Ann. Mag. Nat. Hist., ser. 3, 18: 406, 1866.

TYPE: Russia, Murmansk Region, Kola Peninsula, Svyatoy nos, 1863, Fellman in Fellman, Lich. Arct. no. 28 (BM lectotype, Ahti, Ann. Bot. Fenn. 17: 225, 1980).

ILLUSTRATIONS: Burgaz & Ahti (2009: 51); Ahti & Stenroos (2013: 98); Stenroos *et al.* (2016: 175); Valcuvia Passadore & Gheza (2017: 121).

Primary thallus squamulose, evanescent. Squamules scattered, 4-5 mm long × 3-6 mm wide, almost undivided, greenish brown to violet brown on the margins of the upper side, lower side very white cretaceous. Podetia 20-40 mm long × 2-3 mm wide, simple, rarely dichotomous branching, tips subulate, sometimes forming small scyphi, 2-5 mm wide, a new podetia may develop from the margin, base of the podetia yellowish, upper parts whitish to brownish. Surface corticate, epruinose or pruinose, especially towards the apex, very rarely sorediate at the apex, prominent areolas greenish grey, concave white medullary spots observed on the surface of the podetia. Podetial squamules common, rarely abundant (in Europe). Apothecia very rare, at the scyphal margin, dark brown to almost black. Pycnidia frequent, at the apex of subulate podetia, constricted at base, with hyaline slime.

Chemistry.- Pd⁺ red, K⁺ yellow, yellow base pigment K⁺ purple, KC⁻, C⁻, UV⁺ whitish or yellowish. Atranorin and fumarprotocetraric acid complex.

Habitat and distribution.- It is a rare species that grows in late-snow lies areas and among the cracks of big rocks. It grows in the subalpine, alpine and nival belts of the Eurosiberian region and rarely in the oromediterranean belt. The records from Sistema Central Mountains in Spain constitute the most Southern report in Europe. It has a wide distribution, known from Arctic-Alpine regions of Europe, North America, Asia and South America (Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, France, Italy and Spain.

Remarks.- It is easily recognized by the yellowish never black podetial base, and for developing small squamules at the base and at the margin of the scyphi (Ahti 1980). It can be mistaken for *C. macroceras*, but the latter has the lower part of the podetia dark brown and white medullary spots; the wall of the podetia is thicker. It is one of the few monophyletic species of the *C. gracilis* group (Pino-Bodas *et al.* 2011). Three subspecies have been described, subsp. *ecmocyna*, subsp. *intermedia* and subsp. *occidentalis* but only the subsp. *ecmocyna* is present in Europe.

33. *Cladonia fimbriata* (L.) Fr.

Lichenogr. Eur. Reform.: 222, 1831.

Lichen fimbriatus L., Sp. Pl.: 1152, 1753.

TYPE: Icon in Dillenius, Hist. Musc.: t. 14, fig. 8, 1742, lectotype, Ahti, Regnum Veg. 128: 77, 1993), herb. Dillenius t. 14, fig. 8 p.p. (OXF-Dillenius epitype, Jørgensen *et al.*, J. Linn. Soc. Bot. 115: 376, 1994).

ILLUSTRATIONS: Llimona (1991: 349); Wirth (1995: 326); Calatayud & Sanz (2000: 52); Brodo *et al.* (2001: 254); Wirth *et al.* (2004: 85); Burgaz & Ahti (2009: 35); van Haluwyn & Asta (2013: 215); Ahti & Stenroos (2013: 99); Wirth *et al.* (2013: 371); Stenroos *et al.* (2016: 176); Valcuvia Passadore & Gheza (2017: 123).

Primary thallus consisting of small squamules with the margin crenulate to incised, 2-4 mm long × 1-3 mm wide, sometimes slightly sorediate, persistent. Podetia scyphose, 10-30 mm long × 2-15 mm wide, pale greyish green, even almost brown in exposed locations, generally simple, rarely with proliferations from the margin, which

is entire or sometimes dentated, the scyphi are globose and symmetrical, with elongate and narrow stalk. Surface of podetia finely soresiate, soredia farinose 30-50 µm diameter, soredia remain on the surface of the top and inside the scyphi. The podetial base commonly has a small strip of somewhat verrucous cortex. Apothecia not common, on marginal proliferations of the scyphi or sessile, dark brown, that can conglomerate to form 1-5 mm diameter structures. Pycnidia ovoid, dark brown, at the margin of the scyphus, usually constricted at base, with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex, sometimes quaesitic acid. A chemotype containing fumarprotocetraric and bourgeanic acids has been found in Central Europe (Osyczka 2013).

Habitat and distribution.- *C. fimbriata* is very common in all the bioclimatic belts of the Mediterranean countries. It grows on bare soil, slopes, humus, more rarely on decaying wood and tree bases. In general, it is found on acid substrates and in a great diversity of forests and shrublands. This is a temperate to Arctic species, distributed in both hemispheres (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Andorra, Algeria, Bosnia-Herzegovina, Croatia, Cyprus, France, Greece, Italy, Montenegro, Malta, Morocco, Portugal, Slovenia, Spain, Syria, Tunisia and Turkey.

Remarks.- It can be mistaken for *C. chlorophaea* both with scyphose podetia and abruptly extended scyphi. However, *C. fimbriata* has very small, farinose soredia, while the surface of *C. chlorophaea* is granulose-soresiate, and the size of the granules or soredia is bigger (observed under stereomicroscope). *Cladonia fimbriata* is also recognized for having a lighter green yellowish colour than *C. chlorophaea*, whose podetia are dark greyish green. The morphological study carried out by Osyczka (2013) found that the podetia of *C. fimbriata* have a high ratio of podetium height to scyphus width and this character can be used to distinguish it from the species of *C. chlorophaea* group. It can be mistaken for the scyphose forms of *C. subulata*, both with farinose soredia and similar colour of podetia. However, always some subulate podetia are intermixed with scyphose podetia in *C. subulata*. Additionally, the branching in *C. subulata* is frequently antler-like, with long proliferations borne by the scyphal margins.

34. *Cladonia firma* (Nyl.) Nyl.

Bot. Zeitung (Berlin) 19: 352, 1861.

Cladonia alcicornis var. *firma* Nyl., Syn. Meth. Lich. 1(2): 191, 1860.

TYPE: Portugal, Algarve, Marim, 1951, Tavares, Lich. Lusit. Sel. Exs. no. 39 (H neotype, Ahti, Regnum Veg. 128: 77, 1993).

Cladonia nylanderii Cout., Lich. Lusit. Herb. 38. 1916, nom. illeg. superfl.

ILLUSTRATIONS: Burgaz & Ahti (2009: 37); Valcuvia Passadore & Gheza (2017: 169).

Primary thallus squamulose, with cushion shape, 3-7 cm diameter, persistent. Squamules large, 5-20 mm long × 1-3.8 mm wide, margin from crenate to lobate, with strongly incurved apices and not rounded, glaucous green to olive green on the upper side, and greyish brown below, with the margin somewhat whitish and very finely arachnoid texture. Podetia very rare, usually unnoticed by its small size, slightly scyphose, 0.5-7 mm long × 0.5-1 mm wide, glaucous green to olive green, simple, or rarely proliferating from the center. Surface corticate, smooth up to somewhat verrucose, very rarely with squamules at the margin of the scyphi. Apothecia very rare, on the scyphal margin, dark brown, generally isolated. Pycnidia very rare, at the scyphus margin and sometimes on the basal squamules, sessile, subglobose to ovoid, with hyaline slime.

Chemistry.- Pd+ red, K+ yellow, KC-, C-, UV-. Atranorin (rarely missing) and fumarprotocetraric acid complex.

Habitat and distribution.- It grows on bare soil or on humus, usually in shrubs formations, prefers substrates with acid or subneutral pH. It is very frequent and abundant in the Mediterranean region growing in the thermo-, meso- and supramediterranean belts, also in the colline and montane belts although it is rarest in the Eurosiberian region. Distributed throughout Western Europe, North Africa, Macaronesia, also known from North America (California).

Mediterranean countries.- Andorra, Algeria, Croatia, Egypt, France, Greece, Italy, Lebanon, Libya, Morocco, Portugal, Spain and Turkey.

Remarks.- It can be mistaken for other species with well developed primary thallus and brownish lower side, such as *C. cervicornis*, *C. polycarpoides* or *C. subturgida*. It differs from these species by having thicker and larger squamules and the olive green colour of the upper side usually with whitish apices, greyish brown in the lower

side. Molecular studies are required to confirm the identity of North American specimens.

35. *Cladonia floerkeana* (Fr.) Flörke De Cladon.: 99, 1828.

Cenomyce floerkeana Fr., Sched. Crit. Lich. Suec. 1-4: 18, 1825.

TYPE: Sweden, Fries, Lich. Suec. Exs. no. 82 (UPS lectotype, Ahti, Regnum Veg. 128: 77, 1993).

ILLUSTRATIONS: Wirth (1995: 331); Barreno & Pérez-Ortega (2003: lam. 32); Pérez-Valcárcel *et al.* (2003: 161); Brodo *et al.* (2001: 255); Burgaz & Ahti (2009: 55); van Haluwyn *et al.* (2012: 149); Ahti & Stenroos (2013: 99); Wirth *et al.* (2013: 398); Stenroos *et al.* (2016: 177).

Primary thallus squamulose, ascendent. Squamules rounded or somewhat lobated, 2 mm long \times 1.5-2 mm wide, with dark brown upper side and white below, sometimes orange stains at the base. Podetia generally simple, no scyphose, sometimes with branched apices, 8-20 mm long \times 1-2 mm wide, greyish brown. Surface usually corticate, with some squamules at the base, upper part with thick granules, up to 0.2 mm diameter. Apothecia red, at the apex of the podetia, up to 2 mm diameter, frequently forming clusters. Pycnidia red, at the apex of the podetia, with red slime.

Chemistry.- It is a chemically variable taxon. There were found two chemotypes. Chemotype I: Pd-, K- or K+ reddish (on the orange pigment of the squamules), C-, UV-. Barbatic acid. Chemotype II: Pd+ yellow, K+ yellow, KC-, C-, UV-. Thamnic acid. Sometimes traces of usnic and didymic acids have been detected in both chemotypes. The chemotype I is the most frequent in the Mediterranean countries, while the chemotype II has a more western distribution.

Habitat and distribution.- It grows on plant debris, tree bases or bare soil, always on acid substrates. In general, it lives in oceanic areas along the colline and montane belts in the Eurosiberian region, although it can grow in some humid areas of the meso- and supramediterranean belts. It is a widespread species, also scattered in the Southern Hemisphere, mainly occurring in oceanic areas (Ahti & Stenroos 2013). However, its assumed worldwide distribution is probably inaccurate, due to the confusions with *C. macilenta*.

Mediterranean countries.- Croatia, France, Greece, Italy, Portugal, Slovenia and Spain.

Remarks.- It can be mistaken for *C. macilenta* from which differs in having podetia with a whitish colouration and finely sorediate, farinose soralia of 20-50 μ m diameter. The recent phylogeny of the family showed that specimens of *C. floerkeana* and *C. macilenta* are mixed in a clade (Stenroos *et al.* 2019) and a worldwide study is necessary. *Cladonia cristatella* is another similar taxon, although in this case the podetia are completely corticate. This species has not been found in the Mediterranean countries but is very common in North America.

36. *Cladonia foliacea* (Huds.) Willd. Fl. Berol. Prodr.: 363, 1787.

Lichen foliaceus Huds., Fl. Angl. 457, 1762.

TYPE: Icon in Dillenius, Hist. Musc.: tab. 14, fig. 12A, 1742 (lectotype, Ahti & Stenroos, Nordic Lichen Flora 5: 91, 2013), England, Salop (Shropshire), Haughmond Hill, Leighton, Lich. Brit. Exs. no. 15 (BM epitype, Ahti & Stenroos, Nordic Lichen Flora 5: 91, 2013).

Cladonia convoluta (Lam.) Anders, Strauch- & Blattflechten Nordböh.: 29, 1906.

ILLUSTRATIONS: Wirth (1995: 313); Pérez-Valcárcel *et al.* (2003: 161); Wirth *et al.* (2004: 165); Burgaz & Ahti (2009: 37); van Haluwyn *et al.* (2012: 18, 77); Wirth *et al.* (2013: 388); Ahti & Stenroos (2013: 99); Stenroos *et al.* (2016: 178); Pino-Bodas *et al.* (2018: 278); Valcuvia Passadore & Gheza (2017: 171, 173).

Primary thallus squamulose, persistent, cushion shaped, 3-10 cm diameter, which is sometimes vagrant and dispersed by the wind. Squamules 6-38 mm long \times 1-5 mm wide, margins digitately to irregularly lobate, sometimes with simple, whitish to dark rhizines, apices incurved, yellowish green on the upper side, pale yellow below, which is very finely arachnoid. Podetia rare, simple, slightly scyphose, 5-20 mm long \times 2-5 mm wide, 0.5-2 mm wide at the base, yellowish green, usually unnoticed by its poor development. Surface corticate, smooth, very rarely with squamules on the margin of scyphi. Apothecia common, at the margin of the scyphus, light brown, solitary or in glomerules up to 4 mm diameter. Pycnidia on the squamules of the primary thallus, or rarely at the edge of the scyphus, very frequent, sessile or prominent, subglobose to ovoid, with hyaline slime.

Chemistry.- Two chemotypes are known. Chemotype I: Pd+ red, K-, KC+ yellow, C-, UV-. Fumarprotocetraric

acid complex and usnic acid. Chemotype II: Pd+ red, K+ yellow, KC+ yellow, C–, UV–. Fumarprotocetraric, usnic and psoromic acids. Traces of zeorin are frequently present. The chemotype I is the commonest, while the chemotype II appears scattered, being more frequent in the Eastern Mediterranean countries such as Albania and Greece. But, also in continental localities of Central Spain.

Habitat and distribution. - It grows on bare soil and humus, in open forest and shrublands from acidic to basic soils. It is a very common species, more abundant in the Mediterranean region at lower altitudes, but found from sea level up to 2000 m altitude, growing in colline, montane, thermo-, meso- and supramediterranean belts in Eurosiberian region. It is a Western Eurasian and North African species which extends to Macaronesia and Asia as far as Mongolia and grows in temperate to subtropical areas (Litterski & Ahti 2004; Ahti & Stenroos 2013).

Mediterranean countries. - Albania, Algeria, Bosnia-Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Montenegro, Morocco, Portugal, San Marino, Slovenia, Spain, Syria, Tunisia and Turkey.

Remarks. - *Cladonia convoluta* is placed here under *C. foliacea* because the species delimitation studies carried out (Pino-Bodas *et al.* 2010a, 2018) did not support them as independent lineages, what agrees with the morphological studies that found numerous intermediate specimens between both species (Burgaz *et al.* 1993; Pino-Bodas *et al.* 2010a). The morphological differences are the result of the influence of different environmental conditions. Pino-Bodas *et al.* (2018) considered that the epithet «morph *convoluta*» can be used to recognize the specimens growing on calcareous substrates with longer and wider squamules than those found in acidic soils. It also has a certain similarity to *C. luteoalba*, which also presents yellowish lower side of the squamules, but has the squamules most rounded, cottony, and only contains usnic acid and zeorin. Misidentifications with *C. cervicornis* are very rare since the latter has the squamules under side brownish and not yellowish.

37. *Cladonia furcata* (Huds.) Schrad.

Spic. Fl. Germ.: 107, 1794.

Lichen furcatus Huds., Fl. Angl.: 458, 1762.

TYPE: Icon in Dillenius, Hist. Musc.: t. 16, f. 27, 1742, lectotype, Ahti, Fl. Neotrop. Monogr. 78: 167, 2000, England, South

Huntingdonshire, Winchfield, Leighton in Leighton, Lich. Brit. Exs. no. 401 (BM epitype, Ahti, Fl. Neotrop. Monogr. 78: 167, 2000).

Cladonia subrangiformis Sandst., Abh. Naturwiss. Vereine Bremen 25: 165, 1922. - *Cladonia furcata* subsp. *subrangiformis* (Sandst.) Abbayes, Bull. Soc. Sci. Bretagne 14: 160, 162, 1938 '1937', nom. illeg.

ILLUSTRATIONS: Wirth (1995: 326); Brodo *et al.* (2001: 256); Barreno & Pérez-Ortega (2003: lam. 35, 36); Pérez-Valcárcel *et al.* (2003: 161); Wirth *et al.* (2004: 78, 79); Burgaz & Ahti (2009: 82); van Haluwyn *et al.* (2012: 185); Ahti & Stenroos (2013: 99); Wirth *et al.* (2013: 399); Stenroos *et al.* (2016: 179); Valcuvia Passadore & Gheza (2017: 77, 79).

Primary thallus squamulose, evanescent, seen only in young specimens. Squamules ascendent, scattered or adnate, forming small rosettes, 2-5 mm long × 1-2.5 mm wide, with the margin sinuose to crenulate, greyish green upper side, white below. Podetia 20-90 mm long × 0.7-2 mm wide, subulate, branching pattern anisotomic dichotomously to polytomy, with 3-5 branches, branching angles acute to obtuse, sometimes beyond 120°, axils closed or open, sterile podetia with acute apices while fertile podetia are thicker, often perforate, tips longitudinally fissurate, flattened with pseudoscyphus aspect, but never forming real scyphi and margins involute. Some specimens have white medullary outgrowths, often tuberculous at podetial base. Podetia greyish green to dark brown, usually darker at the top although specimens located in sunny exposures have a uniform dark colour. Surface corticate, smooth or wrinkled, bright, with some areolation, esorediate, squamules scattered to abundant, perpendicular to the podetia, 2-3 mm long × 2 mm wide, with entire margin or somewhat crenulate. Apothecia frequent, solitary, sometimes in terminal groups of corymbose appearance, dark brown. Pycnidia frequent, dark brown or blackish, only located at the apex of sterile podetia, with hyaline slime.

Chemistry. - Chemically a very variable species, six major chemotypes have been identified. Chemotype I: Pd+ red, K–, KC–, C–, UV–. Fumarprotocetraric acid complex, sometimes with traces of physodalic and/or hypoprotocetraric acids. Chemotype II: Pd+ red, K–, KC–, C–, UV–. Fumarprotocetraric acid complex and bourgeanic acid. Chemotype III: Pd+ red, K–, KC–, C–, UV–. Fumarprotocetraric acid complex, psoromic

and consporomic acids. Chemotype IV: Pd+ red, K+ yellow, KC-, C-, UV-. Atranorin, fumarprotocetraric acid complex. Chemotype V: Pd+ yellow, K-, KC-, C-, UV-. Atranorin, psoromic and consporomic acids. Chemotype VI: Pd+ yellow, K-, KC-, C-, UV-. Psoromic and consporomic acids. Chemotype VII: Pd-, K+ yellow, KC-, C-, UV-. Atranorin and bourgeanic acid, additionally fumarprotocetraric acid. The most frequent chemotypes are I and IV. Several chemotypes have been found in a single population. The presence of bourgeanic acid was already detected in German material by Huneck *et al.* (2004), very frequent in specimens from Sweden (Ahti & Stenroos 2013), Iberian Peninsula (Burgaz & Ahti 2009) and Greece. The chemotypes III, V and VI are common in continental locations of Portugal and Spain, being detected also in Greece chemotype V.

Habitat and distribution.- It grows on very different substrates, on bare soil, humus, mossy rocks, tree bases and decaying wood. It occurs on acidic and basic substrates, if there is enough humidity. It is found in different habitats of forests, open forests and several shrublands, growing from sea level to 2500 m altitude. This species is very common in the Mediterranean countries, in all bioclimatic belts. It has a subcosmopolitan distribution from boreal to tropical areas (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Andorra, Algeria, Bosnia-Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Italy, Montenegro, Morocco, Portugal, San Marino, Slovenia, Spain, Syria, Tunisia and Turkey.

Remarks.- The group of *Cladonia furcata* has a complex morphology which has been used to describe numerous different taxonomic entities. We include *C. subrangiformis* in the variability of *C. furcata* because there are many intermediate specimens and the molecular results do not support separation into distinct species (Pino-Bodas *et al.* 2015). It is a morphologically variable taxon that can be mistaken for some specimens of *C. rangiformis*, but it can be distinguished by the presence of a continuous algal layer. In the case of *C. scabriuscula*, the differences are due to the fact that the podetia of the latter have granular apices and are covered by numerous microsquamules, a character that does not appear in *C. furcata*. Although some molecular results do not fully distinguish *C. scabriuscula* from *C. furcata* (Pino-Bodas *et al.* 2015) we still maintain this separation. Mistaking for *C. gracilis* is

also presumable, however, the latter has podetia less branched, always with closed apices, and real scyphi are commonly present.

38. *Cladonia galindezii* Øvstedal Cryptogamic, Bryol. Lichénol. 9: 137, 1988.

TYPE: Antarctica, Graham Land, Argentine Islands, Galindez Island, 1935, British Graham Land (Penola) Expedition 1934-1937, no. 1108 (BM holotype).

ILLUSTRATIONS: Øvstedal 1988: 138; Burgaz & Ahti (2009: 67); Ahti & Stenroos (2013: 99).

Primary thallus squamulose, with welded squamules forming a crust up to 4 cm diameter, with slightly rising margins, up to 3 mm long × 1 mm wide, margin crenulate to slightly digitate, greyish brown on the upper side and somewhat felted surface, whitish underside. Podetia uncommon, up to 15 mm long, brownish green, not scyphose, claviform or cylindrical with longitudinal crack (Øvstedal & Lewis-Smith 2001). Apothecia brown, at the apex of the podetia. Pycnidia on podetial squamules, with hyaline slime.

Chemistry.- Pd-, K+ yellow, C-, UV-. Atranorin and porphyritic acid as major substances, methylporphyritic acid inconstantly.

Habitat and distribution.- In the Mediterranean countries it is only known from Andorra where it grows from 2400 to 2900 m, in the subalpine belt, on small steps of schists and granodiorites. In the specimens from these populations only primary thalli were found (Azuaga *et al.* 2001). Taxon with bipolar distribution, known from Antarctica, where it was considered endemic (Stenroos 1993; Øvstedal & Lewis-Smith 2001), and with a very scarce presence. In the Northern Hemisphere, there are few references of the Nordic countries (Bültmann & Lünterbusch 2008; Hansen & Ahti 2011; Ahti & Stenroos 2013) growing in tundra formations. It has probably unnoticed in other parts of Europe, due to its small size and the absence of podetia.

Mediterranean countries.- Andorra.

Remarks.- It can be mistaken for *C. cariosa* but the presence of porphyritic acid serves to identify it. The crust mats of primary thallus can be mistaken for *C. pocillum* and a chemical study is necessary for accurate identification.

39. *Cladonia glauca* Flörke

De Cladon.: 140, 1828.

TYPE: Germany, Mecklenburg-Vorpommern, Waren ('Wahren'), 1826 Flörke 47 (H lectotype, Ahti, Regnum Veg. 128: 78, 1993).

ILLUSTRATIONS: Wirth (1995: 328); Burgaz & Ahti (2009: 30); van Haluwyn *et al.* (2012: 195); Ahti & Stenroos (2013: 100); Wirth *et al.* (2013: 377); Stenroos *et al.* (2016: 180); Valcuvia Passadore & Gheza (2017: 125).

Primary thallus squamulose, squamules small, 1-3 mm long \times 1-2 mm wide, generally inconspicuous and not persistent, elongate, incised or even deeply lacinated, sometimes slightly sorediate on the underside, greenish grey on the upper side and white below. Podetia 22-50 mm long \times 1-2 mm wide, apex subulate and ascyphose, simple or somewhat branched, axils open, a longitudinal groove is usually observed along the podetia, pale grey to dark brown. Surface covered by farinose soredia in upper part, 20-70 μ m diameter, basal area areolate, sometimes corticate, naked or with scattered squamules, which can occupy a large area of the podetia, squamules lacinate, 2-3 mm long \times 1-2 mm wide. Apothecia very rare, brown, on the tips of the podetia. Pycnidia frequent at the apex of the podetia with hyaline slime.

Chemistry.- Two chemotypes have been found. Chemotype I: Pd-, K-, C-, UV+ white. Squamatic acid with traces of barbatic acid. Chemotype II: Pd+ yellow, UV-. Thamnolic acid with traces of barbatic acid. The chemotype I is the most common.

Habitat and distribution.- It is a frequent species, which grows on rocks, tree bases and acid soils. It grows in the montane, meso- and supramediterranean belts, from 600-1700 m altitude. It is rare in the Eurosiberian region, although it may have been unnoticed. It is distributed in more or less oceanic areas of the Northern Hemisphere (Ahti & Stenroos 2013).

Mediterranean countries.- Croatia, France, Greece, Italy, Portugal, Slovenia, Spain and Turkey.

Remarks.- In absence of apothecia, it can be mistaken for *C. macilenta* which has red apothecia. But the podetia of *C. macilenta* have a whitish colour and no longitudinal fissures. The podetia are also similar to those of *C. subulata*, but this one has a Pd+ red reaction. Another species possibly mistaken is *C. rei*, which also

has no longitudinal fissure, and contains homosekikaic and sometimes fumarprotocetraric acids.

40. *Cladonia gracilis* (L.) Willd. subsp. *gracilis*

Fl. Berol. Prodr.: 363, 1787.

Lichen gracilis L., Sp. Pl. 2: 1152, 1753.

TYPE: Icon in Dillenius, Hist. Musc.: t. 14, f. 13C, 1742, lectotype, Ahti, Regnum Veg. 78: 79, 1993), corresponding specimen in Herb. Dillenius (OXF-Dillenius epitype, Jørgensen *et al.*, Bot. J. Linn. Soc. 115: 377, 1993).

ILLUSTRATIONS: Wirth (1995: 329); Brodo *et al.* (2001: 257); Pérez-Valcárcel *et al.* (2003: 163); Wirth *et al.* (2004: 83); Burgaz & Ahti (2009: 51); Ahti & Stenroos (2013: 100); Wirth *et al.* (2013: 399); Stenroos *et al.* (2016: 182).

Primary thallus squamulose, evanescent, very rarely persistent. Squamules scattered, 2-4 mm long \times 1-5 mm wide, margin crenulate, greyish green to dark brown on the upper side and white below. Podetia grouped, 25-75 mm long \times 0.3-5 mm wide, greenish grey to dark brown, simple or rarely branched once or twice, young specimens subulate, then widen slightly forming small, shallow and narrow scyphi dentate at margin, a variable number of teeth from which new subulate extensions develop, almost black on the lower part. Surface continuously corticate, cortex smooth to verrucose or areolate, bright, squamules can be present throughout the podetia or lack them, apices with thick soredia only very rarely present. Apothecia not common, dark brown, located at the scyphal margin. Pycnidia uncommon at the scyphal margin, with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex.

Habitat and distribution.- It grows on humus, mossy rocks and rocky places, decaying wood, rarely on bare soils, generally in acid substrates. It is more common in the Eurosiberian region where it grows in heathlands and in the interior of deciduous forests, especially beech woodlands. It is a circumpolar taxon, which extends from boreal to temperate areas. It can be considered amphiatlantic in the Northern Hemisphere, with disjunctions in Southern South America. In general, it grows in areas with oceanic influence (Ahti 1980).

Mediterranean countries.- Andorra, Algeria, Bosnia-Herzegovina, Croatia, France, Italy, Montenegro, Portugal, Slovenia, Spain, Tunisia and Turkey.

Remarks.- It is morphologically very variable and many subspecies have been described in Europe and North America (Ahti 1980), most of them polyphyletic (Fontaine *et al.* 2010; Pino-Bodas *et al.* 2011). The material of Southern Europe is not problematic, since only the subsp. *gracilis* is present and is easily recognized for having slender podetia with thin apex and surface smoothly corticate and bright. Misidentification with *C. macroceras* is possible, but the podetia of this species are more robust, with thicker walls. It is also similar to *C. furcata*, but it never has scyphi and its axils are perforate. It differs from *C. crispata* because of the thallus UV+ white, due to the squamatic acid, and the perforate scyphus, forming funnels.

41. *Cladonia graeca* Sipman & Ahti *Mycosystema* 30(6): 879, 2011.

TYPE: Greece, W Aegean, nomos Evvias, Ep. & Dim. Karistos: S Evvia, summit area of Mt. Ochi, alt. 1370 m, 38° 3.5' N 24° 27.9' E, siliceous schist cliffs and boulders in barren rocky area, 26 Sept. 2005, Sipman & Raus 53957a (B holotype, H isotype).

ILLUSTRATIONS: Sipman & Ahti (2011: 879).

Primary thallus squamulose, persistent, 2-3 mm long × 0.5-2 mm wide, green to brownish on the upper side and white to lilac below. Podetia 5-20 mm long × 0.5-1 mm wide, apex subulate and non scyphose, slightly striate, simple or somewhat branched, whitish to brown. Surface esorediate but bearing many phyllidia bullate or plane. Apothecia very rare, brown. Pycnidia very rare at the apex of the podetia.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex.

Habitat and distribution.- A very rare species growing on small steps of schists in shrubland where there are some water runoff. Only known from Evia and Thasos Greek islands (Sipman & Ahti 2011; Linda 2019) and in NE Turkey (Kocakaya *et al.* 2018).

Mediterranean countries.- Greece and Turkey.

Remarks.- It can be mistaken for *C. macrophylla* and *C. decorticata* but the chemistry is different with psoromic acid in the first species and perlatolic acid in the other. Other similar species is *C. ramulosa* which also contains fumarprotocetraric acid but usually has scyphi.

42. *Cladonia grayi* G.Merr. ex Sandst. *Cladon.* Exs. no. 1847, 1929.

TYPE: United States of America, North Carolina ('North Virginia'), Mecklenburg Co., Charlotte, Long Creek, 1928, Gray in Sandstede, *Cladon.* Exs. no. 1847 (FH lectotype, Ahti, *Regnum Veg.* 128: 79, 1993).

ILLUSTRATIONS: Ahti (2000: 120); Burgaz & Ahti (2009: 62); Ahti & Stenroos (2013: 101); Stenroos *et al.* (2016: 183).

Primary thallus squamulose, generally persistent, forming a small crust. Squamules 1 mm long × 1-2 mm wide, ascendant, with crenulate margins. Podetia 5-15 mm long × 2-7 mm wide, scyphose, generally simple, rarely with proliferations from the margin, with a long and narrow stalk, scyphi globose, light greyish green to dark or somewhat brownish. Surface of podetia corticate, sometimes very verruculose, scaling off the podetia becoming decorticate some areas with the age. Upper parts of podetia develop soralia and granules 40-130 µm diameter or detach small squamules as schizids or form numerous squamules. Apothecia not common, at scyphal margin, dark brown. Pycnidia common, on the scyphus margin, with hyaline slime.

Chemistry.- Pd- or Pd+ red, K-, KC-, C-, UV+ ice blue. Grayanic, congrayanic and demethylgrayanic acids, these last two substances appear inconstantly. Sometimes it also contains traces of fumarprotocetraric acid complex.

Habitat and distribution.- It grows on various substrates, decaying wood, humus, bare soil, generally very acid. In the Mediterranean countries it does not seem very frequent only small dispersed populations in the meso- to supramediterranean belts, preferably in the Eurosiberian region on colline to montane belts. It is a subcosmopolitan species, widely distributed in the Northern Hemisphere, from the Arctic to temperate regions, is also found in the Neotropic and Australasia, although scattered and at higher altitudes (Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, Algeria, France, Italy, Portugal, Slovenia and Spain.

Remarks.- It belongs to *C. chlorophaea* group, whose taxa are morphologically very similar and treated as chemotypes by some authors. However, we believe that there are enough morphological differences to lend to *C. grayi* as a species rank. These characters are: the

corticate podetia with granules, rarely with thick soredia, and the dark colour of the thallus. Sometimes it is difficult to differentiate it from *C. merochlorophaea*, but the scyphi are smaller in *C. grayi* and the podetia of *C. merochlorophaea* are clearly sorediate, especially in the central part. However, TLC is required for accurate identifications.

43. *Cladonia homosekikaica* Nuno J. Jap. Bot.: 50: 294, 1975.

TYPE: Japan, Hokkaido, Nemuro District, Shiretoko Peninsula, Mt. Rausu-dake, Togashi 7075 (TNS holotype).

ILLUSTRATIONS: Burgaz & Ahti (2009: 62); Ahti & Stenroos (2013: 101).

Primary thallus squamulose, persistent. Squamules 1-1.5 mm long × 1-1.5 mm wide, with the margin entire or slightly crenulate, olive green on the upper side, white below. Podetia scyphose, scattered or in groups, rarely proliferating in the margin, 7-15 mm long × 3-5 mm wide, greyish green to dark greenish brown, irregular and dentated margin. Podetial surface corticate or ecorticate, with diffuse or scattered soralia, soredia variable in size, from farinose to granular, 20-80 µm diameter, podetial base frequently with squamules. Apothecia not common, at the scyphal margin or on short peduncles, dark brown. Pycnidia frequent, on the scyphal margin, with hyaline slime.

Chemistry.- Pd+ red or Pd-, K-, KC-, C-, UV+ white. Homosekikaic and sekikaic acids, fumarprotocetraric acid complex inconstantly.

Habitat and distribution.- It grows on bare soil, in exposed areas, with preference for acid substrates. It is a rare taxon in the Mediterranean countries, more common in northern localities. Its distribution is scattered throughout the Northern Hemisphere, reaching some outposts in Australia (Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, Croatia, France, Greece, Montenegro, Portugal and Spain.

Remarks.- It was traditionally considered a chemotype of *C. chlorophaea*, but *C. homosekikaica* has farinose soredia. It can be also confused with *C. fimbriata* and *C. coniocraea*, but in the latter two the cortex is restricted to the basal part of podetia, the soredia have smaller size and the podetia are more slender.

44. *Cladonia humilis* (With.) J.R.Laundon Lichenologist 16: 220, 1984.

Lichen humilis With., Bot. Arr. Veg. Great Brit.: 721, 1776.

TYPE: Icon in Dillenius, Hist. Musc.: t. 14, fig. 11, 1742 (holotype), England, London, Greenwich, Charlton and Woolwich, Herb. Dillenius t. 14, fig. 11 (OXF-Dillenius epitype, Ahti, Fl. Neotrop. Monogr. 78: 122, 2000).

ILLUSTRATIONS: Burgaz & Ahti (2009: 39); Pino-Bodas *et al.* (2012c: 167); Ahti & Stenroos (2013: 101).

Primary thallus squamulose, persistent. Squamules large, 1.5-4 mm long × 3-4 mm wide, more or less rounded, with an entire margin or somewhat lobed, sometimes slightly sorediate, lower side sometimes slightly veined light green on the upper side and white below. Podetia scyphose which, in general, widens rapidly, 4-11 mm long × 3.9-5 mm wide, stalk 0.8-1.2 mm wide and shorter than the scyphi, so the scyphi seem sessile, simple, generally very regular, rarely with marginal proliferations, light greenish grey. Surface of the podetia smoothly corticate, somewhat pruinose at the base, frequently the cortex reaches the scyphal margin; outer part and inside the scyphi the surface is covered by farinose soredia, 20-60 µm diameter. Apothecia not common, on margin stalks of scyphi, dark brown. Pycnidia not frequent, at the scyphus margin, with hyaline slime.

Chemistry.- Four chemotypes are known. Chemotype I: Pd+ red, K+ yellow, C-, UV-. Atranorin, fumarprotocetraric acid complex. Chemotype II: Pd+ red, K-, C-, UV-. Bourgeanic and fumarprotocetraric acids. Chemotype III: Pd+ red, K+ yellow, C-, UV-. Atranorin, fumarprotocetraric and bourgeanic acids. Chemotype IV: Pd+ red, K-, C-, UV-. Fumarprotocetraric acid complex. Chemotype I is the most frequent and is widely distributed.

Habitat and distribution.- It is a pioneer species, growing on bare soils and roadside slopes, on sandy slopes, rock crevices, steps, in open sclerophyllous, deciduous or coniferous woodlands, on different shrublands, generally acidic or moderately acidic soils, sometimes on tree bases. It is a very common species in the Mediterranean countries, more frequent in Western Mediterranean, growing from sea level to 2000 m altitude in colline, montane, meso- and supramediterranean belts. It has a subcosmopolitan distribution, being common in temperate zones (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Andorra, Algeria, Croatia, Cyprus, France, Greece, Italy, Malta, Portugal, Slovenia, Spain and Turkey.

Remarks.- This species can be mistaken for other sorediate taxa such as the species of *C. chlorophaea* group or *C. fimbriata*, but it is easily recognized by its short podetia, only partially covered by farinose soredia, and its relatively large squamules of the primary thallus. *Cladonia conista* is also morphologically closely related, considered for long time as a chemotype of *C. humilis* containing bourgeanic acid and podetia slightly longer. However, the molecular results obtained by Pino-Bodas *et al.* (2012c, 2013c) resolved that they are different species. On the other hand, the results of Pino-Bodas (2013c) confirmed that other described species of North America such as *C. pulvinella* or *C. hammeri* (Ahti & Hammer 2002) are not in Europe, and the specimens reported by Burgaz & Ahti (2009) represent part of the morphological and chemical variability of *C. humilis*. However, more molecular studies are being conducted at the moment about this group of species and future taxonomical changes are expected.

45. *Cladonia imbricarica* Kristinsson Lichenologist 6: 143, 1974.

TYPE: Iceland, central Highlands, Thjórsárver, Oddkelsalda, 1971 Kristinsson 24582 (AMNH holotype).

Illustrations: Kristinsson (1974: pl. 1B); Krog *et al.* (1994: 160); Stenroos *et al.* (2011: 144); Ahti & Stenroos (2013: 101); Stenroos *et al.* (2016: 184).

Primary thallus squamulose, persistent. Squamules adnate to imbricate, 0.5-3 mm long × 2-3 mm wide, margins not sorediate, surface greenish grey to brown in the upper side, white below. Podetia scyphose, simple, short, 5 mm long × 2-4 mm wide, regular, brownish to greyish green, surface of the podetia corticate, esorediate and verruculose, with scyphal plates, the cortex disappears and produces schizidia, preferentially inside the scyphus. Apothecia not common, brown. Pycnidia frequent, at the scyphus margin.

Chemistry.- Pd-, K-, C-, UV+ white. Sphaerophorin. One specimen contains additionally fumarprotocetraric acid complex.

Habitat and distribution.- This is a very rare species in the Mediterranean countries. It was recently reported

from Slovakia at 616 m altitude (Palice *et al.* 2018) in the western Carpathians, and we found it in the Dinaric Alps of Montenegro (Nikšić and Žabljak municipalities), growing at 1140-1761 m altitude, on limestone substrate and shrubs with *Ostrya carpinifolia*, *Pinus nigra*, *P. mugo* and *Juniperus communis* (Burgaz *et al.* 2019) and also in Asturias, Northern Spain, at 450 m altitude (unpublished). It has been reported from Europe, Asia, North America and South America, common in high mountains of the Neotropic (Ahti 2000; Ahti & Stenroos 2013). Its range is poorly known.

Mediterranean countries.- Montenegro and Spain.

Remarks.- This species is difficult to identify without chemical analysis and has probably been overlooked by its small size. It is similar to some specimens of *C. pyxidata* by the scyphus appearance.

46. *Cladonia incrassata* Flörke De Cladon.: 21, 1828.

TYPE: Germany, Flörke, Cladon. Exs. no. 5 (G lectotype, Ahti, Regnum Veg. 128: 81, 1993).

ILLUSTRATIONS: Brodo *et al.* (2001: 258); Burgaz & Ahti (2009: 55); van Haluwyn *et al.* (2012: 151); Ahti & Stenroos (2013: 101); Stenroos *et al.* (2016: 185).

Primary thallus squamulose, persistent. Squamules 1-4 mm long × 0.9-2 mm wide, ascending, margins crenulated, greenish yellow upper side, below the surface is granulate-corticate, sorediate at the edges, which is usually incurved. Podetia very rare, with small size, 1-4 mm long × 0.3-2 mm wide, simple, cylindrical. Surface partially granulate-corticate. Apothecia red, 0.3 mm diameter. Pycnidia frequent, sessile on primary thallus, with red slime.

Chemistry.- Pd-, K-, KC-, C-, UV+ white. Didymic, squamatic, rhodocladonic and usnic acids.

Habitat and distribution.- It grows on stumps and decaying wood. It is a very oceanic species that was found in the colline and montane belts in the Eurosiberian region, rarely reaches some outposts in the Mediterranean region. It is a Holarctic taxon, with little presence in tropical areas (Litterski & Ahti 2004).

Mediterranean countries.- France, Italy, Portugal, Slovenia and Spain.

Remarks.- Although apparently it has a fairly restricted distribution, it is likely to have been unnoticed due to its small size. It can be mistaken for *C. parasitica*, but

reacts Pd+ yellow, or for *C. caespiticia*, which reacts Pd+ red, both species lack red apothecia.

47. *Cladonia islandica* Kristinsson & Ahti

Biblioth. Lichenol. 99: 279, 2009.

TYPE: Iceland, South Iceland, Árnessýsla, Herdísarvík, 1978 Kristinsson 22419 (AMNH holotype).

ILLUSTRATIONS: Kristinsson & Ahti (2009: 281); Ahti & Stenroos (2013: 101); Pino-Bodas *et al.* (2014: 26); Ahti & Stenroos (2013: 101).

Primary thallus persistent, squamules 2-5 mm long × 1-2.5 mm wide, divided up to half of their length, upper side light green, lower side grey to black at the base and white toward the tips. Podetia 20-30 mm long × 0.7-2 mm wide, simple or irregularly branching above the basal part, generally subulate, rarely producing narrow scyphi, with closed axils, brownish to green. Surface covered by microsquamules, corticate at the base. Apothecia not observed. Pycnidia black, terminal on the podetia, cylindrical, with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex.

Habitat and distribution.- It grows on acid soils of *Pinus sylvestris* forest. It is a very rare species in the Mediterranean countries, only known from one locality in Salamanca province (Spain, Central System Mountains) at 1390 m altitude (Pino-Bodas *et al.* 2014), belonging to the supra-mediterranean belt. This species has a restricted distribution in cold and oceanic localities from Alaska, Canada and Iceland (Kristinsson & Ahti 2009; Pino-Bodas *et al.* 2014).

Mediterranean countries.- Spain.

Remarks.- It can be mistaken for *C. subulata* but it has sorediate podetia. It also resembles *C. scabriuscula* but the morphology of the squamules are different.

48. *Cladonia luteoalba* Wheld. & A.Wilson

Fl. W. Lancashire: 450, 1907.

TYPE: England, West Lancashire, Greygarth Fall, 1906, Wheldon & Wilson 19 (BM lectotype, Ahti, Lichenologist 3: 86, 1965, as 'holotype').

ILLUSTRATIONS: Stenroos (1990: 31); Burgaz & Ahti (2009: 43); Ahti & Stenroos (2013: 102); Stenroos *et al.* (2016: 186).

Primary thallus squamulose, persistent. Squamules 9-15 mm long × 9 mm wide, rounded, sometimes elongate, edge somewhat crenulate or even lacinated, margins of squamules incurved, underside cottony, yellowish green in upper side, covered with pruine, yellow below, sometimes somewhat warty, medulla white. Podetia very rare, 12 mm long × 3 mm wide, narrowly scyphose, simple, sometimes proliferating from the margins. Surface eorticate, verrucose-arachnoid. Apothecia red located at the scyphal margin, up to 0.2 mm diameter, often anastomosed. Pycnidia at the margin of the podetia or on the surface of the primary thallus, colour of slime not observed.

Chemistry.- Pd-, K-, KC+ yellow, C-, UV-. Usnic acid and zeorin. Other chemotypes have been found elsewhere (Huovinen *et al.* 1989).

Habitat and distribution.- It is apparently a very pioneer taxon, growing on bare acidic or hyperbasic soil as serpentines, and can also grow on thalli of other *Cladonia* species (such as *C. coccifera*, it was found growing on its scyphi). It is quite scarce, only found in Spain from 150 to 1800 m altitude rarely on the colline belt and more common in meso-, supra- and oromediterranean belts. It has a poorly known distribution in the Northern Hemisphere and some points of the Southern Hemisphere (Stenroos 1990).

Mediterranean countries.- Spain.

Remarks.- It may be unnoticed or mistaken for *C. foliacea*, since it is very rare to find it with podetia. Although it is identified easily by the large squamules with intense yellow underside, cottony, no sorediate. The status of this peculiar species is unresolved. According to some hypotheses it is an aberrant morphotype of other *Cladonia* species (Stenroos 1990) and further studies are required.

49. *Cladonia macilenta* Hoffm.

Deutschl. Fl. 2: 126, 1796, nom. cons.

TYPE CONS.: Germany, Niedersachsen, Oldenburg, Litteler Fuhrenkamp. 1919 Sandstede in Sandstede, Cladon. Exs. no. 477 (UPS).

Baeomyces bacillaris Ach., Methodus: 329, 1803, nom. cons. - *Cladonia bacillaris* (Ach.) Genth, Fl. Nassau: 406, 1835.

ILLUSTRATIONS: Wirth (1995: 331); Brodo *et al.* (2001: 259); Wirth *et al.* (2004: 89); Burgaz & Ahti (2009: 55); van Haluwyn *et al.* (2012: 149); Wirth *et al.* (2013: 401); Ahti & Stenroos (2013: 102); Wirth

et al. (2013: 401); Stenroos *et al.* (2016: 187); Valcuvia Passadore & Gheza (2017: 163).

Primary thallus squamulose, persistent. Squamules 1-2 mm long × 1-2 mm wide, crenulate to lobed, sometimes margin with granulose soredia, greyish green in upper side, white below. Podetia 8-4.5 mm long × 1-2 mm wide, not scyphose, usually simple, but sometimes with branched apices, whitish green. Surface sometimes corticate at the base and bearing some small squamules, 2 × 2 mm, upper part of the podetia finely sorediate, soredia 20-50 µm diameter. Apothecia red, located at the apex of the podetia that can become anastomosed, 0.2-0.3 mm diameter. Pycnidia at the apex of the podetia with red slime.

Chemistry.- Chemically variable taxon. Two chemotypes were found. Chemotype I: Pd+ yellow, K+ yellow, KC-, C-, UV-. Thamnic, barbatic and didymic acids, and porphyritic acid in the apothecia, rarely presents usnic acid (found in a specimen from Vizcaya province in Spain), already noted by Christensen (1987) in Danish material. Chemotype II: Pd-, K-, KC-, C-, UV-. Barbatic and didymic acids. The chemotype II has a very restricted distribution in the Mediterranean countries. Some authors have considered this chemotype as a different taxon, *C. bacillaris*. Elsewhere also a third chemotype, with squamatic acid, has been found.

Habitat and distribution.- It grows on wood, stumps, tree bases, acidic or hyperbasic rocks, and soils, in heathland, pine woodlands and deciduous forests. It is quite frequent and has wide distribution through the colline and montane belts and grows also in humid areas of the supramediterranean belt. It has a wide distribution in both hemispheres, being rare in tropical lowlands and high mountains of South America (Ahti 2000).

Mediterranean countries.- Albania, Bosnia-Herzegovina, Croatia, France, Greece, Italy, Montenegro, Portugal, Slovenia, Spain, Tunisia and Turkey.

Remarks.- It can be mistaken for *C. floerkeana* but its podetia have a greyish-brown colouration and the upper part shows thick granules of 0.2 mm diameter. Other species morphologically similar is *C. norvegica* which contains barbatic and 4-*O*-methylbarbatic acids, but is characterized by having a primary thallus squamulose finely divided and podetia also finely sorediate.

50. *Cladonia macroceras* (Delise) Hav.
Bergens Mus. Årbok, Naturvidensk. Rekke
1927(3): 12, 1928 '1927'.

Cenomyce gracilis var. *macroceras* Delise, Bot. Gall.: 624, 1830.

TYPE: France, «ad terram in Alpiibus, monte Aureo, Pyrenaeis» (PC?, not designated).

ILLUSTRATIONS: Wirth (1995: 311); Burgaz & Ahti (2009: 51); Ahti & Stenroos (2013: 102); Wirth *et al.* (2013: 402); Stenroos *et al.* (2016: 188); Valcuvia Passadore & Gheza (2017: 129).

Primary thallus squamulose, evanescent or rarely persistent. Squamules scattered or forming a mat of adnate squamules, similar to the primary thallus of *C. pocillum*, 2.5-4 mm long × 3-5 mm wide, margin entire and recurved, greyish green to dark brown on the upper side, white below. Podetia grow in groups, 20-35 mm long × 1.5-6 mm wide, very dark brown at the top, simple or rarely branched once or twice, axils closed, young specimens subulate, then very rarely widen slightly forming small shallow and short scyphi, toothed scyphus margin, with a variable number of teeth, from which new subulate extensions are developed, greenish grey at the base, if the material is very little exposed to light has a dark yellowish colour to black in the dead parts of the podetia. Surface corticate, smooth to warty or areolate, shiny, squamules present on the podetia or lacking, at podetial base transverse cracks and white medullary outgrowth are frequently present. Apothecia very rare, dark brown, at the scyphus margin. Pycnidia uncommon, also at the margin of the scyphus with hyaline slime.

Chemistry.- Two chemotypes are recognized in the Mediterranean countries. Chemotype I: Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex and quaesitic acid. Chemotype II: Pd+ red, K+ yellow, KC-, C-, UV-. Atranorin and fumarprotocetraric acid complex. Chemotype I is the most frequent, growing at higher altitudes. This chemical variability has already been detected in European material (Ahti 1980; Ahti & Stenroos 2013).

Habitat and distribution.- It grows on steps and bare ground in windy situations, on acid substrates, sometimes in locations protected by snow. This is an Arctic-Alpine taxon that reaches very scarcely the higher altitudes, above 2300 m, in the subalpine and alpine belts of the Eurosiberian region. In the Mediterranean

region only reported from South Italy (Puntillo 1996). These populations represent the southern distribution limit and it is thought that they are relicts isolated during early glaciations.

Mediterranean countries. - Andorra, France, Italy, Montenegro, Slovenia, Spain and Turkey.

Remarks. - It is morphologically very variable, especially if the populations from the Arctic and from the Alps are compared, which are also chemically variable. However not enough material has been included in the phylogenetic studies to determine the taxonomical status of these populations (Pino-Bodas *et al.* 2011; Stenroos *et al.* 2019). It is morphologically close to *C. gracilis* from which it differs by shorter and more robust podetia, with white medullary excrescences at the basal area of the podetia, and also having this area darkened.

51. *Cladonia macrophylla* (Schaer.) Stenh. Lich. Succ. Exs., ed. 2, Fasc. 7: [3] 1865.

Cladonia ventricosa var. *macrophylla* Schaer., Lich. Helv. Spic. 1(6): 316, 1833.

TYPE: Switzerland, Canton Berne, Grimsel Pass, Handeck and Susten Pass, Gadmen, Schaerer, Lich. Helv. Exs. no. 279 (G lectotype, Ahti, Regnum Veg. 128: 83, 1993).

ILLUSTRATIONS: Wirth (1995: 331); Burgaz & Ahti (2009: 77); Ahti & Stenroos (2013: 102); Stenroos *et al.* (2016: 188).

Primary thallus squamulose, persistent. Squamules rounded, elongate or incised, 4–6 mm long × 3–6 mm wide, glaucous-green upper side white below. Podetia uncommon, not scyphose, 10–25 mm long × 1–3 mm wide, simple or somewhat branched at the apex. Surface corticate, cracked and with numerous openings, develop abundant squamules peltate, decorticate at the base of the podetia, grey or blackish. Apothecia not common, at the apex of the podetia, brown. Pycnidia at the apex of the podetia and also in the podetial peltate squamules, with hyaline slime.

Chemistry: - Pd+ yellow, K–, KC–, C–, UV–. Psoromic acid.

Habitat and distribution. - It grows on mossy rocks, mineral soils and peat, between rocks, less frequent in forest soils. It is very rare in the Mediterranean countries growing in montane to alpine belts and in the supramediterranean belt, probably unnoticed because the podetia are often missing. It is a Holarctic taxon, with Arctic-Alpine

distribution with some outlier in Papua New Guinea (Litterski & Ahti 2004; Ahti & Stenroos 2013).

Mediterranean countries. - Italy, Portugal and Spain.

Remarks. - Specimens without podetia can be mistaken for other species with big primary thallus, such as *C. cariosa*, *C. polycarpoides* and *C. symphycarpa*, but the presence of psoromic acid (Pd+ yellow) and the absence of atranorin (K–) are useful to identify it.

52. *Cladonia macrophyllodes* Nyl. Flora 58: 447, 1875.

TYPE: Austria, Tyrol, Ötztal, Kühtai («Kühthei»), 1874 Arnold 23 (H-NYL 38748 lectotype, Ahti, Regnum Veg. 128: 23, 1993).

ILLUSTRATIONS: Brodo *et al.* (2001: 260); Burgaz & Ahti (2009: 64); Ahti & Stenroos (2013: 103); Stenroos *et al.* (2016: 189).

Primary thallus squamulose, persistent. Squamules large, 6–15 mm long × 5–9 mm wide, upper side areolate-verruculose, glaucous green, white below, yellowish to black toward the base. Podetia not common, scyphose, 6–15 mm long × 4–7 mm wide, simple or proliferating from the center of the scyphus, white in the young parts, base of the podetia have dead, necrotic, black. Surface corticate and areolated, slightly tomentose, the margin of the scyphi developing abundant large squamules. Apothecia uncommon, at the scyphal margin, dark brown, generally remain separate. Pycnidia on the squamules of the primary thallus or at the scyphal margin, frequent, with hyaline slime.

Chemistry. - Pd+ red, K+ yellow, C–, UV–. Atranorin and fumarprotocetraric acid complex.

Habitat and distribution. - It grows on acidic soils of the Mediterranean high mountains, along the subalpine and alpine belts. It is a circumpolar taxon, distributed in the Arctic, which extends through the high mountains of Eurasia, North America, reaching exceptionally the Andes and Tierra del Fuego (Ahti 2000; Ahti & Stenroos 2013).

Mediterranean countries. - Andorra, France, Greece, Italy, Montenegro, Spain and Turkey.

Remarks. - It is quite rare and can be mistaken for *C. symphycarpa* or *C. pyxidata*, but it is recognized by the scyphose podetia, with the blackened base, the surface corticate and the presence of numerous large squamules on the margin of the scyphus. Another possible confusion is with *C. subcervicornis* from which it differs by having bigger primary thallus and scyphus.

53. *Cladonia magyarica* Vain.

Schedae Fl. Hung. Exs., cent. 8, p. 8 (no. 715), 1927.

TYPE: Hungary, Com. Pest, Kecskemét, alt. 120 m, May 1924, Timkó, Fl. Hung. Exs., no. 715 (TUR-V 12570, lectotype, Ahti, Ann. Bot. Fenn. 3(3): 388, 1966, as 'holotype').

ILLUSTRATIONS: Farkas & Lökös (1994: 22).

Primary thallus squamulose, persistent. Squamules ascendent, 2-5 mm long × 2-4 mm wide, from subentire to lobated, adnate to ascending, coalescing, margins no serrate, upper surface glaucous green to olive, below white to somewhat brown, that darkens towards the base, relatively thick. Podetia 7-13 mm long × 2-6 mm wide, scyphose, usually simple, regular, the scyphi are symmetrical, with elongate and narrow base, 1-2 mm wide. Surface of the podetia corticate, quartered and areolate, in mature scyphus the cortex disappears and produces numerous elongate squamules, up to 2 mm wide, microsquamules and peltate flat granules are produced inside and outside the scyphus. Apothecia uncommon, dark brown, arranged at the margin of the scyphus. Pycnidia frequent, dark brown to black, at primary squamules, with hyaline slime.

Chemistry.- Pd+ red, K+ yellow, C-, UV-. Atranorin and fumarprotocetraric acid complex.

Habitat and distribution.- It has been reported from Turkey on *Pinus nigra* forest at 1350 m (Kocakaya *et al.* 2018). This species has a restricted distribution to acidic sandy soils of some continental areas of Central Europe especially in the Danube river basin, with some outliers in North America (Litterski & Ahti 2004; Zraik *et al.* 2016).

Mediterranean countries.- Turkey.

Remarks.- It is rather similar to some specimens of *C. pyxidata* but the morphology of podetia, covered with numerous squamules is characteristic. Also molecular results support the monophyly of this species (Stenroos *et al.* 2019). More studies are required to confirm the presence of this species in Turkey and its total range in general.

54. *Cladonia mediterranea* P.A.Duvign. & Abbayes
Rev. Bryol. Lichénol. 16: 95, 1947.

TYPE: France, Gard, Bellegarde, mas de Broussan, 1946, Duvigneaud 332 (PC holotype).

Cladonia mediterranea (P.A.Duvign. & Abbayes) Follmann & Hern.-Padr., Philippia 3: 369, 1978.

ILLUSTRATIONS: Llimona (1991: 403); Wirth *et al.* (2004: 75); Burgaz & Ahti (2009: 19); van Haluwyn *et al.* (2012: 181); Valcuvia Passadore & Gheza (2017: 35).

Primary thallus evanescent. Podetia pale yellow, 45-75 mm long, in general isotomous, although sometimes subisotomous in the apices, thicker branch 1-1.8 mm wide, internode length 3-5 mm. Generally, the apices are erect, not deflexed, branches divergent in all directions, branching type dichotomous, rarely trichotomous, axils closed or with a small hole. Surface felted, compact, uniform and algal layer continuous. Rarely fertile, and in this case, with brown apothecia. Pycnidia at the podetia apex, with hyaline slime.

Chemistry.- Pd-, K-, UV+ pale blue. Usnic and perlatolic acids.

Habitat and distribution.- It occurs scattered in thermic and humid localities with frequent mists in the thermo-, mesomediterranean, colline and montane belts, being more frequent in the Mediterranean region, especially on acid and subneutral soils, less frequent on limestone soils. In many Mediterranean countries, its distribution is restricted to the coastal forests of *Quercus suber*, maquis and shrubland vegetation of beaches. It also appears in open areas of pine forests from sea level up to 500 m altitude, wherever the dew contribution is important. Some records have not been confirmed for instance in Menorca (Stolley & Kappen 2002). It was a very frequent and abundant species along the Portuguese coasts, growing on unaltered habitats, as evidenced by the numerous collections present in the Portuguese herbaria, from the 19th century and first half of the 20th century. Currently its distribution area is being reduced by the serious aggressions suffered by the entire coastline due to the fragmentation of populations and declining habitat quality. Similar situation is observed along the Tyrrhenian coast in Italy. According to Ravera *et al.* (2016) this species is considered endangered in Italy. Conservation measures are necessary to avoid the reduction of its distribution area. As well as *C. stellaris* or *C. portentosa* in Scandinavia, *C. mediterranea* has been used for decoration in South Europe and no regulation exists to control such collection. It has a Mediterranean-Macaronesian distribution (Pino-Bodas *et al.* 2016; Nimis & Martellos 2017) with some populations along the Atlantic coast of France and United Kingdom.

Mediterranean countries.- Algeria, Croatia, France, Greece, Italy, Morocco, Portugal, Spain, Tunisia and Turkey.

Remarks.- It is easily recognized by its dichotomous branching pattern, compact felted surface and pale yellow colour. Generally, the podetia form very characteristic elongate balls. However, it may be mistaken for species with Pd- reaction, such as *C. mitis* and *C. portentosa* morphotype *impexa* when they grow at lower altitude, since they can live together. In both cases, significant differences are observed in the podetial wall thickness, but the differences with *C. mitis* are more pronounced than with *C. portentosa* morphotype *impexa* (Burgaz & Martínez 2008). Anyway, the dominant dichotomous branch pattern in *C. mediterranea* and the absence of perlatolic acid in *C. mitis* are useful characters to differentiate them. Molecular results of Pino-Bodas *et al.* (2016) support the monophyly of *C. mediterranea* too.

55. *Cladonia merochlorophaea* Asahina J. Jap. Bot. 16: 713, 1940.

TYPE: Germany, Niedersachsen, Oldenburg, Oldenburger Sand, 1918 Sandstede in Sandstede, Cladon Exs. no. 389 (TNS lectotype, Ahti, Regnum Veg. 128: 85, 1993).

ILLUSTRATIONS: Burgaz & Ahti (2009: 62); Ahti & Stenroos (2013: 103); Stenroos *et al.* (2016: 191).

Primary thallus squamulose, persistent. Squamules 1-1.5 mm long \times 1.5-3 mm wide, margin widely lobate, greyish green, with a tendency to dark on the upper side, whitish below on the margin, dark brown to almost black at the base. Podetia scyphose, 6-12 mm long \times 3-5 mm wide, gradually flaring, greenish, with a tendency to black necrotic bases. Surface corticate, areolate in the young parts, later with granules of variable sizes, (20-) 40-80 μ m diameter, which are schizids or squamules, but not real soredia, finally detaching from the external and internal surface. Apothecia very rare, on scyphal margin, brown. Pycnidia at the scyphal margin with hyaline slime.

Chemistry.- Pd+ red o Pd-, K-, KC+ red, C+ red, medulla UV+ bluish white. Merochlorophaeic, 4'-*O*-methylcryptochlorophaeic and submero-chlorophaeic acids, fumarprotocetraric acid complex inconstant.

Habitat and distribution.- It is rare in the Mediterranean countries, growing scattered in colline to alpine, meso- and

supramediterranean belts. Small populations usually appear growing together with other taxa, so it is probably unnoticed. It develops on acidic substrates, humus and decaying wood. It is a subcosmopolitan taxon, with distribution from the Arctic to temperate regions (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Andorra, Croatia, France, Italy, Montenegro, Portugal, Slovenia and Spain.

Remarks.- It has traditionally been considered as a chemotype of *C. chlorophaea*, but the scyphi are relatively larger than in other chemotypes and develops numerous vegetative propagules. Therefore, we give it species rank following Ahti (2000).

56. *Cladonia mitis* Sandst. Cladon. Exs. no. 55, 1918.

TYPE: Germany, Niedersachsen, Oldenburg, Kronsberge near Bösel, 1916 Sandstede in Sandstede, Cladon. Exs. no. 55 (BRNU lectotype, Ruoss, Bot. Helv. 97: 260, 1987).

Cladonia arbuscula subsp. *mitis* (Sandst.) Ruoss, Bot. Helv. 97: 260, 1987. - *Cladina mitis* (Sandst.) Mong., Bull. Soc. Agric. Sarthe, ser. 3, 7: 118, 1938. - *Cladina arbuscula* subsp. *mitis* (Sandst.) Burgaz, Nova Hedwigia 59: 400, 1994.

ILLUSTRATIONS: Pérez-Valcárcel *et al.* (2003: 155); Burgaz & Ahti (2009: 19); van Haluwyn *et al.* (2012: 179); Wirth *et al.* (2013: 403); Ahti & Stenroos (2013: 103); Stenroos *et al.* (2016: 192); Valcuvia Passadore & Gheza (2017: 37).

Primary thallus absent. Podetia 30-65 mm long, richly branched, with a clearly defined main axis, internode length 2-5 mm, anisotomic branching type, rarely subisotomous, width of main axis 0.8-1.9 mm. Podetia apices generally unilaterally deflexed, or erect and divergent in all directions. Trichotomous branching, sometimes dichotomous or tetrachotomous, axils open. Surface ecorticate, algal layer discontinuous, more rarely continuous, specimens growing at higher altitude with a rough surface. Apothecia not observed in the Mediterranean specimens. Pycnidia dark, at the tips of podetia, with hyaline slime.

Chemistry.- Pd-, K-, C-, UV-. Usnic and rangiformic acids. Other chemotypes reported elsewhere (Ahti & Stenroos 2013).

Habitat and distribution.- It has a very wide altitudinal range, from sea level to 2100 m, although it is not frequent at lower altitudes, growing on sandy soils, among

mosses, on granite rocks and in heathlands. It is more frequent in the Eurosiberian region from colline to subalpine belts, although it also appears in the Mediterranean region, in areas with oceanic influence, in meso- and supramediterranean belts. It has a temperate to Arctic/Antarctic distribution (Ahti & Stenroos 2013), being very common in continental areas. According to Ravera *et al.* (2016) this species is not endangered in Italy although their populations are declining.

Mediterranean countries.- Andorra, Croatia, France, Italy, Montenegro, Portugal, Spain and Turkey.

Remarks.- *Cladonia arbuscula* and *C. mitis* are morphologically very similar, and sometimes they grow together in mixed populations. In general, *C. mitis* is more frequent and abundant than *C. arbuscula*, reaching more southern locations. However, the Mediterranean specimens of both species are relatively easy to identify by the Pd- reaction of *C. mitis*. It is also observed that the podetial wall thickness is greater in *C. mitis* and there are significant differences in this parameter between the two species (Burgaz & Martínez 2008). Molecular studies showed contradictory results, the data of Piercey-Normore *et al.* (2010) did not support them as different species, while in the phylogeny of Athukorala *et al.* (2016) *C. mitis* was monophyletic. It can hardly be mistaken for *C. mediterranea* since it is often distinguished by constant characters such as: a dichotomous branching pattern, continue algal layer and no verrucose surface. Additionally, *C. mediterranea* contains different secondary metabolites, usnic and perlatolic acids.

57. *Cladonia norvegica* Tønsberg & Holien Nordic J. Bot. 4: 79, 1984.

TYPE: Norway, Sør-Trøndelag, Melhus, 1982, Tønsberg 6870 (TRH holotype).

ILLUSTRATIONS: Stenroos *et al.* (1992: 15); Wirth *et al.* (2013: 403); Ahti & Stenroos (2013: 103); Stenroos *et al.* (2016: 193); Valcuvia Passadore & Gheza (2017: 131).

Primary thallus squamulose, persistent but inconspicuous. Squamules very small, 2-4 mm diameter, lobed to finely divided, sometimes with margin sorediate, greyish green in upper side, white below. Podetia up to 20 mm long × 1-2 mm wide, not scyphose, usually simple, whitish. Surface corticate at the base, bearing some small

squamules, finely sorediate, soredia 20-50 µm diameter. Apothecia rare, ochraceous, located at the apex of the podetia, 0.2-0.3 mm diameter. Pycnidia at the apex of the podetia and with hyaline slime.

Chemistry.- Pd-, K-, C-, UV-. Barbatic and 4-O-demethylbarbatic acids.

Habitat and distribution.- It grows on decaying wood, stumps and coniferous tree bases in forests with high ecological continuity. There are only few reports from Mediterranean countries, in supramediterranean belt and scattered specimens from montane to subalpine belts in the Eurosiberian region. It has a discontinuous Holarctic distribution, occurring mainly in oceanic areas, with some outpost in Southern South America (Ahti & Stenroos 2013).

Mediterranean countries.- Italy, Slovenia and Spain.

Remarks.- Perhaps it is more frequent but completely unnoticed due to its small size. It is similar to *C. macilenta* but differs in having a primary thallus squamulose and finely divided and the podetia also finely sorediate. It is often mistaken for *C. macilenta* var. *bacillaris* since both have the same chemistry, but the apothecia and pycnidia have different colour. Its phylogenetic relationships have not been elucidated.

58. *Cladonia novochlorophaea* (Sipman) Brodo & Ahti

Canad. J. Bot. 74: 1167, 1996.

Cladonia merochlorophaea var. *novochlorophaea* Sipman, Acta Bot. Neerl. 22: 496, 1973.

TYPE: Netherlands, Friesland, West Frisian Islands, Boschplaat, 1971 Sipman 4895 (U holotype).

ILLUSTRATIONS: Stenroos *et al.* (1992: lam. 6, fig. 7); Burgaz & Ahti (2009: 62); Ahti & Stenroos (2013: 103); Stenroos *et al.* (2016: 194).

Primary thallus squamulose, persistent. Squamules small, 6 mm long × 7 mm wide, rounded, margin entire or slightly crenulate, greyish green or dark brown on the upper side, yellowish below. Podetia scyphose, 2.5-5 mm long × 7-11 mm wide, dark brown, sometimes shine, they have a tendency to present the base with necrotic medulla and stereome. Surface corticate, granulose to densely verruculose, granules 30-100 µm diameter, upper part of scyphi frequently eroded, which leaves the dark medulla

exposed in mature thalli, numerous cortical plates and schizidia appear at the top and, at the base numerous squamules. Apothecia not common, at the scyphus margin, pedunculated, dark brown. Pycnidia frequent, pear shape, at the scyphal margin, with hyaline slime.

Chemistry.- Pd- or Pd+ red, K-, C+ yellow, UV+ white. Sekikaic and homosekikaic acids, sometimes metilnorhomosekikaic and 4'-*O*-metilnorsekikaic acids, often also contains fumarprotocetraric acid complex.

Habitat and distribution.- It grows on humus, decaying wood, mossy rocks and, occasionally, on bare soil, usually mixed with other morphologically similar taxa. For this reason, it has probably been unnoticed. It is rare in the Mediterranean countries, growing scattered from the colline to subalpine belts and in the supramediterranean belt. It has a wide distribution (Ahti & Stenroos 2013), more frequent in Europe.

Mediterranean countries.- Croatia, France, Italy, Portugal and Spain.

Remarks.- It has been considered a chemotype of *C. merochlorophaea* but according to Brodo & Ahti (1996) it should be treated as an independent species since the presence of a well-developed verruculose cortex, the dark brown scyphus and the lack of soredioid granules are enough characters to differentiate it. *Cladonia novochlorophaea* has a similar chemical composition as *C. homosekikaica*, but differs in its podetia, never sorediate.

59. *Cladonia parasitica* (Hoffm.) Hoffm. Deutschl. Fl. 2: 127, 1796.

Lichen parasiticus Hoffm., Enum. Lich.: 39, 1784.

TYPE: Germany, Bavaria (Bayern), Munich (München), W of Deisenhofen, Grünwald, 1892, Arnold in Rehm, Cladon. Exs. no. 410 (M neotype, Ahti, Regnum Veg. 128: 87, 1993).

ILLUSTRATIONS: Brodo *et al.* (2001: 263); Burgaz & Ahti (2009: 30); Ahti & Stenroos (2013: 104); Wirth *et al.* (2013: 382); Stenroos *et al.* (2016: 196); Valcuvia Passadore & Gheza (2017: 97).

Primary thallus squamulose, persistent. Squamules 1-3 mm long × 0.5-2 mm wide, elongate, richly branched, with a coraloid appearance, generally with a granulose edge which forms continuous turfs, upper side green and white below. Podetia 1-17 mm long × 0.5-2 mm wide, not common, irregularly deformed, sometimes flattened and branched, with fissures and irregular perforations.

Surface often covered by small granules similar to isidia, partially decorticate, numerous dichotomous squamules frequently present that become detached from the podetia, which take a decorticate aspect, never sorediate. Apothecia very rare, sometimes grouped, brown at the apex of the podetia. Pycnidia frequent, dark, on the surface of the primary thallus and with hyaline slime.

Chemistry.- Pd+ yellow, K+ yellow, C-, UV-. Thamnic acid, and traces of barbatic acid.

Habitat and distribution.- A lignicolous species that grows on decaying wood and wooden fences. In general, it appears in well preserved forests and especially frequent in old stump of *Castanea sativa*. It is a fairly rare species, although it could have been unnoticed due to its small size. It grows in the colline, montane, meso- and supramediterranean belts. It has a Holarctic distribution (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Algeria, Croatia, France, Greece, Italy, Portugal, Slovenia, Spain, Tunisia and Turkey.

Remarks.- It can be mistaken for *C. incrassata* (Pd-), both with granulose primary thallus and podetia, but *C. parasitica* does not have red apothecia, the podetia are perforated and covered with divided squamules. It is more similar to *C. squamosa*, but this one has bigger podetia, completely covered by squamules with few divisions.

60. *Cladonia peziziformis* (With.) J.R.Laundon Lichenologist 16: 223, 1984.

Lichen peziziformis With., Bot. Arr. Veg. Great Brit. 720, 1776, as '*pezizaeformis*'.

TYPE: England, Middlesex, (v.c. 21), London, Camden, Hampstead Heath, icon in Dillenius, Hist. Musc. t. 14, f. 2 (1742) holotype, [England], Herb. Sherard, sheet 1774 (OXF epitype, Ahti, Fl. Neotrop. Monogr. 78: 256, 2000).

Cladonia capitata (Michx.) Spreng. - *Cladonia leptophylla* (Ach.) Flörke - *Cladonia leptophylloides* Harm. - *Cladonia mitrula* Tuck. ex Michener.

ILLUSTRATIONS: Brodo *et al.* (2001: 264); Burgaz & Ahti (2009: 67); Ahti & Stenroos (2013: 104); Schumm & Aptroot (2013: 148); Valcuvia Passadore & Gheza (2017: 135).

Primary thallus squamulose, persistent. Squamules very small, 1.2-2 mm long × 1.4-2 mm wide, almost rounded, with entire or somewhat crenulated and granulated

margins, they often form flattened continuous thallus, with convex and somewhat erect areoles, yellowish green on the upper side, especially in herbarium specimens, white below. Podetia uncommon, thin, 0.5-5 mm long \times 0.5-1.5 mm wide, simple or with apical ramifications partly flattened, cracked and longitudinally grooved, pale greyish green to greenish brown. Surface usually corticate, areolate to verruculose, with age loses the cortex by zones, sometimes some squamules present at the base of the podetia. Apothecia at the apex of the podetia, light brown to dark brown, generally clustered, forming masses wider than the podetia. Pycnidia in the primary thallus, sessile or subsessile, constricted at base, with hyaline slime.

Chemistry.- Pd+ red, K- or K+ brownish, KC-, C-, UV-. Fumarprotocetraric acid complex.

Habitat and distribution.- It grows on bare soil, road slopes, also on humus in open areas of the forest and heathlands, very rare on decaying wood. In the Mediterranean countries it has been mostly collected in the Eurosiberian region. It is a subcosmopolitan species with temperate distribution, frequent in the eastern United States and the Neotropic, but rare in Europe and in the Macaronesia (Ahti & Stenroos 2013; Pino-Bodas *et al.* 2017).

Mediterranean countries.- Albania, Croatia, France, Greece, Italy, Montenegro, Spain and Turkey.

Remarks.- It is a very rare taxon in the Mediterranean countries, which has been unnoticed due to its small size and frequent lack of podetia. It resembles *C. cariosa*, in the podetia longitudinally fissured, but *C. peziziformis* has a much smaller size and never contains atranorin.

61. *Cladonia phyllophora* Hoffm.

Deutschl. Fl. 2: 123, 1796.

TYPE: Germany, Niedersachsen, Hannover, Herrenhausen, Ehrhart in Ehrhart, Pl. Crypt. Exs. no. 287 (GOET lectotype, Ahti, Regnum Veg. 128: 88, 1993).

ILLUSTRATIONS: Brodo *et al.* (2001: 265); Burgaz & Ahti (2009: 64); van Haluwyn *et al.* (2012: 199); Ahti & Stenroos (2013: 104); Stenroos *et al.* (2016: 197).

Primary thallus squamulose, persistent or evanescent. Squamules round, up 5 mm long \times 3 mm wide, greenish grey on the upper side, white below. Podetia 10-30 mm long \times 2-3 mm wide, scyphose, irregular, with dentated

margins from which new podetia originate, up to 3 or 4 tiers, open laterally, with squamules alternating on the margin, greenish grey to dark brown, not shine, black at base. Surface continuous subarachnoid, with scattered areolas at the base. Apothecia infrequent, at the scyphal margin, dark brown. Pycnidia frequent, also at the scyphal margin with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex.

Habitat and distribution.- It grows on acidic substrates, humus, soil and mossy rocks, generally in humid areas, of colline to subalpine belts and thermo-, meso- to supramediterranean belts. It is a rare taxon, who is probably more abundant but unnoticed. It is distributed from temperate to arctic areas with some outposts in Southern South America, having continental tendencies (Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, Bosnia-Herzegovina, Croatia, France, Greece, Italy, Montenegro, Portugal, Spain and Turkey.

Remarks.- A very polymorphic species that can be mistaken for *C. gracilis*, but the latter has regular and narrow podetia, with the surface non arachnoid and the base uniformly dark brown while *C. phyllophora* has pale areolas at the base of the podetia, medulla and stereome black. Another possible mistake is with *C. ramulosa*, but the podetial base and squamules of this one are not blackened. *Cladonia* aff. *dimorpha*, also with marginal proliferations, can be easily distinguished by its split and flattened proliferation, and podetia not black at the base.

62. *Cladonia pleurota* (Flörke) Schaer.

Enum. Crit. Lich. Eur.: 186, 1850.

Capitularia pleurota Flörke, Ges. Naturf. Freunde Berlin Mag. Neuesten Entdeck. Gesammten Naturk. 2: 217, 1808.

TYPE: Germany or Austria, 'data a Flörke Berolini 1811' (UPS neotype, Ahti, Regnum Veg. 128: 89, 1993).

ILLUSTRATIONS: Brodo *et al.* (2001: 265); Burgaz & Ahti (2009: 25); van Haluwyn *et al.* (2012: 145); Ahti & Stenroos (2013: 104); Wirth *et al.* (2013: 404); Stenroos *et al.* (2016: 198); Valcuvia Passadore & Gheza (2017: 65).

Primary thallus squamulose, persistent. Squamules ascending, 1.9-4 mm long \times 2-4 mm wide, sparsely divided and forming rounded lobes, somewhat crenulate or

incise margin, greenish yellow upper side. Podetia scyphose, 5–10 mm long \times 2–5 mm wide, 0.6–1.4 mm wide at the base, sometimes proliferating at the margin, gradually widened, greenish yellow. Surface corticate at the base and sometimes squamulose, other parts of podetia sorediate, soredia farinose to granulose, 60–100 μ m diameter. Apothecia red, at scyphal margin, 1–2 mm diameter. Pycnidia red at scyphal margin, with red slime.

Chemistry.- Pd $-$, K $-$, KC $+$ yellow, UV $-$. Usnic, isousnic, porphyritic (inconstant) and rhodocladonic acids, zeorin (developing fine crystals on surface of podetia in herbarium).

Habitat and distribution.- It is frequent, although its populations are small, grows in acidic soils, mossy rocks and decaying wood, in heathlands and slopes. It was collected in the Eurosiberian region in the colline to alpine belts in the Eurosiberian region and in the Mediterranean region preferably in the supramediterranean belt. It has a Holarctic distribution with outposts in Southern South America and Antarctica (Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, France, Italy, Montenegro, Portugal, Spain and Turkey.

Remarks.- It is similar to *C. coccifera* or *C. diversa*, but *C. pleurota* has the podetia sorediate and rarely with squamules. It can also be mistaken for *C. deformis* or *C. carneola*, both with sorediate podetia, although the soredia are smaller in both species.

63. *Cladonia polycarpoides* Nyl. in Zwackh, Lich. Exs. nos. 626, 626bis, 1892.

TYPE: Switzerland, Zürich, Ober-Riffers-weil, 1884 Heggetschweiler in Zwackh, Lich. Exs. no. 626bis (H-NYL p.m. 963, lectotype, Suominen & Ahti, Ann. Bot. Fenn. 3: 422–423, 1966).

Cladonia subcariosa Nyl., s. lat. Flora 59: 560, 1876 (actually a different, American species in strict sense).

ILLUSTRATIONS: Brodo *et al.* (2001: 266); Burgaz & Ahti (2009: 84); Ahti & Stenroos (2013: 105); Stenroos *et al.* (2016: 200).

Primary thallus squamulose, persistent. Squamules large, 3–10 mm long \times 4–7 mm wide, margins shallowly lobated, glaucous green on the upper side, white arachnoid below, slightly darkened at the base. Podetia very short, simple or somewhat branched, flattened and somewhat flexuose, closed axils, often solid, with a longitudinally lax and fibrous structure. Surface corticate, areolate, verruculose to squamose. Apothecia brown forming compact

corymbose groups at the tips of podetia. Pycnidia on squamules of the primary thallus, globose, sessile or shortly pedunculated, with hyaline slime.

Chemistry.- Pd $+$ yellow to red (slow reaction), K $+$ yellow to red (slow reaction), C $-$, UV $-$. Norstictic and connorstictic acids, exceptionally homohepadric acid, stictic or fumarprotocetraric acid complex, and very rarely atranorin.

Habitat and distribution.- It grows on bare soils, calcareous or subneutrous. Apparently is not frequent but probably unnoticed due to the frequent absence of podetia. It has a wide altitudinal range, from the colline to the subalpine belts, and from meso- to supramediterranean belts. It has subcosmopolitan distribution in warm to temperate regions (Ahti 2000).

Mediterranean countries.- Albania, Andorra, Bosnia-Herzegovina, Croatia, France, Greece, Italy, Portugal, Spain and Turkey.

Remarks.- It can be mistaken for *C. cariosa* and *C. subturgida* in absence of podetia although these taxa have bigger squamules of the primary thallus and atranorin is usually present in both species. This species belongs to *C. subcariosa* complex. Preliminary molecular studies (Kärkkäinen 2000; Pino-Bodas *et al.* 2012a) indicated that the complex includes several species, but the boundaries among them are not clear and future detailed studies are necessary.

64. *Cladonia polydactyla* (Flörke) Spreng. Syst. Veg. 4(1): 274, 1827.

Conomyce polydactyla Flörke, Deutsche Lich. 10: 13, 1821, nom. cons.

TYPE CONS.: Germany, Mecklenburg-Vorpommern, Rostock, Flörke in Flörke, Deutsche Lich. no. 195A (UPS).

Cladonia bouillemiei P.A.Duvign., Bull. Soc. Roy. Bot. Belgique 71: 192, 1939. - *Cladonia flabelliformis* Vain. nom. illeg., Acta Soc. Fauna Flora Fenn. 4(1): 113, 1887. - *Cladonia monguillonii* Harm., Lich. France 3: 347, 1907.

ILLUSTRATIONS: Wirth (1995: 334); Pérez-Valcarcel *et al.* (2003: 165, fig. 64); Burgaz & Ahti (2009: 43); Burgaz & Ahti (2009: 43); Ahti & Stenroos (2013: 105); Wirth *et al.* (2013: 405); Stenroos *et al.* (2016: 201).

Primary thallus squamulose, persistent or evanescent. Squamules small, 2–8 mm long \times 1–8 mm wide, erect, incised to lobated and with deep divisions, up to 3 mm, occasionally sorediate below, yellowish green on the

upper side, white below with orange pigmentation at the base. Podetia 8–28 mm long × 2–7 mm wide, base 1–2 mm wide, subulate when young, later have narrow and irregular scyphi up to 5 mm, frequently proliferating at the margin, greenish yellow or greyish green. Surface almost totally sorediate, soredia farinose to granular, 30–70 µm diameter. Apothecia and pycnidia red on the podetia, frequent, with red pycnidial slime.

Chemistry.- Pd+ yellow, K+ yellow, KC–, C–, UV–. Thamnic and rhodocladonic acids. Specimens with squamatic acid are considered a different chemotype of *C. polydactyla* by some authors (Purvis *et al.* 1992; James 2009), although for the moment we maintain it at species level, *C. umbricola*.

Habitat and distribution.- It grows on decaying wood and at the base of deciduous trees and conifer forests. It has preference for humid and old forests, it is not frequent, although it can be locally so. It has been collected in the colline, montane and subalpine belts, and in scarce humid locations of the supramediterranean belt. It has a mainly restricted distribution to Central and Western Europe (Litterski & Ahti 2004).

Mediterranean countries.- Bosnia-Herzegovina, Croatia, France, Greece, Italy, Portugal, Slovenia and Spain.

Remarks.- It is easily recognizable by the relatively large squamules of the primary thallus, somewhat sorediate and with deep incisions. However, it can be mistaken for *C. digitata* that has more rounded and bigger squamules, with the lower side almost completely sorediate. Other taxa with sorediate squamules are *C. incrassata* and *C. parasitica* but, in both cases, the squamules are smaller and the soredia thicker. There may be some mistake with *C. coniocraea*, but the podetia of this one has a more intense green colour, apothecia brown and Pd+ red reaction. It could also be mistaken for *C. cyathomorpha*, which sometimes has the primary thallus marginally sorediate, but the rest of the squamule is corticate on the underside and it also has Pd+ red reaction.

65. *Cladonia portentosa* (Dufour) Coëm.

Bull. Acad. Roy. Sci. Belgique, ser. 2, 19: 43, 49, 1865.

Cenomyce portentosa Dufour, Ann. Gén. Sci. Phys. 8: 69, 1821.

TYPE: France, Landes, Saint-Sever-sur-Adour, [1818], Dufour (PC-Herb. Desmazières, lectotype, Ahti, Ann. Bot. Fenn. 15: 8 1978).

Cladina portentosa (Dufour) Follm., Philippia 4: 34, 1979. - *Cladina impexa* deLesd., Rech. Lich. Dunkerque 79, 1910. - *Cladonia impexa* Harm., Lich. France 3: 232, 1908 '1907, nom. illeg. - *Cladonia subimpexa* P.A.Duvign. Bull. Soc. Roy. Belgique 71: 196, 1939. - *Cladonia portentosa* f. *subimpexa* (P.A.Duvign.) Ahti, Ann. Bot. Fenn. 15: 8, 1978.

ILLUSTRATIONS: Wirth (1995: 297, 335); Pérez-Valcárcel *et al.* (2003: 167, fig. 65); Wirth *et al.* (2004: 73); Burgaz & Ahti (2009: 72); van Haluwyn *et al.* (2012: 183); Ahti & Stenroos (2013: 105); Wirth *et al.* (2013: 406); Stenroos *et al.* (2016: 202); Valcuvia Passadore & Gheza (2017: 39).

Primary thallus evanescent. Podetia greenish yellow or greenish grey, richly branched, 20–90 mm long, with a clearly defined main axis, 0.6–3 mm wide, internode length 2–4.5 mm, branching pattern anisotomous trichotomous, sometimes dichotomous or more rarely tetrachotomous, or with the main axes not well defined, tips deflexed or erect, axils open. Surface ecorticate, felted, algal layer continuous, rarely discontinuous. Apothecia brown. Pycnidia at the podetia apex, with hyaline slime.

Chemistry.- Three chemotypes are known. Chemotype I: Pd–, K–, C–, UV+ pale blue. Perlatolic and usnic acids. Chemotype II: Pd–, K–, C–, UV+ pale blue. Perlatolic acid. Chemotype III: Pd+ red, K–, C–, UV+ pale blue. Fumarprotocetraric, perlatolic and usnic acids. Chemotype III was found in Southwestern France, previously reported in specimens from the Azores Islands (Pino-Bodas *et al.* 2017) but this is the first record to continental Europe.

Habitat and distribution.- It is a common and abundant taxon, which has preference for acid soils, growing from sea level to 1500 m altitude, more common in the Eurosiberian region and scattered in the Mediterranean region, from mesomediterranean to subalpine belts. Although three forms can grow together, f. *impexa* is most frequent. It has a similar distribution to that of *C. ciliata*, being more frequent in the European Atlantic area. According to Ravera *et al.* (2016) this species is endangered in Italy due to the fragmented populations. It is a Holarctic species with amphi-atlantic distribution in temperate and oceanic locations (Ahti & Stenroos 2013).

Mediterranean countries.- Croatia, France, Italy, Portugal, Slovenia, Spain, Tunisia and Turkey.

Remarks.- It is morphologically variable and several forms have been described, but only f. *subimpexa* differs chemically. There may be confusion with other species reacting Pd–, such as *C. mitis* or *C. mediterranea*. However,

the specimen *C. mitis* contains rangiformic acid, dichotomous branching is dominant and the wall of the podetia is thicker (Burgaz & Martínez 2008). *Cladonia mediterranea* contains the same secondary metabolites, but dichotomous pattern is also dominant. Molecular results showed that both species are phylogenetically closely related but form independent lineages (Athukorala *et al.* 2016; Pino-Bodas *et al.* 2016).

66. *Cladonia pulvinata* (Sandst.) van Herk & Aptroot

Biblioth. Lichenol. 86: 200, 2003.

Cladonia verticillata f. *pulvinata* Sandst., Cladon. Exs. no. 233, 1918.
 TYPE: Germany, Niedersachsen, Oldenburg, Markhausen, 1916, Sandstede in Sandstede, Cladon. Exs. no. 233 (H lectotype, Ahti, Ann. Bot. Fenn. 20: 5, 1983).

Cladonia cervicornis subsp. *pulvinata* (Sandst.) Ahti, Ann. Bot. Fenn. 20: 5, 1983.

ILLUSTRATIONS: Barreno & Pérez-Ortega (2003: lam. 33); Burgaz & Ahti (2009: 64); Ahti & Stenroos (2013: 105); Stenroos *et al.* (2016: 203).

Primary thallus squamulose, persistent, often form pulvinules. Squamules 5-8 mm long × 1-2 mm wide, digitately deeply and irregularly lobed, with the rounded margin, brownish green on the upper side, underside white with yellowish hue, the base somewhat darkened and very finely arachnoid. Podetia scyphose, not common, 14-55 mm long × 2-4 mm wide, podetia simple or proliferating from the center, developing more than one scyphus at the same point, forming 1-2 tiers, dark brownish green. Surface corticate, smooth, slightly arachnoid in the young parts, very rarely with some squamules at the scyphal margin. Apothecia very rare, at the margin of the scyphus, dark brown, usually isolated. Pycnidia frequent, on the margin of the scyphus, sessile or prominent, with hyaline slime.

Chemistry.- Pd+ yellow or Pd+ red, K-, KC-, C-, UV-. Psoromic and conpsoromic acids, occasionally they also contain fumarprotocetraric acid.

Habitat and distribution.- It grows on bare soil, humus and mossy rocks, generally on acid substrates. It is scattered in the colline and montane belts and also supramediterranean belt. It is a rare species, distributed throughout Western Europe in areas with high oceanic influence (Ahti & Stenroos 2013).

Mediterranean countries.- France, Italy, Portugal and Spain.

Remarks.- During long time it was considered as a subspecies of *C. cervicornis* but Van Herk & Aptroot (2003), based on a morphological study, suggested to recognize it a species level. Subsequently phylogenetic studies have proved that *C. pulvinata* is an independent species of *C. cervicornis* (Pino-Bodas *et al.* 2010a, 2013b; Stenroos *et al.* 2019). An essential diagnostic character to distinguish them is the presence of psoromic acid but morphological differences also exist, such as are the thinnest and narrowest scyphi.

67. *Cladonia pyxidata* (L.) Hoffm.

Deutschl. Fl. 2: 121, 1796.

Lichen pyxidatus L., Sp. Pl. 1151, 1753.

TYPE: [Italy] icon in Michelius, Nova Pl. Gen. t. 41, Ordo VIII, f. 1L (third podetium from left) (1729), lectotype, Jørgensen *et al.*, Bot. J. Linn. Soc. 115: 380, 1994; corresponding specimen (FI-M), epitype, Jørgensen *et al.*, Bot. J. Linn. Soc. 115: 380, 1994 (specified here).

Cladonia pocillum (Ach.) Grognot, Pl. Crypt. Saône-et-Loire: 82, 1863.
 - *Cladonia monomorpha* Aptroot, Sipman & van Herk, Lichenologist 33: 273, 2001.

ILLUSTRATIONS: Llimona (1991: 402); Wirth (1995: 307); Brodo *et al.* (2001: 268); Wirth *et al.* (2004: 84); Burgaz & Ahti (2009: 70); van Haluwyn *et al.* (2019: 205); Ahti & Stenroos (2013: 105); Wirth *et al.* (2013: 386); Stenroos *et al.* (2016: 203).

Primary thallus squamulose, persistent. Squamules ascendent, 2-5 mm long × 3-5 mm wide, from entire to lobated, with margins no soredate, surface glaucous green to olive in upper side, white below until somewhat brown, that darkens towards the base, with some fibrils. Podetia scyphose, 7-12 mm long × 4-5 mm wide, base 1-2 mm wide, regular, flaring gradually, usually simple, rarely with proliferations of new scyphi from the margin. Surface of the podetia continuously corticate, sometimes quartered and areolate, at the top the cortex disappears producing schizidia, up to 2 mm wide, microsquamules and peltate granules, flat, which are particularly abundant inside the scyphi. Apothecia frequent, which usually merge forming groups, dark brown, arranged in the margin of the scyphus or on short proliferations up to 3 mm long. Pycnidia frequent, dark brown to black, on the margin of the scyphus, with hyaline slime.

Chemistry.- Four chemotypes were found. Chemotype I: Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex often additionally physodalic acid. Chemotype II: Pd+ red, K+ yellow, KC-, C-, UV-. Atranorin and fumarprotocetraric acid complex. Chemotype III: Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex and psoromic acid. Chemotype IV: Pd+ red, K+ yellow, KC-, C-, UV-. Atranorin, fumarprotocetraric and psoromic acids. The chemotype I is the most frequent, while the chemotype III is quite rare, appearing scattered throughout few Mediterranean countries (Albania, Croatia, Greece and Spain). The chemotype II has been also detected in specimens from Chile and North America (Ahti 1966; Ahti & Kashiwadani 1984). Another chemotype containing homosekikaic, sekikaic and fumarprotocetraric acids found in specimens from Venezuela (Ahti 2000) and Japan.

Habitat and distribution.- This is a common species growing on bare soil, humus, mossy rocks, rarely on decaying wood; appears inside forests, shrublands and pastures, on different pH substrates. It was found in all the bioclimatic belts of Mediterranean countries. It has a cosmopolitan distribution, from the Arctic to the temperate zones (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Andorra, Algeria, Bosnia-Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Lebanon, Libya, Israel, Italy, Malta, Montenegro, Morocco, Portugal, Slovenia, Spain, Syria, Tunisia and Turkey.

Remarks.- It is a very polymorphic species and its species concept is not clear. The molecular studies proved that this species is polyphyletic (Stenroos *et al.* 2019) and further studies are necessary to delimit it. Traditionally, the morphological features used to differentiate *C. pyxidata* from other related taxa were: the presence of large, isolated and corticate podetia; the gradually flaring scyphi with greenish-grey colour; the surface covered with microsquamules and flat peltated plates on the top and especially inside the scyphi. Here we considered *C. pocillum* as synonymous of *C. pyxidata*, because there are many specimens with intermediate morphology and the results of Kotelko & Piercey-Normore (2010) did not support the separation of them into two entities. The main character to distinguish both taxa is the presence of a primary thallus forming cracked rosettes in *C. pocillum*. But the morphology of the primary thallus seems to be correlated to the soil pH. The morphological differences from *C.*

monomorpha, which has bullate plates and not flattened as in *C. pyxidata* are not sufficient to differentiate it as a distinct entity. Recent molecular results (Stenroos *et al.* 2019) did not support *C. monomorpha* as an entity different from *C. pyxidata*. Morphologically is rather similar to *C. chlorophaea*, but the shape of the podetia in *C. chlorophaea* is different, since they are flaring abruptly and the scyphi are narrower and with smaller granules on the scyphus. It could also be mistaken for *C. magyarica*, which has podetia with numerous elongate squamules, up to 2 mm wide on the scyphus surface and contains atranorin and fumarprotocetraric acid. Some specimens of *Cladonia humilis* s.l. have podetia with granules (Pino-Bodas *et al.* 2013c), while others have a primary thallus morphologically similar to *C. pocillum*, difficult to distinguish from *C. pyxidata*.

68. *Cladonia ramulosa* (With.) J.R.Laundon Lichenologist 16: 225, 1984.

Lichen ramulosus With., Bot. Arr. Veg. Great Brit. 723, 1776.

TYPE: Icon in Dillenius, Hist. Musc.: t. 15, f. 20. 1742 (holotype), England, Surrey (v.c. 17), London, Greenwich, Woolwich Heath, Dillenius (OXF-Dillenius epitype, Ahti, Fl. Neotr. Monogr. 78: 149, 2000).

Cladonia anomaea Ahti & P.James, Lichenologist 12: 128, 1980, nom. illeg. - *Cladonia pityrea* (Flörke) Fries, Nov. Sched. Crit. Lich. 3: 21, 1826. - *Cladonia pseudopityrea* Vain., Acta Soc. Fauna Fl. Fenn. 4: 453, 1887.

ILLUSTRATIONS: Pérez-Valcárcel *et al.* (2003: 169, fig. 67); Burgaz & Ahti (2009: 77); van Haluwyn *et al.* (2012:199); Ahti & Stenroos (2013: 105); Stenroos *et al.* (2016: 204).

Primary thallus squamulose, persistent or evanescent. Squamules small, 1-5 mm long × 0.5-2 mm wide, ascending, fragile, incised margins, occasionally with granulate soredia, glaucous green upper side to dark greenish brown, white below. Podetia very variable, 5-30 mm long × 1-3 mm wide, cylindrical or scyphose, abruptly flaring, irregular, simple or branched, new proliferations borne by the scyphal margin. Surface also very variable, completely corticate or only corticate at the base or cortex reaching up to half the podetia, cortex continuous or areolated, areas without cortex have cortical granules or squamules that occur preferentially inside the scyphus, rarely with granular soredia. Apothecia frequent, light brown to dark brown, usually form arranged glomerules

in the apical part, on the margin of the scyphus or on proliferations 0.2-2 mm wide. Pycnidia frequent, dark brown to black, at the margin of the scyphus or on the primary thallus, with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex, occasionally with atranorin and zeorin.

Habitat and distribution.- It grows on bare soils, humus, decaying wood, with preference for acid substrates to sub-neutrous, in colline to montane and meso- to supramediterranean belts. It is a cosmopolitan taxon distributed from subboreal to temperate zones (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Andorra, Algeria, Croatia, Cyprus, France, Greece, Italy, Montenegro, Morocco, Portugal, Slovenia, Spain and Turkey.

Remarks.- It is morphologically a very variable species, numerous morphotypes have been described previously as species level. Specimens having most delicate podetia with cortex plates detaching from the surface of the podetia were described as *C. pseudopityrea*, which is distributed in temperate-humid climates of the Mediterranean region (Ahti & Puntillo 1995). However, unpublished molecular data do not support it as different species of *C. ramulosa* (Pino-Bodas *et al.* in prep) and we include it in the concept of *C. ramulosa*. Also the European specimens identified as *C. prolifica* (Burgaz & Ahti 2009) should be included in the variability of *C. ramulosa* according molecular results (Stenroos *et al.* 2019; Pino-Bodas *et al.* in prep). Thus this Western American species is not present in Europe.

69. *Cladonia rangiferina* (L.) F.H.Wigg.

Prim. Fl. Holsat.: 90, 1780.

Lichen rangiferinus L., Sp. Pl.: 1153, 1753.

TYPE: Sine loco (LINN 1273.240 lectotype, Nourish & Olivier, Biol. J. Linn. Soc. 6: 259, 1974).

Cladina rangiferina (L.) Nyl., Lich. Lapp. Orient.: 110, 1866.

ILLUSTRATIONS: Wirth (1995: 295); Barreno & Pérez-Ortega (2003: lam. 39); Wirth *et al.* (2004: 70); Burgaz & Ahti (2009: 72); van Haluwyn *et al.* (2012: 171); Ahti & Stenroos (2013: 106); Wirth *et al.* (2013: 370, 373); Stenroos *et al.* (2016: 205); Valcuvia Passadore & Gheza (2017: 41).

Primary thallus evanescent. Podetia 30-85 mm long, clearly defined main axis 0.9-1.5 mm wide, with internodes

3.5-10 mm long, branching pattern usually anisotomic trichotomous, sometimes tetrachotomous or dichotomous, in general tips unilaterally deflexed, axils perforated, podetia whitish grey with darkened apices. Surface ecorticate, felted, uniform algal layer except at base, where can be discontinuous. Apothecia very rare. Pycnidia at the podetium apex, with hyaline slime.

Chemistry.- Pd+ red, K+ yellow, C-, UV-. Fumarprotocetraric acid and atranorin.

Habitat and distribution.- It is a rare species that appears dispersed in the highest Mediterranean mountains, between 400-2400 m altitude, where it grows in acidic soils, heathlands and open forest. Rare in the Mediterranean region, only collected in the supra- and oromediterranean belts, it is more frequent through the Eurosiberian region from colline to subalpine belts. According to Ravera *et al.* (2016) this species is not considered endangered in Italy. This species has a temperate to Arctic/Antarctic distribution (Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, Algeria, Bosnia-Herzegovina, Croatia, France, Italy, Montenegro, Portugal, Slovenia, Spain, Tunisia and Turkey.

Remarks.- This species is easily recognizable by the grey podetia with brownish and unilateral deflexed apices. It can be mistaken for *C. stygia* but this taxon has blackish podetial base with whitish areolas clearly differentiated.

70. *Cladonia rangiformis* Hoffm., nom. cons.

Deutschl. Fl. 2: 114, 1796.

TYPE (CONS.): Germany, Niedersachsen, Hannover, Wenden, 1921 Sandstede in Sandstede, Cladon. Exs. no. 803 (H).

Cladonia klementii Oxner, *nom. inval.* Herzogia 1: 142, 1969. - *Cladonia rangiformis* var. *pungens* (Ach.) Vain., Acta Soc. Fauna Flora Fenn. 4(1): 361, 1887. - *C. rangiformis* var. *sorediophora* (Nyl.) Vain., Acta Soc. Fauna Flora Fenn. 4(1): 368, 1887.

ILLUSTRATIONS: Llimona (1991: 403); Wirth (1995: 309); Pérez-Valcárcel *et al.* (2003: 169, fig. 68); Wirth *et al.* (2004: 77); Burgaz & Ahti (2009: 78); van Haluwyn *et al.* (2012: 187); Ahti & Stenroos (2013: 106); Wirth *et al.* (2013: 407); Stenroos *et al.* (2016: 206); Valcuvia Passadore & Gheza (2017: 81).

Primary thallus squamulose, persistent in the young specimens, frequently evanescent. Squamules 2-4 mm long × 1-2 mm wide, ascending, adnate in the center and forming a rosette, margins sinuose to crenulate, greyish

green on the upper side, white below. Podetia 20–60 mm long \times 0.5–3 mm wide, subulate, branching anisotomic, dichotomy to polytomy, in some areas with 3–6 divergent ramifications, axils unperforated, apices not widened, greyish green to dark brown, usually darker at the top of the podetia although sun-exposed specimens are uniformly dark. Surface corticate, smooth, shiny, esorediate, areolate due to the discontinuous algal layer, which gives the podetia a characteristic mottled appearance of green and white spots, scattered perpendicular squamules, 1–2 mm diameter, may appear. Apothecia no frequent, at the apex of the podetia, solitary, or in terminal groups with corymbose appearance, dark brown. Pycnidia frequent, dark brown or black, at the apex of sterile podetia, with hyaline slime.

Chemistry. - There are three chemotypes. Chemotype I: Pd $-$, K $+$ yellow, KC $-$, C $-$, UV $-$. Atranorin, rangiformic and norrangiformic acids. Chemotype II: Pd $+$ red, K $+$ yellow, KC $-$, C $-$, UV $-$. Atranorin, rangiformic, norrangiformic acids and fumarprotocetraric acid complex. Chemotype III: Pd $+$ yellow, K $+$ yellow, KC $-$, C $-$, UV $-$. Atranorin, rangiformic and psoromic acids. The chemotype I is the most common in Spain and Portugal, but in other Mediterranean countries the chemotype II is the commonest. The chemotype III is rather rare only present in Spain and Albania.

Habitat and distribution. - It grows preferably on bare soil, humus, in open shrubland and forests, where it forms large populations. Very rarely it also appears on decaying wood and at the tree bases. It develops on acid and basic substrates. It is one of the most frequent and abundant species in the Mediterranean countries, growing from sea level to 2500 m altitude in all bioclimatic belts. It is distributed in xerothermic areas of Eurasia, although it seems to show somewhat oceanic tendencies (Litterski & Ahti 2004).

Mediterranean countries. - Albania, Algeria, Bosnia-Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Montenegro, Morocco, Portugal, San Marino, Slovenia, Spain, Syria, Tunisia and Turkey.

Remarks. - This species is morphologically very variable and numerous infraspecific taxa have been described. For instance, fertile specimens with thicker podetia were described as *C. rangiformis* var. *pungens* (Ach.) Vain.; the chemotype containing fumarprotocetraric acid (chemotype II) was described as *C. aberrans* (Abbayes) Klem. or

C. klementii Oxner; *C. rangiformis* var. *sorediophora* (Nyl.) Vain. was described for specimens with soralia; Macaronesian specimens with very delicate podetia received the name of *C. rangiformis* var. *gracillima* (Mont.) Ahti. However, unpublished molecular data do not support these infraspecific taxa (Pino-Bodas *et al.* in prep), and they are included in the morphological variability of *C. rangiformis* without any taxonomic rank. It can be mistaken for *C. furcata*, since some specimens can present a continuous algal layer, and TLC analyses are necessary to distinguish them.

71. *Cladonia rei* Schaer.

Lich. Helv. Spic. 1(1): 34, 1823.

TYPE: Italy, Re 124 (G holotype).

Cladonia nemoxyna (Ach.) Arnold., Lich. Exs. no. 1495, 1890 (label).

ILLUSTRATIONS: Brodo *et al.* (2001: 269); Burgaz & Ahti (2009: 35); Dolnik (2010: 346); Ahti & Stenroos (2013: 106); Stenroos *et al.* (2016: 207); Valcuvia Passaloro & Gheza (2017: 143).

Primary thallus squamulose, persistent or evanescent. Squamules small, 3 mm long \times 4 mm wide. Podetia 30–50 mm long \times 1.5–2 mm wide, simple or slightly branched, rarely somewhat scyphose, scyphi rarely with marginal proliferations, greyish green to greenish brown. Surface corticate at the base and sometimes below the apothecia, largely sorediate, soredia from farinose to granulose, 20–60 μ m diameter, base of podetia with squamules. Apothecia infrequent, dark brown, at the apex of the podetia. Pycnidia at the podetia apex, frequent, with hyaline slime.

Chemistry. - Two chemotypes are known. Chemotype I: Pd $-$, K $-$, KC $-$, C $-$, UV $+$ white. Homosekikaic and sekikaic acids. Chemotype II: Pd $+$ red, K $-$, KC $-$, C $-$, UV $+$ white. Fumarprotocetraric, homosekikaic and sekikaic acids. Both chemotypes are equally frequent.

Habitat and distribution. - It grows on bare, from acid to subneutral soils in grassland and heathlands, also in slightly altered habitats like sites with high concentration of heavy metals and anthropogenic habitats. It is frequent in Central Europe, reaching scarcely the northern of the Mediterranean countries and very rare in southern locations, usually at lower altitudes in colline, montane, meso- and supramediterranean belts. It is probably more frequent but unnoticed. It has a Holarctic distribution with continental preferences (Ahti & Stenroos 2013), also reported from New Zealand (Feuerer 2006).

Mediterranean countries.- Albania, Croatia, France, Greece, Italy, Montenegro, Portugal, Slovenia, Spain and Turkey.

Remarks.- It is morphologically very similar to *C. subulata*, both with sorediate podetia. Paus *et al.* (1993) believe that, despite the few morphological differences, both taxa must be considered different species because they grow in different habitats. Spier & Aptroot (2007) subordinated *C. rei* as a chemotype of *C. subulata*, because there are not enough morphological or ecological differences to identify them. However, the molecular studies supported them as different species (Dolnik *et al.* 2010; Pino-Bodas *et al.* 2010b). Morphological comparisons between both species revealed some differences (Pino-Bodas *et al.* 2010b), concluding that *C. rei* has bigger soredia, thicker podetia and a smooth stereome surface. However, the best character to distinguish them is the presence of homosekikaic acid in *C. rei*. A similar species, *C. coniocraea*, can be distinguished by lighter green podetia covered by farinose soredia and UV- and Pd+ red very quickly reactions. Another possible mistake is with *C. glauca*, although it has some longitudinal cracks in the podetia and contains squamatic acid. Turkish specimens reported as *C. arwastbiana* Ahi & Upreti (Yazici & Aslan 2006) belong to *C. rei*, as well as Georgian specimens. Although they resemble *C. arwastbiana* the molecular data confirmed that they belong to *C. rei* (unpublish).

72. *Cladonia scabriuscula* (Delise) Nyl.

Compt. Rend. Hebd. Séances Acad. Sci. 83: 88, 1876.

Cenomyce scabriuscula Delise in Duby, Bot. Gall.: 623, 1830.

TYPE: France (PC-Delise lectotype, Ahti, Fl. Neotrop. Monogr. 78: 172, 2000).

Cladonia furcata var. *scabriuscula* (Delise) Coem. ex Vain., Acta Soc. Fauna Flora Fenn. 4(1): 338, 1887.

ILLUSTRATIONS: Brodo *et al.* (2001: 270); Barreno & Pérez-Ortega (2003: lam. 63); Burgaz & Ahti (2009: 82); Ahti & Stenroos (2013: 106); Stenroos *et al.* (2016: 208); Valcuvia Passadore & Gheza (2017: 83).

Primary thallus squamulose, present in young specimens, soon evanescent. Squamules 1-2 mm long × 1-3 mm wide, adnate, forming rosettes with rising margins, rarely scattered, margin sinuose to crenulate, greyish green on the upper side, white below. Podetia 20-50 mm long ×

0.8-1.2 mm wide, apices subulate, no scyphose, branching anisotomous, dichotomous, forming few ramifications, axils unperforated or slightly perforated, greyish green to brownish, lighter at base but no melanotic. Surface areolate-corticate, with smooth cortex, thin, that comes off to form small squamules, leaving the podetia almost decorticate. The upper part of the podetia has a rough appearance, covered with microsquamules or granules, sometimes slightly sorediate but not in a continuous way. Apothecia uncommon, isolated, at the apex of the podetia, dark brown. Pycnidia frequent, dark brown or black, at the apex of the podetia, with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex. Specimens containing additionally atranorin or bourgeanic acid have been found in other regions.

Habitat and distribution.- It grows on diverse substrates, on bare soil, mossy rocks, humus, in exposed areas or under vegetation. It has a preference for acid substrates, where it is more abundant, provided there is sufficient humidity. In the Mediterranean countries is quite rare, it has only been found in a few localities of the montane to subalpine belts and in meso- to supramediterranean belts. It has probably been overlooked because it does not form large populations, but appears mixed with other taxa with podetia no scyphose. It is subcosmopolitan, widely distributed in the temperate and oceanic areas of the globe (Brodo & Ahti 1996).

Mediterranean countries.- Andorra, Algeria, France, Greece, Italy, Morocco, Portugal, Spain and Turkey.

Remarks.- It is very similar to *C. furcata*, which is distinguished by the presence of scabrous cortex, from which small cortical squamules emerge, and for having the apex of the podetia granulated to sorediate. Although some molecular results do not distinguish *C. scabriuscula* from *C. furcata* (Pino-Bodas *et al.* 2015) we still maintain this separation following Ahti & Stenroos (2013). Another possible mistake is with *C. acuminata*, recognized by the Pd+ yellow after red reaction (it contains norstictic and connorstictic acids).

73. *Cladonia sobolescens* Nyl.

Acta Soc. Fauna Fl. Fenn. 53(1): 80, 1922.

TYPE: United States of America, Tennessee, supra saxa arenaria, Calkins 77 (lectotype, designated by Ahti, 1983, H-NYL 38693).

ILLUSTRATIONS: Brodo *et al.* (2001: 270); Boissière & Le Devehat (2016: 17).

Primary thallus squamulose, persistent. Squamules 3-10 mm long × 4-7 mm wide, often erect, lobed, greyish green on the upper side, white below. Podetia rare, 5-12 mm long × 2-3 mm wide, ascyphose, cylindrical, unbranched or branched near the tips, greyish green. Surface continuously corticate. Apothecia brown, at the apex of the podetia. Pycnidia on the squamules of primary thallus with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex.

Habitat and distribution.- It grows on bare acid soils. In the Mediterranean countries only known from subalpine belt in Andorra. It has a Holarctic distribution, known from Europe, Asia, North America with some outliers in South America (Ahti 2000).

Mediterranean countries.- Andorra.

Remarks.- Difficult to identify because it often lacks podetia, probably much overlooked. It belongs to the *Cladonia subcariosa* complex and the study of secondary metabolites is essential to distinguish it from *C. polycarpoides* and *C. brevis*. It can be mistaken for *C. peziziformis*, although it has smaller squamules. This species was only known from Andorra in Europe but recently has been reported from a region of France outside the studied area, Allier and Puy-de-Dôme (Boissière & Le Devehat 2016).

74. *Cladonia squamosa* Hoffm.

Deutschl. Fl. 2: 125, 1796.

TYPE: Italy, Trentino-Alto Adige ('Tirolia orientalis'), prov. Bolzano, Val di Pusteria, Casteldarre (Ehrenburg), Kernstock in Fritsch, Fl. Exs. Austro-Hung. no. 3525 (H neotype, Ahti, Regnum Veg. 128: 95, 1993).

Cladonia squamosa var. *subsquamosa* (Nyl. ex Leight.) Vain., Meddeland. Soc. Fauna Fl. Fenn. 6: 113, 1881.

ILLUSTRATIONS: Brodo *et al.* (2001: 271); Barreno & Pérez-Ortega (2003: 40, 41); Pérez-Valcárcel *et al.* (2003: 169); Wirth (1995: 309); Wirth *et al.* (2004: 82); Burgaz & Ahti (2009: 30); van Haluwyn *et al.* (2012: 201); Ahti & Stenroos (2013: 106); Wirth *et al.* (2013: 384); Stenroos *et al.* (2016: 209); Valcuvia Passadore & Gheza (2017: 86-87).

Primary thallus squamulose, persistent, sometimes evanescent. Squamules up to 2 mm long, forming compact masses,

with entire, crenulate or lacinate edge, greyish green upper side, white below. Podetia 20-50 mm long × 2.5-7 mm wide, unbranched or irregularly branched, perforated at the apex, sometimes, slightly widened forming funnels, which have numerous marginal proliferations, greyish green to brownish grey. The surface is rough and almost completely covered by squamules that sometimes detach, becoming denuded podetia with visible stereome. Squamules 2-3 mm long × 1-2 mm wide, crenulated or lacinated, however, sometimes the squamules are very small and have a granulose-verrucose appearance, but never sorediate. Apothecia frequent, brown, at podetial apices, it is common to find several of them grouped. Pycnidia very frequent, at the apex of the podetia, with hyaline or red slime.

Chemistry.- There are two chemotypes. Chemotype I: Pd-, K-, C-, UV+ white. Squamatic acid and traces of barbatic acid. Chemotype II: Pd+ yellow, K+ yellow, C-, UV-. Thamnic acid. The chemotype I is widely distributed throughout the Mediterranean countries, while chemotype II is restricted to more oceanic areas but the world distributions of both chemotypes overlap (Ahti 2000).

Habitat and distribution.- It grows on acid soil, rocks and decaying wood, in deciduous and coniferous forests. It has been found from 300 to 2100 m altitude, from colline to subalpine belts, and from meso- to supramediterranean belts. It is a subcosmopolitan species especially abundant in suboceanic to oceanic conditions (Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, Algeria, Bosnia-Herzegovina, Croatia, Cyprus, France, Greece, Italy, Montenegro, Portugal, Slovenia, Spain, Tunisia and Turkey.

Remarks.- It is morphologically very variable, since podetia can be abundantly squamulose or present few squamules, but it can be recognized by its always perforated scyphi without soralia. Mistakes with *C. glauca* are possible in specimens with few squamules, but the latter differs in having sorediate apices and characteristic longitudinal cracks. *Cladonia decorticata* is quite similar, but the presence of perlatolic acid allows differentiate this taxon. Some morphotypes of *C. furcata* have squamulose and open podetia, but they have a Pd+ red reaction and the squamules do not come from the cortex. Squamulose specimens of *C. crispata* are difficult to distinguish from *C. squamosa*, both with open scyphi. For some authors, chemotype II, with thamnic acid, constitutes

C. squamosa var. *subsquamosa*, which is more hygrophytic than var. *squamosa* and often considered as an independent species (Nimis & Martellos 2017). This taxon seems to have more robust podetia and with more squamules, but in the Mediterranean specimens studied we have not found morphological differences. A worldwide study is required to clarify the taxonomy of this variable species.

75. *Cladonia stellaris* (Opiz) Pouzar & Vězda Preslia 43: 196, 1971.

Cenomyce stellaris Opiz, Böh. Phan. Crypt. Gew.: 141, 1823, nom. cons.
TYPE CONS.: Herb. Dillenius no. 107.29E (OXF).

Cladonia alpestris (L.) Rabenh., Clad. Europ. 11, 1869. - *Cladonia stellaris* (Opiz) Brodo, Bryologist 79: 363, 1976.

ILLUSTRATIONS: Wirth (1995: 339); Wirth *et al.* (2004: 74); van Haluwyn *et al.* (2012: 173); Ahti & Stenroos (2013: 107); Wirth *et al.* (2013: 409).

Primary thallus crustose, evanescent. Podetia richly branched, isotomous without a clearly defined main axis, branching mainly tetrachotomous, sometimes trichotomous or pentachotomous, latest branches erect and star-like divergent, whitish grey to yellowish white. Surface ecorticate, felted. Apothecia infrequent, at podetial tips, brown. Pycnidia frequent at podetia apices, with red slime.

Chemistry.- Pd-, K-, C-, UV+ pale blue. Usnic, perlatolic and pseudorrangiformic acids.

Habitat and distribution.- It grows in protected locations usually covered by snow. This is a very rare species in the Mediterranean countries with very few reports from the Alps, Northern Appenines (Nimis *et al.* 2018), and Slovenia (Suppan *et al.* 2000). Although very rarely, it could appear in some locations of the alpine belt of the Pyrenees. Previous reports from Spain refer to *C. portentosa* (Valcárcel *et al.* 1991). According to Ravera *et al.* (2016) this species is endangered in Italy. It is a circumpolar species with an Arctic to Boreal distribution (Ahti & Stenroos 2013).

Mediterranean countries.- France, Italy, Slovenia and Turkey.

Remarks.- It is easily recognized by its tetrachotomous to pentachotomous branching pattern, compact felted surface and pale yellow colour. Generally, the podetia form very characteristic subglobose heads. However, confusion might be with thalli Pd-, such as *C. mitis* and *C. portentosa*

morphotype *impexa* since populations can live together, but the branching pattern is clearly different.

76. *Cladonia straminea* (Sommerf.) Flörke De Cladon.: 87, 1828.

Cenomyce straminea Sommerf., Suppl. Fl. Lapp.: 128, 1826.

TYPE: Norway, Nordland. Saltdalen, Sommerfelt (O-L838, lectotype, Tindal & Tønsberg, Graphis Scripta 24: 35, 2012).

Cladonia metacorallifera Asahina, J. Jap. Bot. 15: 612, 1939.

ILLUSTRATIONS: Tønsberg (1975: 130); Wirth (1995: 332); Burgaz & Ahti (2009: 22); Ahti & Stenroos (2013: 107); Wirth *et al.* (2013: 410); Stenroos *et al.* (2016: 211).

Primary thallus squamulose, persistent. Squamules up 4 mm wide, flattened, margin moderately divided into small, rounded lobes, greyish green on the upper side, white below. Podetia narrowly scyphose, 4.5-7.5 mm long × 2-4 mm wide, base 1.5-2 mm wide, generally unbranched. Surface corticate, covered with numerous squamules and microsquamules, sometimes mixed with granules giving a rough appearance. Basal areas often decorticate with blackened stereome visible. Apothecia red at the scyphal margin. Pycnidia red, at scyphus margin, with red slime.

Chemistry.- Two chemotypes have been reported. Chemotype I: Pd-, K-, UV+ white. Usnic, didymic and squamatic acids. Chemotype II: Pd+ yellow, K+ yellow, UV-. Usnic, didymic and thamnolic acids. They also produce rhodocladonic acid. The chemotype I is widely distributed throughout Europe and North America, while the chemotype II namely *C. metacorallifera* var. *reagens* Asahina was known from Japan, Norway and Sweden (Stenroos 1989). Valcárcel *et al.* (1991) and Barreno & Pérez Ortega (2003) referred the chemotype II from Lugo and Asturias provinces in Spain.

Habitat and distribution.- It is a very rare taxon which has only been collected in few localities, growing on mosses between siliceous blocks in very oceanic areas, in mountain areas usually not protected by snow, in the montane to subalpine belts of the Eurosiberian region. It is distributed throughout the Northern Hemisphere (Stenroos 1989).

Mediterranean countries.- France, Italy and Spain.

Remarks.- It can be mistaken for aged thalli of *C. diversa* with necrotic stereome turning dark, so TLC analyses are essential to distinguish them.

77. *Cladonia strepsilis* (Ach.) Grognot
Pl. Crypt. Saône-et-Loire: 85, 1863.

Baeomyces strepsilis Ach., Methodus, Suppl.: 52, 1803.

TYPE: Sweden (H-ACH 1723A lectotype, Ahti, Reg. Veg. 128: 95, 1993).

ILLUSTRATIONS: Brodo *et al.* (2001: 272); Pérez-Valcárcel *et al.* (2003: 171); Burgaz & Ahti (2009: 30); van Haluwyn *et al.* (2012: 79); Ahti & Stenroos (2013: 107); Stenroos *et al.* (2016: 212).

Primary thallus squamulose, persistent. Squamules 1–2 × 1–2 mm, rounded or elongate, with entire or slightly crenulate margin, greenish brown to yellowish brown on the upper side and white below, often forming small cushions. Podetia uncommon, 3–8 mm long × 2–4 mm wide, simple or somewhat branched at apex, greenish brown to yellowish brown. Surface smooth corticate to areolate, sometimes, with small squamules at the base and some cracks, never sorediate. Apothecia frequent, dark brown, located at the apex of the podetia sometimes forming groups. Pycnidia frequent at the primary thallus, dark brown, with hyaline slime.

Chemistry.- Pd+ yellow, K–, C+ emerald green, UV+ white. Baeomycesic and squamatic acids, and strepsilin, traces of barbatic and 4-*O*-demethylbarbatic acid.

Habitat and distribution.- It grows on bare soils, pine forest and heathlands on acidic soils. It is not very frequent, distributed in the colline, montane, meso- and supramediterranean belts of the Western Mediterranean countries. It is a Holarctic species with some outliers in Central and South America, in Europe is distributed in areas with oceanic influence (Ahti & Stenroos 2013).

Mediterranean countries.- France, Italy, Portugal and Spain.

Remarks.- Specimens without podetia can be mistaken for primary thalli of other species, but it is easily recognized by the yellowish brown colour of the upper side and the C+ emerald green reaction, since it is the only *Cladonia* species with this reaction.

78. *Cladonia stygia* (Fr.) Ruoss
Bot. Helv. 95: 241, 1985.

Cladonia rangiferina f. *stygia* Fr., Sched. Crit. Lich. Suec. 8-9(3): 22, 1826.

TYPE: Sweden, Södermanland, St. Malm, Sörgölet, 1918 Malme in Malme, Lich. Suec. Exs. no. 726 (H neotype, Ahti & Hyvönen, Ann. Bot. Fenn. 22: 223, 1985).

Cladonia stygia (Fr.) Ahti, Beih. Nova Hedwigia 79: 45, 1984.

ILLUSTRATIONS: Burgaz & Ahti (2009: 72); Ahti & Stenroos (2013: 107); Wirth *et al.* (2013: 411); Stenroos *et al.* (2016: 214).

Primary thallus crustose, evanescent. Podetia up to 50 mm long, main axis thickness 1 mm, internode length 5 mm, with a clearly defined main axis, branching pattern usually anisotomic trichotomous, sometimes tetrachotomous or dichotomous, apices darkened and strongly unilaterally deflexed, axils perforated, whitish grey. Surface felted, uniform algal layer except at the base, where it is discontinuous, forming characteristic white areolas intermixed with blackened melanotic medulla. Apothecia at the podetial tips, brown. Pycnidia at apical apices with red slime.

Chemistry.- Pd+ red, K+ yellow, C–, UV–. Fumarprotocetraric acid and atranorin.

Habitat and distribution.- It is a very rare species, which grows mixed with *C. rangiferina*. It has only been collected in acid soils of the montane and subalpine belts of the Pyrenees and Alps (Roux *et al.* 2017; Nimis *et al.* 2018) reaching supramediterranean belt in Western Sistema Central Mountains of Portugal (Burgaz & Ahti 2009), Slovenia (Mayrhofer *et al.* 1996) and Turkey (John & Breuss 2004). According to Ravera *et al.* (2016) this species is considered endangered but with deficient data in Italy. It has a circumpolar distribution (Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, Italy, Portugal, Slovenia and Turkey.

Remarks.- It is easily recognized, and differs from *C. rangiferina* in having the podetia base blackened with white small areolas scattered. Old specimens of *C. rangiferina* have also blackened podetia and can be difficult to distinguish from *C. stygia*. Molecular studies on specimens from central Europe proved that both species are monophyletic (Kanz *et al.* 2015).

79. *Cladonia subcervicornis* (Vain.) Kernst.
Jahresber. Staatsoberrrealschule Klagenfurt 43: 25, 32, 1900.

Cladonia verticillata var. *subcervicornis* Vain., Acta Soc. Fauna Fl. Fenn. 10: 197, 1894.

TYPE: not designated.

ILLUSTRATIONS: Pérez-Valcárcel *et al.* (2003: 171); Burgaz & Ahti (2009: 67); van Haluwyn *et al.* (2012: 75); Ahti & Stenroos

(2013: 108); Stenroos *et al.* (2016: 215); Valcuvia Passadore & Gheza (2017: 177).

Primary thallus squamulose, persistent. Squamules large 6-10 mm long \times 2-5 mm wide, elongate, erect, forming cushions, margin digitately lobed, greyish green to bluish on the upper side, white on the underside, blackened at the base, sometimes almost to the middle of the squamule, very finely arachnoid. Podetia uncommon, scyphose, 5-6 mm long \times 1-2 mm wide, irregular scyphi, which open gradually, simple or prolific from the margin or from the center, greyish green glaucous to olive green. Surface corticate, smooth to areolated or somewhat verruculose, bright, with some squamules on the margin of the scyphus. Apothecia frequent, at the scyphal margin, which can form groups, dark brown. Pycnidia frequent at the scyphal margin, sessile or prominent, with hyaline slime.

Chemistry.- Pd+ red, K+ yellow, KC-, C-, UV-. Fumarprotocetraric acid complex and atranorin.

Habitat and distribution.- It grows on humus, plant debris, mossy rocks, rarely on bare soil, in general in acid soil. It has a very oceanic distribution, being especially abundant in the colline and montane belts of the Western European countries with some outpost in Turkey. It has mainly an Atlantic distribution throughout Western Europe and the Macaronesian Islands (Etayo & Burgaz 1997; Litterski & Ahti 2004; Pino-Bodas *et al.* 2017) very rarely in East European countries, present in temperate to boreal zones.

Mediterranean countries.- France, Italy, Portugal, Spain and Turkey.

Remarks.- It can be mistaken for species having large and squamulose primary thallus, such as *C. cervicornis*, *C. macrophylla* or *C. macrophyllodes*, but it is distinguished from them by the elongate squamules with deep black base on the underside. Phylogenetically it is closely related to *C. firma*, both species containing atranorin and a similar distribution (Stenroos *et al.* 2019).

80. *Cladonia subfurcata* (Nyl.) Arnold in Rehm, Cladon. Exs. no. 263, 1885.

Cladonia degenerans f. *subfurcata* Nyl., in Norrlin, Not. Sällsk. Fauna Fl. Fenn. Förh. 13: 320, 1874.

TYPE: Finland, Kittilän Lappi, Muonio, 1867 Norrlin (H-NYL 38313 lectotype, Ahti, Bryologist 70: 104, 1967).

Cladonia delessertii Vain. *nom. illeg.*, Acta Soc. Fauna Flora Fenn. 4(1): 397, 1887.

ILLUSTRATIONS: Ahti & Stenroos (2013: 108); Stenroos *et al.* (2016: 216).

Primary thallus squamulose, evanescent. Podetia 50-120 mm long \times 0.5-2.5 mm wide, subulate, branching patterns anisotomic polytomous, forming very short branchlets, axils perforated, greyish green to dark brown, blackish at the base of the podetia. Surface corticate, smooth, bright, with some areolations at the base, not sorediate. Apothecia very rare, dark brown. Pycnidia frequently located at the apex of podetia, with red slime.

Chemistry.- Pd-, K-, C-, UV+ white. Squamatic and barbatic acids.

Habitat and distribution.- It grows on humus, plant debris, mossy rocks or decaying wood, in open areas and acidic soils. It has an oceanic distribution, from the montane to the subalpine belts. Very rare species in the Mediterranean countries, scattered distributed only present in some areas of France (Roux *et al.* 2017). It is widespread in Arctic and the Boreal regions, known from Europe, Asia and North America (Ahti & Stenroos 2013).

Mediterranean countries.- France.

Remarks.- It is similar to *C. crispata* var. *cetraiiiformis* but it differs in that *C. subfurcata* does not have squamules on the podetia and its surface being glossy.

81. *Cladonia suburgida* Samp. Ann. Sci. Acad. Polytecn. Porto 13: 106, 1918.

TYPE: Portugal, Beira Alta, Guarda, Barca d'Alva, 1916, Sampaio 1245 (PO holotype).

Cladonia iberica Burgaz & Ahti, Nova Hedwigia 59: 430, 1994.

ILLUSTRATIONS: Burgaz & Ahti (1994: 430, 2009: 84).

Primary thallus squamulose, persistent. Squamules large, 6-25 mm long \times 1.5-4 mm wide, with deeply lobed margins, olive green to greenish brown on the upper side, whitish to brownish on the underside, usually purplish towards tips, very finely arachnoid, sometimes the base is somewhat darker. Podetia uncommon, 5-20 mm long \times 1-1.8 mm wide, branched digitately at the apices, open laterally but twisted in when dry, axils open, light green. Surface corticate, the upper part may lose the cortex showing scattered granules. Apothecia frequent, at the tips of the podetia, dark brown, which fuse to form

glomeruli. Pycnidia on the primary thallus, at the squamules surface or at the margins, sessile or pedunculate, ovoid to conical, constricted at the base, with hyaline slime.

Chemistry.- This species is chemically very variable, six chemotypes are known. Chemotype I: Pd-, K+ yellow, KC-, C-, UV-. Atranorin. Chemotype II: Pd-, K+ yellow, KC-, C-, UV-. Atranorin, protolichesterinic acid and zeorin (inconstant). Chemotype III: Pd+ red, K+ yellow, KC-, C-, UV-. Atranorin, protolichesterinic acid and fumarprotocetraric acid complex. Chemotype IV: Pd+ red, K+ yellow, KC-, C-, UV-. Atranorin, fumarprotocetraric acid complex. Chemotype V: Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex with zeorin (inconstant). Chemotype VI: Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex and protolichesterinic acid. The most frequent is the chemotype II.

Habitat and distribution.- It grows in open woodlands of different *Quercus* species (*Q. suber*, *Q. ilex* or *Q. pyrenaica*) and *Cistus* shrublands. It is very common and has a wide distribution on acid soils, in thermo-, meso- and supramediterranean belts. It is a Mediterranean species reaching the Macaronesia (Pino-Bodas *et al.* 2020a).

Mediterranean countries.- France, Greece, Italy, Portugal, Spain and Turkey.

Remarks.- It has probably be unnoticed by the small size of the squamules and the absence of podetia in many specimens. This species is morphologically variable and in absence of podetia can be mistaken for *C. firma* or *C. cervicornis*, but it is recognized by having fairly fragile squamules with the upper side pale green, lower side grey-brownish and relatively big pycnidia on the squamules. The molecular results conducted by Pino-Bodas *et al.* (2012b) did not support *C. iberica* as a different species and it was synonymized with *C. subturgida*.

82. *Cladonia subulata* (L.) F.H.Wigg.

Prim. Fl. Holsat.: 90, 1780.

Lichen subulatus L., Sp. Pl. 1153, 1753.

TYPE: Icon in Tabernaemontanus, Eicones Pl., t. 809, [upper] f. 1. 1590 (lectotype, Jørgensen *et al.*, Bot. J. Linn. Soc. 115: 381, 1994, sine loco; LINN 1273.249 epitype, Jørgensen *et al.*, Bot. J. Linn. Soc. 115: 382, 1994).

Cladonia cornutoradiata (Leight.) Sandst., Abh. Naturwiss. Vereine Bremen 21: 373, 1912.

ILLUSTRATIONS: Wirth (1995: 303); Brodo *et al.* (2001: 273); Pérez-Valcárcel *et al.* (2003: 171); Wirth *et al.* (2004: 81); Burgaz & Ahti (2009: 35); van Haluwyn *et al.* (2012: 195); Ahti & Stenroos (2013: 108); Wirth *et al.* (2013: 411); Stenroos *et al.* (2016: 217); Valcuvia Passadore & Gheza (2017: 145).

Primary thallus squamulose, evanescent. Squamules 3-5 mm long × 1-2 mm wide, with the margin smooth, sinuate to crenulate, or sorediate on the underside, greyish green on the upper side, white below. Podetia 18-45 mm long × 1-3 mm wide, subulate or forming narrow scyphi, simple, or little branched, forming a wide angle or widening slightly, subulate extensions can born from the scyphal margin, well developed podetia with antler-like aspect, whitish to greenish grey. Surface only corticate at the base, mostly sorediate, with farinose soredia, 20-50 µm diameter, some microsquamules may appear at the base of the podetia. Apothecia uncommon, dark brown, located at the margin of the scyphus or at the apex of the podetia. Pycnidia dark brown or black, frequent, at the apex of the subulate podetia or at the margin of the scyphus, with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex.

Habitat and distribution.- It grows in acidic, sandy soils, road slopes, rock crevices, open forest, rarely on stumps, in general, on well drained and dry substrates. It has a wide distribution in the Mediterranean countries in the colline, montane, subalpine, meso- and supramediterranean belts. It has a worldwide distribution, being more abundant in continental areas (Ahti & Stenroos 2013).

Mediterranean countries.- Albania, Algeria, Andorra, Bosnia-Herzegovina, Croatia, France, Greece, Italy, Montenegro, Portugal, Slovenia, Spain, Tunisia and Turkey.

Remarks.- The scyphose morphotype of *C. subulata* can be mistaken for *C. fimbriata*, since both taxa are almost completely covered by farinose soredia. They can be differentiated because the scyphi of *C. fimbriata* are wider and deeper. In general the dominant morphotype in *C. subulata* has subulate podetia, so there is no possible confusion with *C. fimbriata*. It is also similar to *C. rei*, but this one has less developed and twisted podetia, also has a darker colour and the podetia are UV+ white fluorescent. Both species have clear differences in their ecological preferences, *C. rei* prefers bare and slightly altered

soils, while *C. subulata* grows in somewhat more stable habitats (Paus *et al.* 1993), the molecular results also supported the validity of these taxa (Dolnik *et al.* 2010; Pino-Bodas *et al.* 2010b). Certain similarity to *C. glauca* exists, but the latter usually has a longitudinal groove in the podetia and reacts Pd–.

83. *Cladonia sulphurina* (Michx.) Fr. Lichenogr. Eur. Reform.: 237, 1831.

Scyphoborus sulphurinus Michx., Fl. Bor.-Amer. 2: 328, 1803.

TYPE: 'America Septentrionalis' (Canada), Michaux (PC lectotype, Ahti, Ann. Bot. Fenn. 15: 9, 1978).

Cladonia gonecha (Ach.) Asahina, J. Jap. Bot. 15: 609, 1939.

ILLUSTRATIONS: Wirth (1995: 301); Brodo *et al.* (2001: 274); Burgaz & Ahti (2009: 25); van Haluwyn *et al.* (2012: 147); Ahti & Stenroos (2013: 108); Wirth *et al.* (2013: 412); Stenroos *et al.* (2016: 218).

Primary thallus squamulose, persistent. Squamules 2–2.5 mm long × 2–6 mm wide, flat or ascending, more or less rounded, slightly crenulated, occasionally sorediate, yellowish green on the upperside and white below, sometimes yellowish brown towards the base. Podetia 20–25 mm long × 3–5 mm wide, 2–2.5 mm wide at the base, slightly widened, irregular, apices more or less scyphose, with conspicuous longitudinal fissures, particularly at the top. Surface finely sorediate, farinose soredia, 20–40 µm diameter, base corticate and often squamulose. Apothecia red, not common, at the scyphal margin. Pycnidia red, at the scyphal margin, with red slime.

Chemistry.- Pd–, K–, KC+ yellow, C–, UV+ white. Squamatic, rhodocladonic and usnic acids.

Habitat and distribution.- This is an uncommon taxon in the Mediterranean countries, which grows on stumps of coniferous woodlands, humus or bare soil. It has only been found in montane, subalpine and oromediterranean belts. This is a circumpolar species with primarily Arctic to Boreal distribution but with some outliers in temperate areas, also known from the Southern Hemisphere (Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, Bosnia-Herzegovina, France, Italy, Montenegro, Slovenia, Spain and Turkey.

Remarks.- It can be mistaken for *C. carneola* but this species has ochraceous apothecia, the podetia with a less intense yellow colouration and without longitudinal

fissures. It is also similar to *C. deformis*, but this species lacks squamatic acid (UV–) and longitudinal fissures.

84. *Cladonia symphyrcarpa* (Flörke) Fr. Sched. Crit. Lich. Succ. 8-9: 20, 1826.

Capitularia symphyrcarpa Flörke, Beitr. Naturk. 2: 281, 1810.

TYPE: Germany, Flörke in Arnold, Lich. Exs. [icones] no. 1484 [photo] (H lectotype, Burgaz & Ahti, Fl. Liquenól. Ibér. 4: 81, 2009), Germany, Thüringen, Harz, Nordhausen, Alter Stolberg, 1920, Sandstede & Wein in Sandstede, Cladon. Exs. no. 689 (UPS epitype, Burgaz & Ahti, Fl. Liquenól. Ibér. 4: 81, 2009).

Cladonia hungarica Vain., Acta Soc. Fauna Flora Fenn. 53(1): 18, 1922. - *Cladonia dabliana* Kristinsson, Lichenologist 6(2): 141, 1974.

ILLUSTRATIONS: Brodo *et al.* (2001: 275); Wirth (1995: 341); Burgaz & Ahti (2009: 77); van Haluwyn *et al.* (2012:81); Ahti & Stenroos (2013: 108); Wirth *et al.* (2013: 413); Stenroos *et al.* (2016: 219); Valcuvia Passadore & Gheza (2017: 179).

Primary thallus squamulose, persistent. Squamules well developed, 4–6 mm long × 2–4 mm wide, with smooth and overlapping margins, greyish green, with brownish apices on the upper side, the cortex develops papillae and macules with age, often pruinose, white on the underside and edges darkened with violet tones. Podetia very rare, short and thin, simple or with apical ramifications, greyish brown. Surface from smooth corticate to verruculose, generally aerolate, pruinose, with longitudinally channels. Apothecia at the apex of the podetia, light to dark brown, generally forming groups. Pycnidia on primary thallus, from globose to conical, constricts at the base, with hyaline slime.

Chemistry.- Chemically variable, several chemotypes are known. Chemotype I: Pd+ yellow, K+ yellow after red, C–, KC–, UV–. Atranorin, norstictic and connorstictic acids. Chemotype II: Pd+ yellow, K+ yellow after red, C–, KC–, UV–. Atranorin, bourgeanic and norstictic acids. Chemotype III: Pd+ yellow, K+ yellow, C–, KC–, UV–. Atranorin and psoromic acid. Chemotype IV: Pd–, K+ yellow, C–, KC–, UV–. Atranorin, rangiformic acid and zeorin (inconstant). Chemotype V: Pd+ red, K+ yellow, C–, KC–, UV–. Atranorin, fumarprotocetraric and rangiformic acids, and zeorin (inconstant). Chemotype VI: Pd+ red, K+ yellow after red, C–, KC–, UV–. Atranorin, fumarprotocetraric, norstictic and rangiformic acids. Chemotype VII: Pd+ red, K+ yellow after

red, C–, KC–, UV–. Fumarprotocetraric, norstictic and rangiformic acids. The chemotype I is the most frequent. Chemotype III was previously recognized as a different species, *C. dabliana*. See also Osyczka & Skuba (2011).

Habitat and distribution.– It grows in soils steps, crack of rocks and basic or moderately acid soils, in all bioclimatic belts. It is considered an indicator of calcareous soils, rich in bases. It has a Holarctic distribution with some outliers in South America (Ahti & Stenroos 2013). The absence in Portugal is surprising.

Mediterranean countries.– Albania, Algeria, Andorra, Bosnia-Herzegovina, Croatia, France, Greece, Italy, Montenegro, Slovenia, Spain and Turkey.

Remarks.– Probably it has a greater distribution area but has been overlooked because it usually develops only the primary thallus. It is easily recognized by thick squamules, brown-coloured at the apices. *Cladonia cariosa* is similar but differs from it by having a thinnest thallus and more fissurate podetia. Nevertheless a molecular study of *C. cariosa* group has pointed out the existence of four different lineages with certain morphological and chemical variations (Pino-Bodas *et al.* 2012a) and further studies are necessary in order to clarify the taxonomy of this group. Other possible mistakes occur with *C. subturgida* or *C. firma* but the latter taxa prefer acid substrates and the lower side of their primary thallus is brownish.

85. *Cladonia trassii* Ahti

Folia Cryptog. Estonica 32: 7, 1998.

TYPE: Sweden, Torne Lappmark, Gällivare, Mt. Patjanen, 1922 Stenholm in Sandstede, Cladon. Exs. no. 1134 (H holotype).

ILLUSTRATIONS: Ahti & Stenroos (2013: 109); Stenroos *et al.* (2016: 220).

Primary thallus squamulose, persistent. Squamules ascendent, 1–3 mm long with melanotic base. Podetia 5–80 mm long × 0.5–3 mm wide, very variable, subulate or with narrow scyphus, sometimes branched, deformed and twisted towards the base, axils closed, usually with central proliferations, whitish green to bluish grey, uneven towards base and strongly melanotic, usually little browned at the top of the podetia. Surface smooth, discontinuously corticate, areolate, allowing to see blackened medulla patches, large squamules may appear especially at the scyphal margin.

Apothecia not common, dark brown. Pycnidia frequent, at the apex of the podetia, with hyaline slime.

Chemistry.– Pd+ red, K+, UV–. Atranorin and fumarprotocetraric acid complex.

Habitat and distribution.– It grows on mosses and acidic soil, in subalpine and alpine belts. This is a very rare species in the Mediterranean countries, only reported of Eastern Pyrenees province in France growing at 2345 m altitude (Roux *et al.* 2014), and Northern Italy (Lombardy and Piedmont provinces, Nimis *et al.* 2018). It has an incomplete Holarctic distribution with some outliers in South Hemisphere (Ahti & Stenroos 2013).

Mediterranean countries.– France and Italy.

Remarks.– It can be mistaken for *C. stricta* or *C. uliginosa* but these species have exclusively an Arctic distribution (Ahti & Stenroos 2013). *Cladonia stricta* was earlier confused with this species but in strict sense it is similar to *C. phyllophora* and its podetia do not have regularly central proliferations.

86. *Cladonia turgida* Hoffm.

Deutschl. Fl. 2: 124, 1796.

TYPE: Sweden, Uppland, Uppsala, Ehrhart in Ehrhart, Pl. Cryptog. Exs. no. 297 (GOET lectotype, Ahti & Stenroos, Nordic Lichen Flora 5: 91, 2013).

ILLUSTRATIONS: Ahti & Stenroos (2013: 109); Stenroos *et al.* (2016: 221); Valcuvia Passadore & Gheza (2017: 99).

Primary thallus squamulose, persistent or evanescent. Squamules large, 5–25 mm long × 2–7 mm wide, margin lobed, frequently with incurved apices, greyish green with glaucous tonality on the upper side, white on the underside and darkened at the base. Podetia 5–70 mm long × 2–3 mm wide, variable, with narrow scyphus, irregular with proliferations or subulate and somewhat branched, greyish green glaucous to green brownish. Surface smooth, discontinuously corticate, areolate, often with longitudinal cracks or openings. Apothecia not common, brown, at scyphal margins which can join to form groups. Pycnidia frequent, at the podetial tips or on primary thallus, with hyaline slime.

Chemistry.– Pd+ red, K+ yellow, UV–. Atranorin and fumarprotocetraric acid complex

Habitat and distribution.– It grows on humus, plant debris, rarely on bare soil, in general on acid soil of open

coniferous woodlands. In the Mediterranean countries only grows in the Italian Alps (Nimis *et al.* 2018) and very scattered in France (Roux *et al.* 2017) from montane to subalpine belts. It is a circumpolar species distributed in the Arctic area, reaching boreal to northern temperate situations (Litterski & Ahti 2004; Ahti & Stenroos 2013).

Mediterranean countries. - France and Italy.

Remarks. - The identification is relatively easy due to the big size of the primary thallus and the habitat, usually near the treeline.

87. *Cladonia umbricola* Tønsberg & Ahti Norweg. J. Bot. 27: 307, 1980.

TYPE: Norway, Sør-Trøndelag, Klæbu, Ramgåa SW of Selbusjøen, 1976 Hjelmsstad (TRH holotype).

Cladonia polydactyla var. *umbricola* (Tønsberg & Ahti) Coppins, British Lichen Soc. Bull., Supplement 72: 75, 1993.

ILLUSTRATIONS: Tønsberg & Ahti (1980: 308); Brodo *et al.* (2001: 777); Ahti & Stenroos (2013: 109).

Primary thallus squamulose, persistent. Squamules 2 mm long \times 1-2 mm wide, with deep crenulated margins, yellowish green on the upper side, white on the lowerside and finely sorediate. Podetia 14-21 mm long \times 1.5-2 mm wide, base 1-1.8 mm wide, usually without scyphi, simple. Surface sorediate. Apothecia not frequent, red at the apex of podetia. Pycnidia red, with red slime.

Chemistry. - Pd-, K-, KC-, C-, UV+ white. Squamatic acid.

Habitat and distribution. - It grows on decaying wood, coniferous trunks or plant debris in acid soils. This is a very rare species in the Mediterranean countries, with very few reports of the Eurosiberian region of Croatia, France and Spain from montane to subalpine belts. It is distributed in oceanic areas of North America and Western Europe (Brodo & Ahti 1996).

Mediterranean countries. - Croatia, France and Spain.

Remarks. - It can be mistaken for *C. polydactyla*, since it has sorediate squamules with deep incisions, but in general, the studied specimens have a smaller size and reacts Pd-. Some authors consider that it is only a chemotype of *C. polydactyla* (James 2009). In the phylogeny of *Cladoniaceae* both species were closely related (Stenroos *et al.* 2019) but further studies with additional material is necessary to establish the species boundaries.

88. *Cladonia uncialis* (L.) F.H.Wigg. subsp. *uncialis*

Prim. Fl. Holsat.: 90, 1780.

Lichen uncialis L., Sp. Pl.: 1153, 1753, nom. cons.

TYPE (CONS): Sweden, Dalarna, Stora Kopparberg, Rotneby, Stenhammar in Stenhammar, Lich. Succ. Exs., ed. 2, no. 210 (UPS).

ILLUSTRATIONS: Brodo *et al.* (2001: 278); Burgaz & Ahti (2009: 87); Ahti & Stenroos (2013: 109); Wirth *et al.* (2013: 414); Stenroos *et al.* (2015: 227); Stenroos *et al.* (2016: 223); Valcuvia Passadore & Gheza (2017: 89).

Primary thallus evanescent. Podetia 22-50 mm long \times 0.9-1.3 mm wide, internode 4-8 mm length, length of the last branch 2-5 mm, subulate, branching pattern anisotomic dichotomous, ultimate branchlets trichotomous, tetrachotomous or polytomous, rarely dichotomous, axils generally perforated, greenish yellow, darkened at apices. Specimens with prostrate podetia have perpendicular branches. Surface smoothly corticate, inner surface of the podetia fibrouse although sometimes it is somewhat grainy-powdery, especially in the apex. Apothecia very rare at the tips of podetia, brown. Pycnidia at the apex of the podetia, with hyaline slime.

Chemistry. - Pd-, K-, C-, UV- or UV+ white. Usnic acid, sometimes also squamatic acid. Another chemotype containing hypothamnolic acid is known from other regions (Stenroos *et al.* 2015).

Habitat and distribution. - It grows on acid soils, in cracks, rocks and heathlands. It is a rare taxon in the Mediterranean countries that grows scattered and mixed with subsp. *biuncialis*, in the montane to subalpine belts, rarely in colline and supramediterranean belts. However the accurate distribution is not well known, since many references do not differentiate between two subspecies. It has a circumpolar, Arctic to temperate distribution (Ahti & Stenroos 2013).

Mediterranean countries. - Andorra, Croatia, France, Greece, Italy, Montenegro, Portugal, Spain, Tunisia and Turkey.

Remarks. - The molecular phylogeny of *Cladonia uncialis* and members of the traditionally Section *Unciales*, recognized *Cladonia uncialis* subsp. *uncialis* and subsp. *biuncialis* as distinct taxa (Stenroos *et al.* 2015) but kept them at subspecies level.

Cladonia uncialis subsp. biuncialis (Hoffm.)

M.Choisy

Bull. Mens. Soc. Linn. Lyon 20: 9, 1951.

Cladonia biuncialis Hoffm., Deutschl. Fl. 2: 116, 1796.

TYPE: ?Germany? Hoffmann s.n. (MW-Hoffmann 8614, neotype, Ahti, Ann. Bot. Fenn. 15: 9, 1978, lectotype Ahti, Regnum Veg. 128: 100, 1993).

ILLUSTRATIONS: Wirth (1995: 342); Barreno & Pérez-Ortega (2003: lam. 42); Wirth *et al.* (2004: 76); Burgaz & Ahti (2009: 87); van Haluwyn *et al.* (2012:189); Ahti & Stenroos (2013: 109); Stenroos *et al.* (2016: 223).

Primary thallus evanescent. Podetia 15-50 mm long × 0.6-1.5 mm wide, internode 2-11 mm length of last branch, acute apices, branching pattern anisotomic dichotomous, axil closed, sometimes perforated but always with a small hole, greenish yellow with darkened apices. Surface smoothly corticate, with high coverage of algal layer, inner surface powdery-granulose, especially on the top. Apothecia very rare, brown. Pycnidia at the apex of the podetia, with hyaline slime.

Chemistry.- Pd-, K-, C-, UV+ white. Usnic and squamatic (inconstant) acids. Another chemotype containing hypothamnolic acid is known from other regions (Stenroos *et al.* 2015).

Habitat and distribution.- It appears on acid soils growing between rocks, bare soil, inside forests or among shrubs. In the Mediterranean countries is much more frequent and abundant than subsp. *uncialis*. Its global distribution is incompletely known.

Mediterranean countries.- France, Greece, Italy, Montenegro, Portugal, Spain and Turkey.

Remarks.- Sometimes mixed populations with both subspecies growing together can be found. In these cases, distinguishing the subspecies is particularly difficult because specimens with intermediate characters appear. However a combination of characters usually help to identify the subspecies *biuncialis* such as closed axils, the dichotomous branching, and the thickness of the podetial wall (Burgaz & Martínez 2008).

89. Cladonia verticillata (Hoffm.) Schaer.

Lich. Helv. Spic. 1(1): 31, 1823.

Cladonia pyxidata [unranked] *verticillata* Hoffm., Deutschl. Fl. 2: 122, 1796.

TYPE: Icon in Dillenius, Hist. Musc.: t. 14, f. 6h. 1742, lectotype, Ahti, Biblioth. Lichenol. 96: 17, 2007, sine loco (Germany?), MW-Herb. Hoffmann 8642 epitype, Ahti, Biblioth. Lichenol. 96: 17, 2007). *Cladonia cervicornis* var. *verticillata* (Hoffm.) Flot., Jahresber. Schles. Ges. Vaterl. Cult. 27: 105, 1849. - *Cladonia cervicornis* subsp. *verticillata* (Hoffm.) Ahti, Lichenologist 12: 126, 1980.

ILLUSTRATIONS: Wirth (1995: 319); Brodo *et al.* (2001: 246); Wirth *et al.* (2004: 86); van Haluwyn *et al.* (2012: 75); Wirth *et al.* (2013: 394); Ahti & Stenroos (2013: 110); Stenroos *et al.* (2016: 224); Valcuvia Passadore & Gheza (2017: 149).

Primary thallus squamulose, persistent, forming pulvinules. Squamules 3-6 mm long × 2-5 mm wide, entire or with shallow lobulations, brownish green upper side, whitish on the underside and very finely arachnoid. Podetia common, scyphose, 14-55 mm long × 2-4 mm wide, simple, scyphi centrally proliferating forming up to 7 tiers, dark brownish green. Surface corticate, smooth, slightly arachnoid in the young parts, squamules very rarely borne at the scyphal margin. Apothecia uncommon, dark brown, at the scyphal margin. Pycnidia frequent, at the scyphal margin, sessile or prominent, with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex.

Habitat and distribution.- It grows on bare soil, humus, mossy rocks, generally on acidic substrates. It is not common in the Mediterranean countries, with a boreal-montane distribution, throughout Western Europe in meso-, supramediterranean, montane to subalpine belts. It is widespread, known from Europe, Asia, North America and Australasia (Ahti 2007; Ahti & Stenroos 2013).

Mediterranean countries.- Algeria, France, Italy, Greece, Portugal, Slovenia, Spain and Turkey.

Remarks.- It is morphologically close to *C. cervicornis*, which was subordinated for long time, but according to van Herk & Aptroot (2003) enough morphological differences exist to consider it as species level. It differs in having smaller squamules of the primary thallus, with small divisions and not recurved, and the thinnest and narrowest scyphi with more proliferation tiers. The molecular results also support this taxonomic change (Pino-Bodas *et al.* 2013b; Stenroos *et al.* 2019). However, *C. verticillata* is polyphyletic (Pino-Bodas *et al.* 2013b; Stenroos *et al.* 2019) and a worldwide study is necessary. A project to establish the species boundaries in the *C. verticillata* group within the European taxa is in progress (Pino-Bodas *et al.* in prep).

90. *Cladonia zopfii* Vain.

Meddeland. Soc. Fauna Fl. Fenn. 45: 4, 306, 1920.

TYPE: Germany, Niedersachsen, Oldenburg, Zwischenahn, Ohrwege, Kehnmoor, 1886 Sandstede in Zwackh, Lich. Exs. no. 996 (TUR-V 13875 lectotype, Ahti, Regnum Veg. 128: 102, 1993).

ILLUSTRATIONS: Pérez-Valcárcel *et al.* (2003: 173); van Herk & Aptroot (2004: 165); Burgaz & Ahti (2009: 87); Ahti & Stenroos (2013: 110).

Primary thallus evanescent. Podetia 23-40 mm long \times 0.8-2.5 mm wide, internode length 3-7 mm and length of last branch 2-9 mm, subulate, dichotomously branched, closed axils, light yellow, without darkened apices. Surface corticate, with non-thickened cells, verruculose with age, internal surface of the podetia striated fibrous. Apothecia not seen. Pycnidia at the apex of the podetia, hyaline slime.

Chemistry.- Pd-, K-, C-, UV-. Usnic acid and sometimes terpenoids.

Habitat and distribution.- It grows on acid soils, in colline and montane belts, very rarely in supramediterranean belt. It is a rare and sparse species in Mediterranean countries, which grows mixed with thalli of *C. uncialis* s. lat. It is distributed more frequently in Northwestern of the Mediterranean countries. It is restricted to Northern and Western Europe (Litterski & Ahti 2004).

Mediterranean countries.- France, Italy, Portugal and Spain.

Remarks.- It can be mistaken for *C. uncialis* but it is easily distinguishable by having long podetia, without darkened apex and without squamatic acid, but needle crystals are often diagnostic in herbarium specimens.

SPECIES UNDER STUDY***Cladonia dimorpha* S.Hammer**

Mycotaxon 37: 339, 1990.

TYPE: United States of America, California, Humboldt Co., Honeydew Road near Rockefeller Memorial Redwood Grove, 1988, S. Hammer 1130 (FH holotype, SFSU isotype).

ILLUSTRATIONS: Hammer & Ahti (1990: 340); Ahti (2000: 113); Schumm & Aptroot (2013: 111, 112, 113).

Primary thallus squamulose, persistent or evanescent. Squamules 2 mm long \times 1-3 mm wide, entire to lobed

margin, greyish green on the upper side, white below, darker towards the center. Podetia 15-40 mm long \times 4-10 mm wide, scyphose, with marginal proliferations lateral splited, flattened and branched, similar to the tips of fertile podetia in *C. furcata*. Surface corticate, not sorediate, smooth or warty that sometimes gives rise to some squamules at the base of the podetia. Apothecia frequent, brown, at the apex of the marginal proliferations of the podetia. Pycnidia on the scyphal margin, frequent, pyriform and short pedunculated, with hyaline slime.

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex, sometimes it can present an unknown fatty acid (Ahti 2000).

Habitat and distribution.- It grows on slopes and bare soils with acidic pH. This species was described from California and extends along the west coast of North America to British Columbia and from the south to the Dominican Republic (Ahti 2000). It has also been reported from the Canary Islands (Schumm & Aptroot 2013) and in Mediterranean continental Europe (Burgaz & Ahti 2009).

Mediterranean countries.- Albania, Algeria, Croatia, Cyprus, Greece, Italy, Portugal and Spain.

Remarks.- It is apparently frequent, but unnoticed due to sterile podetia that hinder distinguishing it from other species. The diagnostic character of this species is the narrow split proliferations borne on scyphal margins. Sterile specimens can be mistaken for *C. pyxidata*, due to the presence of some flat plates inside the podetia and for *C. ramulosa* by the lateral proliferations of the podetia, but the proliferations of *C. dimorpha* are clearly different since they resemble fertile podetia of *C. furcata*. Molecular studies on this species are being carried out (Pino-Bodas *et al.* in prep). Our preliminary results indicate that *C. dimorpha* s. str. is not present in Europe but the identity of the European specimens of *C. dimorpha* has not yet been clarified.

SPECIES TO LOOK FOR***Cladonia brevis* (Sandst.) Sandst.**

Abh. Naturw. Ver. Bremen 25: 192, 1922.

Cladonia verticillata f. *brevis* Sandst., Cladon. Exs. no. 234, 1918.

TYPE: Germany, Niedersachsen, Oldenburg, Sandhatten, 1918 Sandstede in Sandstede, Cladon. Exs. no. 234 (H, lectotype Ahti, Regnum Vegetabile 128: 69, 1993).

ILLUSTRATIONS: Thomson (1968: fig. 35); Boissière & Le Devehat (2016: 21).

Primary thallus persistent. Squamules small, 1-3 mm long, lobed, glaucous green on the upper side, white arachnoid below. Podetia up to 8 mm, simple or branched near the apex, flattened. Surface corticate areolate. Apothecia brown at the tips of podetia. Pycnidia constricted at the base, on the primary thallus.

Chemistry.- Pd+ yellow, K-, KC-, C-, UV-. Psoromic and 2'-*O*-demethylpsoromic acids.

Habitat and distribution.- In the Mediterranean countries only reported from Massif Central in France (Clauzade & Roux 1987). This species was described from Germany, later reported from other countries in Europe, Asia and North America, where it is most common. It is included in the red list of several countries in the endangered category (Roux *et al.* 2014; Löhmus *et al.* 2019).

Mediterranean countries.- France.

Remarks.- Probably an overlooked species because the podetia are not always developed. It is morphologically similar to the species of the *Cladonia subcariosa* complex (Evans 1944; Ahti 2000) but is phylogenetically distant, related to *C. macrophylla* (Stenroos *et al.* 2019). Unpublished molecular results show that specimens from North America and Europe are genetically homogenous. The identity of French specimens is uncertain and we exclude it from the territory.

***Cladonia nana* Vainio**

Acta Soc. Fauna Fl. Fenn. 10: 23, 1894.

TYPE: Brazil, Minas Gerais, Antônio Carlos (Sítio), 1885, E. A. Vainio (TUR-V no. 17230 lectotype, Ahti, Regnum Veg. 128: 86, 1993).

ILLUSTRATIONS: Schumm & Aptroot (2013: 140, 141).

Primary thallus squamulose, persistent. Squamules 1-7 mm long × 0.3-2 mm wide, elongate entire or long laciniated, pruinose upper side, underside and cotton-like margins with granular soredia, sometimes, some veins are observed, squamules becoming ribbed when podetia develop, darken taking a yellowish colour towards the base. Podetia very small 0.2-2.5 mm long × 0.1-1 mm wide, growing on the squamules margin of the primary thallus, simple or with branched apex, phyllopodiate, at the beginning with quadrangular section, then flattened.

Surface corticate at the beginning then decorticate in areas and with verruculose patches, rarely with squamules. Apothecia very dark brown (Ahti 2000).

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex.

Habitat and distribution.- It grows on bare soil and slopes on acid substrates. It is considered a first colonizer, with a behavior similar to *C. caespiticia*. There is a specimen of Estremadura (Portugal) in LISU herbarium that only presents the primary thallus, but since no more specimens were found, we cannot really confirm its presence. Widely distributed in the Neotropics at low altitude, and has also been reported in the Azores (Aptroot 1989; Litterski & Ahti 2004; Aptroot *et al.* 2010). However, Neotropical and Macaronesian specimens are not genetically similar (Pino-Bodas *et al.* 2017) and further studies are required.

***Cladonia stereoclada* Abbayes**

Portugaliae Acta Biol., Sér. B, Sist. 1: 245, 1947.

TYPE: The Azores, Faial, Caldeira, 1937 R. Palhinha & L. Sobrinho (LISU lectotype, Burgaz & Ahti, Fl. Liquenól. Ibér. 4: 85, 2009).

ILLUSTRATIONS: des Abbayes (1946: 246).

Very similar to *C. furcata* from which it differs by presenting thinnest podetia 0.3-0.7 mm wide, solid inside and not hollow. It grows in very humid and oceanic areas of Western Europe. It is known from Ireland, Scotland (Purvis *et al.* 1992; James 2009) and Macaronesia (Hafellner 1995).

Chemistry.- Pd+ red, K-, KC-, C-, UV-. Fumarprotocetraric acid complex. Recently Pino-Bodas *et al.* (2017) found a new chemotype in Azores with bourgeanic acid additional to fumarprotocetraric acid complex.

Habitat and distribution.- It grows on road banks, on volcanic rocks and heathlands. A species distributed in the Macaronesia and with few scattered records in Ireland and Scotland.

EXCLUDED ESPECIES

***Cladonia perlomera* Kristinsson**

Bryologist 72: 432, 1969.

This species belongs to *C. chlorophaea* group, containing perlatolic, merochlorophaeic and 4-*O*-merochlorophaeic

acids. It was described from North Carolina in Eastern North America (Culberson & Kristinsson 1969) and later on it was reported from Italy growing on rotting wood. However, the data of this collection are deficient (Nimis & Martellos 2017) and in the absence of new material we cannot confirm the presence of this species in Europe.

Pilophorus Th.Fr.

Stereoc. Piloph. Comm.: 40, 1857

Species type: *Pilophorus robustus* Th.Fr.

Primary thallus crustose to granulose, persistent in most of the species. Pseudopodetia vertical, cylindrical, solid and sometimes hollow with age, simple or branched towards apex, forked to umbellate, up to 50 mm high \times 3 mm wide. Surface of pseudopodetia smoothly corticate, partially corticate, granulose or soresiate. Photobiont of main thallus chlorocoid, *Asterochloris*. Cephalodia on the primary thallus or on pseudopodetia, light to dark brown with irregular shape, contain *Nostoc* or *Stigonema*. Apothecia frequent, biatorin, at the pseudopodetia apex, dark brown to black, globose to cylindrical. Spores simple, hyaline, ellipsoid or fusiform, $9\text{--}30 \times 4\text{--}7 \mu\text{m}$. Pycnidia on primary thallus or on sterile pseudopodetia, frequent, with bottle shape. Conidia simple, hyaline $5\text{--}6 \times 1 \mu\text{m}$.

Chemistry.- Atranorin, zeorin, isousnic and stictic acids.

Habitat and distribution.- It has a widespread distribution but is restricted to Northern Hemisphere. In Europe it is distributed on montane, temperate and boreal regions but in general it is more abundant in the Arctic regions with clear oceanic tendencies.

Remarks.- Traditionally, the genus *Pilophorus* was included in the *Stereocaulaceae* family, but molecular studies showed that *Pilophorus* belongs to the family *Cladoniaceae* (Wedin *et al.* 2000; Stenroos *et al.* 2019). *Pilophorus* comprises twelve species, four of which are present in Europe (Ahti & Stenroos 2013).

1. *Pilophorus cereolus* (Ach.) Hellb.

Öfvers. Kongl. Vetensk.-Akad. Förhandl. 1875(3): 60, 1875.

Lichen cereolus Ach., Lichenogr. Suec. Prodr.: 89, 1799, '1798'.

TYPE: Sweden (H-ACH no. 1756D, lectotype, Jahns, Lichenologist 4: 206, 1970, as 'holotype).

ILLUSTRATIONS: Jahns (1981: 303); Ahti & Stenroos (2013: 110); Stenroos *et al.* (2016: 517).

Primary thallus crustose, persistent, greyish white, granulose to soresiate, with brown cephalodia. Pseudopodetia 1.5-4 mm long \times 0.3-0.8 mm wide, unbranched, pin-like, often curved, greyish green, solid. Surface variable, soresiate, granulose, 20-30 μm diameter, rarely old specimens esoresiate. Apothecia not frequent, globosus, without columella, black, at the pseudopodetial apex, usually isolates. Pycnidia common at pseudopodetia apex.

Chemistry.- Pd-, K+ yellow, C-, UV-. Atranorin and zeorin.

Habitat and distribution.- It grows on acidic rocks in moist localities near treeline in the Italian Alps (Nimis *et al.* 2018). Very rare in the Mediterranean countries, only known a few historical records of the Italian Alps (Nimis *et al.* 2018). It has an incomplete circumpolar distribution in the Holarctic region being rather frequent in the Nordic countries with some outposts in the Azores (Ahti & Stenroos 2013).

Mediterranean countries.- Italy.

Remarks.- This is the only species reported in the Mediterranean countries, maybe overlooked because it is very small and probably only present in high mountains.

Pycnothelia Dufour

Ann. Gén. Sci. Phys. 8: 46, 1821.

Species type: *Pycnothelia papillaria* Dufour

Protothallus fibrous, whitish to dark noted on the lower side of the primary thallus. Primary thallus persistent, continuous, granulose, greyish white. Secondary thallus fruticulose, hollow, cylindrical, swollen or slightly flattened, not scyphose. Surface esoresiate, smoothly corticate or partially decorticate and cracked. Podetial wall comprises a corticate layer and a stereome. Apothecia dark brown to black, grouped at the apex of the podetia. Ascospores fusiform up to elliptical, colourless, simple or 1-3 septa. Conidioma pycnidia type on the apex of the podetia, rarely on the primary thallus, cylindrical, hyaline pycnidial slime. Pycnidiospores falciform, hyaline. Photobiont is a chlorocoid alga, of the genus *Asterochloris*.

Chemistry.- Contains some depsidones, atranorin and fatty acids.

Habitat and distribution.- It grows on bare soils, sands or clays, but also on soils with plant debris, in general, on acid soils. It is distributed throughout the temperate zones of both hemispheres with a disjunct distribution, although with a restricted location.

Remarks.- Traditionally, the genus *Pycnothelia* was included in the genus *Cladonia* (Vainio 1897; Mattick 1938; Dahl 1952; Thomson 1968), although Ahti (1993), Tehler (1996) or Kirk *et al.* (2001) considered that is an independent genus belonging to the *Cladoniaceae*. This assumption was confirmed by molecular studies, which show that *Pycnothelia* belongs to that family (Stenroos & DePriest 1998; Stenroos *et al.* 2002, 2019). Some taxa of the genus *Cladonia* also have granular primary thallus, but evanescent. Other similar taxa, such as *Dibaeis* or *Baeomyces* have persistent granular thallus, but the secondary thallus is solid. Currently, these two genera are included in the families *Imadophilaceae* and *Baeomycetaceae* respectively (Stenroos *et al.* 2002; Miadlikowska *et al.* 2014). *Pycnothelia* is constituted only by three species (Pino-Bodas *et al.* 2020b), one of which is present in Europe. This genus is phylogenetically closely related to the genus *Carassea*, endemic in Southeast Brazil (Stenroos *et al.* 2019).

1. *Pycnothelia papillaria* Dufour

Ann. Gén. Sci. Phys. 8: 46, 1821.

TYPE: England, Surrey, Bagshot, icon in Dillenius, Hist. Musc.: t. 16, f. 28. 1742, lectotype, Laundon, Lichenologist 18: 172, 1986, corresponding specimen in Herb. Dillenius (OXF epitype, Ahti, Fl. Neotrop. Monogr. 78: 345, 2000).

Pycnothelia trapezuntica J.Steiner., Ann. Naturhist. Mus. Wien 23: 112, 1909.

ILLUSTRATIONS: Wirth (1995: 790); Burgaz & Ahti (2009: 84); Ahti & Stenroos (2013: 111); Stenroos *et al.* (2016: 568).

Primary thallus persistent, crustose, formed by ecor-ticate granules, which are grouped into rosettes of 20-40 mm diameter. Podetia 2-12 mm long × 1-6 mm wide, hollow, cylindrical, simple or somewhat branched, but not widened, grey-whitish, with darkened apices. Surface bright, but not really corticate, verrucose, pseudoparenchymal cortex, internal surface of the podetia cartilaginous and striated. Apothecia not common. Pycnidia at the apex of the podetia, frequent, dark, with hyaline slime.

Chemistry.- Pd-, K+ yellow, C-, UV+ bluish white. Atranorin, chloratranorin, protolichesterinic, lichesterinic acids, and rarely squamatic acid in traces.

Habitat and distribution.- It grows on acid soils of the colline to alpine belts, rarely in the supramediterranean belt. It is a rare and scarce species in the Mediterranean countries, although sometimes it can be locally frequent. It is a Holarctic element (Ahti & Stenroos 2013).

Mediterranean countries.- Andorra, Croatia, France, Italy, Portugal, Slovenia, Spain and Turkey.

Remarks.- It is easily recognizable by its characteristic swollen podetia, with grey and whitish tones and darkened apices. It can be mistaken for *C. galindezii* when it is not fertile, but it differs in the bullate squamules of the primary thallus of *Pycnothelia*. The molecular study of specimens of *Cladonia trapezuntica* from Turkey resolved that these specimens are a robust morphotype of *P. papillaria* (Şenkardeşler *et al.* 2016).

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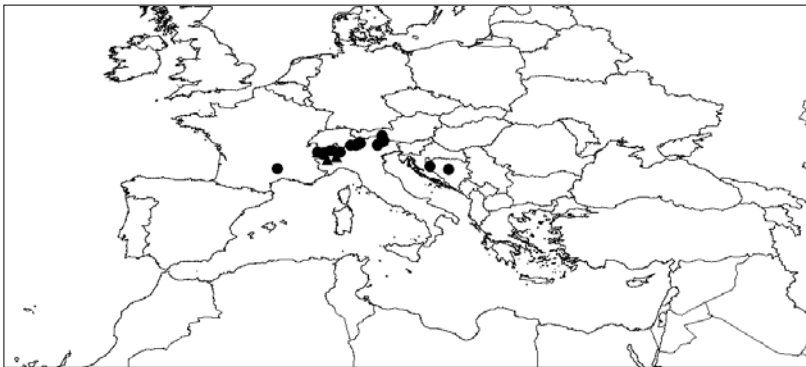
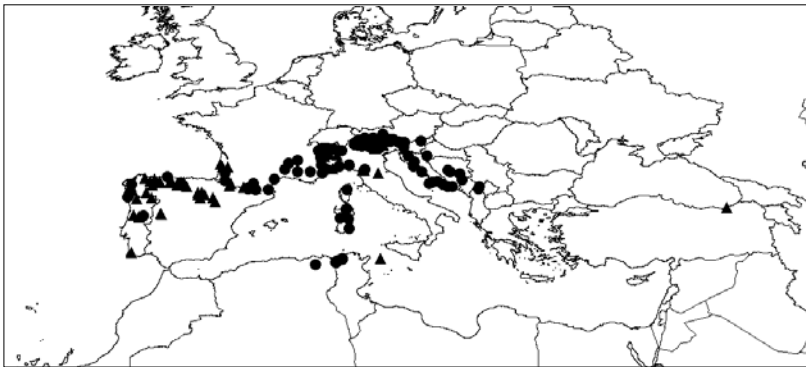
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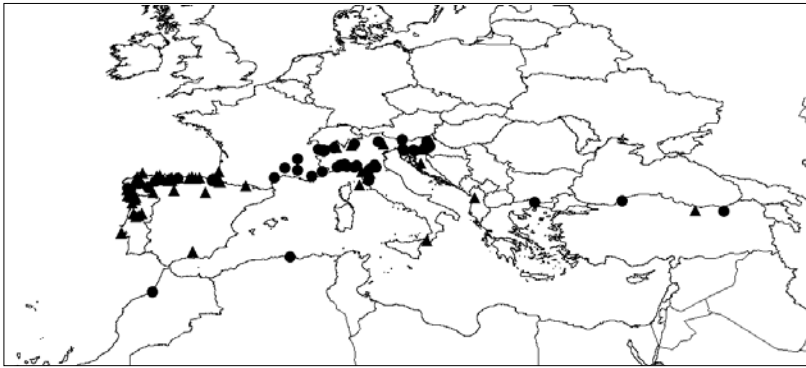
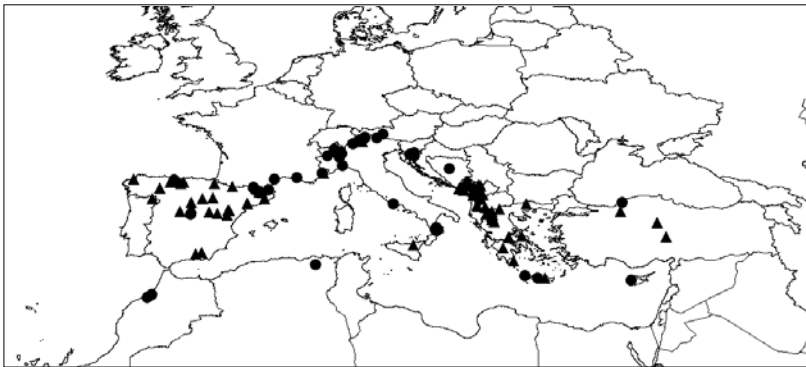
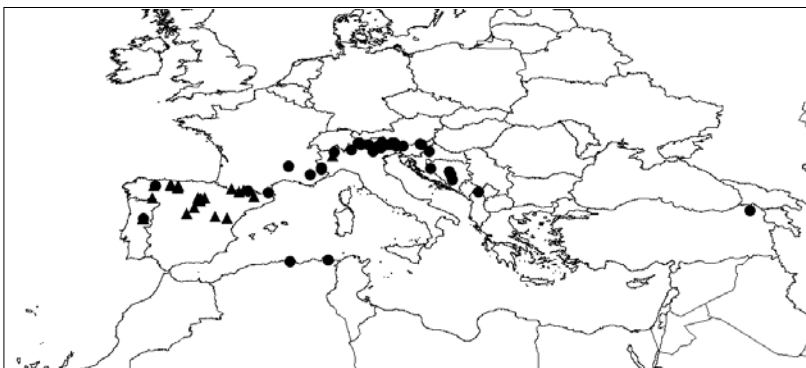
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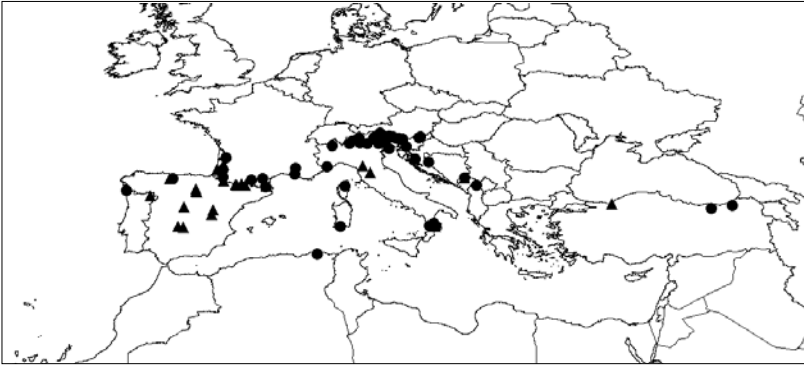
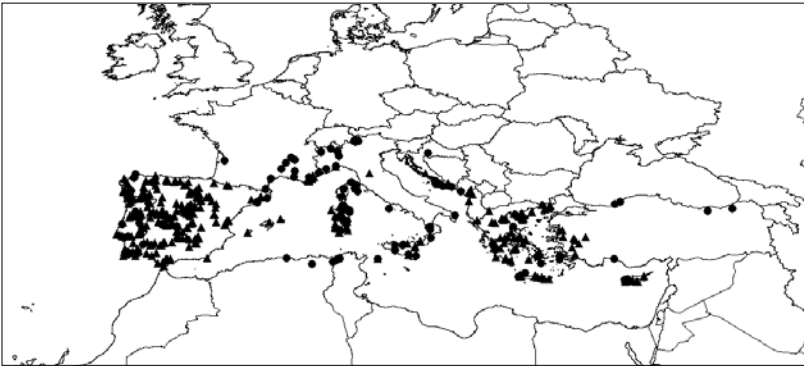
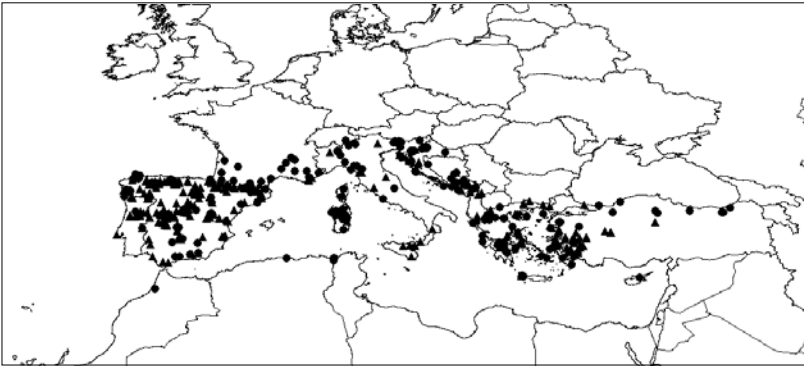
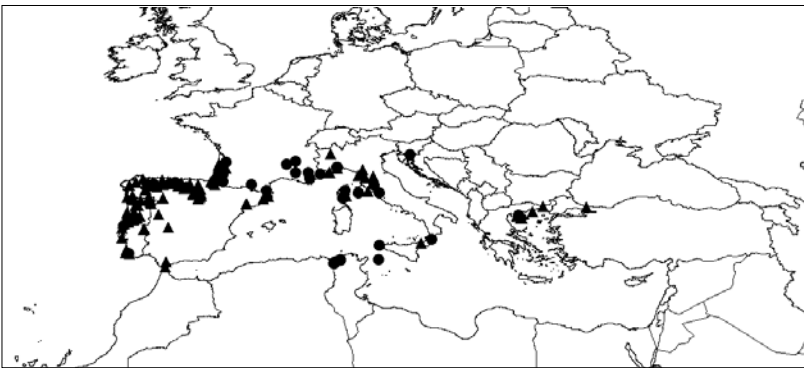
MAPS

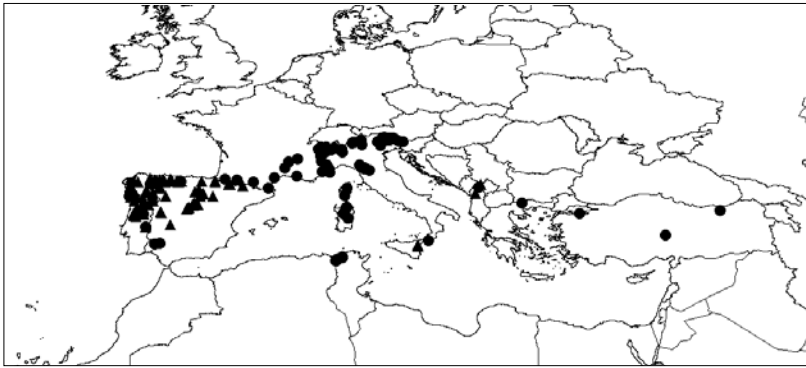
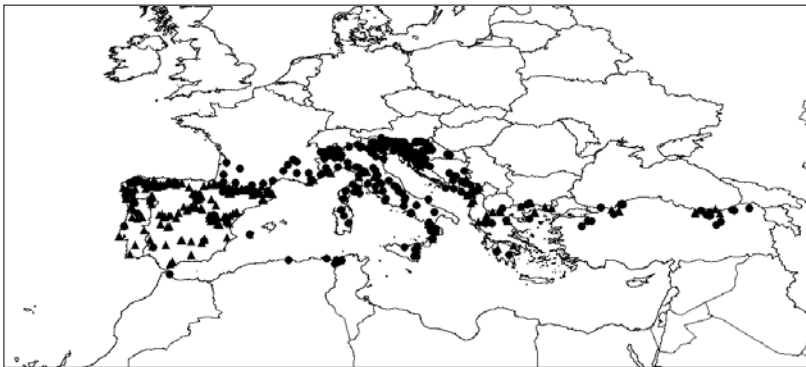
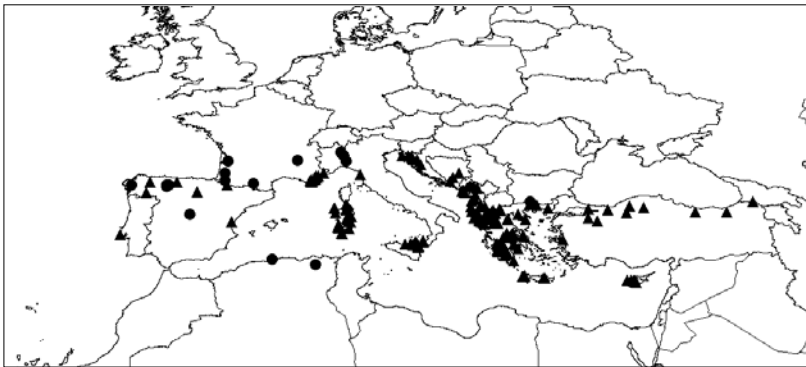
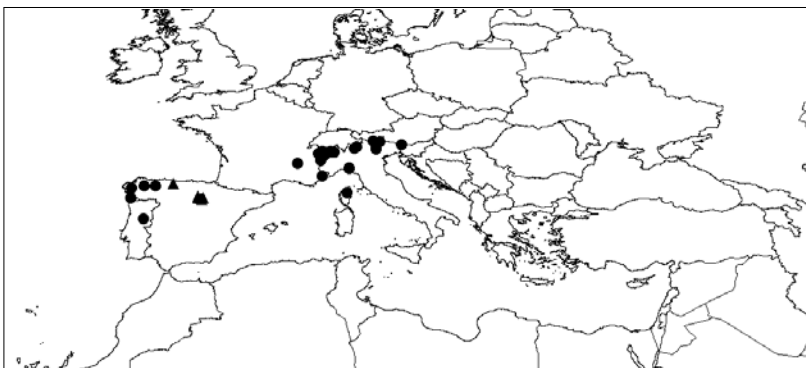
- (▲) specimens studied
- (●) literature reports

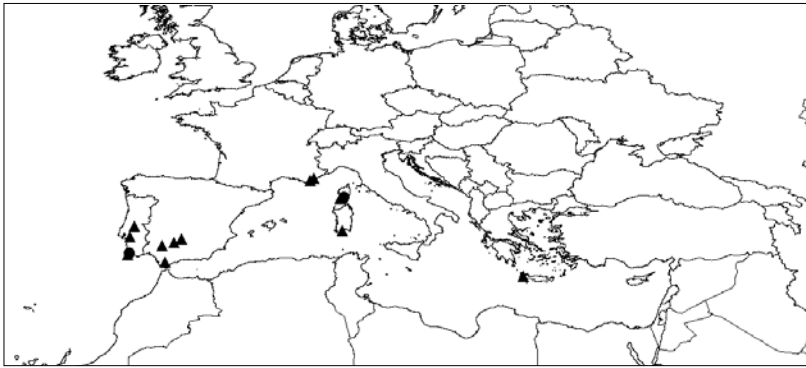
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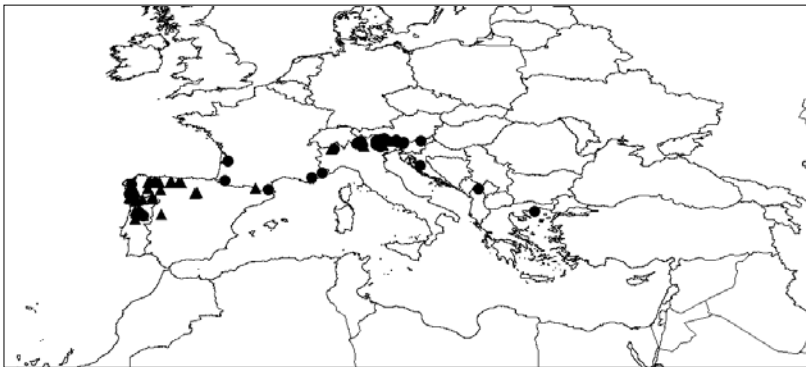
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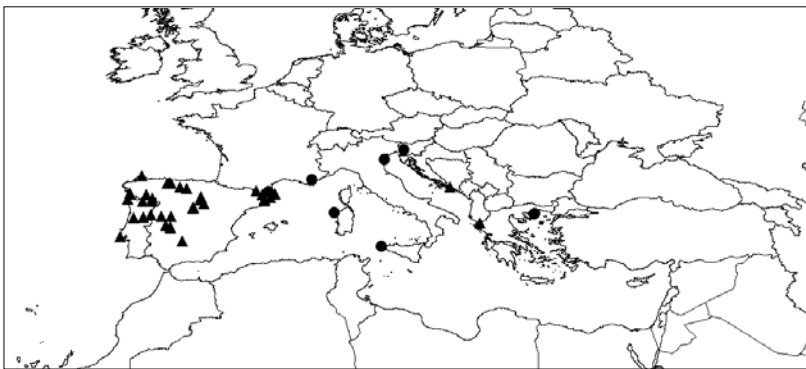
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Cladonia corsicana



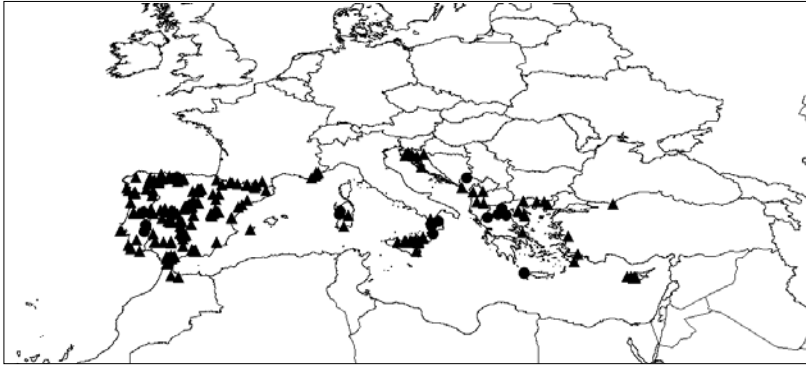
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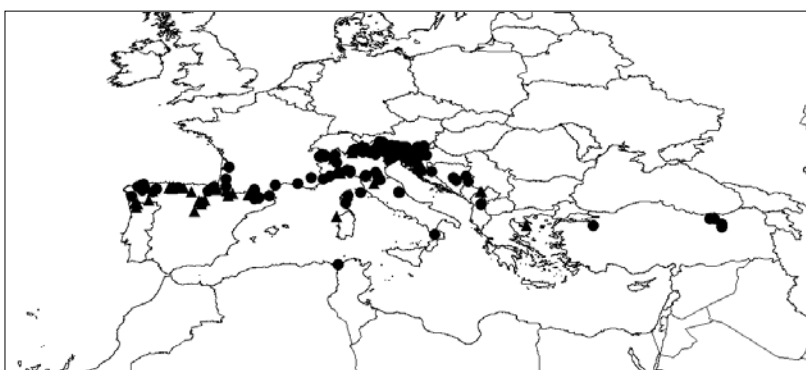
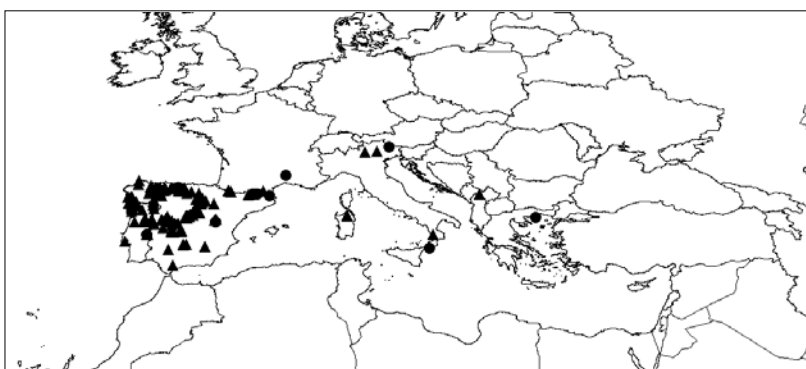
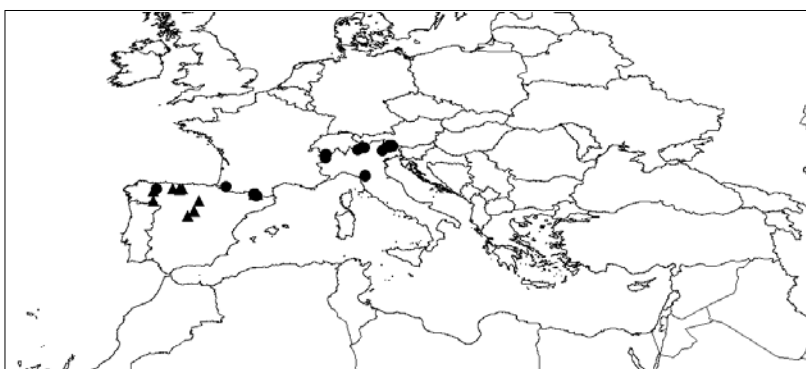


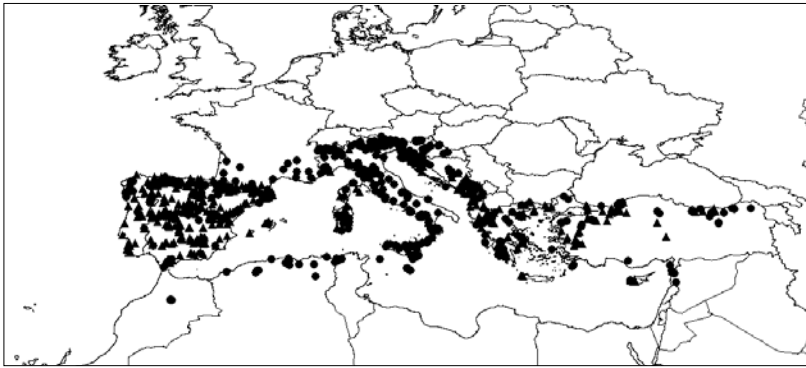
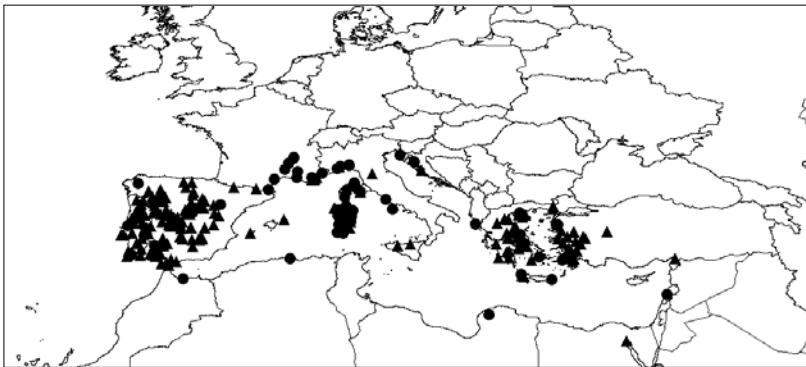
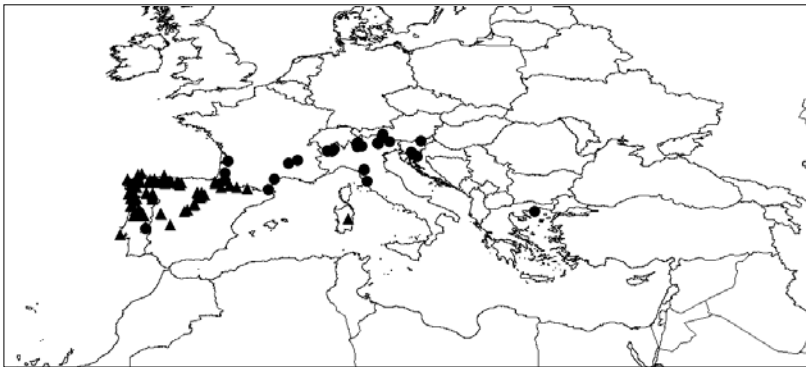
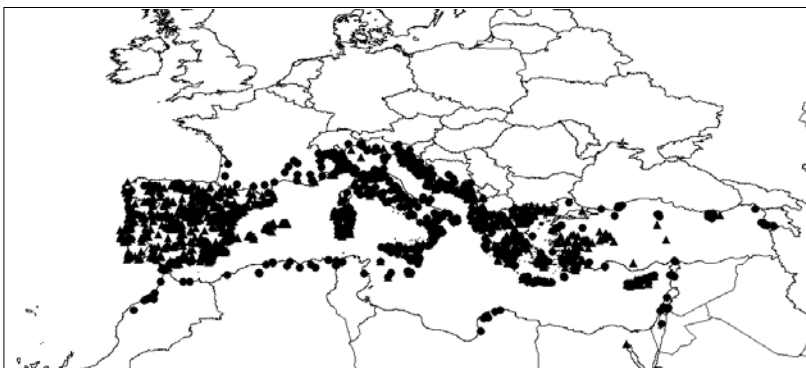
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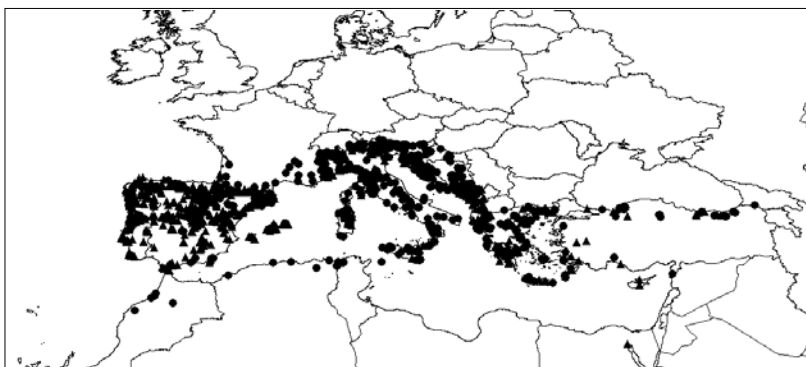
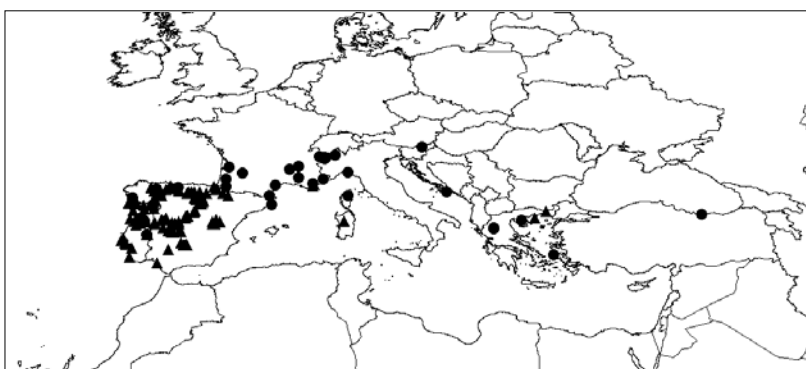
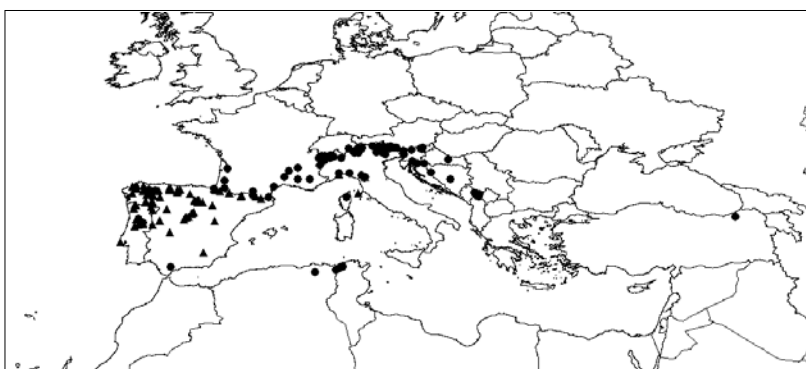


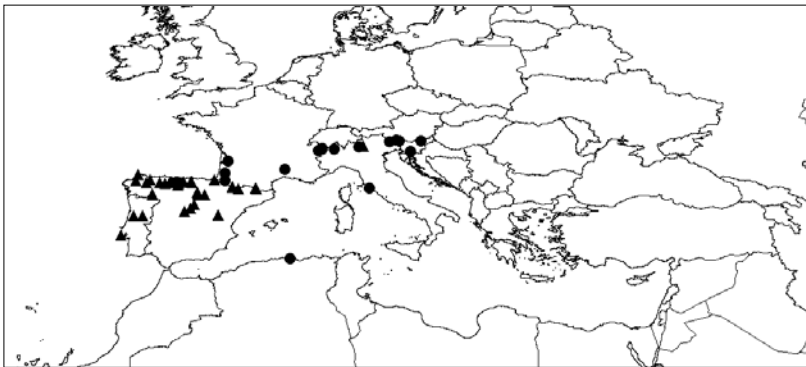
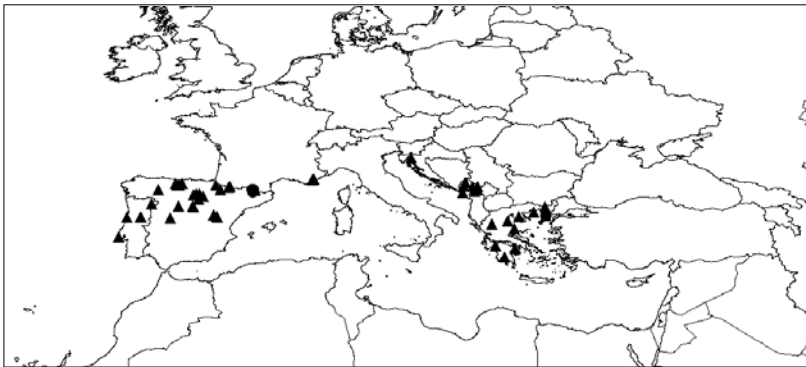
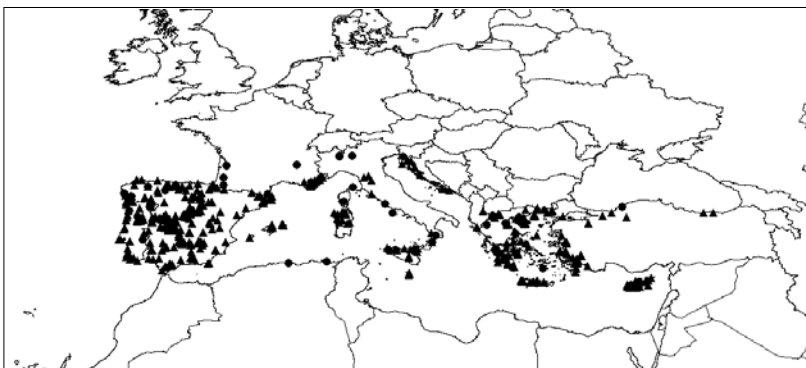
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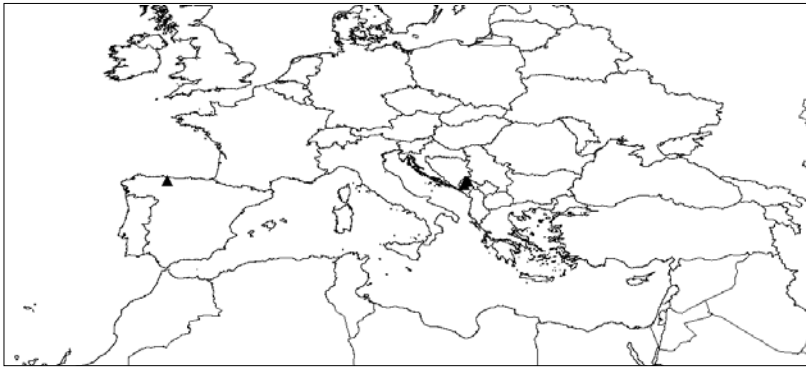
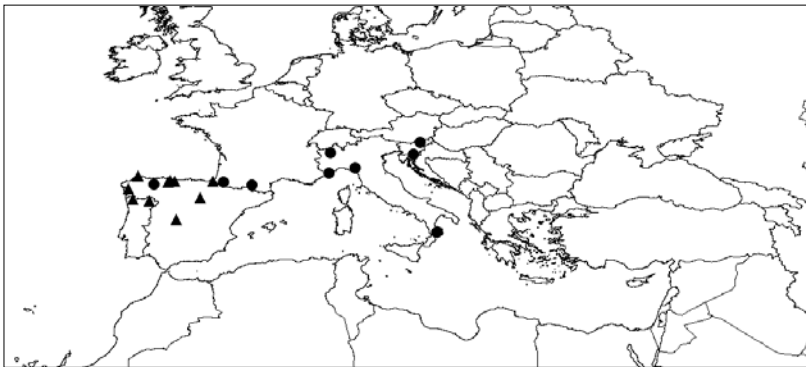
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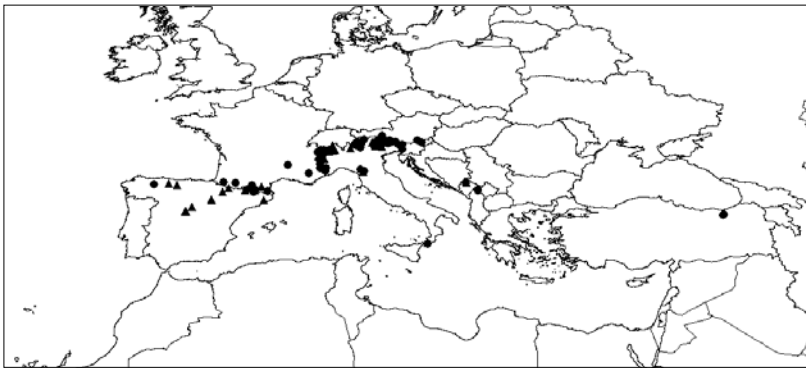
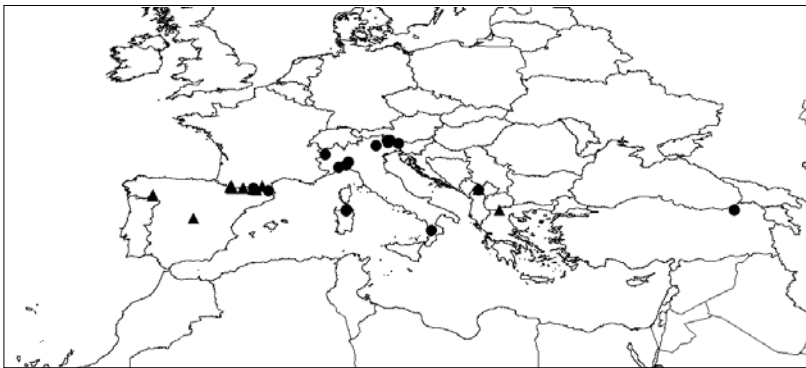
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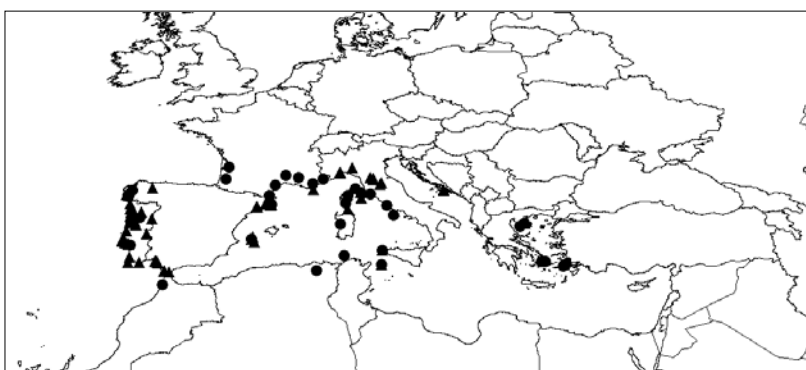
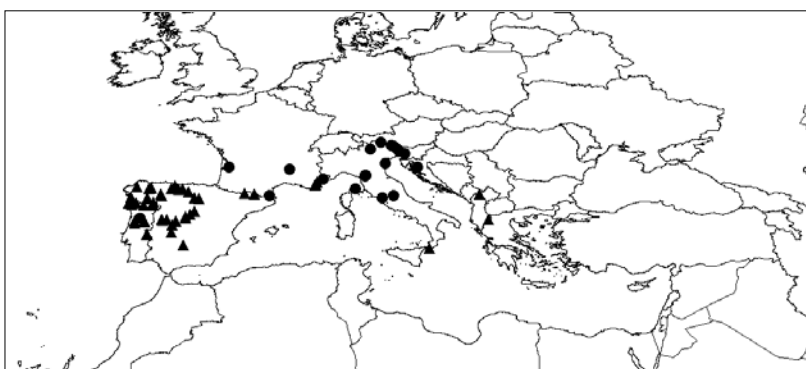
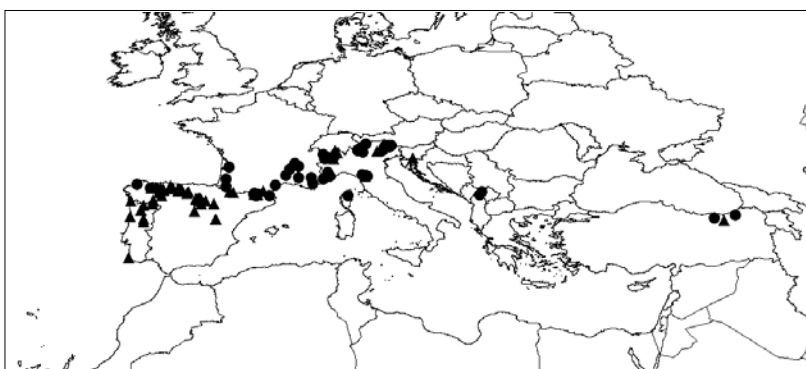
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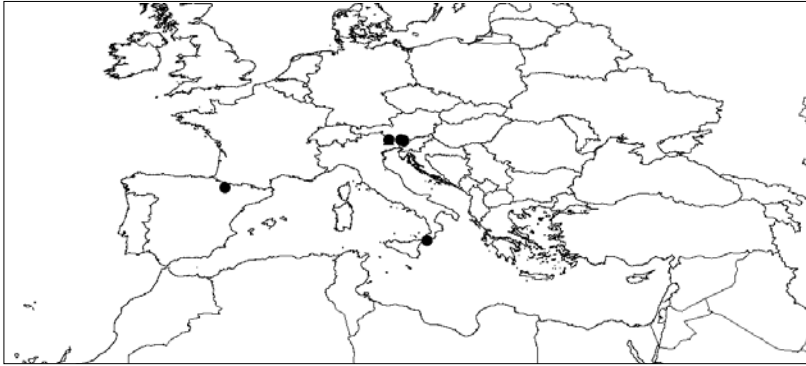
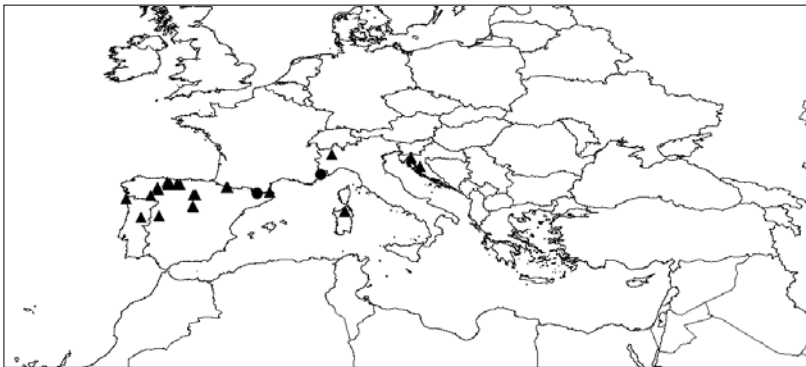
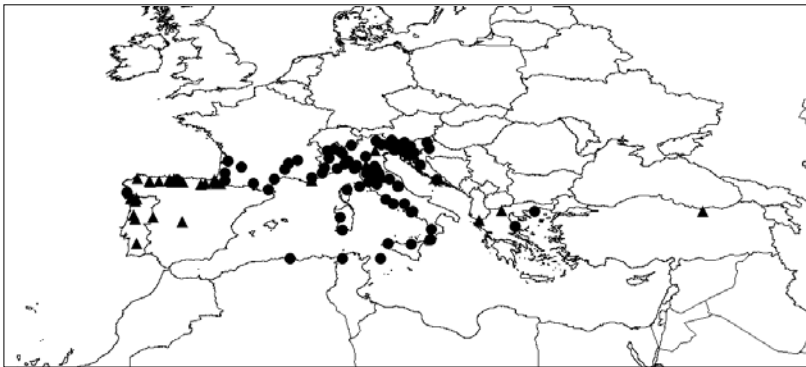
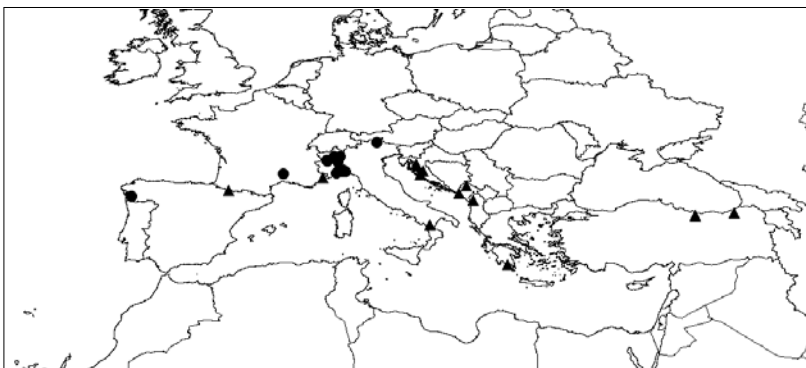
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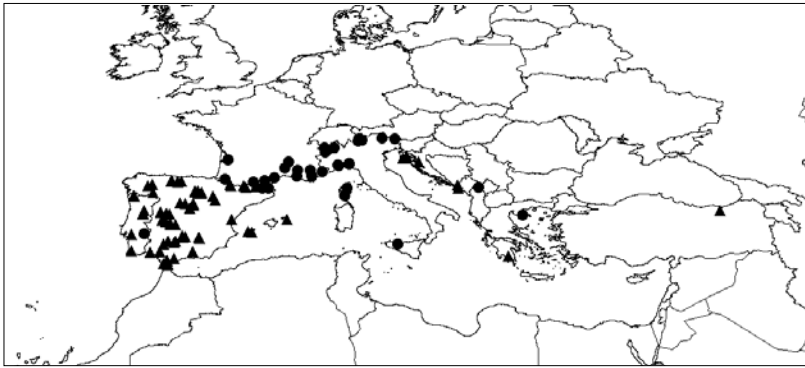
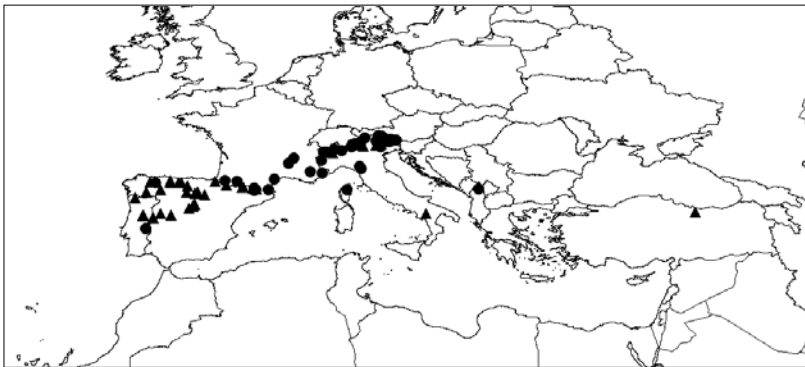
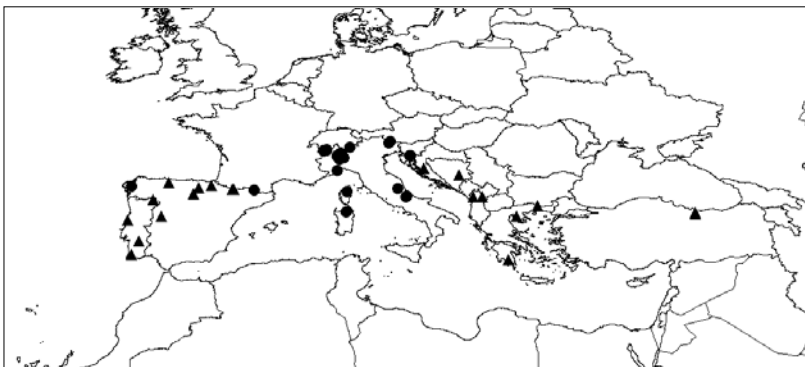
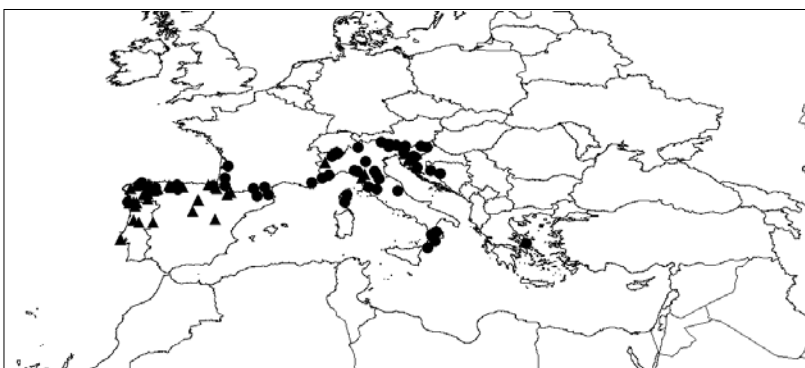
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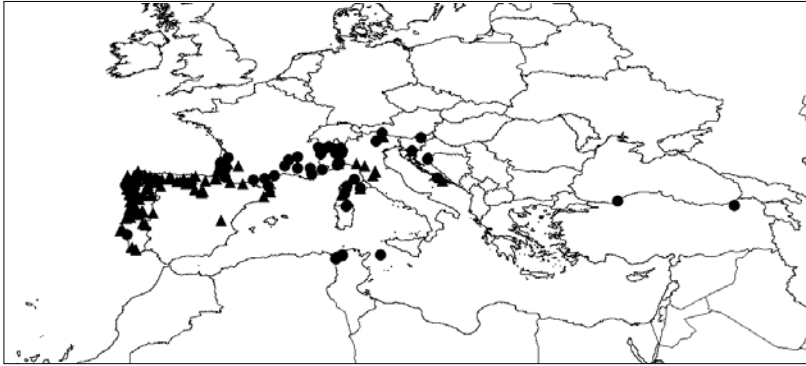
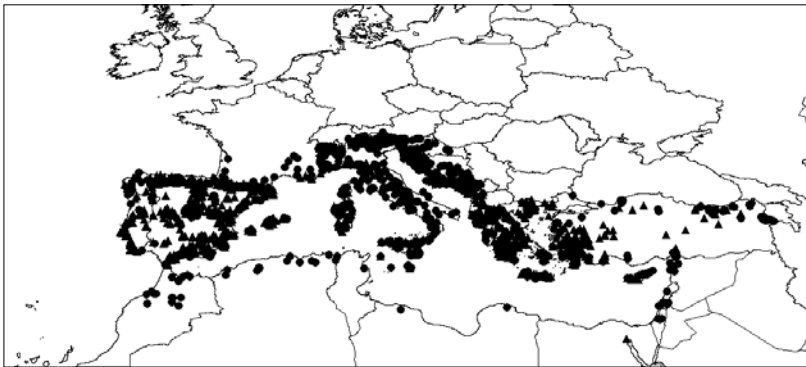
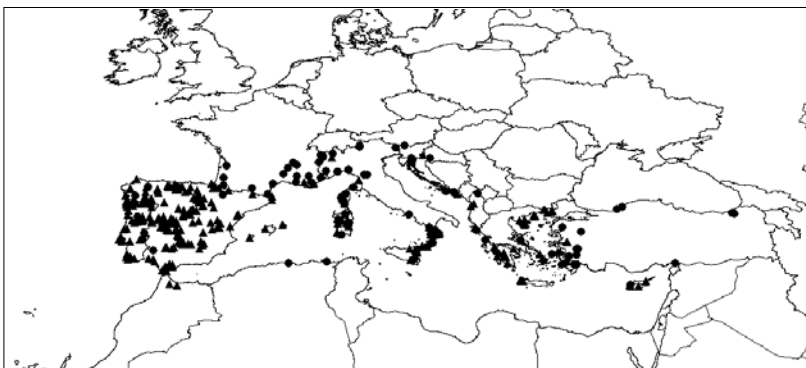
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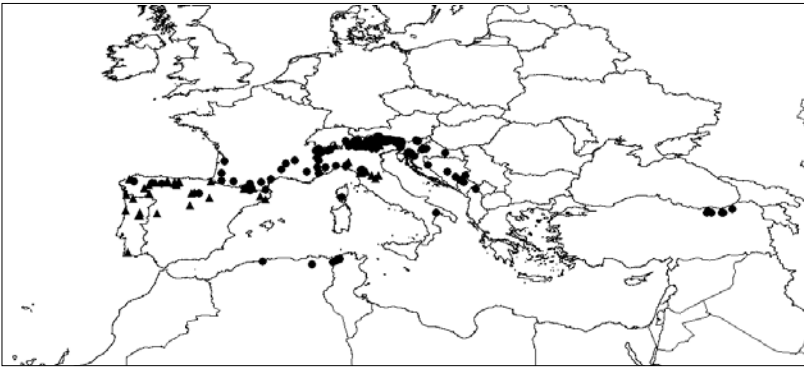
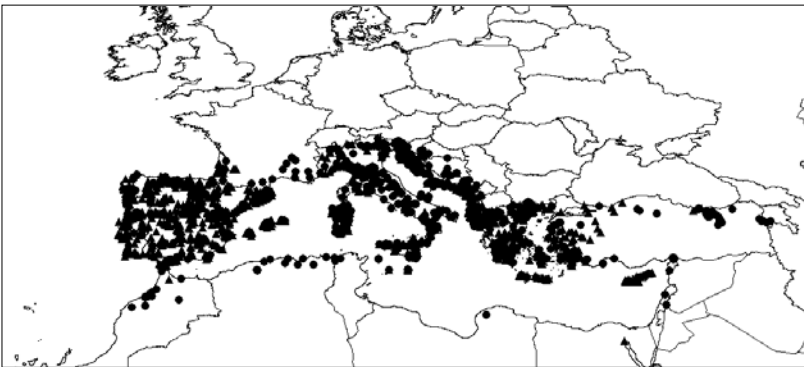
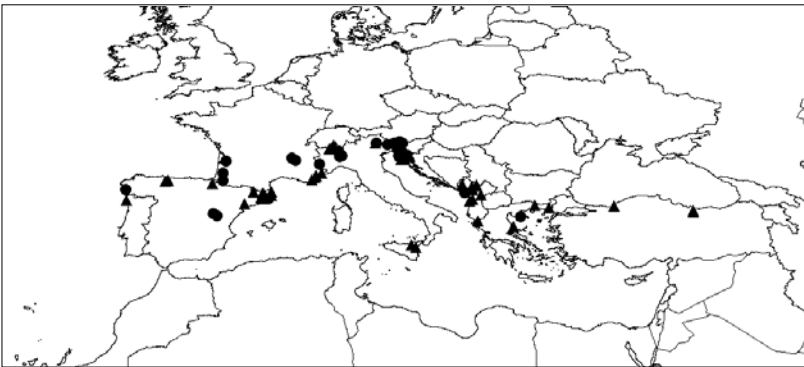
*Cladonia macilenta**Cladonia macroceras**Cladonia macrophylla**Cladonia macrophyllodes*

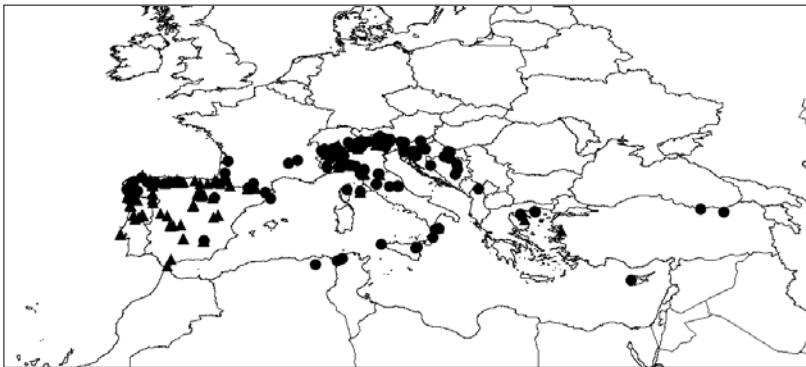
*Cladonia magyarica**Cladonia mediterranea**Cladonia merochlorophaea**Cladonia mitis*

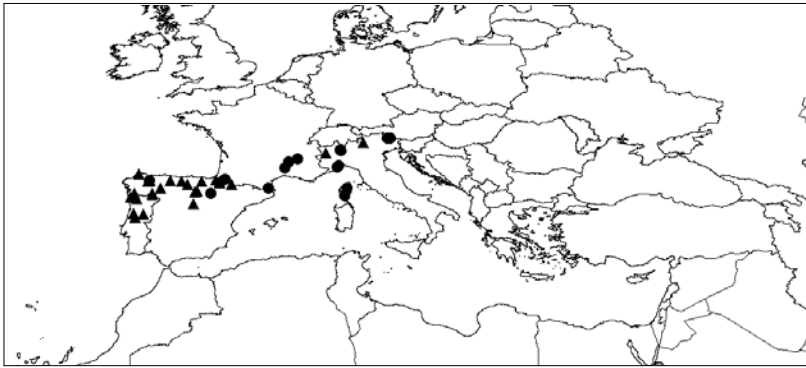
*Cladonia norvegica**Cladonia norvochlorophaea**Cladonia parasitica**Cladonia peziziformis*

*Cladonia phyllophora**Cladonia pleurota**Cladonia polycarpoides**Cladonia polydactyla*

*Cladonia portentosa**Cladonia pulvinata**Cladonia pyxidata**Cladonia ramulosa*

*Cladonia rangiferina**Cladonia rangiformis**Cladonia rei**Cladonia scabriuscula*

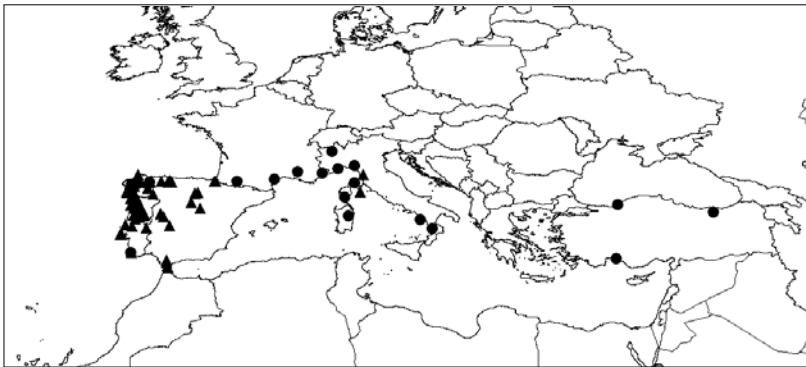
*Cladonia sobolescens**Cladonia squamosa**Cladonia stellaris**Cladonia straminea*



Cladonia strepsilis



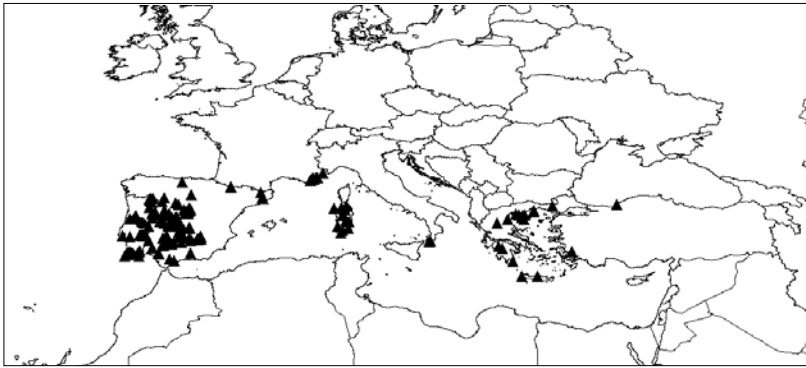
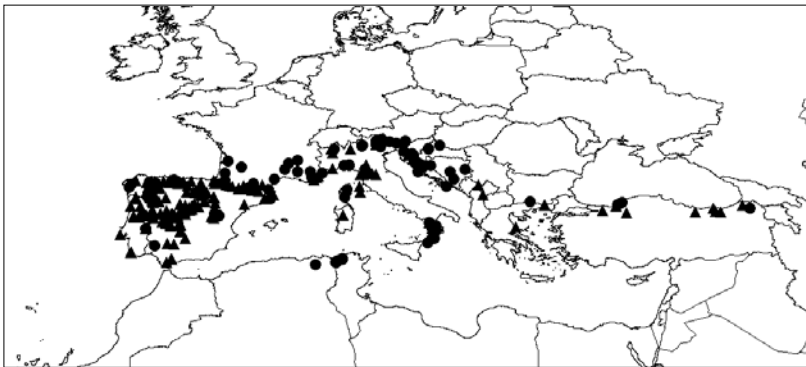
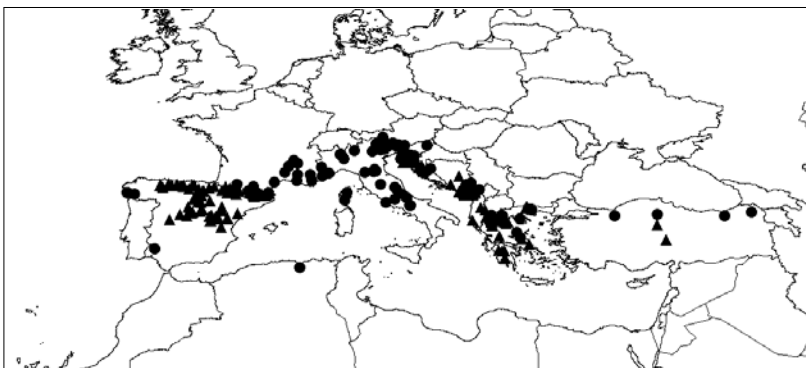
Cladonia stygia



Cladonia subcervicornis



Cladonia subfurcata

*Cladonia suburgida**Cladonia subulata**Cladonia sulphurina**Cladonia symphyarpa*



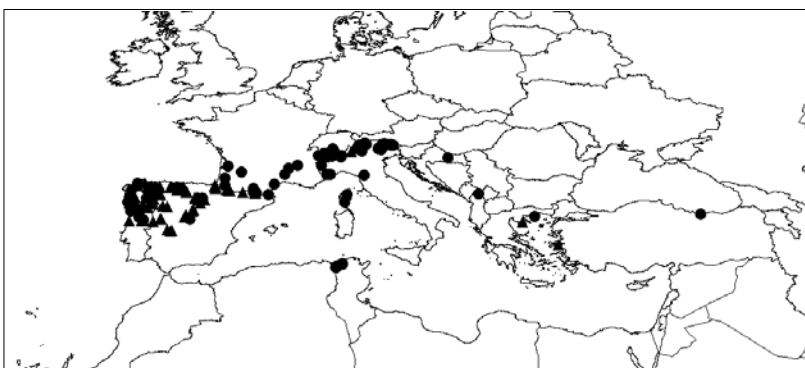
Cladonia trassii



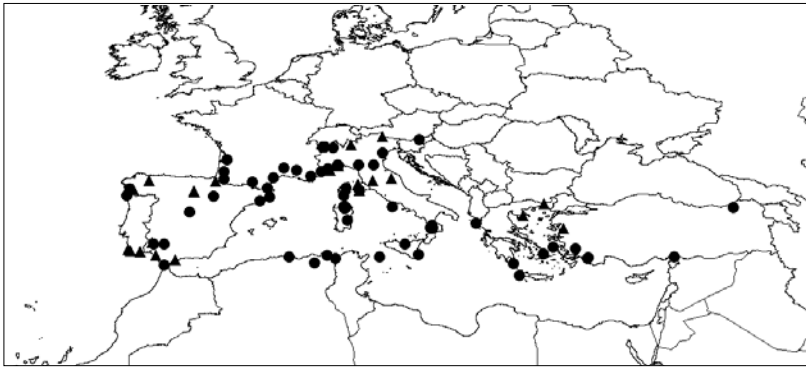
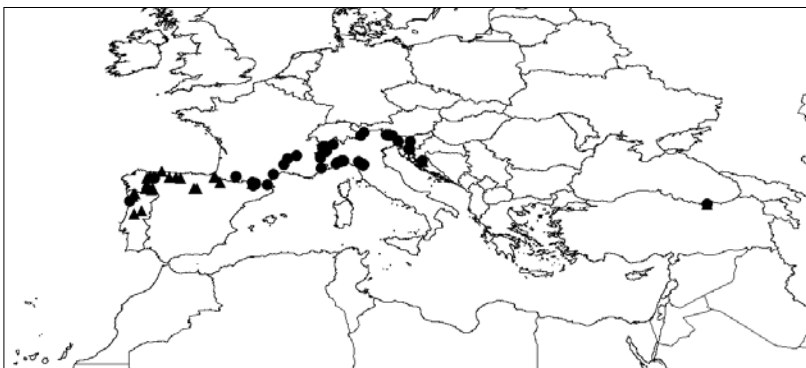
Cladonia turgida



Cladonia umbricola



Cladonia uncialis

*Cladonia verticillata**Cladonia zopfii**Pilophorus cereolus**Pycnotelia papillaria*

PHOTOGRAPHS



Cladonia acuminata



Cladonia amaurocraea



Cladonia arbuscula



Cladonia asabinae



Cladonia bacilliformis



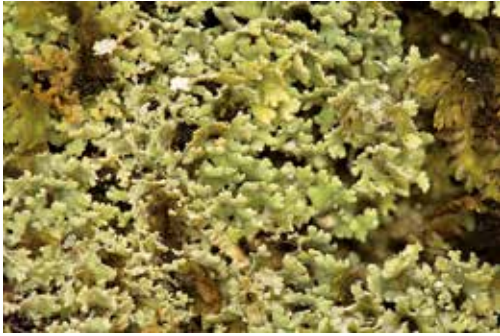
Cladonia bellidiflora



Cladonia borealis



Cladonia botrytes



Cladonia caespiticia



Cladonia callosa



Cladonia cariosa



Cladonia carneola



Cladonia cenotea



Cladonia cervicornis



Cladonia chlorophaea



Cladonia ciliata



Cladonia coccifera



Cladonia coniocraea



Cladonia comista



Cladonia cornuta



Cladonia corsicana



Cladonia crispata



Cladonia cryptochlorophaea



Cladonia cyathomorpha



Cladonia dactylota



Cladonia decorticata



Cladonia deformis



Cladonia digitata



Cladonia diversa



Cladonia ecmocyna



Cladonia fimbriata



Cladonia firma



Cladonia floerkeana



Cladonia foliacea



Cladonia furcata



Cladonia glauca



Cladonia gracilis



Cladonia grayi



Cladonia homosekikaica



Cladonia bumilis



Cladonia imbricaria



Cladonia incrassata



Cladonia islandica



Cladonia luteoalba



Cladonia macilenta



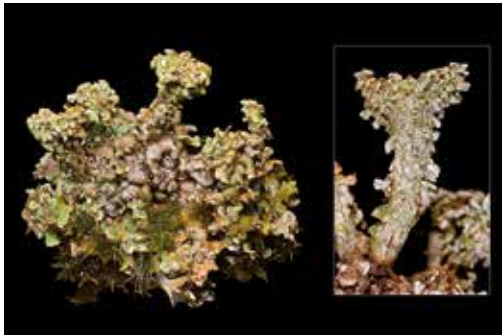
Cladonia macroceras



Cladonia macrophylla



Cladonia macrophyllodes



Cladonia magyarica



Cladonia mediterranea



Cladonia merochlorophaea



Cladonia mitis



Cladonia novochlorophaea



Cladonia parasitica



Cladonia peziziformis



Cladonia phyllophora



Cladonia pleurota



Cladonia polycarpoides



Cladonia polydactyla



Cladonia portentosa



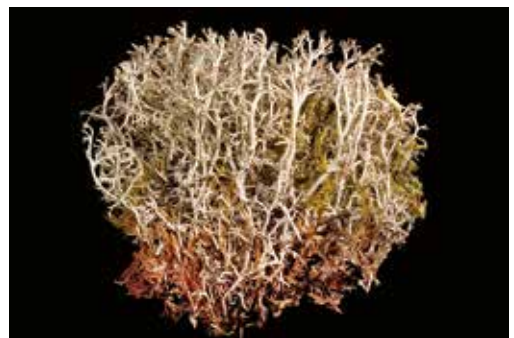
Cladonia pulvinata



Cladonia pyxidata



Cladonia ramulosa



Cladonia rangiferina



Cladonia rangiformis



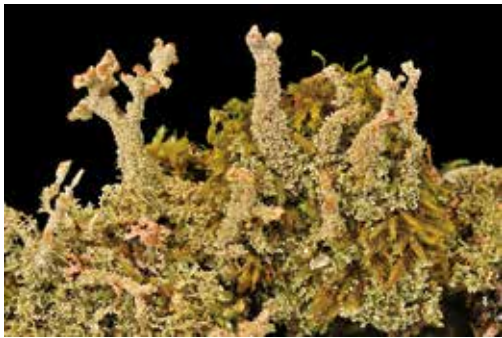
Cladonia rei



Cladonia scabriuscula



Cladonia sobolescens



Cladonia squamosa



Cladonia stellaris



Cladonia straminea



Cladonia strepsilis



Cladonia stygia



Cladonia subcervicornis



Cladonia subfurcata



Cladonia suburgida



Cladonia subulata



Cladonia sulphurina



Cladonia symphyarpa



Cladonia umbricola



Cladonia uncialis subsp. *biuncialis*



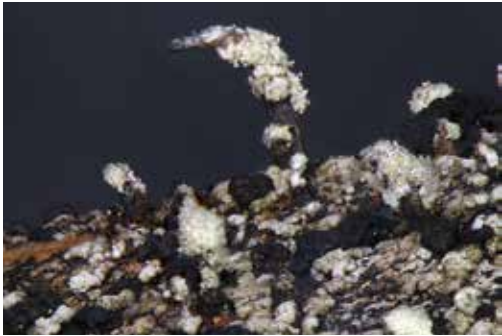
Cladonia uncialis subsp. *uncialis*



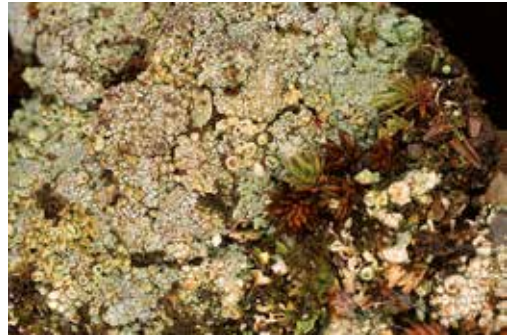
Cladonia verticillata



Cladonia zopfii



Pilophorus cereolus. © Raquel Pino-Bodas



Pycnotelia papillaria

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Cladoniaceae is a family of lichen forming fungi with subcosmopolitan distribution. *Mediterranean Cladoniaceae* is a compendium of the knowledge of the *Cladoniaceae* inhabiting the Mediterranean region. It is based on material from an extensive field work and from a number of herbaria. In total 92 species representing three genera, *Cladonia*, *Pilophorus* and *Pycnothelia* are treated. The species are described and illustrated. Data about secondary metabolites, morphological variation, habitat and taxonomical notes are provided. Distribution maps of each species, based on material studied and literature references, are presented.