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THE LICHEN GENUS *USNEA* ON *QUERCUS SUBER* IN IBERIAN CORK-OAK FORESTS

Simón FOS* and Philippe CLERC‡

Abstract: Fifteen species of *Usnea* are recorded from Iberian cork-oak forests: *U. ceratina*, *U. cornuta*, *U. dasaea*, *U. esperantiana*, *U. flammea*, *U. fulvorangeans*, *U. glabrata*, *U. hirta*, *U. mutabilis*, *U. rubicunda*, *U. subcornuta*, *U. subfloridana*, *U. subscabrosa*, *U. substerilis* and *U. wasmuthii*. A key for these species is provided. Details of morphology, chemistry, distribution, ecology and taxonomy are discussed. *Usnea dasaea* is reported as new to the Iberian Peninsula. New chemotypes of *U. fulvorangeans* (with squamatic acid) and *U. wasmuthii* (with psoromic acid) have been identified. Distribution maps of *U. dasaea* and *U. subcornuta* in Europe are presented. A new combination, *Usnea subfloridana* subsp. *praetervisiva* (Asahina) P. Clerc, is proposed.

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Introduction

Recently, several studies have focused on the systematics of European species of *Usnea* (Clerc 1984a, b, 1987a, b, c, 1991, 1992, 1994, 1997, 1998; Myllys 1994; Halonen & Puolasmaa, 1995; Halonen 1997) and have provided valuable information on this difficult genus of fruticose lichens, so that accurate identification of especially SW European species is now possible. *Usnea* species are frequent and abundant in cork-oak forests on *Quercus suber*, where they attain a high degree of coverage on branches and a scattered growth on boles. The lack of updated studies on the systematics, floristic and ecology of the genus *Usnea* in Spain prompted us to focus on this genus.

Quercus suber is a Western Mediterranean endemic, distributed both in Europe and North Africa. It occurs preferentially in siliceous areas with a warm Mediterranean climate with oceanic influence. Its distributional area covers a total of 2.35 M Ha, of which about 1.18 M Ha are found in Spain and Portugal (Montoya 1988). Cork-oak forests are mainly distributed in the south-west of the Iberian Peninsula, although scattered localities are numerous, including the Catalanian (Barcelona and Girona) and Valencian (Valencia and Castellón) areas. The cork oak can be found in several biogeographic provinces, in the thermo- and mesomediterranean vegetation belts with dry to hyperhumid ombroclimates (terminology of bioclimatic zones follows Rivas-Martínez 1987). This biogeographical and bioclimatological

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heterogeneity has allowed the differentiation of several vegetation series (Rivas-Martínez 1987; Rivas-Martínez *et al.* 1990).

In general Iberian evergreen sclerophyllous forests are basically dominated by *Q. suber*, which may be accompanied by other trees such as *Q. canariensis*, *Q. faginea*, *Q. rotundifolia*, *Pinus pinaster*, etc. and bushes such as *Arbutus unedo*, *Phillyrea angustifolia*, *P. latifolia*, *Viburnum tinus*, *Erica arborea*, etc. Since cork harvesting is an important economic resource, the landscape of the cork-oak territories is deeply influenced by forestry practices such as understorey removal or forest opening. The outcome is that cork-oak forests show very different structures ranging from dense stands, mostly in Cádiz and Catalonia, to grass-woodlands in the Extremadura plains.

The aim of the present study is to give a comprehensive account of the *Usnea* species occurring on *Q. suber* in the Iberian cork-oak forests. It adds one species to the lichen flora of the Iberian Peninsula and presents the European distribution of two poorly understood species. Furthermore, short morphological descriptions, chemical information, including new chemotypes of *U. fulvorangeans* and *U. wasmuthii*, and a key for the species studied are provided.

Materials and Methods

The material studied has been collected in different cork-oak forests of the Iberian Peninsula (Fig. 1). A list of the localities studied, with vegetation series, elevation and UTM co-ordinates, is provided below. Throughout the text bold numbers are used to identify the different sites.

A. Mesomediterranean subhumid series of cork oak in NE Spain: *Carici depressae-Quercus suberis sigmetum*.

1. Girona, **Agullana**, Pla de Pujalts, 300 m, 31TDG8594. 2. Girona, **Begur**, Sa Tuna, 250 m, 31TEG1845. 3. Girona, **Sant Sadurní**, Puig dels Cristians, 350 m, 31TDG9239. 4. Girona, Castell d'Aro, Santa **Cristina d'Aro**, Les Taules, 140 m, 31TEG0129. 5. Girona, **Castell d'Aro**, La Coma, 40 m, 31TEG0229. 6. Girona, Caldes de Malavella, Riera de **Reclà**, 120 m, 31TDG8627. 7. Girona, Caldes de **Malavella**, Llagostera-Caldes de Malavella road, 100 m, 31TDG8831. 8. Girona, **Lloret de Mar**, Los Pinares, 180 m, 31TDG8520. 9. Barcelona, **San Celoni**, Torrent de Olzinelles, 220 m, 31TDG5814. 10. Barcelona, **Fogàs de Monclús**, La Costa-Mosqueroles road, 580 m, 31TDG5121. 11. Girona, **Santa Coloma** de Farnés, Serrat del Corb, 260 m, 31TDG6736.

B. Meso-thermomediterranean subhumid series of cork oak in E Spain: *Asplenio onopteridis-Quercus suberis sigmetum*.

12. Castellón, Alcudia de Veo, **Benitandús** artificial lake, 350 m, 30SYK2724. 13. Castellón, Algimia de Almonacid, Bco. de **Agua Negra**, 800 m, 30SYK2320. 14. Castellón, **Ahín**, Los Noguerales, 725 m, 30SYK2718. 15. Castellón, Azuebar, **Mosquera**, 700 m, 30SYK2517.

C1. Meso-thermomediterranean humid-hyperhumid series of cork oak in SW Spain: *Teucrio baetici-Quercus suberis sigmetum*.

16. Cádiz, **Grazalema**, Cerro del Montón, 1100 m, 29STF8574. 17. Málaga, **Cortes de la Frontera**, Cerro del Alcornocal, 870 m, 30STF8354. 18. Cádiz, **Jimena** de la Frontera, Between Jimena de la Frontera and La Saucedá, 220 m, 30STF7540. 19. Cádiz, Jerez de la Frontera, **Puerto Galiz**, 440 m, 30STF6748. 20. Cádiz, Alcalá de los Gazules, Cerro de las **Beatas**, 280 m, 30STF6144. 21. Cádiz, Los Barrios, **El Mojón**, 140 m, 30STF6713. 23. Cádiz, Jerez de la Frontera, **Loma de la Mesa**, 360 m, 30STF6347.

C2. Thermomediterranean subhumid series of cork oak in SW Spain: *Myrto communis-Quercus suberis sigmetum*.

22. Cádiz, Tarifa, Puerto del **Bujeo**, 460 m, 30STE7195. 23. Cádiz, Tarifa, **El Tiradero**, 200 m, 30STF6705.
38. PORTUGAL, Algarve, Cao, Serra do **Espinhaço**, 160 m. 39. Baixo Alentejo, **Odemira**, Fonte Soude, 175 m.

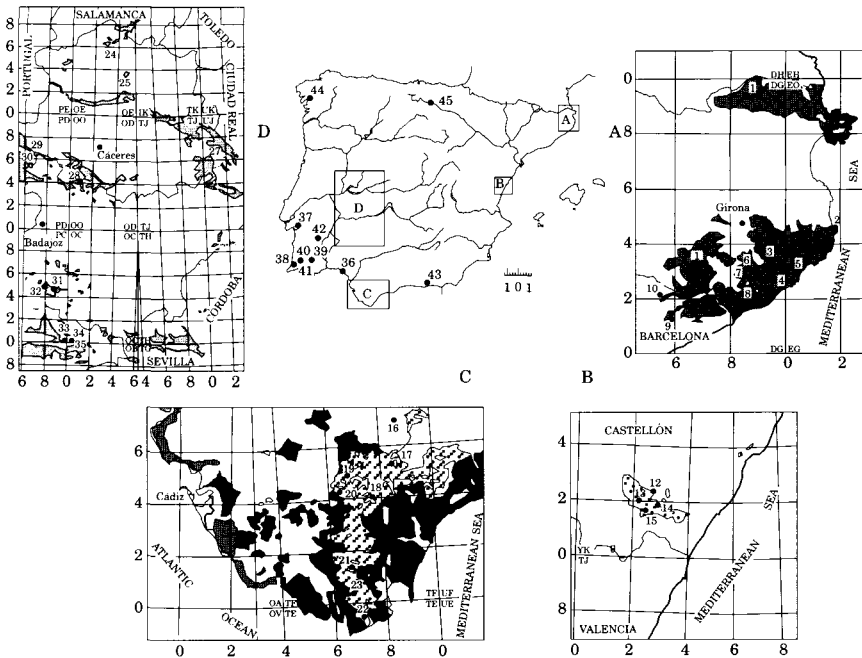


FIG. 1. Potential areas of Iberian cork-oak forests (dotted areas; according to Rivas-Martínez 1987) and location of the localities studied. A, Catalonia (*Carici-Quercus suberis* S.); B, Valencia-Castellón (*Asplenio-Quercus suberis* S.); C, Cádiz-Málaga [1, *Teucrio-Quercus suberis* S. (oblique lines); 2, *Myrto-Quercus suberis* S. (dark grey); 3, *Oleo-Quercus suberis* S. (pale grey)]; D, Extremadura (*Sanguisorbo-Quercus suberis* S.).

C3. Thermomediterranean dry-subhumid-humid series of cork-oak in SW Spain: *Oleo sylvestris-Quercus suberis sigmetum*.

36. Huelva, **Almonte**, Cerro Burraco, 50 m, 29SQB0616. 37. PORTUGAL, **Ribatejo**, Between Aguas de Moura and Setubal, 30 m.

D. Mesomediterranean subhumid-humid series of cork oak in C to W Spain: *Sanguisorbo agrimonioidis-Quercus suberis sigmetum*.

24. Cáceres, **Casar de Palomero**, El Pasil, 490 m, 29TQE3464. 25. Cáceres, **Plasencia**, 380 m, 29TQE4935. 26. Cáceres, Castañar de Ibor, Sierra de Porrinas, 700 m, 30STJ9287. 27. Cáceres, **Alia**, Vega del Guadarranquejo, 470 m, 30SUJ1772. 28. Cáceres, **Cáceres**, Dehesa de Calabazas, 380 m, 29SQD1045. 29. Badajoz, S. Vicente de Alcántara, **Puerto de Elice**, 590 m, 29SPD6966. 30. Badajoz, S. Vicente de Alcántara, **La Venta**, 530 m, 29SPD6368. 31. Badajoz, **Jerez de los Caballeros**, Higuera de Vargas road, 440 m, 29SPC8847. 32. Badajoz, Jerez de los Caballeros, **Zahinos**-Higuera de Vargas road, 300 m, 29SPC7746. 33. Huelva, **La Nava**, Sierra de la Mesa, 480 m, 29SPC9902. 34. Huelva, **Galaroza**, Sierra Navahermosa, 680 m, 29SQC0400. 35. Huelva, **Marines**, Sierra de San Ginés, 760 m, 29SQB0897.

40. PORTUGAL, Algarve, Serra de **Monchique**, Between Monchique and Aljerce, 450 m. 41. Algarve, Serra do **Caldeirao**, Bco. do Velho, 250 m. 42. Alto Alentejo, **Portel**, Serra do Mendro, 310 m.

Other vegetation series.

43. Granada, Polopós, **Haza del Lino**, Sierra de la Contraviesa, 1300 m, 30SVF7174. 44. Pontevedra, Coto de **Couso**. Ulla river, 50 m, 29TNH33. 45. Burgos, **Bozoo**, Monte Recuenco, 850 m, 30TVN9131.

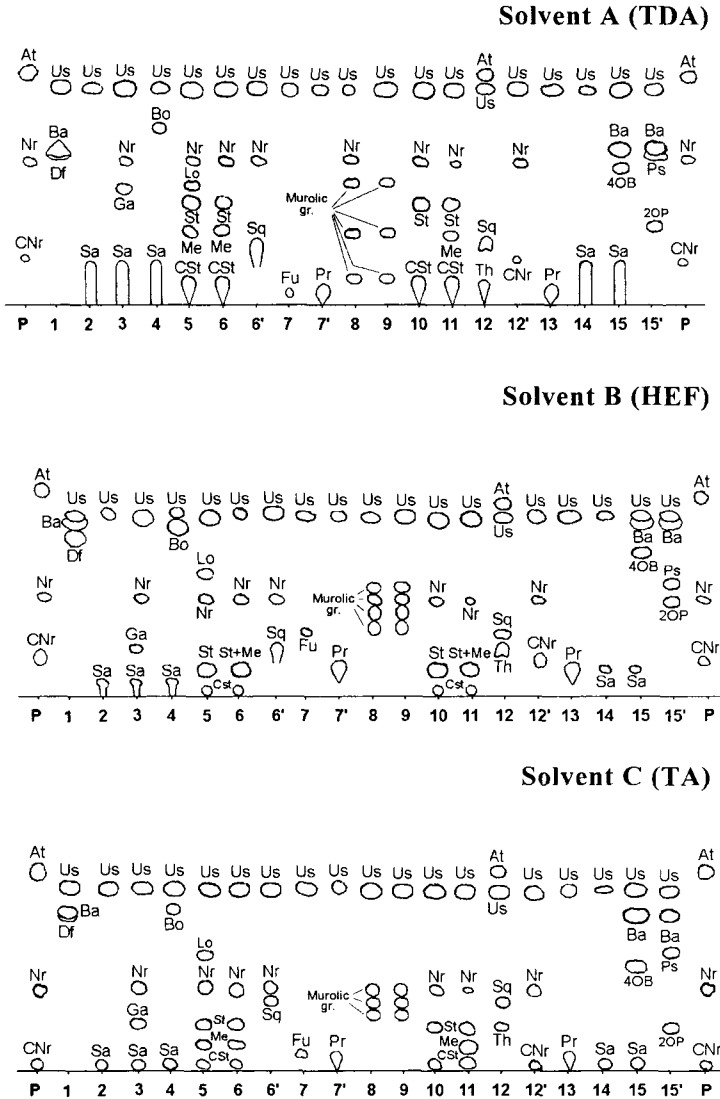


FIG. 2. Chromatograms of the species of *Usnea* studied in relation to the standard control and solvent system A (TDA), B (HEF) and C (TA) after acid spraying and heating (Culberson & Ammann 1979). Abbreviations of the substances as in Table 1. Species: P = control of *Parmelia acetabulum* and *Platismatia glauca*; 1 = *U. ceratina*; 2 = *U. cornuta*; 3 = *U. dasaea*; 4 = *U. esperantiana*; 5 = *U. flammea*; 6 = *U. fulvovireagens*; 6' = *U. fulvovireagens* chemorace with squamatic acid; 7 = *U. glabrata*; 7' = *U. glabrata* with protocetraric acid only; 8 = *U. hirta*; 9 = *U. mutabilis*; 10 = *U. rubicunda*; 11 = *U. subcornuta*; 12 = *U. subfloridana*; 12' = *U. subfloridana* subsp. *praeteroisia*; 13 = *U. subscabrosa*; 14 = *U. substerilis*; 15 = *U. wasmuthii*; 15' = *U. wasmuthii* with psoromic acid.

Most of the material has been examined by thin-layer chromatography (TLC) using the techniques described by Culberson & Kristinsson (1970), taking into account the late modifications of Culberson (1972, 1974) and White & James (1985) (first author) and Culberson & Ammann (1979) (second author). Rf classes are given according to the solvents A/B/C. The main lichen substances are listed in Table 1. The appearances of the spots on the TLC plates are compared in Fig. 2. Spot tests were performed with conventional tests (Clerc 1984a); unless otherwise stated, they were performed on the medulla of a branch of the middle part of the thallus, longitudinally cut with a razor blade.

Most old records of *Usnea* species are unreliable and thus information about geographical distribution in Spain is mainly based on specimens examined by ourselves. Literature records published after 1990, when several of the systematics studies of European species provided enough information for accurate identification, have been also included and are marked with an asterisk (*) although these specimens were not seen by ourselves.

Reference collections have been deposited in the VAB-Lich. Herbarium (Facultat de Ciències Biològiques. Universitat de València. Spain).

The second author is primarily responsible for the taxonomy, whereas all collecting and field observations were made by the first author. Both authors contributed to chemical studies.

Key to the Species

Young, necrotic or abnormal specimens with badly developed characters or growing in extreme localities are difficult to identify. Thus, the chemistry should be investigated with TLC and a specialist should preferably be consulted.

- 1 Thallus with a red, purple-red or pink pigment in the cortex (sometimes present only in the older parts of the thallus) or in the medulla (sometimes subcortical) 2
Thallus without such a pigment (the medulla might be sometimes tinted orange close to the central axis) 5
- 2(1) Pigment in the cortex **10. U. rubicunda**
Pigment in the medulla 3
- 3(2) Pigment subcortical, limited to a thin layer adjacent to the cortex **11. U. subcornuta**
Pigment \pm in the whole medulla, not limited to a thin layer adjacent to the cortex 4
- 4(3) Medulla CK+ yellow-orange (diffractaic and barbatic acids); soralia at the top of raised tubercles **1. U. ceratina**
Medulla CK- (fatty acids of the murolic acid group); soralia flat or slightly tubercular **9. U. mutabilis**
- 5(1) Medulla PD+ rust-red and K- (protocetraric acid as main substance) 6
Medulla PD- and K- or PD+ and K+ (\pm protocetraric acid as accessory substance) 7
- 6(5) Lateral branches constricted at point of attachment; cortex thin (3–5%); soralia conspicuous, excavate to irregularly efflorescent-excrecent, usually exceeding half width of branches, without isidiomorphs **7. U. glabrata**

- Lateral branches not constricted at point of attachment; cortex thick (8–15%); soralia small, punctiform, superficial, smaller than half width of branches, with fragile isidiomorphs when young
 **13. *U. subscabrosa***
- 7(5) Lateral branches constricted at point of attachment, or \pm fusiform
 8
 Lateral branches not constricted at point of attachment, never fusiform 11
- 8(7) Fibrils short and spinulose, densely but \pm irregularly covering restricted parts (rarely the entire length) of branches; galbinic acid present **3. *U. dasaea***
 Fibrils usually longer and slender, scattered on whole thallus; galbinic acid absent 9
- 9(8) Soralia without isidiomorphs, large, more than half width of branches; terminal branches often twisted and contorted, resembling skeletal fingers; bourgeanic acid present
 **4. *U. esperantiana***
 Soralia with isidiomorphs, large or small, punctiform; terminal branches usually not twisted; bourgeanic acid absent 10
- 10(9) Cortex mat, never glossy; basal part pale, whitish to brownish, with numerous and conspicuous annulations; soralia usually large, more than half width of branches; salazinic acid never present
 **5. *U. flammea***
 Cortex glossy; basal part brownish to jet black, with few and thin annulations; soralia punctiform but often becoming confluent and thus looking like a single large soralium; salazinic acid sometimes present **2. *U. cornuta***
- 11(7) Mature soralia usually punctiform, smaller than half width of branches (large in some rare morphotypes of *U. subfloridana*), usually covered with isidiomorphs 12
 Mature soralia usually large, isidiomorphs absent or present . . 13
- 12(11) Basal part pale, never jet black; main branches \pm angular, ridged, with depressions; papillae absent; norstictic acid or fatty acid of the murolic acid aggr. **8. *U. hirta***
 Basal part jet black; main branches terete; papillae present; thamnolic acid \pm squamatic acid **12. *U. subfloridana***
- 13(11) Branches mostly anisotomic-dichotomous (best seen on terminal branches), uneven in thickness, \pm swollen, often sinuous; usnic or salazinic \pm barbatic acid **15. *U. substerilis***
 Branches mostly isotomic-dichotomous, tapering, not swollen, rarely sinuous 14
- 14(13) Basal part pale, whitish to brownish, with conspicuous annulations; mature soralia usually with numerous isidiomorphs; stictic acid aggr., norstictic acid **5. *U. flammea***

- Basal part jet black, annulated or not; mature soralia usually with few or without isidiomorphs 15
- 15(14) Soralia deeply excavate, reaching central axis, not longitudinally stretched when mature, without isidiomorphs; basal part without small longitudinal cracks (at 50 × magnification); stictic acid aggr., norstictic and ± diffractaic acids **6. U. fulvoreagens**
- Soralia flat to slightly excavate, usually not reaching central axis, longitudinally stretched when mature, isidiomorphs present (mostly on young soralia in protected parts of the thallus); ± salazinic, ± barbatic, ± psoromic acids or thamnolic ± squamatic acids **15. U. wasmuthii**

The Species

1. *Usnea ceratina* Ach.

Lich. Univ.: 610 (1810).

Taxonomy. A detailed description is given in Halonen *et al.* (1998) and Herrera-Campos *et al.* (1998). The most characteristic features are the pendulous (shrubby when young or in suboptimal conditions), coarse and rigid thallus, the pinkish pigment in the medulla, the hard and vitreous cortex, the conspicuous tubercles that might become soresiate on top, and the CK+ yellow-orange reaction of the medulla (diffractaic and barbatic acids).

Ecology and distribution. Corticolous, usually on branches in areas with common and persistent fog; rarely saxicolous (Rowe & Egea 1986). It also grows on trunks of acid-barked old trees in relict woodlands, in well-lit sites or thin tree canopies. This species has a wide distribution in boreal and temperate regions of the Northern Hemisphere (James *et al.* 1992; Nimis 1993). In the Iberian Peninsula, it has been reported several times from northern Spain (Etayo 1989, 1990; Bahillo & Carballal 1991; Terrón *et al.* 1992*).

It is quite rare in the Iberian cork-oak forests, being restricted to some humid and Atlantic cork-oak forests of southern (17, 21) and north-eastern Spain (7) and central Portugal (37). At these stands the biomass of other *Usnea* species such as *U. rubicunda*, *U. subscabrosa* or *U. subcornuta* is also high, especially on branches. Thalli of *U. ceratina* can exceed one metre in length in favourable sites (Bahillo 1989; Etayo 1989; James *et al.* 1992); specimens studied are usually no longer than 20 cm.

Specimens examined. **Spain:** *Andalucía:* 17, 1993, E. Calvo, VAB-Lich. 4664; 21, 1992, S. Fos, VAB-Lich. 4537. *Catalonia:* 7, 1991, S. Fos, VAB-Lich. 4541.—**Portugal:** *Ribatejo:* 37, 1990, E. Barreno & S. Fos, VAB-Lich. 4578.

2. *Usnea cornuta* Körb.

Parerga Lichenol.: 2 (1865).

Taxonomy. *Usnea cornuta* s. str. is distinguished by the short, erect, tufted thallus, the lateral branches that are distinctly constricted at their point of

attachment, the minute and numerous soralia, usually with abundant isidiomorphs, the thin (4–7%) and glossy cortex and by its chemistry. In Europe, three morphologically indistinguishable chemical strains have been described (Clerc 1987a). The secondary chemistry in Iberian cork-oak forest seems to be fairly uniform (Table 1; Fig. 2): all specimens tested by TLC contained usnic and salazinic acids.

Ecology and distribution. This euoceanic species in the sense of Degelius (1935) grows on wood, bark or rocks, usually in well-lit open situations. It is more frequent on branches, although it also occurs on the boles of numerous phorophytes. This species is limited to extremely oceanic parts of West Europe, with some rare Mediterranean localities, ranging from SW Norway to Portugal (Clerc 1987a; Jørgensen 1996), although it is more frequent in western Europe (Nimis 1993). In Spain, it has been reported mainly from the north, in the Eurosiberian region.

In our survey, it has only been found in the southern limit of the Badajoz province (32) and in Catalonia (8), on boles of peripheral trees. These records are especially interesting, because *U. cornuta* has a strong preference for the Atlantic areas and is rare in Mediterranean territories. These two areas have a suboceanic climate, as evidenced by the richness and biomass of several *Usnea* species (*U. flammea*, *U. rubicunda*, *U. subscabrosa*, *U. wasmuthii*) and of several other oceanic-suboceanic lichens. We have also studied one specimen collected in Pontevedra by Barreno *et al.* in the NE of Spain (44).

Specimens examined. **Spain:** Catalonia: 8, 1991, S. Fos, VAB-Lich. 4633. Extremadura: 32, 1992, S. Fos, VAB-Lich. 4530, 4657, 4658. Galicia: 44, 1982, Barreno, Crespo & Sancho, VAB-Lich. 8021.

3. *Usnea dasaea* Stirt.

Scott. *Naturalist* 6: 104 (1881).

Taxonomy. *Usnea dasaea* seems to be closely related to *U. cornuta*. It differs in having some branches at least with densely disposed spinulose fibrils on some parts of them, giving them a spinulose appearance, and in its chemistry (galbinic acid in the medulla, Clerc 1987a; Clerc & Herrera-Campos 1997). This is the only European *Usnea* with galbinic acid.

Ecology and distribution. *Usnea dasaea* is mainly corticolous, but it also can occur on rocks (Clerc & Herrera-Campos 1997). It has a worldwide distribution, except Antarctica and Australasia (Clerc & Herrera-Campos 1997). *Usnea dasaea* has a southwestern distribution in Europe (Fig. 3). It was collected in Spain by E. Frey in the Catalonian cork-oak forests (see additional specimens examined, Clerc unpublished). It has also been reported from Italy, though the records require confirmation (Nimis 1993). This species is here reported as new for the Iberian Peninsula.

In this study, *U. dasaea* has only been collected in a Catalonian cork-oak forest (6). This site is located in an area with a subhumid ombroclimate and under coastal influence with frequent fog, and hosts other rare lichens (see Fos 1998).

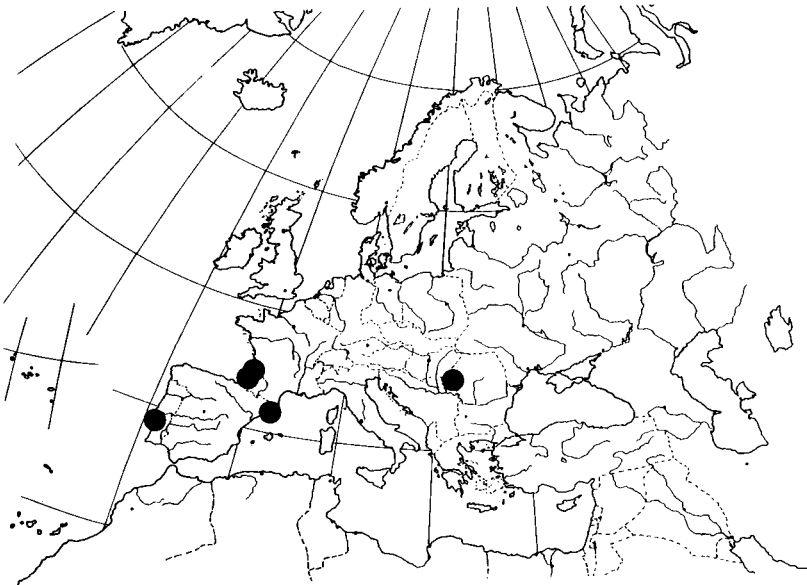


FIG. 3. Known European distribution of *Usnea dasaea*.

Specimens examined. **Spain:** Catalonia: 6, 1991, S. Fos, VAB-Lich. 4620.

Additional specimens examined. **France:** Landes: Gironde, 'Cestas', sur *Ulmus*, 1949, *Plomb* (MARS); Landes: Moliets entre Soustons et Léon, plantations de *Quercus suber* et *Pinus maritima*, 1950, *Frey* (BERN-Frey 14479)—**Portugal:** *Estremadura:* Serra de Sintra, parque da Pena, prox. dos Lagos, sobre *Fagus*, 1944, C. Tavares (LISA).—**Romania:** an Buchen des Berges Ruszka im Banate, 1872, *Lojka* (W—holotype of *U. dolosa* Motyka).—**Spain:** Catalonia: Girona, Massanès près de la station RENFE Empalme, colline en granit avec *Quercetum suberis*. Troncs et couronnes de *Q. suber*, NW, 120 m, 1950, *Frey* (BERN-Frey 14502); Girona, Blanes-Tossa, Korkeichenwälder an der Strasse, auf *Cistus monspeliensis*, 80 m, 1934, *Frey* (BERN-Frey 4308); Girona, Bosche del Vilar bei Blanes, *Quercetum suberis*, 1951, *Frey* (BERN-Frey 17536).

4. *Usnea esperantiana* P. Clerc

Candollea 47: 2 (1992).

Taxonomy. This species, recently described by Clerc (1992), belongs to the *U. fragilescens* aggregate. Distinctive are the large and flat (sometimes slightly excavate) soralia at the tips of branches, without isidiomorphs, lateral branches distinctly constricted at their point of attachment, basal part concolorous with the main branches, and the presence of bourgeanic acid, beside salazinic acid.

Ecology and distribution. Corticolous, on a large variety of trees and bushes, especially on twigs and thin branches, always in areas with frequent fog (Clerc 1992). It has a distinct South European-Atlantic distribution, being known from the Canary Islands and from several localities in western Europe (Clerc 1992; Nimis 1993). Halonen *et al.* (1998) mention *U. esperantiana* for the first time for North America (W California and British Columbia).

In this study, it was found in only two sites (11, 22).

Specimens examined. **Spain:** *Andalucía:* 22, 1988, E. Barreno, VAB-Lich. 4635. *Catalonia:* 11, 1991, S. Fos, VAB-Lich. 4628.

5. *Usnea flammea* Stirt.

Scott. Naturalist 6: 104 (1881).

Taxonomy. Among the erect to subpendulous taxa, *U. flammea* differs from other sorediate species by its pale basal part with numerous annulations, its efflorescent, \pm protuberant and large soralia with numerous isidiomorphs and its chemical properties (norstictic, stictic acid aggr., \pm lobaric acids) (Clerc 1987a).

Ecology and distribution. This euoceanic species grows on all types of phorophytes including decorticated wood, and also on rocks and soil (James *et al.* 1992). It occurs in old, humid Atlantic forests, where the epiphytic lichen flora is dominated by oceanic species. Its distribution in Europe extends from the south western coast of Norway and the British Isles to Spain and Portugal (Clerc 1987a). It can be considered as rare in the Mediterranean region, although it is known from Yugoslavia, Greece, Italy and Portugal (Jones 1980; Clerc 1987a; Nimis 1993). In Spain, it has been reported only from the north (Bahillo 1989; Bahillo & Carballal 1991; Etayo 1989, 1990; Etayo *et al.* 1991; Paz Bermúdez *et al.* 1995*).

In the areas studied, *U. flammea* seems to be very rare. It was found only in the luso-extremadurensis cork-oak forests (Fig. 1D), at the same site (32) and in the same ecological position as *U. cornuta* (see note on this species).

Specimens examined. **Spain:** *Extremadura:* 32, 1992, S. Fos, VAB-Lich. 4657.

6. *Usnea fulvoreagens* (Räsänen) Räsänen

Lich. Fenn. Exs.: nr. 13 (1935).

Taxonomy. *Usnea fulvoreagens* belongs to the erect to subpendulous, tufted and sorediate *Usnea* with lateral branches that are not constricted at ramification points. In the past, this species has been confused with *U. lapponica* Vain. (syn. *U. sorediifera* auct.). Indeed, both taxa have the same kind of soralia that are deeply excavate, typically reaching the central axis and tearing off the adjacent cortex, and never producing isidiomorphs. However, these two taxa are very distinct and not closely related at all. *Usnea fulvoreagens* has a distinct isotomic-dichotomous branching pattern, cylindrical and tapering branches, a much thinner medulla (13–22%), a distinct chemistry (see below) and a suboceanic distribution pattern. *Usnea lapponica* has a distinct sympodial branching pattern, branches that are cylindrical or \pm deformed and irregular, rarely tapering, a wider medulla (21–30%), a different chemistry (salazinic or psoromic or caperatic acids) and a continental distribution (Clerc 1992). In Europe, two chemotypes seem to occur so far in *U. fulvoreagens*: one with norstictic acid, \pm stictic acid aggr., \pm diffractaic acid (Clerc 1987a, 1992;

James *et al.* 1992). The second chemotype contains norstictic and squamatic acids (VAB-Lich. 4629, 4640), and has been detected in this work for the first time (Table 1; Fig. 2). The two strains can be found in the same site, as in Galaroza (34), and are morphologically indistinguishable. In North America, this species seems to be difficult to separate from *U. glabrescens* (Vain.) Vain. (Halonen *et al.* 1998).

Ecology and distribution. Corticolous, preferentially on branches of several phorophytes although more frequent on conifers. Acidophilous and anitrophilous (Wirth 1980), *U. fulvoreagens* is a suboceanic species, reported only a few times from Europe. It is known from Italy (Nimis 1993), the British Isles (James *et al.* 1992), Portugal (Jones 1980*), Madeira (Kalb & Hafellner 1992*) and Spain (Bahillo & Carballal 1991; Etayo 1990; Paz-Bermúdez *et al.* 1995*). In the Iberian Peninsula, it is present in the meso- and supra-mediterranean belts. In North America, it is known from British Columbia (Halonen *et al.* 1998) and from the Appalachians (Dey 1978).

Usnea fulvoreagens is present only in a few luso-extremadurensis cork-oak forests, in particular those with an Atlantic influence ('Marianico-Monchiquense' subsector). In the shadier sites (34, 33), it is restricted to the branches, which can be densely covered, on peripheral trees, where it is associated with *U. subfloridana* and *U. wasmuthii*. When the canopy structure allows higher light penetration, it is also abundant on tree boles (31).

Specimens examined. **Spain:** *Andalucía:* 33, 1992, *S. Fos*, VAB-Lich. 4623; 34, 1992, *S. Fos*, VAB-Lich. 4606, 4631, 4640. *Extremadura:* 31, 1992, *S. Fos*, VAB-Lich. 4629. *Galicia:* 44, 1982, Barreno, Crespo & Sancho, VAB-Lich. 8022.

7. *Usnea glabrata* (Ach.) Vain.

Ann. Acad. Sci. Fennicae A 6(7): 7 (1915).

Taxonomy. *Usnea glabrata* is one of the smallest *Usnea* species with an erect, tufted and sorediate thallus. Good descriptions are given in James *et al.* (1992), Myllys (1994) and Halonen *et al.* (1998). Like the species of the *U. fragilesceus* aggr., lateral branches are distinctly constricted at ramification points and the cortex is glossy. Distinctive features are the conspicuous, mostly erumpent, convex-globular soralia, mostly situated at the tips of branches, the absence of isidiomorphs and true papillae, a thick and lax medulla, and the production of fumarprotocetraric acid as the main secondary substance.

Ecology and distribution. Corticolous, on numerous deciduous and coniferous trees. It occurs in open forests and may avoid stands with high atmospheric humidity (Myllys 1994). Its ecology is similar to that of the former species, though *U. glabrata* is rarely present in *Lobarion* communities. *Usnea glabrata* is widespread, but not frequent, in central and northern Europe, much rarer in the southern part of the continent, where it is mostly confined to mountainous forests (Clerc 1987c; Myllys 1994). Its global range extends to Asia, North America (Goward & Ahti 1992; Halonen *et al.* 1998) and

Macaronesia (Hafellner 1995). Goward & Ahti (1992) suggested that its range is primarily low-boreal to temperate, perhaps primarily oceanic.

Usnea glabrata is present in the luso-extremadurensis cork-oak forests, and is one of the few *Usnea* species collected in more continental 'Toledano-Tagano' territories. At the same site (24), *U. subfloridana* and, more frequently, *U. wasmuthii* also occur.

Specimens examined. Spain: Andalucía: 34, 1992, S. Fos, VAB-Lich. 4630. Extremadura: 24, 1990, S. Fos, VAB-Lich. 4632.

8. *Usnea hirta* (L.) F. H. Wigg.

Prim. Fl. Hols.: 91 (1780).

Taxonomy. One of the most well known and commonly collected small tufted *Usnea* species, the typical features of which are the pale basal part, the absence of true papillae, the \pm deformed and foveolated main branches, the minute and numerous soralia covered with isidiomorphs and the chemistry (\pm norstictic acid, \pm fatty acids of the murolic acid complex) (Clerc 1987a; James *et al.* 1992; Halonen & Puolasmaa 1995; Halonen *et al.* 1998).

Ecology and distribution. Corticolous, especially on acid bark, and lignicolous. *Usnea hirta* grows mostly on the branches of conifers, especially on *Pinus*, and less frequently on deciduous trees. Photophilous (Halonen *et al.* 1991), it can often be found in open sites, where it usually forms dense stands on trees, whereas it is rare in shady and moist sites (Halonen & Puolasmaa 1995). It is a strongly continental species that occurs within the *Usneion barbatae* Ochsner 1928 and *Pseudevermietum furfuraceae* (Hililtzer) Ochsner 1928 communities, in open pine forests of the supra- and oromediterranean belts (*Sabino-Pino sylvestris sigmetum*); in Eurosiberian vegetation belts, it is distributed from the lower montane to the subalpine belts. It can frequently be found occurring within nitrophilous *Xanthorion* communities (Nimis 1981). It is relatively resistant to air pollution (Wirth 1980; Kauppi & Halonen 1992). *Usnea hirta* is a species of worldwide distribution (Clerc 1997; Halonen *et al.* 1998). In Europe, it has been reported from boreal areas to Mediterranean mountains (Wirth 1980; Clauzade & Roux 1985; Nimis 1993; Halonen & Puolasmaa 1995). Widespread in the Iberian Peninsula, especially in continental areas.

Due to its preference for climatically continental areas, *U. hirta* is seldom found in cork-oak forests. This species is present in those sites where the climate is rather more continental and it is quite abundant in the supra-mediterranean cork-oak forest of Burgos (45). It also occurs in Catalonia, but it is restricted to the highest elevations sites (10), and at North of Huelva (33).

Specimens examined. Spain: Andalucía: 33, 1992, S. Fos, VAB-Lich. 4615. Castilla-León: 45, 1995, P. Pérez-Rovira & G. Renobales, VAB-Lich. 4662. Catalonia: 10, 1991, S. Fos, VAB-Lich. 4622.

9. *Usnea mutabilis* Stirt.

Scott. *Naturalist* 6: 107 (1881).

U. marocana Motyka (Clerc 1994, 1997)

Taxonomy. A detailed description of this mainly North American species is given in Clerc (1994). *Usnea mutabilis* is closely related to *U. hirta* but has a wine-red pigment in the medulla, a thicker cortex (6.5–10.5%) and a more compact medulla (Clerc 1994). Chemically, it produces the same fatty acids of the murolic acid complex as *U. hirta*. Both species are the only *Usnea* in the Northern Hemisphere that are known to produce this type of substance.

Ecology and distribution. Mainly corticolous, rarely saxicolous (Clerc & Herrera-Campos 1997), *U. mutabilis* shows a typical disjunctive distribution in the four continents of the Northern Hemisphere (see distribution map in Clerc 1994). In Europe and North Africa it is only present in the Mediterranean region: Morocco, Iberian Peninsula, France and Italy (Werner 1975; Gómez-Bolea 1985; Boqueras & Gómez-Bolea 1986, 1987; Abbasi-Maaf & Roux 1986; Clauzade & Roux 1989; Nimis 1993; Clerc 1994).

In our survey, *U. mutabilis* was found only in an especially humid site (6, see comments for *U. dasaea*) close to the forests of *Q. canariensis*. It colonises the upper part of the trunks and the exposed branches, where it is accompanied by such species as *U. dasaea*, *U. rubicunda*, *Parmelia hypoleucina*, *P. caperata* Gómez-Bolea (1985) and Boqueras & Gómez-Bolea (1986, 1987) found it in several sites of Catalonia within the *Usneetum marocanae* Boqueras & Gómez-Bolea 1987 synusia. They described this union from the shady areas of the littoral mountains and pre-littoral depression, where fog episodes are frequent. In the cork-oak forest of Cádiz, *U. mutabilis* has been reported by Werner (1975) between Algeciras and Gibraltar.

Specimens examined. **Spain:** Catalonia: 6, 1991, S. Fos, VAB-Lich. 8462.

10. *Usnea rubicunda* Stirt.

Scott. *Naturalist* 6: 102 (1881).

Taxonomy. This is the only *Usnea* known to occur in Europe that has a red cortical pigment. This pigment is sometimes difficult to see and one should especially look at the basal part. Necrotic thalli of other species collected on soil might be reddish and thus confused with *U. rubicunda*. Other typical features are the punctiform soralia covered with isidiomorphs, the non-blackened basal part, the cylindrical and tapering branches.

Ecology and distribution. Corticolous, on several deciduous trees and, rarely, on conifers, mostly on branches; it seldom grows on siliceous rocks (Swinscow & Krog 1979; Rowe & Egea 1986). Photophilous and hygrophilous, it is common in areas with an oceanic climate, in ancient woodlands or on isolated trees near waysides and boundaries. *Usnea rubicunda* has a cosmopolitan distribution in many suboceanic and oceanic temperate and tropical regions and has been recorded from both Hemispheres. In Europe, it is the most

common species in the western part of the continent, extending west to Macaronesia, Central Europe and the Atlantic-Mediterranean areas (James 1979; Wirth 1980; Hafellner 1995). In the Iberian Peninsula, it has been frequently reported from coastal or oceanic areas.

Usnea rubicunda is the most common and abundant *Usnea* in the areas studied within the climatic conditions mentioned above: cork-oak forests of Catalonia and in *Oleo-Quercetum suberis* and *Myrto-Quercetum suberis* forest from Cádiz, Huelva and Portugal. It usually grows on exposed branches, which become abundantly covered, though it is not rare on boles. It also occurs in other areas, such as luso-extremadurensis forests associated with hyperhumid ombroclimate (40).

Specimens examined. Spain: Andalucía: 18, 1992, *S. Fos*, VAB-Lich. 3535; **19**, 1992, *S. Fos*, VAB-Lich. 3565; 1988, *E. Barreno*, VAB-Lich. 9315; **20**, 1992, *S. Fos*, VAB-Lich. 3455; **21**, 1992, *S. Fos*, VAB-Lich. 3746, 4981; **22**, 1992, *S. Fos*, VAB-Lich. 3768; 1988, *E. Barreno*, VAB-Lich. 4533, 8083; **23**, 1992, *S. Fos*, VAB-Lich. 3487; **36**, 1995, *S. Fos*, VAB-Lich. 4681. *Catalonia: 1*, 1991, *S. Fos*, VAB-Lich. 9120; **2**, 1994, *S. Fos*, VAB-Lich. 4543; **3**, 1991, *S. Fos*, VAB-Lich. 3316; **4**, 1991, *S. Fos*, VAB-Lich. 8068; **5**, 1991, *S. Fos*, VAB-Lich. 4542; **6**, 1991, *S. Fos*, VAB-Lich. 3890, 8463; **7**, 1991, *S. Fos*, VAB-Lich. 3387; **9**, 1991, *S. Fos*, VAB-Lich. 4540; **10**, 1991, *S. Fos*, VAB-Lich. 9448; **11**, 1991, *S. Fos*, VAB-Lich. 8045.—**Portugal: Algarve: 38**, 1990, *E. Barreno* & *S. Fos*, VAB-Lich. 3023; **40**, 1990, *E. Barreno* & *S. Fos*, VAB-Lich. 3073; *Ribatejo: 37*, 1990, *E. Barreno* & *S. Fos*, VAB-Lich. 3017.

11. *Usnea subcornuta* Stirt.

Scott. Naturalist **6**: 107 (1881).

Taxonomy. This is a rare and poorly known species. Hawksworth *et al.* (1980) considered it as a synonym of *U. cornuta*. Based on observations made on the type material, Clerc (1987a) indicated that *U. subcornuta* is a distinct species, characterised by the presence of an orangish pinkish red pigment under the cortex (subcortical) in the medulla. Unfortunately the original material consists of two small and badly developed thalli and it was not easy to understand this species on this basis. More recent collections (see Fig. 4), however, now give us a better idea about what this species really is. Morphologically, *U. subcornuta* is very similar to *U. flammea* (see under this species), differing only by the presence of the subcortical pigment and of a glossy cortex. Lateral branches are not constricted at attachment points. Chemically the type specimens have several yellow pigments whereas the three collections from Morocco, Portugal and Russia have the stictic acid aggr. and norstictic acid.

Ecology and distribution. A very rare corticolous species. Known only from a few localities in Europe (Fig. 4) where it seems to have a western Mediterranean-Macaronesian type of distribution with 'microclimatic' outposts, as for instance in the western Caucasus where other *Usnea* species with a similar type of distribution (*U. hesperina* and *U. mutabilis*) have been found (Clerc 1991).

The specimen referred to in this study was collected in a Portuguese cork-oak forest within *Oleo-Quercetum suberis* (37). It occurs on peripheral and

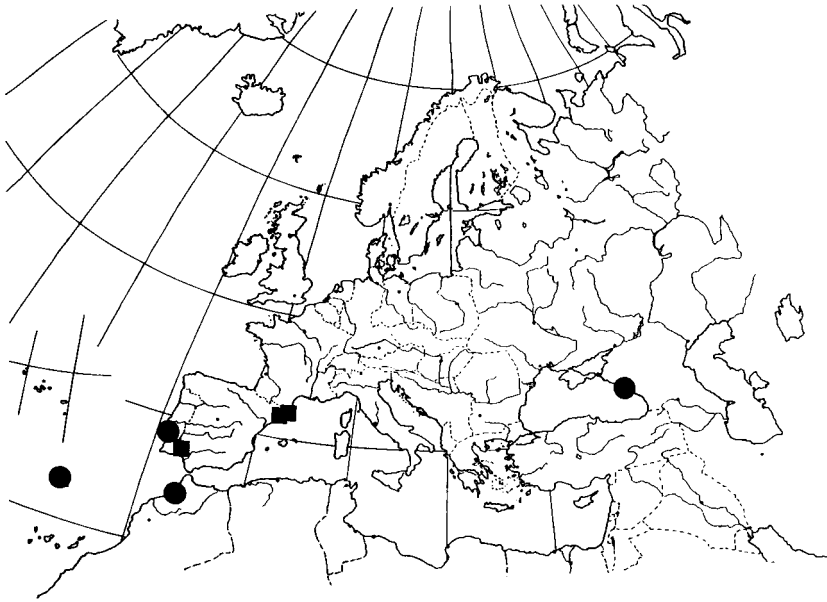


FIG. 4. Known world distribution of *Usnea subcornuta*. Studied specimens (●) and literature records (■).

exposed branches of young trees with very open crowns, accompanied by *U. rubicunda* and *Parmelia hypoleucina*.

Specimens examined. Portugal: Ribatejo: 37, 1990, E. Barreno & S. Fos, VAB-Lich 4654.

Additional specimens examined. Portugal: Madeira: near Funchal, Payne (BM—holotype).—

Morocco: Ad corticem *Quercus suberis* in Mamora silva prope Rabat, 31 xii 1933, leg. ? (unreadable) (BERN-Frey 3881).—**Russia:** Caucasus occidentalis: distr. Khosta, in valle fluminis Khosta, loco 'Navalishenskoie uscelie' dicto, 200–300 m, 1980, V. Vasak, GZU 130–83.

12. *Usnea subfloridana* Stirt.

Scott. Naturalist 6: 294 (1882).

Taxonomy. Descriptions of this species can be found in James *et al.* (1992) and in Halonen *et al.* (1998). The following combination of characters is diagnostic: thallus erect to subpendulous, basal part jet black pigmented; small, plane and numerous soralia, covered with isidiomorphs; isotomic-dichotomous branching; branches terete, tapering, not constricted at attachment points; medulla dense to compact; thamnolic, ± hypothamnolic acid ± squamatic, ± alectorialic acids or squamatic acid alone in the medulla. Most specimens collected in this study have thamnolic ± squamatic acids (Table 1; Fig. 2). These two chemotypes are morphologically indistinguishable and they do not seem to show any ecological difference. Both are usually present in the same sampling plot and often on the same tree.

Specimens belonging to a third chemotype (norstictic and connorstictic acids) (Fig. 2) have been collected in this study (VAB-Lich. 4603, 4665).

They correspond to *Usnea subfloridana* subsp. *praetervisa* (Asahina) P. Clerc comb. nov. [Basionym: *Usnea comosa* subsp. *praetervisa* Asahina, Lichens of Japan III. Genus *Usnea*: 95 (1956)]. This taxon is known to occur in North America (Clerc unpublished), Europe and Eastern Asia (Asahina 1956). More work is needed to assess its status.

Ecology and distribution. Corticolous, occurring on a great variety of phorophytes. Photophilous (Etayo 1989), it prefers well-lit open localities where it grows mostly on branches. It is present in Atlantic and Mediterranean areas, extending to the upper mesomediterranean and lower supramediterranean belts with subhumid to hyperhumid ombroclimates (Marcos Laso 1985). However, in Italy, it is one of the few *Usnea* species that are also present at low altitudes, and sometimes even near urban settlements, in areas with low air pollution (Nimis 1993). *Usnea subfloridana* is rather common throughout Europe (Clerc 1987a, c). In Spain, *U. subfloridana* has been reported frequently, especially from the northern Iberian Peninsula, and seldom in typical Mediterranean vegetation.

In our survey, *U. subfloridana* seems to have its optimum in luso-extremadurese cork-oak forests. It is almost exclusive to these territories and it is present in numerous sites, where it can locally reach significant development and biomass. It usually grows on branches, often forming dense stands, but in open woodlands it is one of the most frequent *Usnea* species on trunks as well. Outside this province, it has been found only in Málaga (17) and Burgos (45). The absence from Cádiz and Catalonia seems to indicate preference for rather continental areas.

Specimens examined. **Spain:** *Andalucía:* 17, 1993, E. Calvo, VAB-Lich. 4665; 33, 1992, S. Fos, VAB-Lich. 4603; 34, 1992, S. Fos, VAB-Lich. 4601, 4605, 4625, 4652; 35, 1992, S. Fos, VAB-Lich. 4636, 4653. *Castilla-León:* 45, 1995, P. Pérez-Rovira & G. Renobales, VAB-Lich. 4661. *Extremadura:* 24, 1990, S. Fos, VAB-Lich. 4604; 29, 1993, S. Fos & E. Barreno, VAB-Lich. 4647; 30, 1993, E. Barreno & S. Fos, VAB-Lich. 4648, 4626.

13. *Usnea subscabrosa* Motyka

Lich. Gen. Usnea Stud. Monogr., Pars Syst 2: 313 (1937).

Taxonomy. For a detailed description, see Clerc (1992), James *et al.* (1992), and Herrera-Campos *et al.* (1998). The main diagnostic characters are the thick and vitreous cortex, minute soralia with or without isidiomorphs, pale trunk often with a reddish hue, and chemistry with protocetraric acid as the main substance (Clerc & Herrera-Campos 1997) (Table 1; Fig. 2).

Ecology and distribution. Both corticolous and saxicolous, moderately acidophilous, anitrophilous and moderately toxitolerant (Wirth 1980), *U. subscabrosa* displays a south-western European-Macaronesian-NE American disjunction (Clerc 1992; Esslinger & Egan 1995; Clerc & Herrera-Campos 1997). In Europe, it has been reported from several localities, from Portugal and the British Isles to Yugoslavia; it is known also from South America (Clerc 1997). In the Iberian Peninsula, it has been reported by numerous authors.

In our survey, *U. subscabrosa* is especially well represented in the cork-oak forests of Cádiz, both in *Myrto-Quercetum suberis* and in *Teucrio-Quercetum suberis* stands. It grows preferentially on branches and frequently colonises well-lit trunks. In the Portuguese cork-oak forests it is present in all vegetation series, being here the most common *Usnea*, although *U. rubicunda* is more abundant in more oceanic sites. In other localities, such as Malavella (7), in Catalonia, and Zahinos (32), in the Mariánico-Monchiquense sector (Luso-extremadurensis province), *U. subscabrosa* is also quite abundant. The specimen reported from Catalonia as *Usnea mollis* Stirt. (Boqueras & Gómez-Bolea 1986:63) also corresponds to *U. subscabrosa*.

Specimens examined. **Spain:** *Andalucía:* 18, 1992, S. Fos, VAB-Lich. 4608; 21, 1992, S. Fos, VAB-Lich. 4613; 22, 1992, S. Fos, VAB-Lich. 4621; 1988, E. Barreno, VAB-Lich. 4611; 23, 1992, S. Fos, VAB-Lich. 4645; 34, 1992, S. Fos, VAB-Lich. 4630. *Catalonia:* 7, 1991, S. Fos, VAB-Lich. 4609, 4616, 4617, 4624. *Extremadura:* 32, 1992, S. Fos, VAB-Lich. 4610, 4659, 4660.—**Portugal:** *Algarve:* 38, 1990, E. Barreno & S. Fos, VAB-Lich. 4655, 4656; 40, 1990, E. Barreno & S. Fos, VAB-Lich. 4614; 41, 1990, E. Barreno & S. Fos, VAB-Lich. 4668. *Alto Alentejo:* 42, 1990, E. Barreno & S. Fos, VAB-Lich. 4651. *Baixo Alentejo:* 39, 1990, E. Barreno & S. Fos, VAB-Lich. 4612, 4607; *Ribatejo:* 37, 1990, E. Barreno & S. Fos, VAB-Lich. 4666, 4667.

Additional specimens examined. **Spain:** *Catalonia:* Girona, La Selva, Llagostera-Caldes de Malavella road, km 17, 31TDG82, 120 m, 1984, A. Gómez-Bolea, BCC-Lich. 3121.

14. *Usnea substerilis* Motyka

Wyd. Muz. Slask. Katowic. 3 (2): 24 (1930).

Taxonomy. A modern concept of this species is given in Halonen *et al.* (1998). *Usnea substerilis* is closely related to *U. lapponica*, from which it differs in its soralia that are not deeply excavate but superficial, not tearing off the adjacent cortex, usually with isidiomorphs when young. The thallus is usually short, erect-tufted; branches are circular to \pm deformed, swollen, irregular to more rarely tapering. Chemically, it produces salazinic \pm barbatic acid in the medulla (Table 1; Fig. 2).

Ecology and distribution. This corticolous taxon occurs in areas with \pm continental climate, often together with *U. lapponica* and *U. scabrata*. It is one of the most frequent *Usnea* from low altitudes to mountainous areas in the Alps. It is also frequent in the boreal zone of Europe, North America and Russia. In Spain, it has been reported by Sarrión *et al.* (1993) from Sierra Madrona Mountain (Ciudad Real, C Spain).

It is the only *Usnea* species found in the cork-oak forest of Haza del Lino (43).

Specimens examined. **Spain:** *Andalucía:* 43, 1991, S. Fos, VAB-Lich. 4602.

15. *Usnea wasmuthii* Räsänen

Flecht. Estlands I., Suom. Tidenknd. Taim. 34 (4): 17–19 (1931).

Taxonomy. Good descriptions can be found in Clerc (1992) and James *et al.* (1992). *Usnea wasmuthii* is closely related to *U. subfloridana* (see

above) but soralia are slightly excavate, ulcer-like, longitudinally stretched (mature soralia), with isidiomorphs only in young soralia and the basal blackened part of thallus with faint, transverse and longitudinal cracking ($\times 50$) forming a fine rimose areolation. Chemically, *U. wasmuthii* differs from *U. subfloridana* in having salazinic \pm barbatic acids or barbatic acid alone in the medulla. Most specimens collected in our survey contain both salazinic and barbatic acid (Table 1; Fig. 2). However, several specimens have been found that produce thamnolic \pm squamatic acids, the typical substances for *U. subfloridana*. Thus, what has been considered as a possible 'hybrid' (Clerc 1992) might well be considered as a rare chemotype of *U. wasmuthii*. Additionally, we have found a new chemotype with barbatic and psoromic acid (Fig. 2). These various chemotypes have been found not only in the same sampling plot, but also, side by side in the same herbarium packet.

Ecology and distribution. Corticolous, on several phorophytes. This is an Eurasian oceanic-suboceanic species, the European distribution of which very much resembles that of *U. florida* (Clerc 1984a, 1992). It is widespread but not frequent in the whole of Europe (Clerc 1987c). In the Iberian Peninsula it is known only from Eurosiberian areas with a humid-hyperhumid ombroclimate (Bahillo & Carballal 1991; Etayo 1989) and Mediterranean territories with Atlantic influence (Sarrión *et al.* 1993; Vázquez & Burgaz 1996*; Aragón & Martínez 1997*; Aragón & Rico 1997*; Seaward & Arvidsson 1997; Martínez & Sarrión 1998).

Like *U. subfloridana*, *U. wasmuthii* seems to have its optimum in the southwestern part of the Iberian Peninsula, although it could not be found in the Portuguese cork-oak forests. It seems to be absent from areas with a coastal influence. In the luso-extremadurensis province, it occurs with unequal frequency in dense, humid and shady stands, where it is especially abundant. It is also found in grassy woodlands exposed to strong sunshine and desiccating winds, although its presence is rather occasional in this environment. Curiously, it is the only species of *Usnea* found in the cork-oak forests of Valencia-Castellón.

Specimens examined. Salazinic and barbatic acids: Spain: Andalucía: 16, 1993, Barreno, Calatayud Sanz & Nash, VAB-Lich. 4643; **34**, 1992, S. Fos, VAB-Lich. 4601, 4639; *Comunidad Valenciana: 12*, 1992, M. A. Codoñer & S. Fos, VAB-Lich. 4989; **13**, 1992, M. A. Codoñer & S. Fos, VAB-Lich. 4990; **14**, 1992, E. Calvo & S. Fos, VAB-Lich. 4991; **15**, 1992, S. Fos, VAB-Lich. 4988. *Extremadura: 24*, 1990, S. Fos, VAB-Lich. 4618; **25**, 1990, S. Fos, VAB-Lich. 4644; **26**, 1990, S. Fos, VAB-Lich. 4634; **27**, 1990, S. Fos, VAB-Lich. 4619, 4637; **28**, 1990, S. Fos, VAB-Lich. 4638; **29**, 1993, S. Fos & E. Barreno, VAB-Lich. 4646; **30**, 1993, E. Barreno & S. Fos, VAB-Lich. 4626, 4627, 4641, 4649; **31**, 1992, S. Fos, VAB-Lich. 4663.

Thamnolic \pm squamatic acids: Spain: Andalucía: 34, 1992, S. Fos, VAB-Lich. 4630. *Extremadura: 29*, 1993, S. Fos & E. Barreno, VAB-Lich. 4650; **30**, 1993, E. Barreno & S. Fos, VAB-Lich. 4627, 4649; **31**, 1992, S. Fos, VAB-Lich. 4642.

Barbatic and psoromic acids: Spain: Extremadura: 24, 1990, S. Fos, VAB-Lich. 4618.

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REFERENCES

- Abbassi Maaf, L. & Roux, C. (1986) Les peuplements lichéniques corticoles de la Chênaie verte: étude comparée de la gardiole de Rians et de L'ille de Port-Cros (Var). *Bulletin de la Société Linnéenne de Provence* **38**: 189–245.
- Aragón, G. & Martínez, I. (1997) Contribución al conocimiento de los líquenes epifíticos de los Montes de Toledo (Toledo, España). *Cryptogamie, Bryologie et Lichénologie* **18**: 63–75.
- Aragón, G. & Rico, V. J. (1997) Los macrolíquenes del macizo del Calar del Mundo (Albacete) y de la Sierra de Segura (Jaén, España). *Lazaroa* **18**: 45–93.
- Asahina, Y. (1956) *Lichens of Japan. Vol. III. Genus Usnea*. Tokyo: Research Institute for Natural Resources Shinjuku.
- Bahillo, L. (1989) *Vegetación y Flora de los Líquenes Epifitos de la Cuenca del río Oitaven (Pontevedra)*. Doctoral Thesis, University of Santiago, Spain.
- Bahillo, L. & Carballal, R. (1991) Fragmenta Chorologica Occidentalia, Lichenes, 3467–3499. *Anales del Jardín Botánico del Madrid* **49**: 113–115.
- Boqueras, M. & Gómez-Bolea, A. (1986) Líquens epifits, i els seus fongs paràsits, observats sobre *Quercus suber*, a Catalunya. *Folia Botanica Miscelanea* **5**: 49–69.
- Boqueras, M. & Gómez-Bolea, A. (1987) La vegetación líquénica epifítica de *Quercus suber* L. en Catalunya (España). *Actas del VI Simposio Nacional de Botánica Criptogámica*: 371–382.
- Clauzade, G. & Roux, C. (1985) Likenoj de Okcidenta Europo. Ilustrita determinlibro. *Bulletin de la Société Botanique Centre-Ouest, Nouvelle série-Numéro Spécial* **7**: 1–893.
- Clauzade, G. & Roux, C. (1989) Likenoj de Okcidenta Europo. Ilustrita determinlibro. Suplemento 3a. *Bulletin de la Société Linnéenne de Provence* **40**: 73–110.
- Clerc, P. (1984a) Contribution à la révision de la systématique des Usnées (Ascomycotina, *Usnea*) d'Europe I. *Usnea florida* (L.) Wigg. emend. Clerc. *Cryptogamie, Bryologie et Lichénologie* **5**: 330–360.
- Clerc, P. (1984b) *Usnea wirthii*—a new species of lichens from Europe and North Africa. *Saundersia* **15**: 33–36.
- Clerc, P. (1987a) Systematics of the *Usnea fragilesceus* aggregate and its distribution in Scandinavia. *Nordic Journal of Botany* **7**: 479–495.
- Clerc, P. (1987b) On the morphology of soralia in the genus *Usnea*. *Bibliotheca Lichenologica* **25**: 99–107.
- Clerc, P. (1987c) *Usnea*. In *The Lichens and Lichenicolous Fungi of Sardinia (Italy)* (P. L. Nimis & J. Poelt, eds). *Studia Geobotanica* **7**: 237–239.
- Clerc, P. (1991) *Usnea madeirensis* Mot (ascomycète lichénisé): une espèce méconnue de l'Europe et de l'Amérique du Nord. *Candollea* **46**: 427–438.
- Clerc, P. (1992) Some new or interesting species of the genus *Usnea* (Lichenized Ascomycetes) in the British Isles. *Candollea* **47**: 513–526.
- Clerc, P. (1994) Comment *Usnea mutabilis* Stirton, une espèce nord-américaine, se cache en Europe sous le nom d'*Usnea marocana* Motyka. Une contribution à la systématique du genre *Usnea* (ascomycètes lichénisés). *Bulletin de la Société Linnéenne de Provence* **45**: 309–316.
- Clerc, P. (1997) Notes on the genus *Usnea* Dill. ex Adanson. *Lichenologist* **29**: 209–215.
- Clerc, P. (1998) Species concepts in the genus *Usnea* (Lichenized Ascomycetes). *Lichenologist* **30**: 321–340.
- Clerc, P. & Herrera-Campos, M. A. (1997) Saxicolous species of *Usnea* Subgenus *Usnea* (Lichenized Ascomycetes) in North America. *Bryologist* **100**: 281–301.
- Culberson, C. F. (1972) Improved conditions and new data for the identification of lichen products by a standard thin-layer chromatographic method. *Journal of Chromatography* **72**: 125–133.
- Culberson, C. F. (1974) Conditions for use of Merck silica-gel 60F 254 Plates in the standardized thin layer chromatographic technique for lichen products. *Journal of Chromatography* **97**: 107–108.
- Culberson, C. F. & Ammann, K. (1979) Standardmethode zur Dünnschichtchromatographie von Flechtensubstanzen. *Herzogia* **5**: 1–24.
- Culberson, C. F. & Kristinsson, H. D. (1970) A standardized method for the identification of lichen products. *Journal of Chromatography* **46**: 85–93.
- Degelius, G. (1935) Das ozeanische Element der Strauch- und Laubflechtenflora von Skandinavien. *Acta Phytogeographica Suecica* **7**: 1–411.

- Dey, J. P. (1978) Fruticose and foliose lichens of the high-mountain areas of the southern Appalachians. *Bryologist* **81**: 1–93.
- Esslinger, T. L. & Egan, R. S. (1995) A sixth checklist of the lichen-forming, lichenicolous, and allied fungi of the continental United States and Canada. *Bryologist* **98**: 467–549.
- Etayo, J. (1989) *Líquenes Epífitos del Norte de Navarra*. Doctoral Thesis, University of Navarra, Spain.
- Etayo, J. (1990) Ensayo de la vegetación líquénica epífita del Norte de Navarra. *Príncipe de Viana (Suplemento de Ciencias)* **10**: 39–71.
- Etayo, J., López de Silanes, M. E. & Bahillo, L. (1991) Contribución a la flora líquénica de Galicia central-Tras os Montes, I. *Nova Acta Científica Compostelana (Biología)* **2**: 31–39.
- Fos, S. (1998) *Líquenes Epífitos de los Alcornocales Libéricos. Correlaciones Bioclimáticas, Anatómicas y Densiméticas con el Corcho de Reproducción*. Guineana 4. Bilbao: Servicio Editorial de la E.H.U.
- Gómez-Bolea, A. (1985) *Líquenes Epífitos de Cataluña*. Barcelona: Comitè de Publicacions, Intercanvi científic i Extensió Universitaria. Universitat de Barcelona.
- Goward, T. & Ahti, T. (1992) Macrolichens and their zonal distribution in Wells Gray Provincial Park and its vicinity, British Columbia, Canada. *Acta Botanica Fennica* **147**: 1–60.
- Hafellner, J. (1995) A new check-list of lichens and lichenicolous fungi of insular Laurimacaronesia including a lichenological bibliography for the area. *Fritschiana* **5**: 1–32.
- Halonen, P. (1997) The lichen genus *Usnea* in eastern Fennoscandia. II. *Usnea longissima*. *Graphis scripta* **8**: 51–56.
- Halonen, P. & Poulasmaa, A. (1995) The lichen genus *Usnea* in eastern Fennoscandia. I. *Usnea hirta*. *Annales Botanici Fennici* **32**: 127–135.
- Halonen, P., Hyvärinen, M. & Kauppi, M. (1991) The epiphytic lichen flora on conifers in relation to climate in the Finnish Middle Boreal Subzone. *Lichenologist* **23**: 61–72.
- Halonen, P., Clerc, P., Goward, T., Brodo, I. M. & Wulf, K. (1998) Synopsis of the genus *Usnea* (Lichenized Ascomycetes) in British Columbia, Canada. *Bryologist* **101**: 36–60.
- Hawksworth, D. L., James, P. W. & Coppins, B. J. (1980) Check-list of British lichen-forming, lichenicolous and allied fungi. *Lichenologist* **12**: 1–115.
- Herrera-Campos, M. A., Clerc, P. & Nash III, T. H. (1998) Pendulous species of *Usnea* from the temperate forest in Mexico. *Bryologist* **101**: 303–329.
- James, P. W. (1979) Notes on *Usnea rubiginosa* and *U. rubicunda*. *Lichenologist* **11**: 322–323.
- James, P. W., Clerc, P. & Purvis, O. W. (1992) *Usnea* Hill. (1753). In *The Lichen Flora of Great Britain and Ireland*. (O. W. Purvis & B. J. Coppins, D. L. Hawksworth, P. W. James & D. M. Moore, eds): 620–629. London: Natural History Museum Publications.
- Jones, M. P. (1980) Epiphytic macrolichens of the Algarve, Portugal. *Lichenologist* **12**: 253–275.
- Jørgensen, P. M. (1996) The oceanic element in the Scandinavian lichen flora revisited. *Symbolae Botanicae Upsaliensis* **31**: 297–317.
- Kalb, K. & Hafellner, J. (1992) Bemerkenswerte Flechten und lichenicole Pilze von der Insel Madeira. *Herzogia* **9**: 45–102.
- Kauppi, M. & Halonen, P. (1992) Lichens as indicators of air pollution in Oulu, northern Finland. *Annales Botanici Fennici* **29**: 1–9.
- Marcos Laso, B. (1985) *Flora y Vegetación Líquénica Epífita de las Sierras Meridionales Salmantinas*. Doctoral Thesis, University of Salamanca, Spain.
- Martínez, I. & Sarrión, G. (1998) Líquenes epífitos de *Olea europaea* L. en la Sierra de Santa Olalla (NW-Cáceres, España). *Botanica Complutensis* **22**: 75–81.
- Montoya, J. M. (1988) *Los Alcornocales*. 2nd Edn. Madrid: Ministerio de Agricultura, Pesca y Alimentación.
- Myllys, L. (1994) *Usnea glabrata* (lichenized Ascomycotina) in East Fennoscandia. *Acta Botanica Fennica* **150**: 125–130.
- Nimis, P. L. (1981) Epiphytic lichen vegetation in the Lumiei-Valley (Carnian Alps). *Gortania* **3**: 123–142.
- Nimis, P. L. (1993) *The Lichens of Italy. An Annotated Catalogue*. Monografia XII. Torino: Museo Regionale di Scienze Naturali.
- Paz Bermúdez, G., Carballal, R. & López de Silanes, M. E. (1995) Líquenes epífitos sobre *Betula* L. en Galicia (España). *Cryptogamie, Bryologie et Lichénologie* **16**: 61–70.
- Rivas-Martínez, S. (1987) *Memoria del Mapa de Series de Vegetación 1:400.000*. Madrid: Ministerio de Agricultura, Pesca y Alimentación.

- Rivas-Martínez, S., Lousa, M., Diaz, T. E., Fernández González, F. & Costa, J. C. (1990) La vegetación del Sur de Portugal (Sado, Alentejo y Algarve). *Itinera Geobotanica* **3**: 5–126.
- Rowe, J. G. & Egea, J. M. (1986) Liqueenes silicícolas de las sierras costeras occidentales de la comarca de Algeciras (Cádiz, España). *Acta Botánica Malacitana* **11**: 55–74.
- Sarrión, F. J., Martínez, I. & Burgaz, A. R. (1993) Liqueenes epífitos de Sierra Madrona (Ciudad Real, España). *Cryptogamie, Bryologie et Lichénologie* **14**: 389–400.
- Seaward, M. R. D. & Arvidsson, L. (1997) Additions to the lichen flora of Málaga Province, S. Spain. *Nova Hedwigia* **64**: 129–135.
- Swinscow, T. D. V. & Krog, H. (1979) The fruticose species of *Usnea* subgenus *Usnea* in East Africa. *Lichenologist* **11**: 207–252.
- Terrón, A., Llamas, B. & Penas, A. (1992) Aportaciones al estudio de algunas comunidades brioliquénicas de la provincia de León. *Lazaroa* **13**: 23–31.
- Vázquez, S. & Burgaz, A. R. (1996) Flora liquénica de la provincia de Toledo (Toledo, España). *Botanica Complutensis* **21**: 39–50.
- Werner, R. G. (1975) Etude écologique et phytogéographique sur les lichens de l'Espagne méridionale. *Revue Bryologique et Lichénologique* **41**: 55–82.
- White, F. J. & James, P. W. (1985) A new guide to microchemical techniques for the identification of lichen substances. *British Lichen Society Bulletin* **57**(Suppl.): 1–41.
- Wirth, V. (1980) *Flechtenflora. Ökologische Kennzeichnung und Bestimmung der Flechten Südwestdeutschlands und Angrenzender Gebiete*. Stuttgart: Verlag Eugen Ulmer.

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