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Chrysothrix flavovirens, *Lepraria elobata,* and *Ochrolechia arborea* new to Portugal

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Abstract — *Chrysothrix flavovirens, Lepraria elobata,* and *Ochrolechia arborea* are reported as new to Portugal, based on surveys carried out in pine forests along the Portuguese coast. Data on the distribution, secondary products and ecology of the species are presented.

Key words — lichens, epiphytic, sand dunes

Introduction

The epiphytic lichen flora of pine forests in coastal areas in Portugal is poorly studied and is in need of a thorough survey. Pine forests are a common biotope along the Portuguese coast and many of them are classified as Natural Parks or Nature Reserves (Fig. 1a&b: 3, 8, 18–19, 21–22, 24), while others are national forests or forest perimeters that are owned and/or partially managed by the Portuguese State (Fig. 1a&b: 1, 7, 9–18, 20, 24). Moreover, many of them are currently classified as Natura 2000 sites (ICN 2006) by the European Commission (Fig. 1a&b: 1–3, 8, 10, 12, 18–19, 21–22, 24). The only known inventory of epiphytic lichen species in pine forests on sand dunes was generated by Catarino et al. (1985) in the framework of biomonitoring studies.

In the course of our investigations on the epiphytic lichens of these areas — particularly the well-preserved Dunas de Quiaios (Figueira da Foz) (Fig. 1a&b: 12) — new epiphytic lichen records were reported for the Iberian Peninsula (Rodrigues et al. 2007) and a new *Lecanora* species has been published (Rodrigues et al. 2011). These discoveries point to the importance of coastal

pine forests as habitats for lichens, which is an extra incentive to ensure their future preservation. At Dunas de Quiaios, the tree vegetation, rich in epiphytic lichens, is a planted *Pinus pinaster* forest mixed with *P. pinea, Acacia longifolia, A. melanoxylon,* and *Eucalyptus globulus*. *Arbutus unedo* and *Myrica faya* are also appropriate supports for lichens (Almeida 1997, Danielsen 2008, Rodrigues et al. 2007, 2011).

The aim of this work is to report three crustose and sorediate epiphytic lichens growing on *P. pinaster* and *P. pinea*, new to Portugal: *Chrysothrix flavovirens*, *Lepraria elobata* and *Ochrolechia arborea*. Data on their distribution along the Portuguese coast, secondary products, and ecology are also provided.

Materials & methods

Unless otherwise stated, all specimens were collected by the first author (SAR) on *P. pinaster* trunks in pine forests on sand dunes along the Portuguese coast (Fig. 1A&B, see also EXAMINED SPECIMENS). Samples were deposited in AVE, BG, and LEB herbaria. Distribution maps are based on UTM grid projection and coordinates of the locations are given in MGRS. Maps [A] and [B] represent the distribution along the Portuguese coast of *C. flavovirens*, and *O. arborea* respectively. The location where *L. elobata* was found [12] appears on both maps. Visited locations (indicated by numbers on each map) were geo-referenced using GoogleEarth and maps were plotted using ArcGis version 9.2.

Samples were analysed morphologically and chemically, with standard identification methods for lichenized fungi (Nash et al. 2001, Smith et al. 2009) and compared to authentic material deposited in BG herbarium. Morphology of the thallus was examined with a Leica MS5 stereomicroscope and anatomical observations of hand cut sections of apothecia were performed under a Leitz HM-LUX 3 microscope. For that, sections were mounted in distilled water and K/I and the latter was used for measuring anatomical characters. Chemical analyses followed standardized TLC methods (White & James 1985; Orange et al. 2001). Data regarding companion species were retrieved at Dunas de Quiaios (Fig. 1A&B: 12) during a small biomonitoring campaign, using the method proposed by Asta et al. (2002), in which 9 sampling units with 10 or 12 trees each were studied. Only *C. flavovirens* was detected using this method, and therefore it is the only species for which such data are provided. Only species present in each 10 × 10 cm quadrate where *C. flavovirens* was detected were considered as companion species.

The species

Chrysothrix flavovirens Tønsberg FIG. 1A

This common species is characterized by a vivid yellowish-green and leprose thallus, which is neither stratified nor lobed. The soralia are discrete to contiguous, forming an areolate or, more often, a thin to thick, continuous thallus. In our material, diffractaic and rhizocarpic acids and ± unidentified substances were detected. Fertile material was found at Mata do Camarido (Caminha) (Fig. 1A: 1). Fertile specimens had scattered and sessile apothecia,

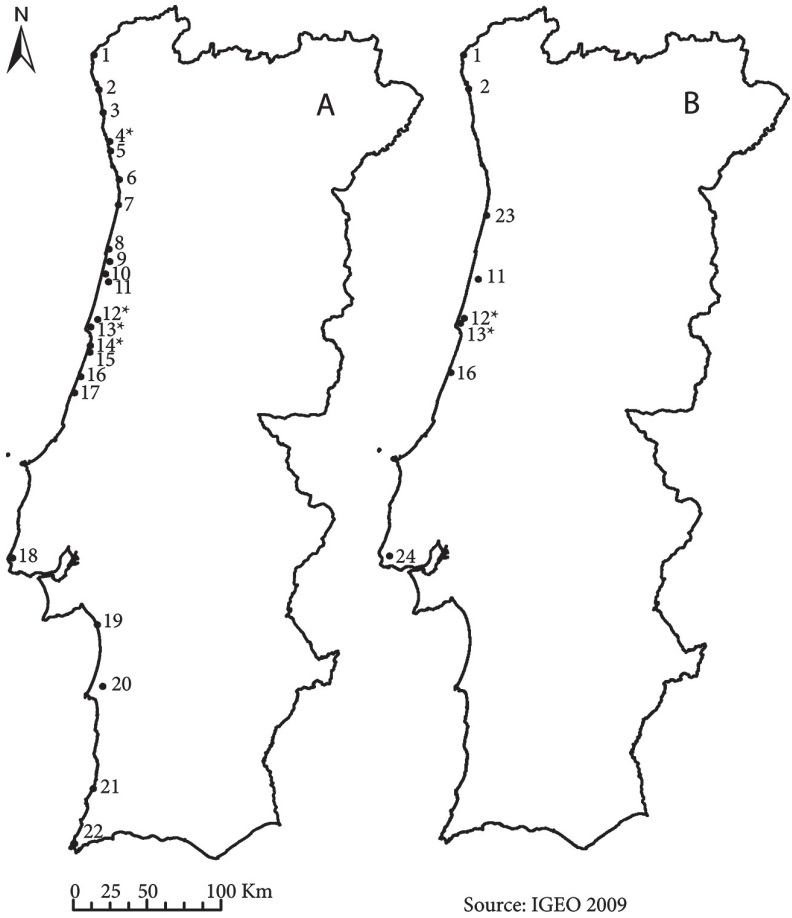

Fig. 1. Distribution of *Chrysothrix flavovirens* [A] and *Ochrolechia arborea* [B] along the Portuguese coast; *Lepraria elobata* [12] appears in both [A] and [B]. Dot numbers correspond to the localities shown in square brackets within the Specimens examined sections. Asterisks flag locations where the species were found on both *Pinus pinaster* and *P. pinea*.

which were 0.3–0.6 mm in diam. (n = 30), yellowish brown in colour, mostly rounded, convex and immarginate, but sometimes surrounded by soredia as also reported by Laundon (1981). Sections of the apothecia reacted K+ violet in the centre and intensified yellow at the border of the section. The epihymenium, hymenium, and hypothecium were constituted by anastomosing paraphysis, and reacted K/I+ blue. The epihymenium was 2.5–12.5 µm (n = 15) high, the hymenium 38–83.5 µm (n = 8) and the hypothecium 148.5–265 (n = 8). Asci were clavate, sometimes slightly curved, 23–40.5 × 8.5–14 µm (n = 14). Spores

were narrowly ellipsoid, some slightly curved, mostly 3-septate, 9.5–12.5 × 2–4 µm (n = 21), although some were found 2-septate and 1-septate, but of smaller sizes. Detailed descriptions can be found in Laundon (1981), Smith et al. (2009), and Tønsberg (1992).

Habitat and Distribution — *Chrysothrix flavovirens* may form large patches extending over a large part of the pine trunk or appear as small patches associated with other species. At Dunas de Quiaios (Fig. 1a: 12) it was found together mostly with *C. candelaris* (L.) J.R. Laundon, *Hypogymnia physodes* (L.) Nyl., and *Pyrrhospora quernea* (Dicks.) Körb. but also with *Usnea rubicunda* Stirt., *U. subscabrosa* Nyl. ex Motika, and *Flavoparmelia caperata* (L.) Hale, *Lecanora strobilina* (Spreng.) Kieff., *Parmotrema reticulatum* (Taylor) M. Choisy and *Trentepohlia* sp.

This species was frequently found in well-preserved to open coastal pine forests on sand dunes and also in localities with scanty pines, growing on *P. pinaster* and in some sites also on *P. pinea* (Fig. 1a, see also examined specimens). It was also collected in mountains near the coast at Serra da Boa Viagem (Figueira da Foz) (Fig. 1a: 13) and Serra de Sintra (Sintra) (Fig. 1a: 18). Elevations observed ranged from about 2 m at Dunas de Ofir/Fão (Esposende) (Fig. 1a: 3) to about 260 m at Serra de Sintra. Although *C. flavovirens* is widespread throughout the Atlantic and Mediterranean biogeographic regions of Portugal (ICN 2006), it was not found in surveys at a coastal pine forest in south-eastern Portugal, Dunas de Vila Real de Santo António (Vila Real de Santo António). This species, which is frequent and of which reports are increasing, is regarded as a preferentially coastal species of acidic bark (Laundon 1981 [as sorediate thalli of *C. chrysophthalma* (P. James) P. James & J.R. Laundon], Kowalewska & Jando 2004, Tønsberg 1992 [as sorediate thalli of *C. chrysophthalma*], Smith et al. 2009).

Chrysothrix flavovirens is widely distributed in Europe (Aptroot et al. 2003; Kowalewska & Jando 2004; Laundon 1981; Llimona & Hadlun 2001; Nimis & Martellos 2008; Smith et al. 2009; Søchting & Alstrup 2008; Sparrius et al. 2002; Suija et al. 2009; Tønsberg 1992, 1994) and is also known from North America (Richardson et al. 2009) and Asia (Kowalewska & Jando 2004). A very similar species recently described from eastern North America, *C. chamaecyparicola* Lendemer, is similar to *C. flavovirens* except that it lacks diffractaic acid (Lendemer & Elix 2010).

Specimens examined (square bracketed numbers refer to localities indicated in Fig. 1a): **PORTUGAL**. **Minho**: [1] **Caminha.** Moledo, Mata Nacional do Camarido, 29TNG1133, 14 m, 22.3.2009, *AVE-L 337, LEB-Lichenes 7810*. [2] **Viana do Castelo.** Chafé, Praia da Amorosa, 29TNG1510, 17 m, 5.9.2009, *AVE-L 380, LEB-Lichenes 7811*. [3] **Esposende**. Fão, Dunas de Ofir/Fão (Parque Natural do Litoral Norte), 29TNF1894, 2 m, 15.5.2009, *AVE-L 358*. **Douro Litoral**: [4] **Vila do Conde**. Mindelo, Reserva Ornitológica do Mindelo, 29TNF2275, 24 m, 25.6.2009, *AVE-L 376, LEB-Lichenes 7812;* id., on trunk of *Pinus pinea AVE-L 364*. [5] **Matosinhos**.

Angeiras, Parque de Campismo de Angeiras — in a small pine stand on sand dunes used for camping, 29TNF2368, 23 m, 15.5.2009, *AVE-L 366*. [6] **Vila Nova de Gaia**. Valadares — in an area with scanty pines, 29TNF2949, 24 m, 15.5.2009, *AVE-L 359*. **Beira Litoral:** [7] **Ovar**. Cortegaça, Dunas de Ovar, 29TNF2932, 8 m, 25.6.2009, *AVE-L 375, LEB-Lichenes 7813*. [8] **Aveiro**. S. Jacinto, Dunas de S. Jacinto (Reserva Natural das Dunas de S. Jacinto), 29TNF2302, 2 m, 23.4.2009, *AVE-L 349, LEB-Lichenes 7814*. [9] **Ílhavo**. Gafanha do carmo, Dunas da Gafanha, 29TNE2394, 13 m, 9.9.2009, *AVE-L 377, LEB-Lichenes 7815*. [10] **Vagos**. Gafanha do Areão, Dunas de Vagos, 29TNE2185, 21 m, 23.3.2009, *AVE-L 340*. [11] **Mira**. Seixo, Dunas de Mira, 29TNE2280, 24 m, 26.3.2009, *AVE-L 341, LEB-Lichenes 7816*. **Figueira da Foz**. [12] Quiaios, Dunas de Quiaios, 29TNE1654, 49 m, 4.9.2007, *AVE-L 383*; id., 29TNE1554, 49 m, 11.1.2007, *BG-L 88214, LEB-Lichenes 7817*; id., epiphytic on trunk of *P. pinea,* 29TNE1353, 45 m, 26.6.2009, *AVE-L 373*. [13] Serra da Boa Viagem, Mata do Prazo de Santa Marinha/Serra da Boa Viagem — in a pine forest in a mountainous area, 29TNE1149, 205 m, 26.6.2009, *AVE-L 371*; id., epiphytic on trunk of *P. pinea,* 29TNE1149, 200 m, 26.6.2009, *AVE-L 372*. [14] Costa de Lavos, Dunas da Leirosa, 29TNE1137, 21 m, 25.4.2009, *AVE-L 356, LEB-Lichenes 7818;* id., epiphytic on trunk of *P. pinea,* 29TNE1037, 16 m, 25.4.2009, *AVE-L 354, LEB-Lichenes 7819*. [15] Leirosa, Mata do Urso, 29TNE1132, 28 m, 25.4.2009, *AVE-L 352, LEB-Lichenes 7820*. [16] **Leiria**. Pedrógão, Mata do Pedrógão, 29SNE0416, 24 m, 25.4.2009, *AVE-L 344, LEB-Lichenes 7821*. **Estremadura:** [17] **Marinha Grande**. S. Pedro de Muel, Mata de Leiria, 29SNE0004, 49 m, 25.4.2009, *AVE-L 351*. [18] **Sintra**. Serra de Sintra, Ulgueira, Perímetro Florestal da Serra de Sintra (Parque Natural de Sintra Cascais) — in a pine forest in a mountainous area 29SMC5993, 260 m, 27.4.2009, *AVE-L 347*. **Baixo Alentejo:** [19] **Alcácer do Sal**. Comporta, Praia da Comporta, 29SNC1748, 24 m, 1.6.2009, *AVE-L 367*. [20] **Santiago do Cacém**. Relvas Verdes, Área Florestal de Sines, 29SNC2106, 75 m, 3.4.2009, *AVE-L 336*. **Algarve:** [21] **Aljezur**. Rogil, Praia de Vale dos Homens (Parque Natural do Sudoeste Alentejano e Costa Vicentina), 29SNB1537, 49 m, 30.5.2009, *AVE-L 370*. [22] **Vila do Bispo**. Sagres, Pinhal de Vale Santo (Parque Natural do Sudoeste Alentejano e Costa Vicentina) — epiphytic on branch of *P. pinaster*, 29SNB0300, 74 m, 31.5.2009 *AVE-L 369*.

Remarks — Recently separated as the sorediate counterpart of *C. chrysophthalma* (Smith et al. 2009, Tønsberg 1994), *C. flavovirens* may be confused with *C. candelaris*, which also occurs on pine trees in the study areas, but developing a more yellowish thallus with calycin (Elix & Kantvilas 2007, Laundon 1981). The chemical constitution of *C. flavovirens* (Elix & Tønsberg 2004, Laundon 1981, Tønsberg 1992) is variable, as Elix & Kantvilas (2007) refer to the presence of barbatic and conrhizocarpic acids, as well as epanorin, and the absence of atranorin in samples from the United Kingdom and Sweden.

Lepraria elobata Tønsberg

This species develops a diffuse, leprose, predominantly non-lobed and non-stratified, bluish-grey thallus, without medulla and with profuse more or less continuous fine soredia (Saag et al. 2009, Tønsberg 1992). Our sterile material of *L. elobata* contained atranorin, zeorin and stictic acid with satellites. Detailed descriptions are provided by Saag et al. (2009), Smith et al. (2009) and Tønsberg (1992).

Habitat and Distribution: Only one specimen of *L. elobata* was found epiphytic on *P. pinaster* bark at Dunas de Quiaios (Fig. 1a&b: 12), at an altitude of about 49 m, where it appears to be uncommon. This species occurs preferentiality on bark but is also known to grow on soil and siliceous rocks in shady and wet locations (Kukwa 2006). Regarding bark preferences, *L. elobata* seems to prefer deciduous to conifer trees (Saag 2007) and should be expected to occur in other habitats in Portugal.

Lepraria elobata is known from several European countries (Bayerová & Kukwa 2004, Boom et al. 1996, Coppins 2002, Czyżewska & Kukwa 2005, Diederich et al. 2009, Ekman & Tønsberg 2002, Feuerer 2009, Lukošienė & Naujalis 2009, Nimis & Martellos 2008, Osyczka & Stolarczyk 2005, Paz-Bermúdez et al. 2000, Prügger 2000, Tønsberg 1992) and North America (Saag et al. 2009, Tønsberg 2004).

Specimen examined - **PORTUGAL. Beira Litoral**: [Fig. 1a&b: 12] **Figueira da Foz**. Quiaios, Dunas de Quiaios, 29TNE1554, 49 m, 11.1.2007, *AVE-L 390, BG-L 88184.*

Remarks — *Lepraria nylanderiana* Kümmerl. & Leuckert is the most frequent *Lepraria* species at Dunas de Quiaios and is thought to be widespread in pine forests on sand dunes in the central west coast of Portugal. Both *L. elobata* and *L. nylanderiana* have a leprose, bluish-grey thallus, but *L. nylanderiana* has a delimited margin where minute lobes may appear in well-developed specimens. Also, *L. nylanderiana* usually has a whitish medulla, medium to coarse soredia, and thamnolic and roccellic acids and atranorin (Smith et al. 2009). *Lepraria elobata* is morphologically similar to *L. caesiella* R.C. Harris and *L. incana* (L.) Ach., which are differentiated chemically by the content in atranorin and zeorin, and divaricatic acid and zeorin, respectively (see Saag et al. 2009). Neither species has been found so far epiphytic on pine at Dunas de Quiaios.

Ochrolechia arborea (Kreyer) Almb. Fig. 1b

This species is characterized by a whitish grey, sorediate and thin thallus, which may be tuberculate in the centre. The soralia are mostly discrete and may be delimited and orbicular or more or less diffuse, rarely being confluent, but not covering the whole thallus (Boqueras et al. 1999, Tønsberg 1992). Our material was sterile and contained gyrophoric and lecanoric acids, lichexanthone (UV+ orange), and ± atranorin (Tønsberg 1992).

Habitat and Distribution — *Ochrolechia arborea* was found in localities along the western coast from Minho to Estremadura provinces (Fig. 1b, see also examined specimens) in Portugal's Atlantic and Mediterranean regions (ICN 2006). It was also found in mountainous locations at Serra da Boa Viagem (Figueira da Foz) (Fig. 1b, 13) and Serra de Sintra (Cascais) (Fig. 1b: 24),

having been recorded at altitudes up to 205 m at Serra da Boa Viagem. Most specimens were found on *P. pinaster*, but some were also found on *P. pinea*. Contrary to *C. flavovirens*, *O. arborea* is not restricted to maritime habitats and has been reported from inland countries such as Switzerland (Diederich & Sheidegger 1996) and Mongolia (Hauck & Javkhlan 2006). It is expected to occur in inland Portugal on a wide variety of phorophytes as reported in the literature (Boqueras et al. 1999, Christensen & Svane 2007, Kukwa 2009, Tønsberg 1992). The species has been noted as typical of shady habitats or soft barks (Johansson et al. 2007).

Ochrolechia arborea is currently known from several European countries (Andrianova et al. 2006, Boqueras et al. 1999, Brodo 1991, Christensen & Svane 2007, Coppins 2002, Diederich et al. 2009, Dietrich & Scheidegger 1996, Farkas et al. 2009, Feuerer 2009, Jabłońska & Kukwa 2007, Kukwa 2009, Liška et al. 2008, Nimis & Martellos 2008, Prügger 2000, Roux et al. 2008, Søchting & Alstrup 2008, Tibell 1992, Tønsberg 1992). It is also known from North and South America (Brodo 1991) and Asia (Hauck & Javkhlan 2006, John & Nimis 1998, Koneva 2007).

Specimens examined (square bracketed numbers refer to localities indicated in Fig. 1b): **PORTUGAL**. **Minho:** [1] **Caminha**. Moledo, Mata Nacional do Camarido, 29TNG1133, 15 m, 17.5.2009, *AVE-L 320, LEB-Lichenes 7822*. [2] **Viana do Castelo**. Chafé, Praia da Amorosa, 29TNG1510, 20 m, 17.5.2009 *AVE-L 323, LEB-Lichenes 7823*. **Beira Litoral:** [23] **Ovar**. Furadouro, 29TNF2823, 9 m, 23.3.2009 *AVE-L 310*. [11] **Mira**. Seixo, Dunas de Mira, 29TNE2280, 24 m, 26.3.2009, *LEB-Lichenes 7824*; id., on a branch of *Pinus pinaster,* 29TNE2280, 24 m, 26.3.2009, *AVE-L 312*. **Figueira da Foz**. [12] Quiaios, Dunas de Quiaios, on a branch of *P. pinaster,* 29TNE1353, 42 m, 14.4.2006, *AVE-L 389*; id., epiphytic on trunk of *P. pinea,* 29TNE1758, 49 m, 26.6.2009, *AVE-L 326, LEB-Lichenes 7825*. [13] Serra da Boa Viagem/ Mata do Prazo de Santa Marinha/Serra da Boa Viagem — in a pine forest in a mountainous area, 29TNE1149, 205 m, 26.6.2009, *AVE-L 328*; id., on trunk of *P. pinea,* 29TNE1149, 200 m, 26.6.2009, *AVE-L 324*. [16] **Leiria**. Pedrógão, Mata do Pedrógão —on a branch of *P. pinaster,* 29SNE0416, 24 m, 25.4.2009, *AVE-L 315*. **Estremadura:** [24] **Cascais**. Serra de Sintra, Penha Longa, Perímetro Florestal da Penha Longa (Parque Natural de Sintra Cascais) — in a pine forest in a mountainous area, on a branch of *P. pinaster,* 29SMC6490, 149 m, 27.4.2009, *AVE-L 317*.

Remarks — In our study area, *O. arborea* specimens growing on branches frequently developed roundish and delimited soralia, while those on trunks often generated confluent soralia. Orsellinic acid, detected in Spanish specimens (Boqueras et al. 1999), was not found in our material. *Ochrolechia microstictoides* Räsänen is another very common species in pine forests on sand dune areas in the centre of Portugal. This species, which has confluent soralia towards the centre of the thallus that give it a leprose appearance, contains variolaric and lichesterinic acids (Tønsberg 1992).

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