

## A synopsis of *Lichenostigma* subgen. *Lichenogramma* (*Arthoniales*), with a key to the species

Vicent CALATAYUD<sup>1</sup>, Pere NAVARRO-ROSINÉS<sup>2</sup> and Josef HAFELLNER<sup>3</sup>

<sup>1</sup>Fundación Centro de Estudios Ambientales del Mediterráneo, Charles R. Darwin 14, ES-46980 Paterna, València, Spain.

<sup>2</sup>Departament de Biologia Vegetal (Botànica), Facultat de Biologia, Universitat de Barcelona, Diagonal 645, ES-08028 Barcelona, Spain.

<sup>3</sup>Institut für Botanik, Karl-Franzens-Universität, Holteigasse 6, A-8010 Graz, Austria.

E-mail: vicent@ceam.es

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A synopsis of the subgenus of lichenicolous fungi *Lichenogramma* is presented. It comprises eight species of *Lichenostigma* with oval to elongate ascomata connected to superficial strands of vegetative hyphae. Five of them are described here as new: *Lichenostigma diploiciae* (on *Diploicia subcanescens*); *L. epipolina* (on *Diplotomma epipolium*); *L. gracilis* (on *Acarospora fuscata*); *L. rouxii* (on *Squammarina* spp.); and *L. subadians* (on *Acarospora* spp., mainly subgen. *Acarospora*). The concept of the genus *Lichenostigma* is enlarged to accommodate also species with submuriform ascospores. A key to all the species of the subgenus is provided.

### INTRODUCTION

The generic name *Lichenostigma* was introduced by Hafellner (1982) for the single species *Lichenostigma maureri* (on *Pseudevernia furfuracea*, *Usnea* spp., and other fruticose epiphytic lichens), a lichenicolous fungus with rounded ascomata, fissitunicate asci, without hamathecial filaments but with  $\pm$  spherical cells filling the interascal spaces, and with 1-septate, brown ascospores. Two further species with similar rounded ascomata, *L. rugosa* on *Diploschistes* spp. (Thor 1985), and *L. hyalospora* on *Haematomma eremaeum* (Kalb, Hafellner & Staiger 1995), were subsequently described. Whereas *L. rugosa* was differentiated from the type species by its fissured spore wall, hyaline ascospores were distinctive of *L. hyalospora* with regard to the other species known at that time. Afterwards, Navarro-Rosinés & Hafellner (1996) established subgen. *Lichenogramma* for *L. elongata* (on *Aspicilia* and *Lobothallia* spp.), a taxon characterized by elongate ascomata and conspicuous, dark superficial plurihyphal strands. These authors also discussed the linguistic basis for the female gender of the generic name. More recently, two other species, but having mostly simple hyphal strands, have been referred to this subgenus: *L. semiimmersa* on thalli of *Buellia elegans* (Hafellner 1999) and *B. zoharyi* (Trinkaus & Mayrhofer 2000), both species of the *B. epigaea* group, and

*L. cosmopolites* on *Xanthoparmelia* spp. (Hafellner & Calatayud 1999). In *L. cosmopolites*, the asci showed an amyloid ring (*Arthonia*-type), and a conspicuous I+ orange-red hemiamyloid reaction in the centrum, features not observed in the other species. The occurrence of this type of ascus confirmed the inclusion of the genus *Lichenostigma* in the *Arthoniales* (Hafellner & Calatayud 1999). Therefore, the genus *Lichenostigma* currently comprises species with the following combination of characters: ascomata rounded or elongated, connected or not to superficial, black, simple or plurihyphal vegetative strands, interascal spaces filled with  $\pm$  spherical cells, centrum I+ or I–, asci subglobose to broadly obovate, fissitunicate, and ascospores 1-septate, hyaline or brown.

*Lichenothelia* species resemble *Lichenostigma* by having similar pseudoparenchymatous (stromatic) ascomata. The genus *Lichenothelia* was established by Hawksworth (1981) for two saxicolous species: *L. scopularia* and *L. metzleri*. In contrast to *Lichenostigma*, these two species have cushion-like to  $\pm$  apothecioid ascomata, asci produced in a hymenium-like layer, and filiform interascal filaments. In *Lichenostigma* the ascomata are never apothecioid, and the asci are scattered within pseudoparenchyma of the stromatic ascomata, interascal filaments being lacking. However, Henssen (1987) described 18 new species and enlarged the concept of *Lichenothelia* to include also

taxa with non-apothecioid ascomata, without interascal filaments but with the interascal cavity filled with pseudoparenchymatous cells, and frequently producing thallus-borne macroconidia. Since several of these species (*L. convexa* pro parte, *L. patagonica* pro parte, and *L. tenuissima* pro parte) are said to grow on lichens, it is possible that a few unrecognized *Lichenostigma* species are hidden among this material (Hafellner & Calatayud 1999).

In the course of our studies on *Lichenostigma*, five new species have been discovered, all of them belonging to subgen. *Lichenogramma*. This study provides a synopsis of this subgenus, including a key to all the known species. The inclusion of a species with submuriform ascospores enlarges the circumscription of the genus.

## MATERIALS AND METHODS

Hand sections of the material were mounted in water, Lugol's Iodine solution (I), 10% diluted KOH (K), and lactophenol cotton blue, and examined by conventional and DIC microscopic techniques. K/I indicates the application of Lugol's after diluted KOH. Most of the microscopic photos were taken with DIC, and the figures were made with the help of a drawing tube fitted to the microscope. All measurements were made in water. For the ascospores, the range given outside parentheses was calculated after rejecting 10% of the highest and 10% of the lowest values measured (both for the length and the width), the averages are given in italics and the extremes within parentheses. A superscript L<sup>(L)</sup> indicates that the specimen is stored in the mentioned herbarium under the name of the host.

## THE SPECIES

***Lichenostigma cosmopolites*** Hafellner & Calatayud, *Mycotaxon* 72: 108 (1999).

*Type: Spain: Prov. Valencia: Serra Calderona, Puçol, El Picaio, UTM 30SYJ3091, 350 m, sobre arenisca, on Xanthoparmelia tinctoria, 26 Feb. 1992, V. Calatayud 7982 (VAB-holotype).*

*Illustrations:* Hafellner & Calatayud (*loc. cit.*: 109 fig. 1 – surface view, vegetative hyphae, ascoma, asci, ascospores)

*Vegetative hyphae* partly superficial, spreading over the host thallus and rarely also on the apothecial discs, single stranded, dark brown, septate ramified to net-like, hyphae connecting also the ascomata, slightly constricted at the septa, hyphal cells 6–8(–10) × (4–)5–7 µm, upper surface sculptured, sculptural elements punctiform, less than 1 µm in diam, sometimes with short longitudinal rows, additional deeper cracks sometimes present. *Ascomata* superficial, scattered subglobose to ellipsoid, dark brown to black, rough but without setae, 60–100 × 30–45 µm, opening apically with roundish to irregular ruptures; in section, outermost cells brown, subglobose, 5–7 µm diam, covered by a granular brown

pigment (from the outside cells of ascomata wall with punctiform sculpture), internal cells hyaline, subglobose, 3–6 µm diam, filling up the ascomata. Centrum usually I+ orange-red, K/I+ blue. *Asci* about 4–8 per ascoma, broadly clavate to obovate, 15–20 × 12–15 µm, fissitunicate of *Arthonia*-type, ascal wall apically thickened, 8-spored, ascus wall K/I+ bluish around the apex of the ocular chamber but this reaction difficult to see in mature asci. *Ascospores* hyaline, sometimes brown with age, 1-septate, lower cell slightly narrower than upper cell, often guttulate, young ascospores with prominent perispore forming a halo, perispore sheath later condensing and forming a fine punctiform sculpture on the surface of the spore wall, 8–9.1–10(–11) × 3–3.8–4(–5) µm, length/width ratio ca 2.4. *Anamorph:* Unknown.

*Life form:* Lichenicolous on the thallus and occasionally on the apothecia of *Xanthoparmelia* spp. Recently, we have examined similar collections on *Rimelia* and *Flavoparmelia*. They merit a critical study based on better developed material.

*Comments and affinities:* This species has superficial, ramified to net-like, single stranded vegetative strands spreading over the thallus (rarely on the apothecia) of *Xanthoparmelia* species. Also distinctive features are its I+ orange-red centrum, and its relatively small ascospores. It must not be confused with a much more rare undescribed *Sphaerellothecium* species restricted to the apothecial discs of the same host genus: it has a different ascomatal structure, not ornamented hyphae immersed in the host hymenium, and a I– centrum. *Echinothecium reticulatum*, the name under which *L. cosmopolites* has been most frequently reported, has ascomata with septate seta-like hyphae and seems to be restricted to *Parmelia* s. str. Other *Lichenostigma* species with vegetative strands mostly formed by a single row of cells are *L. semiimmersa* and *L. epipolina*. In both species, the ascospore size is different, the centrum of the ascomata is I– or only slightly red, and they have a different host selection.

*Habitat and distribution:* Widespread in extratropical regions of both hemispheres (Europe, Asia, Africa, North America, South America, Australia); in temperate regions mainly in the lowlands, in tropical regions only from mid elevations upwards.

***Lichenostigma diploiciae*** Calatayud, Nav.-Ros. & Hafellner, *sp. nov.* (Figs 1–11, 45)

*Etym.*: The specific epithet refers to the host genus.

*Lichenostigma elongata* similis, praecipue differt sporis postremo submuriformibus.

*Type: Spain: Andalucía: Prov. Almería, Cabo de Gata, San José, Playa de Monsul, UTM 30SWF7565, on Diploicia subcanescens, on volcanic rocks, alt. 15 m, 16 Sept. 2000, leg. V. Calatayud & C. Trescoli (BCC-Lich. 13811 – holotypus, GZU, h. Calatayud 73 – isotypi, 20 other isotypes to be distributed in Triebel, Microf. Exs. no. 0816).*



*Vegetative hyphae* superficial, forming black patches on the surface of the host; strands irregularly disposed or, frequently, grouped and with a loosely radial arrangement; then, more densely clustered in the central part of each group, where the ascomata evolve, and becoming more separated among them and  $\pm$  radiating towards the margins (Figs 1–2). Strands simple or scarcely ramified, about (50–)100–250(–400)  $\mu\text{m}$  long and about (9–)10–16(–20)  $\mu\text{m}$  thick, formed by (1–)2–5 rows of cells, paraplectenchymatic (stromatic) in section (Figs 3–4). Additional vegetative hyphae penetrating into the host thallus, hyaline. *Ascomata* black, superficial, subglobose to elongated, recognizable as thickenings of the hyphal strands, 50–80  $\times$  40–65  $\mu\text{m}$ , frequently in groups evolving in the center of  $\pm$  radially disposed strands of vegetative hyphae (Figs 3, 5). Internal structure paraplectenchymatic, stromatic, hyphal cells  $\pm$  spherical, mostly 4–6  $\mu\text{m}$  diam; wall of the external cells dark brown, with a granular pigment, paler in the internal ones. Interascal filaments lacking, interascal space filled with spherical cells. Centrum I– or I+ bluish, KI+ bluish. *Asci* several per ascoma, fissitunicate, subglobose to broadly obovate, ca 25–32  $\times$  15–18  $\mu\text{m}$ , 8-spored (Fig. 6). *Ascospores* initially 1-septate, finally submuriform, 2–6(–7) celled,  $\pm$  broadly obovate, with rounded apices, markedly constricted at the equatorial septum, and slightly constricted at the other septa, hyaline and with a thin halo when young, becoming brown, without a visible halo, and with a granular surface when mature, (9–)10–11.5–13(–15)  $\times$  6–7.4–9(–10)  $\mu\text{m}$ , length/width ratio = (1.2)1.3–1.6–1.8(2), (45 ascospores measured) (Figs 7–11, 45). *Anamorph*: Unknown.

*Life form*: Lichenicolous on *Diploicia subcanescens*. This fungus grows on the thallus and occasionally on the apothecia of the host, blackening its surface with its hyphae and ascomata. However, it does not produce any apparent bleaching or alterations in the host, having a mostly superficial development, and is presumed commensalistic.

*Comments and affinities*: As in *L. elongata*, *L. diploiciae* has superficial hyphal strands and ascomata recognizable as thickenings of these strands. Besides occurring in different host genera, *L. diploiciae* differs from *L. elongata* in its generally smaller and more globose ascomata, which are arranged in denser groups. In addition, the vegetative strands are somewhat smaller in *L. diploiciae*, and they are usually more densely grouped and arranged  $\pm$  radially. The submuriform ascospores represent the most important differential character between these two species. This is also a distinctive feature of this species with regard to the other taxa of the genus so far described. All of them have 1-septate ascospores, and only one of the species introduced in this paper, *L. rouxii*, has ascospores with up to three septa. The examination of mature material is critical for a correct observation of this character, since in the early stages, the submuriform ascospores are 1-septate.

*Habitat and distribution*: This new species is known from volcanic coastal zones from both the Iberian Peninsula (Gata Cape and Columbretes Islands), the Azores (Flores), and the Canary Islands (La Palma, La Gomera and Lanzarote). Its host species, *Diploicia subcanescens*, is distributed in coastal areas of western and southern Mediterranean Europe, North Africa and Macaronesia, extending northwards along the Atlantic coast of Europe (Nimis 1993). In the localities here reported, *L. diploiciae* was quite abundant, and in the area of Cabo de Gata it was possible to gather enough material for its distribution in an exsiccata.

*Additional material examined* (all on *Diploicia subcanescens*): **Spain**: *Andalucía*: Prov. Almería, Cabo de Gata, San José, Playa de Monsul, UTM 30SWF7565, on volcanic rocks, alt. 15 m, 15 March 1993, E. Barreno, V. Calatayud & M. J. Sanz (VAB-Lich. 2902); Cabo de Gata, ca 5 km südwestlich von San José, 20–100 m alt., auf Vulkanitblöcken, 22 Sept. 1980, J. Hafellner 52508 (GZU). *Comunidad Valenciana*: Prov. Castelló, Illes Columbretes, La Foradada, UTM 31SCE0116, on volcanic rocks, alt. ca 30 m, 4 May 1973, X. Llimona (BCC-Lich.). Prov. Castelló, Illes Columbretes, La Ferrera, UTM 31SCE0018, on volcanic rocks, alt. ca 30 m, 3 May 1973, X. Llimona (BCC-Lich.). – **Azores**: *Flores*: westlichster Punkt der Insel, ca 150 m über der Steilküste, auf Lavablöcken, Oct. 1990, E. Mölbach (GZU, h. Hafellner 52507). – **Canary Islands**: *La Palma*: near Fuencaliente, lavas del volcán Martín, on volcanic rocks, alt. ca 700 m, 28 Feb. 1991, E. Barreno & A. Santos (VAB-Lich. 7833). *La Gomera*: between San Sebastián de la Gomera and Ayamosna, ca 28° 5' N, 17° 8' W, on volcanic rocks, alt. ca 500 m, 13 June 2000, V. Calatayud & M. J. Sanz (h. Calatayud 56). *Lanzarote*: sanft geneigte Hänge nordöstlich von Arrieta, bei der Abzweigung nach Cueva de los Verdes, 29° 09' 30" N, 13° 26' 10" W, ca 60 m alt.; Malpais mit Sukkulantenbusch, auf niederen, porösen Lavablöcken, 8 Apr. 1999, A. Hafellner & J. Hafellner 47627 (h. Hafellner).

*Lichenostigma elongata* Nav.-Ros. & Hafellner, *Mycotaxon* 57: 213 (1996).

*Type*: **Spain**: *Catalonia*: Prov. Tarragona, Ribera d'Ebre, Mora d'Ebre, loco dicto els Xarcums, UTM 31TBF9454, 300 m, ad saxa calcarea supra thallum *Lobothalliae radiosae* crescens, 14 Nov. 1987, M. Giralt & P. Navarro-Rosinés (BCC-Lich.-holotype).

*Illustrations*: Navarro-Rosinés & Hafellner (*loc. cit.*: 214 fig. 1 – habit, 215 fig. 2 – ascomata, hyphal strands, 216 fig. 3 – ascomata, 217 fig. 4 – ascospores, ascus, 218 fig. 5 – ascomata, ascospores).

*Vegetative hyphae* partly superficial, forming black patches on the surface of the host; simple or with few ramifications, about 200–500  $\mu\text{m}$  long and of rather variable thickness (8–20  $\mu\text{m}$ ), additional vegetative hyphae penetrating into the host, hyaline, frequently such hyphae attach the stromatic ascomata to the cortical layer of the host. *Ascomata* black, superficial, elongated, recognizable as intercalar thickenings of hyphal strands, somewhat convex, 50–200  $\times$  30–60  $\mu\text{m}$ . Internal structure paraplectenchymatic, stromatic, hyphal cells  $\pm$

spherical, 4–6 µm diam; wall of the external cells dark brown, with a granular pigment, internal cells hyaline, vertical thickness 40–70(–100) µm. Centrum I–, KI–, *Asci* 1–5 per ascoma, developing close to the upper surface, fissitunicate, subglobose to broadly obovate, 20–25 × 15–18 µm, 8-spored. *Ascospores* 1-septate, broadly obovate, uncoloured and provided with distinct gelatinous perispore when young, becoming brown at maturity, with finely granular surface at this stage, slightly constricted at the septum, (9–)10–11.5–13 × 6–7.0–8.5 µm, length/width ratio (1.3)1.4–1.7–1.9 (37 ascospores measured). *Anamorph*: Unknown.

*Life form*: Lichenicolous on *Aspicilia* and *Lobothallia* spp. Slightly parasitic, especially when growing on the apothecia of the host.

*Comments and affinities*: *L. elongata* was the first species of the subgenus *Lichenogramma* described. It has simple, or with few ramifications, plurihyphal vegetative strands, not distinctly radiating, and elongate ascomata. For its separation from *L. rouxii*, a similar species occurring on *Squamaria* spp., see comments to that species.

*Distribution and habitat*: It is widespread in Europe, where it has a mainly central European-Mediterranean distribution, and it is also known from Africa, Asia, North America, and Australia. It occurs both on *Aspicilia* and *Lobothallia* species, on calcareous and on siliceous rocks, being locally abundant in relatively dry regions.

***Lichenostigma epipolina*** Nav.-Ros., Calatayud & Hafellner, sp. nov. (Figs 12–18, 46)

*Etym.*: The specific epithet refers to the host, *Diplotomma epipolium*.

*Lichenostigma elongata* similis, praecipue differt filamentis superficialibus simplicibus et brevioribus, (20–)50–300 µm longis et 6–12(–20) µm crassis, et pseudothecia subglobosa vel parce elongata, 35–65 × 35–50 µm.

*Type*: **Spain**: Cataluña: Prov. Tarragona, Ribera d'Ebre, Mora d'Ebre, Els Xarcums, 31TBF9454–9554, on *Diplotomma epipolium*, on calcareous rocks, alt. 300 m, 14 Nov. 1987, P. Navarro-Rosinés & M. Giral (BCC-Lich. 13473 – holotypus).

*Vegetative hyphae* superficial, forming small black strands on the surface of the host, arranged ± radially on the host thallus, but usually lax and separated, rarely in dense groups (Figs 12–13). Strands simple or scarcely ramified, about (20–)50–300 µm long and about 6–12(–20) µm thick; in section, strands mostly formed by a single row of ± quadrangular cells, and paraplectenchymatic (stromatic), 2–3 cells thick when closer to the ascomata (Figs 14–15). Additional vegetative hyphae penetrating into the host thallus, hyaline. *Ascomata* black, superficial, subglobose, not or scarcely elongated, recognizable as thickenings of the hyphal strands, 35–65 × 35–50 µm, evolving in the central part of strands of vegetative hyphae (Figs 14, 16). Internal

structure paraplectenchymatic, stromatic, hyphal cells ± spherical, mostly 4–6 µm diam; wall of the external cells dark brown, with a granular pigment, paler in the internal ones. Interascal filaments lacking, interascal space filled with spherical cells. *Asci* normally only 1 per ascoma, fissitunicate, subglobose, ca 32 × 28 µm (6–)8-spored (Fig. 16). *Ascospores* 1-septate, broadly obovate, with rounded apices, not or slightly constricted at the septum, pale brown and halonate when young, becoming brown, without a visible halo, and with a granular or also rugose surface when mature, 10–11–12(–13) × 5.5–6.4–7(–8) µm, length/width ratio = (1.4–)1.6–1.8–1.9(–2.0), (44 spores measured) (Figs 17–18, 46). *Anamorph*: Unknown.

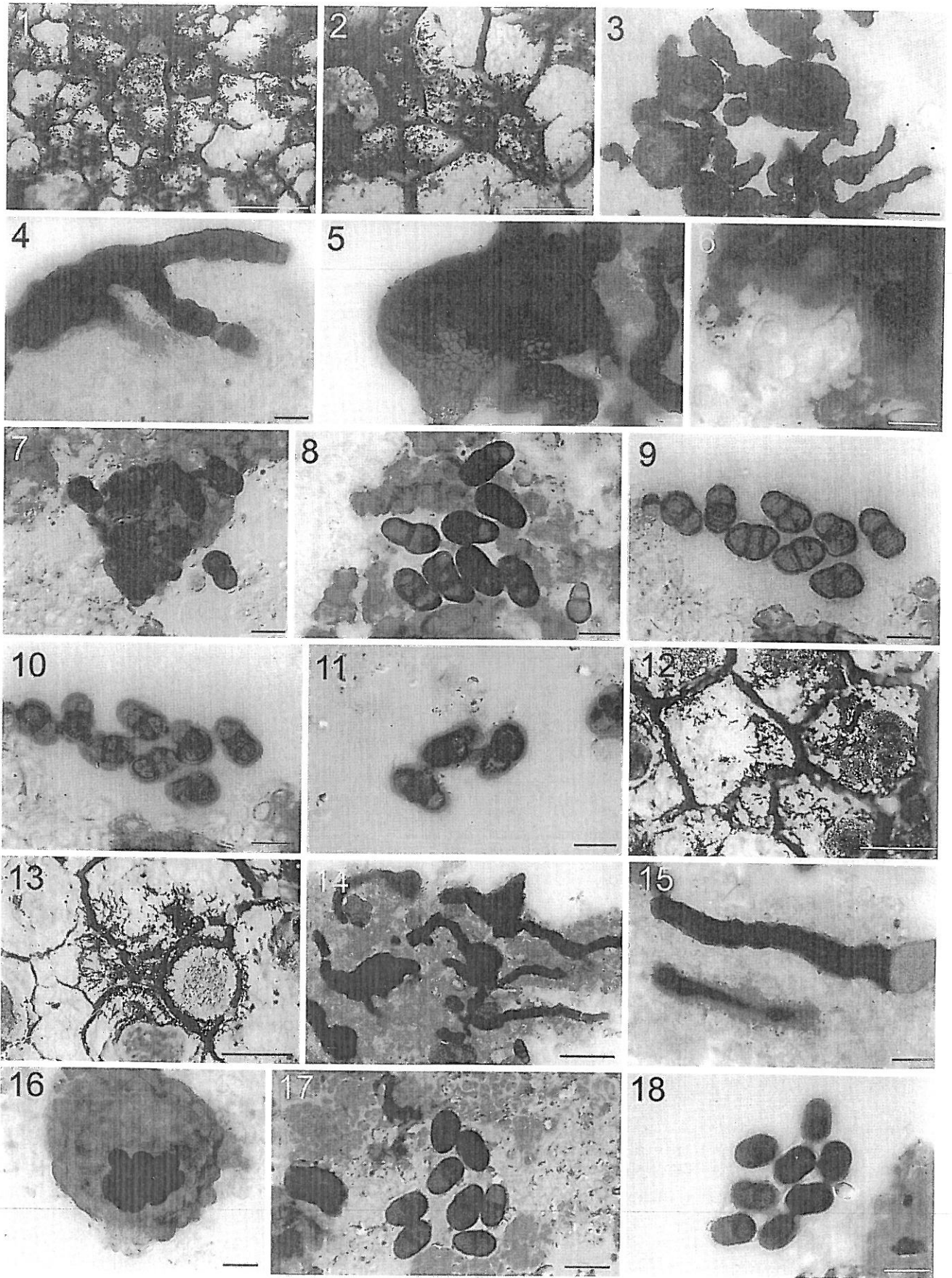
*Life form*: Lichenicolous on *Diplotomma epipolium*. This fungus grows on the thallus and occasionally on the apothecia of the host, blackening its surface with its hyphae and ascomata. Mostly it causes no apparent damage or alterations in the host because of its mainly superficial development, however, sometimes infested areoles are somewhat ensunken.

*Comments and affinities*: *Lichenostigma epipolina*, as *L. cosmopolites* (on *Xanthoparmelia* spp.), has subglobose ascomata and vegetative strands formed mostly by a single row of cells (Hafellner & Calatayud 1999). However, in the latter species, the strands are ramified to net-like, and the ascospores in *L. epipolina* are larger and brown. *L. semiimmersa* (on *Buellia elegans* and *B. zoharyi*) also has similar vegetative strands with a single row of cells, but its ascomata are ellipsoid, and the ascospores are smaller (7–10 × 4–5 µm) and hyaline (Hafellner 1999). With respect to *L. elongata*, it differs in its shorter superficial hyphal strands, formed largely by a single row of cells; only when these strands are close to the ascomata do they become thicker and paraplectenchymatic, as is typical of other *Lichenostigma* species. Another differential character is the shape of the ascomata, which in *L. epipolina* are mostly subglobose and not elongated as in species such as *L. elongata* and *L. rouxii*. The ascospores are also slightly smaller than in these two species.

*Distribution and habitat*: *Lichenostigma epipolina* is known in Europe from Spain (several localities in the north east and east of the Iberian Peninsula) and Italy. Outside Europe it is here recorded from Northern Africa (Tunisia) and arid Asia (Jordanian, Afghanistan). It occurs on well-developed thalli of *Diplotomma epipolium*, growing on stable stones, flagstones or low outcrops. Apparently, this fungus needs the host thalli to be rather thick and cracked or cracked-areolate, since it has not been found in thin and smooth host thalli. Considering the relatively high number of localities in which it has been found, it is probably common, but might have been overlooked due to its small size. *L. epipolina* has been found in localities from the lowlands, even close to the coast, to high alpine areas.

*Additional material examined* (all on *Diplotomma epipolium*): **Spain**: Cataluña: Prov. Barcelona, Anoia, Castellolí,





Figs 1–18. For caption see facing page.

Port dels Brucs, UTM 31TCG9405, sobre pedres calcàries, alt. 600 m, 20 Feb. 1992, P. Navarro-Rosinés & A. Sánchez-Cuxari (BCC-Lich. 13472). Prov. Girona, Ripollés, Queralbs, Vall de Núria, Coma Mulleres, UTM 31TDG39, sobre calcoesquists, alt. 2300 m, 15 Nov. 1986, X. Llimona (BCC-Lich. 4172<sup>L</sup>). Prov. Girona, Ripollés, Queralbs, Vall de Núria, sota el Pic de l'Àliga, UTM 31TDG39, sobre esperons de calcoesquists, alt. 2400 m, 15 Nov. 1986, P. Navarro-Rosinés & X. Llimona (BCC-Lich. 4169<sup>L</sup>). Prov. Tarragona, Baix Ebre, Tivenys, Barranc del Xato, UTM 31TBF9130-9230, sobre roca carbonatada, alt. 100-150 m, 5 Nov. 1988, A. Gómez-Bolea & P. Navarro-Rosinés (BCC-Lich. 13475). Murcia: Mazarrón, Punta de Cala Bela, cerca de Bolnuevo, U.T.M. 30SXG4858, alt. 20 m, sobre rocas calizas, 30 Sept. 1992, J. M. Egea, P. Navarro-Rosinés & Cl. Roux. (BCC-Lich. 13487, 13488). Comunidad Valenciana: Prov. Alacant, Baix Vinalopó, Elx, Serra del Carabassí, prop del Clot d'en Galbany, UTM 30SYH13, sobre roca carbonatada, alt. 0-50 m, 23 March 1991, P. Navarro-Rosinés (BCC-Lich. 13474). Prov. Castelló, Els Ports, cerca de Coratxar, ca 40° 41' N, 00° 05' W [UTM 31TBF5208], sobre roca carbonatada, 1300 m, 20 Nov. 2000, V. Calatayud (h. Calatayud 75). Prov. Soria: Tal des Rio Jalón zwischen Arcos de Jalón und Sta. Maria de Huerta, erodierte Hänge nördlich der Straße, ca 800 m alt., verfestigter Feinschutt mit Mergelblöcken, 24 May 1983, H. Mayrhofer (GZU<sup>L</sup>). - Italy: Toskanischer Archipel, Elba: Monte Orello nördlich von Lacona, alt. 100-250 m; südexponierte, anstehende Felsen in einer Macchie, 28 Aug. 1982, H. Mayrhofer 3947 (GZU). Liguria: Prov. Savona: Chisano sul Neva, nordwestlich von Albenga, alt. 60-90 m; auf kalkhaltigen Konglomeratblöcken in südexponierter Felsheide, 20 May 1978, M. Steiner (GZU). Friuli-Venezia Giulia: Prov. Udine, Karnische Alpen: Südhang des Monte Novarza nördlich von Lateis bei Sauris, alt. 1600-1830 m, 10 Sept. 1987, J. Poelt (GZU<sup>L</sup>). Prov. Udine, Karnische Alpen: Bergkette nördlich von Sauris, M. Pieltinis, Nordwestseite des Gipfels, ca 2000 m alt.; Werfener Schiefer, auf niederen Schrofen, 28 July 1993, J. Hafellner 52502 (h. Hafellner). - Jordan: Prov. Maan: Petra, Umgebung des Großen Opferplatzes auf dem Zibb Atuf, ca 1100 m alt., 5 March 1992, J. Poelt (GZU<sup>L</sup>). - Afghanistan: Prov. Paktia: 5 km südlich von Tani, ca 18 km südwestlich von Khost, 33° 12' N, 69° 49' 30" E, 1450 m alt., Felsköpfe aus Kalk in Northwest-Exposition zwischen lockerem Strauchbestand, 6 July 1970, M. Steiner (GZU). 4 km südlich von Ya'qubi, an der Straße nach Khost, 33° 25' N, 69° 59' 30" E, 1175 m alt.; Ost-West verlaufende, ca 3 m hohe Felsrippe aus mergeligem Kalk, 4 July 1970, M. Steiner (GZU<sup>L</sup>). Prov. Kabul: Logar-Tal, Stupa Guldura, südlich von Saydkhel, 34° 23' N, 69° 16' E, 2100 m alt.; auf kalkhaltigen Felsen, 25 Nov. 1978, D. Podlech (GZU<sup>L</sup>). Hügel ca 3 km östlich des neuen Flughafens, 34° 35' N, 69° 17' E, 1850 m alt.; Felsköpfe aus Kalkschiefer auf einem Steppenhang, 30 Apr. 1970, M. Steiner (GZU<sup>L</sup>). - Tunisia: niedere felsige Kuppe etwa 46 km nordöstlich of Gafsa, ca 350 m alt., in einer Halfa-Steppe, 17 Apr. 1968, J. Poelt (GZU).

**Lichenostigma gracilis** Calatayud, Nav.-Ros. & Hafellner, sp. nov. (Figs 19-27, 47)

*Etym.*: *gracilis* (Lat., slender), refers to the vegetative strands which are more slender than in other species of this genus, especially *L. subradians*, another species on *Acarospora*.

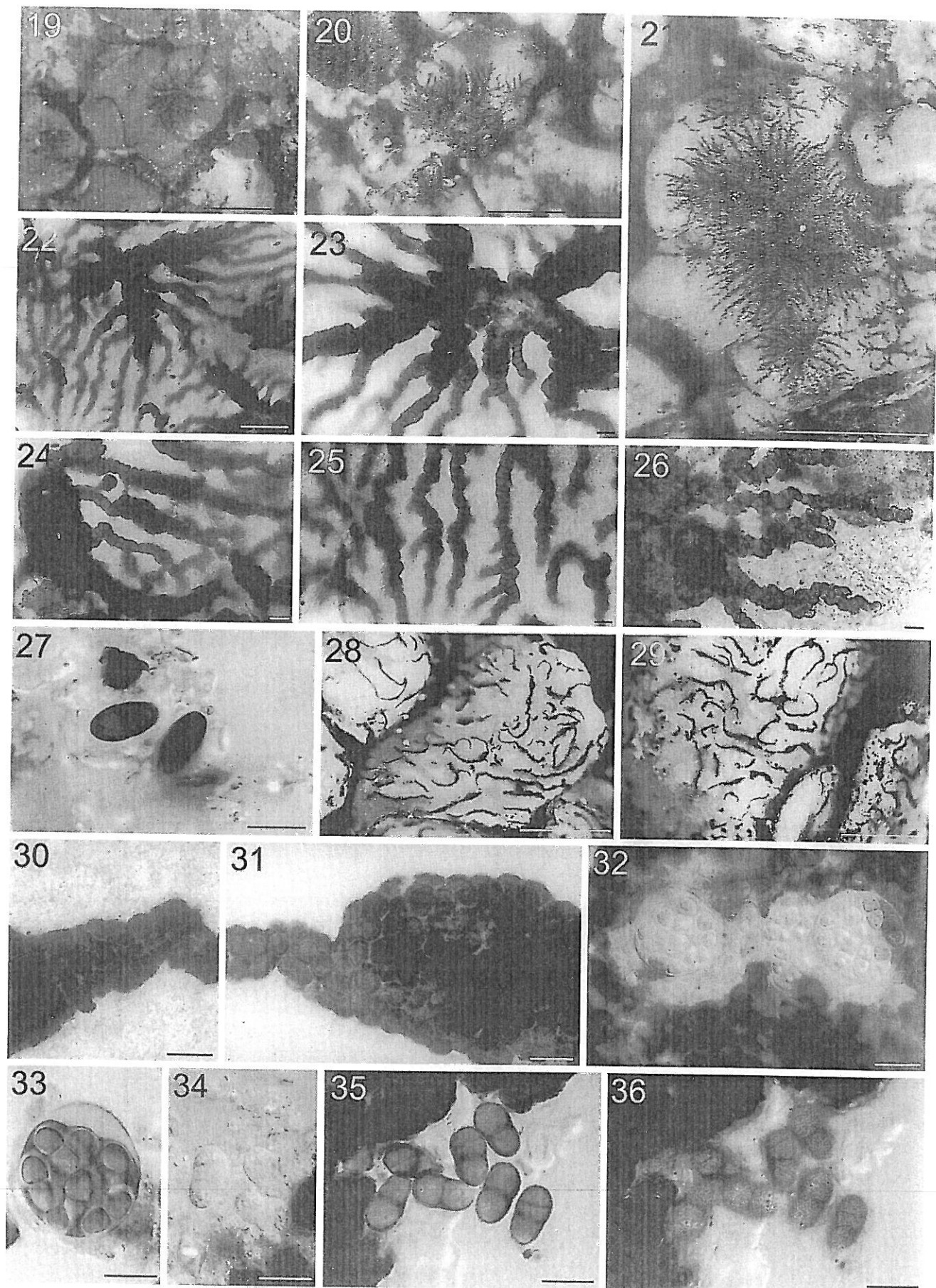
*Lichenostigma elongata* similis, praecipue differt filamentis compositis superficialibus plus ramosis, radiantibus, gracilioribus et sporis minoribus, (8-)9-12(-13) × (4-)5-6(-7) µm. A *Lichenostigma subradiante*, species altera quae crescit supra *Acarospora*, differt filamentis gracilioribus et perspicue plus ramosis.

**Type: Spain: Comunidad Valenciana:** Prov. Castelló, Desert de les Palmes, Benicàssim, Agulles de Santa Àgueda, UTM 31TBE4840 [40° 04' N, 0° 03' E], on *Acarospora fuscata*, on sandstone, alt. 300 m, 11 Feb. 2001, V. Calatayud & C. Trescolí (GZU - holotypus; h. Calatayud 72 and BCC-Lich.-isotypi, 20 other isotypes will be distributed in Triebel, Microf. Exs. no. 0817).

**Vegetative hyphae** superficial, tightly adpressed or only scarcely elevated on the host surface, black, forming ± orbicular groups. In young individual infections the main strands are arranged radially, arising from a central point (Fig. 19); in larger infections this radiate arrangement is clear towards the margin of each infection while may be less marked in the central zone, that usually becomes darkened by the abundance of ramified strands and ascomata (Figs 20-21). Each strand usually formed by a main axis with frequent lateral, relatively long ramifications, which are single or slightly ramified; lateral ramifications inserted in an acute angle, verging towards the border of the individual infections; main strands about 100-300 µm long, about 12-25(-30) µm thick and formed by 2-4 rows of cells towards their base, and attenuated towards their tips, frequently ending in a single row of cells; lateral branches about 6-10 µm thick, formed by 1-2 rows of cells; strains paraplectenchymatic (stromatic), and golden brown in section (Figs 24-26). **Ascomata** black, superficial, elongated, recognizable as thickenings of the hyphal strands, 45-120(-150) µm long and 40-60 µm wide, arising mostly towards the center of each group of strands, where an elongate, irregular or ± stellate cluster of ascomata is frequently formed (Figs 22-24). Internal structure paraplectenchymatic, stromatic, with plasmn; spherical hyphal cells, of 4-7 µm diam.; wall of the external cells golden brown, with a granular pigment, paler in the internal ones. Interascal filaments lacking, interascal space filled with spherical cells. Centrum I-. **Asci** several per ascoma, fissitunicate, subglobose to broadly obovate, ca 17-25 × 15-20 µm,

**Figs 1-18.** Figs 1-11. *Lichenostigma diploiciae* (Figs 1-8, 11, holotype; Figs 9-10, BCC-Lich.s.n.). **Figs 1-2.** Habit. **Fig. 3.** Group of ascomata and hyphal strands. **Fig. 4.** Plurihyphal vegetative strands. **Fig. 5.** Ascoma with several asci inside (dark zones). **Fig. 6.** Ascus. **Figs 7-9.** Ascospores. **Figs 10-11.** Ornamentation of the ascospores. **Figs 12-18.** *L. epipolina* (Figs 12-13, holotype; Figs 14-18, BCC-Lich. 13475). **Figs 12-13.** Habit. **Fig. 14.** Group of ascomata and vegetative hyphae. **Fig. 15.** Simple vegetative hyphae. **Fig. 16.** Ascoma with an ascus inside (after K). **Fig. 17.** Ascospores. **Fig. 18.** Ornamentation of the ascospores. Bars Figs 1-2, 12-13 = 1 mm; 3, 14 = 50 µm; 4-11, 15-18 = 10 µm.





Figs 19–36. For caption see facing page.

8-spored. *Ascospores* 1-septate, ellipsoid or slightly obovate, with rounded apices, slightly constricted at the septum, pale brown and halonate when young, becoming brown, without a visible halo, and with a granular surface when mature, (8–)9–10.7–12(–13) × (4–)5–5.5–6(–7) µm, length/width ratio (1.6–)1.8–2.2(–2.4), (52 ascospores measured), (Figs 27, 47). *Anamorph*: Unknown.

*Life form*: Lichenicolous on the thallus of *Acarospora fuscata*. This fungus seems to have a more marked adverse effect on the host than other species of the genus, since the infected areoles may become slightly bullate with a cracked surface, and sometimes also bleached.

*Comments and affinities*: Among the species so far described, *L. gracilis* is well characterized by its slender and abundantly branched hyphal strands, golden brown, markedly radiating, tightly adpressed or only scarcely elevated on the host surface. Another species growing on *Acarospora*, *L. subadians* (described below), can be distinguished by its thicker hyphal strands which are well elevated above the surface of the host thallus. Single strands of *L. subadians* have few or no branches, and these branches deviate more or less at right angles. Under the light microscope, the strands differ in both species: medium to dark brown in *L. subadians*, and a paler golden brown in *L. gracilis*. In *L. elongata* and *L. rouxii* the strands are thicker, with scarce branches, and are not arranged radially. *L. diploiciae*, also described here, has thicker, much less ramified strands, and 1-septate to submuriform ascospores. *L. semiimmersa* (Hafellner 1999), and *L. epipolina* have mostly simple hyphal strands.

*Distribution and habitat*: The material examined comes from two collections from the province of Castelló (eastern Spain). In the type locality, abundant material was collected; it will be distributed in an exsiccata. So far, this species has been observed exclusively on the thallus of a single brown species of *Acarospora*, *A. fuscata*. Although abundant samples of *A. fuscata* kept at BCC, GZU and VAB were examined searching for *L. gracilis*, no more material than the here mentioned was found, suggesting that it is a quite rare fungus.

*Additional material examined*: **Spain**: *Comunidad Valenciana*: Prov. Castelló, Desert de les Palmes, La Pobla Tornesa, Marmudella, UTM 31TBE4644, on *Acarospora fuscata*, on sandstone, alt. 450 m, 6 Sept. 1993, V. Calatayud (VAB-Lich. 7835).

***Lichenostigma rouxii* Nav.-Ros., Calatayud & Hafellner, sp. nov.** (Figs 28–36, 48)

*Etym.*: Named after Claude Roux, who collected material of this species together with P.N.-R., for his

outstanding contribution to our knowledge of lichenicolous fungi. The world-wide key compiled under his coauthorship is an indispensable tool for researchers interested in lichenicolous fungi.

*Lichenostigma elongata* similis, praecipue differt filamentis compositis superficialis longioribus, (200–)400–1000(–1500) µm longis, et sporis 1–3-septatis.

*Type*: **France**: *Provence*: Vaucluse, Gordes, Col de Gordes, on *Squamarina stella-petraea*, sobre bloques de areniscas carbonatadas, en el muro del margen del camino, alt. 350 m. orientación W, 10 June 1993, G. Clauzade, C. Roux & P. Navarro-Rosinés (BCC-Lich. 13476 – holotypus; MARSSJ, h. Cl. Roux 21548 – isotypus).

*Vegetative hyphae* superficial, forming black strands on the surface of the host, simple or with some lateral branches inserted ± perpendicularly to the main branch; strands never forming dense groups, in general scattered and isolated, but a few strands may be grouped with a loose radial arrangement in the better developed material (Figs 28–29). Each strand about (200–)400–1000(–1500) µm long and about 8–13(–16) µm thick; in section, formed by (1–)2–3 rows of cells, paraplectenchymatic, stromatic (Fig. 30). Additional vegetative hyphae penetrating into the host thallus, hyaline. *Ascomata* black, superficial, elongated, recognizable as thickenings in the hyphal strands, 80–120 × 35–70 µm, evolving isolated or, not rarely, in number of 2–3 per strand, inserted in the central part of the strands of vegetative hyphae (Fig. 31). Internal structure paraplectenchymatic, stromatic, hyphal cells ± spherical, mostly 4.5–6.5 µm diam; wall of the external cells dark brown, with a granular pigment, paler in the internal ones. Interascal filaments lacking, interascal space filled with spherical cells (Fig. 32). Centrum I–. *Asci* several per ascoma, fissitunicate, subglobose to broadly obovate, ca 25–30 × 20–24 µm, 8-spored (Figs 32–33). *Ascospores* 1(–3)-septate, ± broadly obovate or ellipsoid, with rounded apices, slightly constricted at the equatorial septum, hyaline and with a thin halo when young (Fig. 34), becoming brown, without a visible halo, and with a fine granular surface when mature, (10–)10.5–11.9–13.5(–15.5) × (5.5–)6–6.5–7(–8) µm, length/width ratio (1.4–)1.6–1.8–2.0(–2.4), (46 spores measured) (Figs 35–36, 48). *Anamorph*: Unknown.

*Life form*: Lichenicolous on *Squamarina stella-petraea* and *S. cartilaginea*. The fungus grows on the thallus, forming scattered black lines, never grouped in dense clusters, and not or scarcely affecting the host thallus. Nevertheless, under the hyphal strands, the epinecral

**Figs 19–36.** Figs 19–27. *Lichenostigma gracilis* (Figs 19, 26, VAB-Lich. 7835; Figs 20–25, 27, h. Calatayud 72). Figs 19–21. Habit. Figs 22–23. Group of ascomata and hyphal strands. Fig. 24. Ascoma connected to hyphal strands. Figs 25–26. Hyphal strands. Fig. 27. Ascospores. Figs 28–36. *L. rouxii* (Figs 28–29, holotype; Figs 30–36, h. Calatayud 74). Figs 28–29. Habit. Fig. 30. Plurihyphal strand. Fig. 31. Elongated ascoma. Fig. 32. Two asci with interascal spaces filled with ± spherical cells. Fig. 33. Ascus (after K/I). Fig. 34. Young ascospores. Fig. 35. Mature ascospores. Fig. 36. Ornamentation of the ascospores. Bars Figs 19–21 = 0.5 mm; 22 = 50 µm; 23–24 = 20 µm; 26–27 = 10 µm; 28–29 = 1 mm; 30–36 = 10 µm.



layer of the lichen becomes somewhat thickened, and it forms crests following the base of the strands. Also, in the affected zones, there is a superficial proliferation of cyanobacteria which usually is not observed in other parts of the thallus.

**Comments and affinities:** *L. rouxii* is most similar to *L. elongata*. Besides occurring on different host species, *L. rouxii* differs in the longer, more isolated hyphal strands, and higher number of ascomata per strand. Although the size of the ascospores is almost identical in both taxa, in *L. rouxii* the ascospores may have up to three septa, while in *L. elongata* they are always 1-septate. Also rather similar is *L. subadians*, described here on *Acarospora* subgen. *Acarospora*, whose hyphal strands often have some short rectangular ramifications and in which in young infections the strands are arranged in a radiating disposition. Ascospores of *L. subadians* are always 1-septate. Furthermore, *L. rouxii* must not be confused with a hitherto undescribed species of *Sphaerellothecium* growing occasionally on thalli of *Squamarina cartilaginea*, but which has globose pseudothecoid ascomata connected with superficial hyphae not forming hyphal strands.

**Distribution and habitat:** *L. rouxii* is known from southern France, several provinces of Spain, Bosnia-Herzegovina, Macedonia, insular and mainland Greece, as well as dry valleys in the French and Austrian Alps. The hosts have a mainly mediterranean to sub-mediterranean distribution. In a locality from Valencia, abundant material was collected that will be distributed in Triebel, Microfungi Exsiccati no. 0818.

**Additional material examined:** **Austria:** Tirol, Samnaun-Gruppe, Umgebung von Tözens im oberen Inntal, Hänge nördlich vom Ort unweit der Kapelle St. Georg, ca 1050–1100 m, MTB 8929; lückiger Föhrenwald mit Felsschrofen, auf südostexponierten Kalkschieferschrofen, on *Squamarina cartilaginea*, 6 Sept. 1991, J. Hafellner 52512 (h. Hafellner). – **France:** *Provence:* Vaucluse, Gordes, Col de Gordes, bloques de areniscas carbonatadas, en el muro del margen del camino, on *S. stella-petraea*, alt. 350 m, orient. W, 14 May 1993, P. Navarro-Rosinés & C. Roux (MARSSJ, h. C. Roux 21548). Vaucluse, Joucas, on *S. stella-petraea*, 19 Aug. 1969, X. Llimona (BCC-Lich. 179). *Dauphiné:* Isère, Grandes Alpes du Dauphiné, südwestliche Umgebung von la Mure, Mayres-Savel, ca 610–630 m alt., Kalkschiefer, on *S. cartilaginea*, 11 July 1975, J. Hafellner 1633 (h. Hafellner). – **Spain:** *Cataluña:* Prov. de Lleida, les Garrigues, Casteldans, pineda prop del poble, UTM 31TCG1396–1397, alt. 360 m, on *S. cartilaginea*, sobre el sòl que es forma entre roques carbonatades, 17 Dic. 1996, X. Llimona & J. Vila (BCC-Lich. 13477). *Comunidad Valenciana:* Prov. València, La Poble de Vallbona, Pla dels Alchups, UTM 30SYJ1290, alt. 150 m, on *S. cartilaginea*, sobre suelo arcilloso, 9 July 2000, S. Fos (VAB-Lich. 10913, 10951). *Ibid.*, on clayey soil, 6 Nov. 2000, V. Calatayud (h. Calatayud 74; 20 duplicates will be distributed in Triebel, Microf. Exs. no. 0818). *Murcia:* sudeste de Murcia, Sierra de Columbares, UTM 30SXC79, ca 400 m alt., on *S. cartilaginea*, suelos calcáreos, 8 March 1980, X. Llimona (BCC-Lich. 13489). *Navarra:* Fustiñana, Reserva natural Caidas de la Negra y el Juego de Pelota, alt. ca 600 m, on *Squamarina* sp., on calcareous rocks, 26 Feb. 1995, J. Etayo (h. J. Etayo).

– **Bosnia-Herzegovina:** Debelo brdo bei Sarajevo, auf Kalkfelsen, on *S. cartilaginea*, 5 Nov. 1899, [collector unknown] (GZU, two specimens). – **Macedonia:** Ohrid, supra lacum Ohrisko ezero prope vicum Elsani haud procul Pestani, alt. 980 m, in rupibus calcareis, on *S. cartilaginea*, 10 July 1975, A. Vězda (GZU<sup>L</sup>). – **Greece:** *Thessalia:* Meteora-Klöster, am Ortsende von Kastraki in Richtung Meteora, bei den ersten Felsklippen linkerhand der Straße gegenüber vom Campingplatz, ca 300 m; auf Moosen über Konglomeratfelsen, on *S. cartilaginea*, 14 Sept. 1989, M. Matzer 188 & B. Pelzmann (GZU<sup>L</sup>). *Rhodos:* Rücken eines Hügels etwa 2 km nördlich von Phaliraki, südlich der Stadt Rhodos, ca 50 m alt.; Konglomeratfelsen in Phrygana-Vegetation, on *S. cartilaginea*, 5 Sept. 1983, J. Poelt (GZU<sup>L</sup>). *Dodekanes:* Insel Simi, beim Kloster Panormitis, 36° 32' N, 27° 51' E, ca 10 m s. m.; auf nordexponierten Kalkfelsen, on *S. cartilaginea*, 20 July 2000, N. Cernic (h. Hafellner 41392).

**Lichenostigma semiimmersa** Hafellner, *Linzer Biol. Beitr.* 31: 513 (1999).

**Type:** **Austria:** *Steiermark:* Eisenerzer Alpen, Grüblzinken, southwestern crest above Rottörl, ca 1900 m, J. Hafellner 46589 & A. Hafellner (GZU-holotype, isotype; Santesson, *Fungi lichenic. Exs.* no. 320 – isotypes).

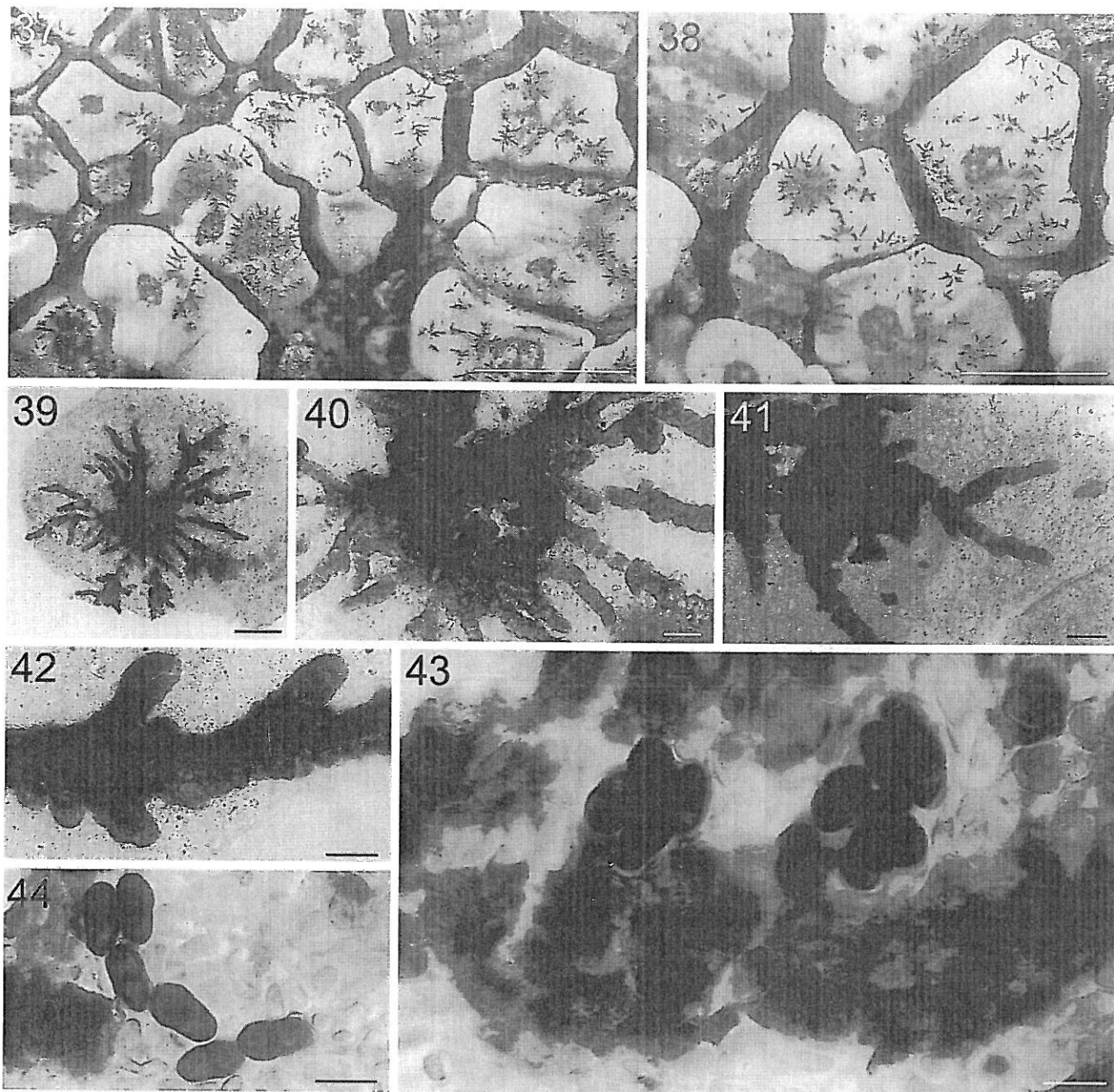
**Illustrations:** Hafellner (*loc. cit.*: 511 fig. 3 – ascus, ascospores).

**Vegetative hyphae** superficial, black, most of them semi-immersed in small fissures of the upper surface of thallus lobes. Strands with many ramifications, sometimes reticulate, mostly 300–500 µm long, at the growing edge of a colony up to 1000 µm and even longer, about 8–12 µm thick, simple, only close to ascomata sometimes 2–3 rows of cells developed, somewhat constricted at the septa, strand cells with rough sculpture on the upper surface. Additional vegetative hyphae penetrating into the host thallus, hyaline. **Ascomata** black, superficial, applanate, ellipsoid, intercalary in strands, 30–50(–100) µm in diam. Interascal filaments lacking, interascal space filled with spherical to polygonal cells. **Centrum I** –, sometimes gel in the centrum I + slightly reddish. **Asci** some per ascoma, fissitunicate, subglobose to broadly obovate, c. 20–25 × 12–15 µm, 8-spored. **Ascospores** 1-septate, ± broadly obovate, with rounded apices, somewhat constricted at the septum, lower cell slightly narrower, hyaline, without a visible halo in LM, only overaged ascospores becoming brownish, 7–8.3–9(–10) × 4–4.3–5 µm, length/width ratio ca 1.9. **Anamorph:** Unknown.

**Life form:** Lichenicolous on terricolous *Buellia* species of the *B. epigaea* group (*Buellia elegans* and *Buellia zoharyi*).

**Comments and affinities:** The species is similar to *L. cosmopolites* of which it can be easily distinguished by the roughly sculptured vegetative hyphae, the larger ascomata, the size of the ascospores and the host selection.

**Habitat and distribution:** The species is known from a number of localities in Europe (Austria, Spain), Asia (Afghanistan, Pakistan) and North America (Canada,



Figs 37–44. *Lichenostigma subradians* (VAB-Lich. 7836): Figs 37–38. Habit. Fig. 39. Individual infection showing a radiate arrangement of the hyphal strands. Fig. 40. Detail of the central part of an individual infection, where ascomata are formed. Fig. 41. An Ascoma connected to hyphal strands. Fig. 42. Plurihyphal strand. Fig. 43. Two asci containing ascospores surrounded by  $\pm$  rounded cells. Fig. 44. Ascospores. Bars Figs 37–38 = 1 mm; 39 = 50  $\mu$ m; 40–41 = 20  $\mu$ m; 42–44 = 10  $\mu$ m.

U.S.A., Greenland). Its host lichens preferably grow in open habitats with enough soil surface available for colonisation. Whereas *B. elegans* is a species of winter cold steppes, *B. zoharyi* is a characteristic ground lichen in hot semideserts. Larger populations of host lichens have frequently been found infested with *L. semiimmersa*.

***Lichenostigma subradians* Hafellner, Calatayud & Nav.-Ros., sp. nov.** (Figs 37–44, 49)

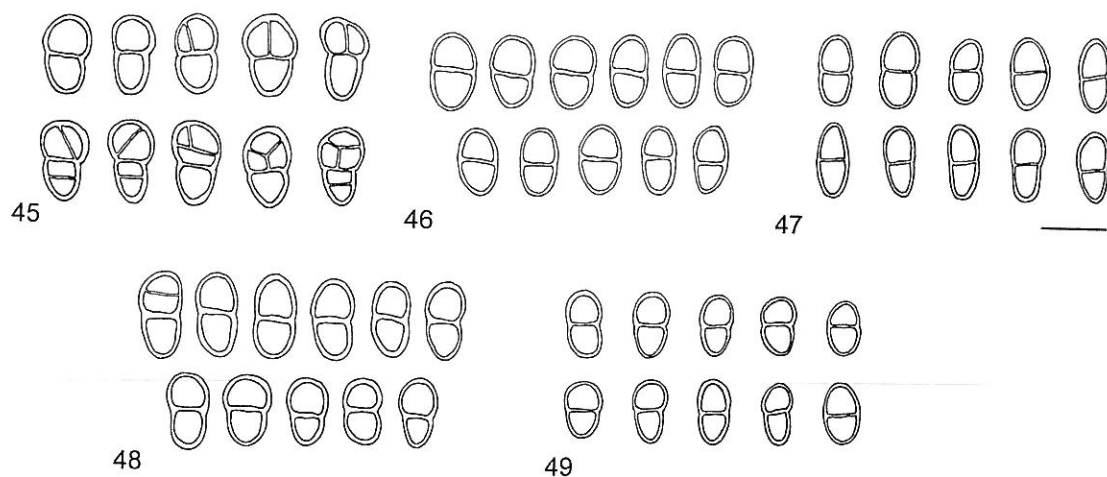
*Etym.*: *subradians* (Lat.), refers to the radiating vegetative strands often seen in young infections by this fungus.

*Lichenostigma elongata* similis, ab ea praecipue differt filamentis compositis superficialibus frequenter in ordine radianti dispositis et sporis minoribus, (8–)9–10(–11)  $\times$  (4–)5–6(–7)  $\mu$ m. A *Lichenostigma gracili*, species altera quae crescit supra *Acarospora*, differt filamentis maioribus et perspicue minus ramosis.

*Type*: USA: Arizona: Maricopa County, Phoenix, South Mountain Park, Guadalupe Canyon, alt. 450 m, Upper Sonoran Desert community, on *Acarospora* subgen. *Acarospora* sp., 9 Febr. 1987, T. Nash & J. Poelt (GZU – holotypus, ASU – isotypus).

*Vegetative hyphae* superficial, forming black strands on the surface of the host, in young infections strands





Figs 45–49. Ascospores. Fig. 45. *Lichenostigma diploiciae* (holotype). Fig. 46. *L. epipolina* (holotype). Fig. 47. *L. gracilis* (VAB-Lich. 7835). Fig. 48. *L. rouxii* (holotype). Fig. 49. *L. subradicans* (VAB-Lich. 7836). Bar 45–49 = 10  $\mu$ m.

frequently arranged in groups and then several strands markedly radiating, but in older infections strands dispersed or only loosely radiating (Figs 37–39). Each strand usually formed by a main axis with few lateral, short ramifications deviating more or less rectangularly; main strands about 250–400  $\mu$ m long, and of rather variable thickness, about 12–20(–30)  $\mu$ m, formed by 2–4 rows of cells, attenuated towards the extreme; lateral branches mostly 20–60  $\mu$ m long about 6–10  $\mu$ m thick, formed by 1–2 rows of cells; strains paraplectenchymatic (stromatic), and dark brown in section (Figs 40–42). Additional vegetative hyphae penetrating into the host thallus, hyaline. *Ascomata* black, superficial, mostly elongated, recognizable as thickenings of the hyphal strands, 60–150  $\mu$ m long and 25–40  $\mu$ m wide, arising mostly towards the center of each group of radiating strands, where a large,

elongate or  $\pm$  stellate cluster of ascomata is frequently formed, up to 250  $\mu$ m diam (Fig. 40), later on ascomata separating by fragmentation of the strand and dispersed. Internal structure paraplectenchymatic, stromatic, with  $\pm$  spherical hyphal cells, of 6–8  $\mu$ m diam.; wall of the external cells dark brown, with a granular pigment, cells paler to hyaline towards the centre (Fig. 43). Interascal filaments lacking, interascal space filled with spherical cells, 4–6  $\mu$ m diam. Centrum I–. *Asci* several per ascoma, fissitunicate, subglobose to broadly obovate, ca 25–30  $\times$  18–25  $\mu$ m, 8-spored (Fig. 43). *Ascospores* 1-septate, ellipsoid or obovate, with rounded apices, slightly constricted at the septum, pale brown and halonate when young, becoming brown, without a visible halo, and with a granular surface when mature, (8–)9–9.7–10(–11)  $\times$  (4–)5–5.5–6(–7)  $\mu$ m, length/width ratio (1.3–) 1.6–1.8–2(–2.4),

#### Key to the species of *Lichenostigma* subgen. *Lichenogramma*

- |      |   |                     |
|------|---|---------------------|
| 1    | Vegetative strands mostly formed by a single row of cells   | 2                   |
|      | Vegetative strands plurihyphal (stromatic), ascomata usually elongated  | 4                   |
| 2(1) | Mature ascospores brown, 10–12(–13) $\times$ 5.5–7(–8) $\mu$ m. On <i>Diplotomma epipolium</i>  | <i>epipolina</i>    |
|      | Mature ascospores mostly hyaline  | 3                   |
| 3(2) | Most of the brown vegetative hyphae ensunken in fissures of the host thallus, strand cells with rough sculpture on the upper surface, ascospores 7–9(–10) $\times$ 4–5 $\mu$ m, centrum I– or slightly reddish.   |                     |
|      | On species of the <i>Buellia epigaea</i> group  | <i>semiimmersa</i>  |
|      | Brown vegetative hyphae developed on smooth thallus surface, elevated (thallus section!), upper surface of strand cells mainly with punctiform sculptural elements, ascospores 8–10(–11) $\times$ 3–4(–5) $\mu$ m, centrum usually I+ orange-red. On <i>Xanthoparmelia</i> spp.   |                     |
| 4(1) | Ascospores finally submuriform, 2–6(–7) celled. On <i>Diploicia subcanescens</i>  | <i>cosmopolites</i> |
|      | Ascospores not submuriform  | <i>diploiciae</i>   |
| 5(4) | Strands of vegetative hyphae, at least in young infections, markedly radiating; ramified or not   | 5                   |
|      | Strands of vegetative hyphae not markedly radiating, simple or scarcely ramified  | 6                   |
| 6(5) | Strands of vegetative hyphae loosely adpressed and distinctly elevated above the thallus surface; each strand formed by a main axis with few short lateral rectangular ramifications or ramifications none; ascospores 1-septate, (8–)9–10(–11) $\times$ (4–)5–6(–7) $\mu$ m. Mostly on yellow <i>Acarospora</i> species              | <i>subradicans</i>  |
|      | Strands of vegetative hyphae tightly adpressed and hardly elevated above the thallus surface; each strand with several lateral ramifications deviating in an acute angle and verging towards the border of the individual infections; ascospores 1-septate (8–)9–12(–13) $\times$ (4–)5–6(–7) $\mu$ m. On <i>Acarospora fuscata</i> . | <i>gracilis</i>     |
| 7(5) | Strands of vegetative hyphae (200–)400–1000(–1500) $\mu$ m long; ascomata 80–120 $\times$ 35–70 $\mu$ m; ascospores 1–3 septate. On <i>Squamaria</i> species  | <i>rouxii</i>       |
|      | Strands of vegetative hyphae 200–500 $\mu$ m long; ascomata 50–200 $\times$ 30–60 $\mu$ m wide; ascospores 1-septate. On <i>Aspicilia</i> and <i>Lobothallia</i> species  | <i>elongata</i>     |

(52 ascospores measured) (Figs 44, 49). *Anamorph*: Unknown.

*Life form*: Lichenicolous on the thallus and ascospores of yellow *Acarospora* species, more rarely on brown *Acarospora* species, and then mainly when growing side by side or intermingled with yellow species.

*Comments and affinities*: *L. subradicans* resembles *L. elongata* and *L. rouxii* in having superficial, dark hyphal strands. Besides occurring on different host genera, they are easily distinguished superficially since *L. subradicans* shows a markedly radial disposition of the strands, which are laterally ramified with shorter branches. The radiating arrangement of the strands may be less distinct in older infections and on areoles with a sharp relief. On such areoles the strands follow mostly the tiny ridges on the surface (e.g. *Hafellner 36841*). In *L. elongata* the strands are simple or with few irregular branches, and are not arranged radially. The ascospores also show significant differences between both species: they are larger in *L. elongata*, with (9–)11–13 × 6–8.5 µm, than in *L. subradicans*. In *L. rouxii* (described above), the arrangement of the hyphal strands and the size of the ascospores are similar to those of *L. elongata*. The consistently 1-septate ascospores of *L. subradicans* are diagnostic with respect to *L. diploiciae*, in which the ascospores are 1-septate to submuriform. *L. semimmersa* (Hafellner 1999), and *L. epipolina* (also described above), have mostly simple hyphal strands. *L. gracilis*, growing on *Acarospora fuscata*, has a very different strand architecture (see above).

*Distribution and habitat*: The material examined comes from Asia (Saudi Arabia), the Canary Islands and the Sonoran Desert region in North America (USA) and seems to be widespread in dry areas.

*Additional material examined* (when no host is named, it is an undetermined species of *Acarospora* subgen. *Acarospora*): **Saudi Arabia**: Asir Region, ca 20 km northeast of Abha, Mahala, 18° 20' N, 42° 40' E, on granite rocks in slight shade, on *A. lavicola* s. lat., 5 Apr. 1978, D. L. Hawksworth (GZU). – **Canary Islands**: *Tenerife*: Güimar, La Ladera, Alta Vista, UTM 28RCS6230, alt. 520 m, on volcanic rocks, on *A. lavicola*, 29 Apr. 1992, E. Barreno, V. Calatayud & S. Fos (VAB-Lich. 7836). Teno-Gebirge, nordwestlich unter Teno Alto am Steig hinab zur Nordküste, hoch oberhalb von Las Casas (kurz östlich der Punta de Teno), 18° 21' 05" N, 16° 54' 20" W, ca 400 m; Vulkanitschrofen im Sukkulantenbusch, 16 Dec. 1998, J. Hafellner 46437 (GZU). Teno-Gebirge, Paß zwischen Masca und Carrizal Alto, am Kamm in Richtung Westen, 28° 18' 30" N, 16° 51' 20" W, alt. 780–830 m; Sukkulantenbusch, nordwestexponiert auf Blöcken und Schrofen am Grat, 17 Dec. 1998, J. Hafellner 46385 (h. Hafellner). *La Palma*: auf der Westseite der Insel südlich unter El Time, ca 520 m alt., 28° 39' 20" N, 17° 56' 15" W; niedere, südexponierte Vulkanitschrofen in *Kleinia-Euphorbia*-Gesellschaft, 29 Nov. 1991, J. Hafellner 29664 (h. Hafellner). *Gran Canaria*: kurz nördlich ober Fataga an der Straße nach San Bartolomé de Tirajana, ca 750 m alt., 27° 53' 40" N, 15° 34' W; Basaltschrofen im Sukkulantenbusch, auf

nordwestseitigen Steilflächen, 26 Feb. 1994, J. Hafellner 45595 (h. Hafellner). – **USA**: *Arizona*: Apache Co., 13 km north of Spingerville by the road (Hwy 180) to Saint Johns, about 4 km south of intersection with county road 4162, ca 1900 m alt., 34° 14' N, 109° 20' 30" W, outcrops of lava flow in a pasture, on volcanic rock exposed to NW, 6 July 1994, J. Hafellner 36841 (GZU). Santa Cruz Co., Coronado National Forest, Sycamore Canyon ca 25 km west of Nogales, ca 1200 m alt., 31° 25' N, 111° 11' W; siliceous rocks, on cliffs exposed to NW, 7 Feb. 1993, J. Hafellner 45082 & A. Hafellner (h. Hafellner). Gila Co., 0.5 km north of Coolidge Dam above San Carlos Lake, east-facing hillside above the road, ca 870 m, 33° 10' 50" N, 110° 31' 50" W, rock outcrops in semidesert, on rhyolite, 14 July 1994, J. Hafellner 36952 (h. Hafellner). – **Mexico**: *Baja California*: by the road (Hwy 1) about 60 km east of El Rosario, ca 570 m alt., 30° 02' N, 115° 15' W; desert scrub with *Idria columnaris* in hilly landscape, south-facing slope, on low volcanic outcrops and boulders, 23 Feb. 1993, J. Hafellner 44560 & A. Hafellner (GZU). West coast between Guerrero Negro and Rosarito, Laguna Manuela 12 km west of Villa Jesús Maria, ca 20–50 m alt., 28° 15' N, 114° 07' W; hills northwest above the beach, on small volcanic boulders exposed to the E, 21 Feb. 1993, J. Hafellner 44360 & A. Hafellner (GZU, h. Hafellner). *Baja California Sur*: Desierto de Vizcaino, 24 km west of San Ignacio, hill about 1 km south of the road to Punta Abrejos, ca 200 m, 27° 18' N, 113° 08' W; rocky north-facing hillside, on low outcrops and big boulders, 21 Feb. 1993, J. Hafellner 44935 & A. Hafellner (h. Hafellner).

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## REFERENCES

- Hafellner, J. (1982) Studien über lichenicole Pilze und Flechten II. *Lichenostigma maureri* gen. et sp. nov., ein in den Ostalpen häufiger lichenicoler Pilz (*Ascomycetes*, *Arthoniales*). *Herzogia* 6: 299–308.
- Hafellner, J. (1999) Beiträge zu einem Prodromus der lichenicolen Pilze Österreichs und angrenzender Gebiete. IV. Drei neue Arten und weitere bemerkenswerte Funde hauptsächlich in der Steiermark. *Linzer Biologische Beiträge* 31: 507–532.
- Hafellner, J. & Calatayud, V. (1999) *Lichenostigma cosmopolites*, a common lichenicolous fungus on *Xanthoparmelia* species. *Mycotaxon* 72: 107–114.
- Hawksworth, D. L. (1981) *Lichenothelia*, a new genus for the *Microthelia aterrima* group. *Lichenologist* 13: 141–153.
- Henssen, A. (1987) *Lichenothelia*, a genus of microfungi on rocks. *Bibliotheca Lichenologica* 25: 257–293.
- Kalb, K., Hafellner, J. & Staiger, B. (1995) *Haematomma*-Studien. II. Lichenicole Pilze auf Arten der Flechtengattung *Haematomma*. *Bibliotheca Lichenologica* 59: 199–222.
- Navarro-Rosinés, P. & Hafellner, J. (1996) *Lichenostigma elongata* sp. nov. (*Dothideales*), a lichenicolous ascomycete on *Lobothallia* and *Aspicilia* species. *Mycotaxon* 62: 211–225.



- Nimis, P. (1993) *The Lichens of Italy: an annotated catalogue*. [Monografie No. 12.] Museo Regionale di Scienze Naturali, Torino.
- Thor, G. (1985) A new species of *Lichenostigma*, a lichenicolous ascomycete. *Lichenologist* **17**: 269–272.
- Trinkaus, U. & Mayrhofer, H. (2000) Revision de *Buellia epigaea*-Gruppe (lichenisierte Ascomyceten, *Physciaceae*) I. Die Arten der Nordhemisphäre. *Nova Hedwigia* **71**: 271–314.

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