

## *Llimonaea sorediata*, a new lichen (Ascomycota), widely distributed in western Europe

P. P. G. van den BOOM and A. M. BRAND

**Abstract:** The first soreciate species in the genus *Llimonaea*, *L. sorediata* is described from coastal areas of western Europe. This new species is easily mistaken for *Dirina massiliensis* f. *sorediata* with which it often co-occurs. It grows on vertical or overhanging acidic cliffs. Fertile specimens were recently collected in Portugal. A description of the species together with notes on distribution, ecology and chemistry are provided and a key to the species of *Llimonaea* is also provided.

**Key words:** *Arthoniales*, coastal habitats, corticolous, saxicolous, species nova, *Trentepohlia*

### Introduction

A detailed survey of lichens and lichenicolous fungi in western Portugal on a small rocky hill (São Bartolomeu) led to the discovery of several new records for the country (van den Boom 2006). One fertile soreciate specimen was identifiable only to genus level. Its hyaline, halonate ascospores, which become brown with age, in combination with immersed to semi-immersed,  $\pm$  roundish apothecia and richly branched and anastomosed paraphysoids, indicated that it belonged to the recently described *Llimonaea* Torrente & Egea, a genus easily mistaken for *Lecanographa* (Torrente & Egea 1991). According to Egea & Torrente (1994). *Llimonaea* shows affinities with the family *Roccellaceae*, however the genus *Llimonaea* is currently placed in the *Arthoniales* incertae sedis (Eriksson 2006). According to the key to the species of *Llimonaea* (Sparrius 2004) there are four known species, all of which are non-soreciate. Following the discovery of the fertile material from Portugal, several additional specimens were located in the herbarium of the second

author. These specimens were collected in recent years from several coastal localities in western Europe, including Ireland, Brittany (France), north-western Spain and western Portugal. Additional material from southern England which had the unpublished name *Dirina* 'zonata', was sent to us. One sterile corticolous species from California (USA) appears to be related to this new taxon.

### Material and Methods

This study is based on lichen specimens collected recently by A. M. Brand and P. P. G. van den Boom and herbarium material from E and MUB. Microscopic measurements of ascospores, hyphae, algae, etc. were made in water at  $\times 400$  or  $\times 1000$  magnification. Amyloid reactions were examined using Lugol's iodine solution (K/I). The secondary metabolites present in most specimens were identified by TLC (Culberson & Ammann 1979; Culberson & Johnson 1982; Elix & Ernst-Russell 1993) and/or by HPLC (Elix *et al.* 2003).

*Additional comparative specimens examined.* *Llimonaea occulta* Egea & Torrente. **Portugal:** Estremadura: Sintra, Cabo da Roca, 20–140 m, 1987, *Egea* 13619 (MUB, hb. v.d. Boom).

*Llimonaea californica* (Tuck.) Sparrius. **USA:** California: Monterey, Pacific Grove, Ocean View Blvd., coastal area from Berwick Park to Lovers Point, granite outcrops and *Cupressus* trees, on *C. macrocarpa*, 10 m, 2002, P. & B. van den Boom 29276 (hb. v.d. Boom); San Luis Obispo, S of Morro Bay, State Park road, N of Museum of Natural History, mature trees at beach side, on *Cupressus macrocarpa*, c. 2 m, 2002, P. & B. van den Boom 29477 (hb. v.d. Boom).

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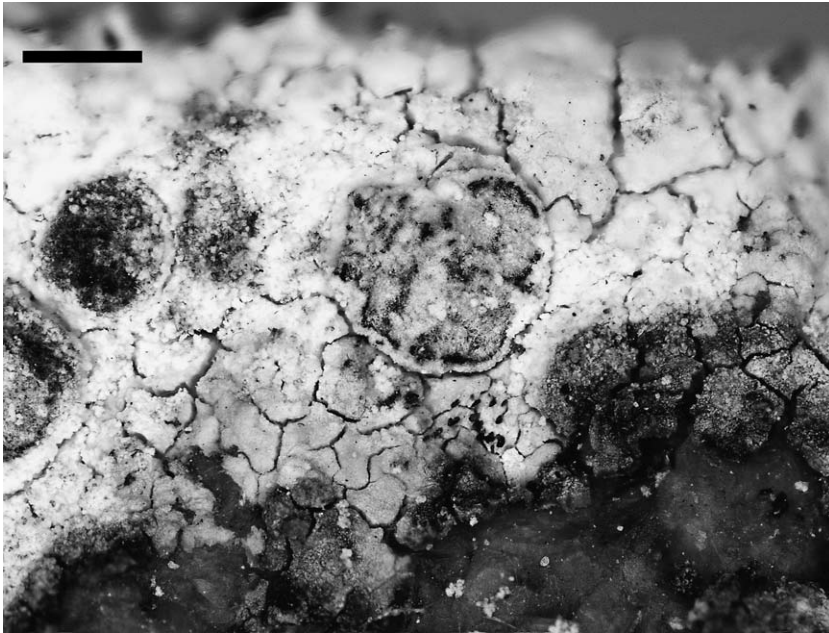


FIG. 1. *Llimonaea sorediata*, habitus with apothecia (holotype). Scale=0.5 mm.

### Taxonomy

#### *Llimonaea sorediata* van den Boom, M. Brand & Elix sp. nov.

Thallus saxicola, crustaceus, corticatus, soralia formans, albus, prothallo fusco vel nigrocinctus, areolatus, areolis angulatis, isodiametris 0.1–0.5 mm latis vel elongatis magnitudine ad 0.15 × 0.4 mm; soralia punctiformia vel confluentia, farinosa; algae ad *Trentepohlias* pertinetes. Ascomata immersa vel subimmersa, dendritica, 1 mm diam. vel ellipsoidae 0.8–1.2 × 0.4–0.7 mm, marginibus thallinis instructa, disco nigro, pruinoso. Paraphysoides ramosae et anastomosantes, 1.5–2.5 µm crassae. Asci cylindrici vel subclavati, 50–80 × 10–20 µm, octospori, ascosporis elongate fusiformibus 35–50 × 4.5–5.5(–6) µm (sine perispora), 8–14-septatis, septis incrassatis, primum hyalinis, demum brunneis, perispora gelatinoso. Pycnidia non visa. Thallus atranorinum, erythrinum, isoerthyrium et acida lecanorinum et placodiolicum, continens.

Typus: Portugal, Estremadura, E of Nazaré, São Bartolomeu, on top of small rocky hill, on E exposed overhanging outcrops, 9°03.7'W 39°35.5'N, 150 m, 15 July 2001, P. & B. van den Boom 27645 (LG—holotypus; hb. v.d. Boom—isotypus).

(Figs 1 & 2)

*Thallus* crustaceus, forming delimited circular patches up to 3.5 cm wide, areolate

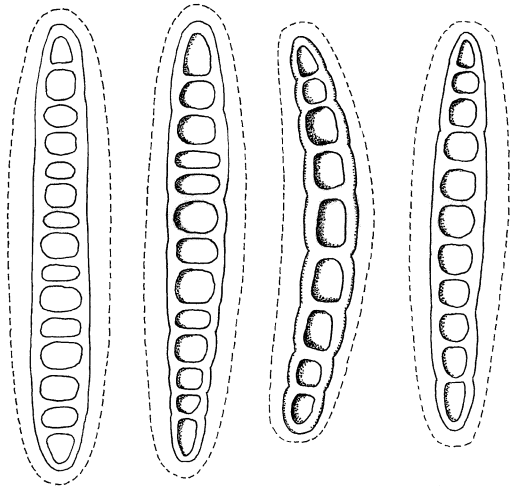


FIG. 2. *Llimonaea sorediata*, ascospores (holotype). Scale=10 µm.

to rimose areolate; areoles angular, 0.1–0.5 mm wide, or elongate and up to 0.15 × 0.4 mm, somewhat radiating, rather thin, up to 0.25(–0.3) mm thick, sorediate; upper surface smooth to slightly uneven, pale cream, to creamy white, sorediate parts pure

white, slightly brightish pink when fresh. *Soralia* initially punctiform and discrete, developing from the edge or on top of the areoles, soon becoming confluent, forming a farinose thallus in the centre; soredia 25–35 µm diam., containing 1 or a few algal cells of *c.* 12(–15) µm diam. and loose, thin, intricate hyphae. *Cortex* not well developed, with intricate hyaline hyphae; epinecral layer not developed; surface layer *c.* 15 µm thick, without algae, hyaline, except at the top where the hyphae are pale brownish pigmented, homogeneously filled with many crystals (erythrin) which are also abundantly present in the soredia. *Medulla* mostly completely filled with algae and intricate, elongate, smooth, 2.5–3.5 µm thick hyphae; *Photobiont Trentepohlia*, cells roundish, up to 12(–15) µm diam. or ellipsoid and up to 20 × 12 µm. *Prothallus* nearly always present, conspicuous, visible as a thick, dark brown to blackish rim around the thallus.

*Apothecia* immersed to semi-immersed, roundish and up to 1 mm diam. or ellipsoid and 0.8–1.2 × 0.4–0.7 mm. *Thalline margin* level with disc, concolorous with the thallus, thin, 0.03–0.07 mm wide, often flexuose and deformed, soon excluded, interspersed with crystals. *Disc* plane to often uneven, dark brown to black, whitish pruinose. *Proper exciple* up to 80 µm wide laterally, continuous with the apothecial base, dark brown to blackish, hyphae with strongly gelatinized walls, inner part brownish-olive pigmented. *Epihymenium* mid-brown and slightly olive pigmented in the lower part, K+ greenish intensifying, abundantly interspersed with hyaline crystals. *Hymenium* hyaline, 110–140 µm. *Hypothecium* dark brown, up to 25 µm high, continuous with the excipulum. *Paraphysoids* richly branched and anastomosing, 1.5–2.0 µm wide, apical cells not widened nor pigmented. *Asci* cylindrical-clavate, fissitunicate, 8-spored, 50–80 × 10–20 µm, of *Grumulosa*-type (Torrente & Egea 1989). *Ascospores* elongate-fusiform, rarely slightly curved, 35–50 × 4.5–5.5(–6) µm (excluding perispore), 8–14-septate, hyaline when young, mature spores often brownish pigmented (especially the outer wall), thick-walled, with thickened

septa and usually with a perispore, up to *c.* 2 µm thick.

*Pycnidia* not seen.

*Chemistry.* Thallus C+ red, K–, KC–, P–. Erythrin (major), isoerythrin (minor), lecanoric acid (trace), placodiolic acid (trace), atranorin (trace), determined by TLC in solvent C & HPLC.

*Distribution and ecology.* *Llimonaea sorediata* is known from five countries along the Atlantic coast in western Europe (Ireland, England, France, Spain and Portugal). In Portugal (type locality) it was not relocated two years later (2003), during a second visit to the same locality by the first author. During a visit to that locality by the second author in 2003, only sterile material of the new species was collected.

The new species is found mainly on vertical to overhanging cliffs in coastal areas, on acidic outcrops in west-exposed situations, and more rarely on rock walls and on one occasion, on a very old *Quercus* tree.

At the type locality, associated species growing close to *L. sorediata*, included *Buellia leptoclinoides* (Nyl.) J. Steiner, *Dirina massiliensis* Durieu & Mont. s.str., *D. massiliensis* f. *sorediata* (Müll. Arg.) Tehler, *Peterjamesia circumscripta* (Taylor) D. Hawksw. and *Rinodina beccariana* Bagl. s.lat. In some localities in France, additional associated species were *Diploicia canescens* (Dicks.) A. Massal., *Ramalina lacera* (With.) J. R. Laundon and *Rocella phycopsis* (Ach.) Ach. In one French locality the new species was found on a very old *Quercus* together with *Arthonia pruinata* (Pers.) Steud. ex A. L. Sm., *Cresponea premnea* (Ach.) Egea & Torrente, *Opegrapha atra* Pers., *O. varia* Pers. and *O. viridis* (Ach.) Nyl. In a collection of *Llimonaea occulta* Egea & Torrente from Portugal, Cabo da Roca (Egea 13633), *L. sorediata* was found together with *Lecanographa wernerii*. This specimen of *L. sorediata* was also fertile, with three apothecia. *Peterjamesia sorediata* (Sparrius, P. James & M. A. Allen) D. Hawksw. has also been found as an accompanying species but is easily mistaken for *L. sorediata*, although the

former differs chemically, as it contains only psoromic acid.

*Notes.* The relationship of the genus *Llimonaea* with genera such as *Dirina*, *Lecanactis*, *Lecanographa* and *Peterjamesia* (syn. *Sclerophyton*) is treated in Torrente & Egea (1991). *Llimonaea sorediata* can easily be mistaken for *Dirina massiliensis* f. *sorediata*. Both taxa have been found growing side by side and forming mosaics in most of their habitats. The thalli of both species are generally sterile and sorediate, initially with punctiform soralia but then becoming completely sorediate. When growing on acidic rocks the *Dirina* even has a somewhat paler brown prothallus (but not on calcareous rock). In contrast to *L. sorediata*, the thallus of *D. massiliensis* f. *sorediata* is not pure white, but pale brownish cream to pale cream, the soralia are not clearly white, and the thallus is generally much thicker (0.6–1.6 mm). The soralia in the *Dirina* are larger, 0.5–1.8 mm wide, level with the thallus, or slightly excavate and irregularly confluent; the soredia are grey to brown and 30–40 µm diam. The areoles of the *Dirina* are wider, 1.0–2.0 mm wide and more knobby. Mature apothecia in *D. massiliensis* f. *sorediata* have only rarely been observed, but aborted apothecia are not rare. Pycnidia are sometimes present in the *Dirina* but were not found in *L. sorediata* (all specimens were carefully checked). The apothecia of *L. sorediata* resemble those of *Lecanographa werneri* (Faurel, Ozenda & Schotter) Egea & Torrente, and even the ascospores are somewhat similar. However the thallus of *L. werneri* is smooth to uneven rugose, not sorediate, thicker and darker cream with a more brownish tinge in comparison to *L. sorediata*.

So far, two chemical profiles have been reported for the genus *Llimonaea*, erythrin with lecanoric acid (in *L. occulta*) and 'lecanoric/gyrophoric acids' in *L. flexuosa* Egea, Torrente & Mies (Egea *et al.* 1995). Additional metabolites have now been detected including isoerythrin, placodiolic acid and atranorin. There is also a remarkable chemical similarity between *L. sorediata*

and *Dirina massiliensis* f. *sorediata*, as both species contain erythrin, isoerythrin, lecanoric acid and atranorin in very similar proportions.

In south-western USA, a sterile *Llimonaea* specimen has been found at Pacific Grove (Monterey) in a coastal area, on the bark of *Cupressus macrocarpa* where it forms a mosaic with *Lecanographa subdriophila* (Follmann & Vězda) Egea & Torrente. A second specimen from that area has been found associated with *Arthonia pruinata*. Anatomically the American material is identical with the European collections of *L. sorediata*, however their chemistry differs (with lecanoric acid as the major component). This most probably represents an undescribed taxon but further study and fertile material is required.

*Specimens of Llimonaea sorediata examined:* **Ireland:** *Connemara:* 13 km ENE of Clifden, near NW end of Kylemore Lough, on vertical to overhanging schistose rocks, shaded by trees, 9°52.2'W 53°33.6'N, 2000, *M. Brand* 40648 (hb. Brand).—**British Isles:** *England:* **V. C. 9** Dorset, Isle of Portland, N of Rufus Castle, Penn's Weare, 30(SY)69.71, on underside of a large boulder, 2005, *B. J. Coppins* 22103, *B. Edwards & V. J. Giavarini*(E).—**France:** *Manche:* Cotentin, 13 WNW of Cherbourg, Gruchy, Rocher du Castel-Vendon, 1°46.9'W 49°40.9'N, NW-exposed overhanging granite rock, high above sea, 1997, *M. Brand* 36117 (hb. Brand); *ibid.*, 10 km WNW of Cherbourg, Urville-Nacqueville, Manoir Dur Ecu, 1°45.2'W 49°40.6'N, on very old *Quercus* in yard of mansion, 1997, *M. Brand* 36089 (hb. Brand); *ibid.*, 2 km SE of Fermanville, Carneville, 1°26.6'W 49°40.2'N, on N-exposed granite of wall of house, 1997, *M. Brand* 36050 (hb. Brand); *ibid.*, 10 km ENE of Cherbourg, Pointe du Brick, 1°29.5'W 49°40.2'N, on NE-exposed vertical and overhanging granite rock above shore, 1997, *M. Brand* 36072 (hb. Brand). *Seine-Maritime:* 2 km SE of St. Valery-en-Caux, Manneville, 0°45'W 49°51'N, church in village, on brick, 1999, *M. Brand* 37795 (hb. Brand); 10 km S of Granvilles, Carolles, N of Cabane Vauban, 1°34'W 48°44'N, on steep W-exposed granite above sea, 1996, *M. Brand* 33977 (hb. Brand). *Finistère:* 6 km W of St Pol de Leon, Sibiril, Manoir de Kérouzère, 4°3.8'W 48°40.2'N, on *Quercus* in forest at N edge, 1997, *M. Brand* 36341 (hb. Brand); Crozon Peninsula, Roscanvel, headland 0.3 km N of Anse de Fraternité, N-exposed slope, on overhanging quartzitic rock, 1997, *M. Brand* 36598b (hb. Brand); *ibid.*, Pointe de Penhir, 4°36.9'W 48°15.5'N, on quartzite rock, overhang on E slope, 1978, *M. Brand* 30575 (hb. Brand); *ibid.*, Pt. de Dinan, Château de Dinan, 4°34.2'W 48°14.1'N, 1996, *M. Brand* 34705 (hb. Brand); N of Pointe du Raz, Pointe du Van (N



side), 4°42.6'W 48°03.8'N, 1997, *M. Brand* 36867 (hb. Brand); 10 km SE of Concarneau, Pointe de Trévignon, 3°51.2'W 47°47.4'N, on coarse granite on W-exposed overhanging coastal rock, 1999, *M. Brand*, 38585 (hb. Brand). *Côtes Armor*: Perros-Guirec, N-coast, W of Sphinx, 3°26.5'W 48°49.1'N, 1996, *M. Brand* 34186 (hb. Brand); 16 km W of st. Malo, Pointe de St. Cast, 0.5 km E of P. de la Corbière, 2°14.9'W 48°38.6'N, migmatite of low N-exposed overhanging rock, 1999, *M. Brand* 38857 (hb. Brand); 2 km SSE of Concarneau, coastal area 1 km SE of Pointe de Cabellou, 3°54.6'W 47°51'N, coastal slope, underside of large block of granite, 1999, *M. Brand* 38597 (hb. Brand).—**Spain**: *Cantabria*: Pechon, mouth of Rio Deva, overhanging sandstone rocks at shore, 2003, *M. Brand* 48762b (hb. Brand). *Lugo*, Faro de Roncadoiro, E side, NE vertical steep rock face, 2003, *M. Brand* 49111b (hb. Brand). *Galicia*: c. 48 km W of La Coruña, 0.5 km NE of Punta Roncudo, granite on gentle NE slope above sea, vertical side of N-exposed standing

rocks, 2003, *M. Brand* 49232b (hb. Brand).—**Portugal**: *Estremadura*: Sintra, Cabo da Rocha, on volcanic rock, 20–140 m, 1987, *J. Egea* 13633b (MUB, hb. v.d. Boom); *ibid.*, S side of cape, vertical sides of large blocks of rock, on ridge, 30 ix 2003, *M. Brand* s.n. (hb. Brand); E of Nazaré, São Bartolomeu, on top of small rocky hill, on E-exposed coarse overhanging granite, 9°03.7'W 39°35.5'N, 150 m, 2001, *P. & B. van den Boom* 26968, 26971 (hb. v.d. Boom); *ibid.*, 2003, *M. Brand* 49642 (hb. Brand).

*Specimens of Llimonaea sp. examined. USA: California*: Monterey, Pacific Grove, S of Ocean View Blvd., near lighthouse, coastal area with scattered *Cupressus macrocarpa* trees, on *C. macrocarpa*, 2002, *P. & B. van den Boom* 29333 (hb. v.d. Boom); *ibid.*, Ocean View Blvd. coastal area from Berwick Park to Lovers Point, granite outcrops and scattered *Cupressus macrocarpa* trees, on *C. macrocarpa*, 2002, *P. & B. van den Boom* 29567 (hb. v.d. Boom).

**Key to the species of *Llimonaea***

- 1 Thallus soredate . . . . . 2
- Thallus not soredate . . . . . 3
- 2(1) Thallus containing erythrin (major); apothecia rare, immersed; mostly saxicolous, occasionally corticolous (western Europe) . . . . . **L. soredata**
- Thallus containing lecanoric acid (major); apothecia unknown; corticolous (south-western USA) . . . . . **L. sp.**
- 3(1) Apothecia lirelliform to dendritic (Cape Verde) . . . . . **L. flexuosa**
- Apothecia roundish, short lirelliform, or forming lecanorine apothecia . . . . . 4
- 4(3) Ascospores 6–10-septate, occasionally submuriform; apothecia lirelliform (south-western USA to north-western Mexico) . . . . . **L. cerebriformis**
- Ascospores with 4–7 transverse septa; apothecia lecanorine . . . . . 5
- 5(4) Thallus yellow; excipulum 15–25 µm wide laterally; saxicolous and corticolous (south-western America) . . . . . **L. californica**
- Thallus whitish; excipulum 25–40 µm wide laterally; saxicolous (western Europe, northern Africa) . . . . . **L. occulta**

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