Notes on Lichen Genus *Buellia* De Not. (lichenized Ascomycetes) from South Korea

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Based on a literature survey and assessment of the important features of lichen genus *Buellia* (spore shape and size, anatomy of the exciple as well as analysis of the lichen substances), the present paper describes four new records of *B. maritima*, *B. polyspora*, *B. spuria* and *B. stellulata* from South Korea. Among them, *B. maritima* and *B. polyspora* are firstly reported in East Asia including in China, the Korean Peninsula and Japan. Brief description of all the new records along with earlier described species placed under genus *Amandinea* and *Hafellia* are provided with their distribution and chemistry. A key to all the *Buellia* species reported so far from South Korea is also provided.

KEYWORDS : Geographical distribution, Key, Lichen-forming fungi, Taxonomy

Lichen genus *Buellia* was named by De Notaris after his friend Esperanzo Buelli. Represented by approximately 400 species worldwide, the genus is characterized by black lecideine apothecia; one- to pluriseptate, oblong to ellipsoid, rarely citriform, brown ascospores; and deep reddish-brown to yellow to very rarely hyaline hypothecium [1].

The genus has remained a perpetual challenge to taxonomists. If a narrow generic concept is adopted, numerous small genera (like “*Hafellia*”), each with only a few species, must be segregated from *Buellia sensu stricto*. *Rinodina*, *Caloplaca* and *Lecanora* are just as heterogeneous and artificial as *Buellia sensu lato* (s. l.), with unresolved phylogeny, but nevertheless they have been split like the latter genus. Henceforth in the present paper, the authors have followed Bungartz *et al.* [1] and adopted the wider concept of *Buellia* s. l. until the phylogeny of this genus is resolved, and all the species reported and described previously under *Amandinea* and *Hafellia* from this country are retained here within *Buellia* s. l.

The genus has been well worked out in China and Japan but not in South Korea. Wei reported 26 species, 6 varieties and 1 form of *Buellia* from China, while Harada *et al.* reported 21 species and 5 varieties of this genus from Japan [2, 3]. However, only two species, *B. disciformis* and *B. punctata*, were reported from South Korea by Park, under the genus *Hafellia* and *Amandinea*, respectively [4]. To date, no further record of this genus is reported from these East Asian countries. However, while examining *Buellia* specimens deposited in the herbarium

of the Lichen & Allied Bioresource Center, Korean Lichen Research Institute (KoLRI), Suncheon National University, the authors found four new records from this country, of which *B. maritima* and *B. polyspora* are new among all East Asian countries, while *B. spuria* and *B. stellulata* were known previously from Japan and China. This work thus contributes to the knowledge of the distribution of *Buellia* s. l. as well as of lichen diversity in East Asia, including China and Japan. Brief taxonomic descriptions and comments for each species are provided along with an artificial key for their identification.

This study is based on lichen specimens deposited in the herbarium of the Lichen & Allied Bioresource Center, Korean Lichen Research Institute (KoLRI), Suncheon National University, South Korea. Specimens were examined using standard microscopical techniques and were hand-sectioned under a NIKON C-PS 1068908 dissecting microscope (Nikon, Tokyo, Japan). All measurements were made on material mounted in water, and lactophenol cotton blue (LCB) was used as a stain. Spot test reactions were carried out on hand sections of thalli and apothecia under an OLYMPUS BX 50 microscope (Olympus, Tokyo, Japan). Iodine reactions (I) were carried out by applying Lugol's iodine solution on medulla and recording the colour change. UV tests were performed by placing the specimen in an UV Chamber (CE 07 21470) and visualizing the colour change at 365 nm wavelength. Secondary metabolites were identified by TLC as described by Culbertson [5], Elix *et al.* [6], and White and James [7] using solvent system C (Toluene : Acetic acid :: 85 : 15). The terminology for tissues generally follows that of Nash and Gries [8].

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Taxonomic Treatment of the Species

Artificial key to the lichen genus *Buellia* in South Korea

1. Growing on bark or wood 2
 - 1a. Growing on rocks 4
2. Hymenium with numerous oil droplets; *dispersa*-type proper exciple; asci 8 spored *B. disciformis*
- 2a. Hymenium without oil droplets; *aethalea*-type proper exciple; asci 8 to 16 spored 3
3. Thallus indistinct to granular, subsquamulose; asci 16 spored *B. polyspora*
- 3a. Thallus scurfy, rimose to rimose-areolate; asci 8 spored *B. punctata*
4. Thallus with a chalky consistency, with large amounts of calcium oxalates; maritime distribution *B. maritima*
- 4a. Thallus without chalky consistency, without calcium oxalates; montane or maritime distribution 5
5. Exciple deep brown, with aeruginose pigment (HNO_3 -) *B. punctata*
- 5a. Exciple olive brown or bluish green, always with aeruginose pigment (HNO_3 + violet) 6
6. Medulla amyloid (I+ blue); montane distribution *B. spuria*
- 6a. Medulla not amyloid (I-); maritime distribution *B. stellulata*

***Buellia disciformis* (Fr.) Mudd. (Fig. 1)**
 Man. Brit. Lich.: 216 (1861).

Basionym: *Lecidea parasema* var. *disciformis* Fr., Novae Sched. Crit.: 9, 1826.

Synonyms: *Buellia gothlandica* J. Steiner; *B. hyperiza* (Stirt.) Zahlbr.; *B. major* (Vain.) De Not.; *B. obtecta* Nilsson; *B. parasema* (Ach.) Th. Fr.; *Diplotomma hyperizum* (Stirt.) Szatala; *Hafellia disciformis* (Fr.) Marbach & H. Mayrhofer; *Lecidea disciformis* (Fr.) Nyl.

Diagnostic characteristics. The species is characterized by rimose to rimose-areolate, dull gray thallus; medulla lacking calcium oxalate crystals (H_2SO_4 -); HNO_3 - epihymenium; hymenium with oil droplets; *dispersa*-type proper exciple; 8 spored asci; and 1-septate *Callispora*-type, narrowly ellipsoid ascospores, which occasionally have two additional false septa with a non-thickened, narrow, proper septum.

Chemistry. Thallus K+ yellow, C-, KC-, P-; medulla I- (non-amyloid); UV-; atranorin.

Ecology. The species is found growing on bark at an elevation of 761 m.

Geographical distribution. Outside S. Korea, the species is reported from temperate regions of USA, Europe

and China [1, 2].

Remarks. The species is close to *B. desertica* (Marbach) Bungartz, which differs in having ellipsoid to $\pm$ citriform ascospores with a distinctly thickened septum, and has a restricted distribution in Baja California.

Specimen examined. South Korea, Kangwon Prov., Mt. Duta, N37°26'36.8", E128°59'35.3", alt. 761 m, on bark, 11.05.2008, Hur 080106 (KoLRI).

***Buellia maritima* (A. Massal.) Bagl. (Fig. 2)**
 In Massalongo, Schedul. Critic. 8: 150 (1856).

Basionym: *Catolechia maritima* A. Massal., Framm. Lich.: 22, 1855.

Synonym: *Buellia lactea* var. *maritima* (A. Massal.) Anzi

Diagnostic characteristics. The species is characterized by a crustose, rimose to rimose-areolate, white to pale grey, dull, chalky, heavily pruinose thallus; medulla with calcium oxalate crystals (H_2SO_4 + needle shaped crystals); HNO_3 + violet epihymenium; hymenium without oil droplets; *aethalea*-type proper exciple; 8-spored asci; and 1-septate *Buellia*-type, oblong to ellipsoid ascospores with a non-thickened proper septum.

Chemistry. Thallus typically K+ yellow to red (crystals), C-, KC-, P+ yellow; medulla I- (non-amyloid); UV-; norstictic and connorstictic acids.

Ecology. At the collection site, the species grows on volcanic rocks along with species of *Ramalina* and *Phaeophyscia*, in coastal regions at an elevation of 5 m.

Geographical distribution. Southwestern North America, Mediterranean regions of southern Europe & North Africa, and the Sonoran Desert [1].

Remarks. In external morphology and general appearance, the species is close to *B. venusta* (Körb.) Lettau, but can be easily differentiated by their ascospores: *B. maritima* has 1-septate ascospores while *B. venusta* has pluriseptate ones.

Specimens examined. South Korea, Jeju Prov., Jeju Island, N33°30'17.8", E126°54'47.5", alt. 5 m, on shore rocks, 17 October 2006, Hur 061020 (KoLRI); Jeonnam Prov., Bogil Island, N34°08'08.9", E126°30'23.5", alt. 5 m, on shore rocks, 30 December 2004, Hur 041646 (KoLRI).

***Buellia polyspora* (Willey) Vain. (Fig. 3)**
 Acta Soc. Fauna Fl. Fenn. 7: 171 (1890).

Basionym: *Buellia myriocarpa* var. *polyspora* Willey, in Tuck., Syn. N. Americ. Lich. 2: 97, 1888.

Synonym: *Amandinea polyspora* (Willey) E. Lay & P. May

Diagnostic characteristics. The species is characterized by a crustose, indistinct to granular, subsquamulose (when well developed) pale brown to greyish brown, dull thallus; medulla lacking calcium oxalate crystals (H_2SO_4 -); HNO_3 - epihymenium; hymenium without oil droplets; *aethalea*-type proper exciple; polysporous asci (16-spored); 1-septate *Buellia*-type, oblong to ellipsoidal small ascospores ($8.4\text{--}10.2 \times 3.2\text{--}4.2 \mu\text{m}$) with a narrow, non-thickened proper septum; and filiform conidia.

Chemistry. Thallus K- (rarely K+ yellow), C-, P-; medulla I- (non-amyloid); UV-; no substances or rarely with atranorin.

Ecology. At the collection site, the species is found growing on the bark of *Alnus* between elevations of 115–120 m.

Geographical distribution. Eastern and southern USA and the Sonoran Desert [1].

Remarks. The species is often confused with *B. schaereri* De Not. due to having similar small ascospores, but the latter species never has polysporous asci and always has bacilliform conidia.

Specimens examined. South Korea, Jeonnam Prov., Suncheon, N34°58'00.4", E127°28'32.9", alt. 115 m, on *Alnus* bark, 08 October 2005, L. Lökös 050672 (KoLRI); Jeonnam Prov., Jangheung, Mt. Cheongwan, N34°32'56.1", E126°56'11.1", alt. 120 m, on *Alnus* bark, 07 October 2005, L. Lökös 050632 (KoLRI).

***Buellia punctata* (Hoffm.) A. Massal. (Fig. 4)**
Ricerch. Auton. Lich.: 81 (1852).

Basionym: *Verrucaria punctata* Hoffm., Deutschl. Fl.: 192, 1796.

Synonyms: *Amandinea punctata* (Hoffm.) Coppins & Scheid.; *B. punctata* var. *globulans* Zahlbr.

Diagnostic characteristics. The species is characterized by a crustose, scurfy, rimose to rimose-areolate, pale gray to pale brown to greenish-brown dull thallus; medulla lacking calcium oxalate crystals (H_2SO_4 -); HNO_3 - epihymenium; hymenium without oil droplets; *aethalea*-type proper exciple; 8-spored asci; 1-septate, faintly to smoothly ornamented, *Buellia*-type, ellipsoid ascospores with a narrow, non-thickened proper septum.

Chemistry. Thallus typically K, C, KC, P; medulla I (non-amyloid); UV; no lichen substances detected.

Ecology. In South Korea, the species is found growing on the bark of *Zelkova* at an altitude of 40 m.

Geographical distribution. Cosmopolitan [1].

Remarks. As genus *Amandinea* is currently not well supported by Bungartz *et al.* [9], the species is retained here within *Buellia*.

Specimen examined. South Korea, Jeollanam Prov., Suncheon, Suncheon National University, N34°58'00.9, E127°28'48.0, alt. 40 m, on *Zelkova* bark, 05.10.2005, Lökös 050623 (KoLRI).

***Buellia spuria* (Schaer.) Anzi. (Fig. 5)**
Cat. Lich. Sondr.: 87 (1860).

Basionym: *Lecidea spuria* Schaer., Lich. Helvet. Spicil. Sect. 3: 127, 1828.

Synonyms: *Buellia amblyogona* Müll. Arg.; *B. atroalba* var. *spuria* (Schaer.) Boist.; *B. italica* A. Massal.; *B. krempehuberi* Zahlbr.; *B. lactea* (A. Massal.) Körb.; *B. liguriensis* de Lesd.; *B. olivaceofusca* (Anzi) Jatta; *Catolechia recobarina* A. Massal.; *Lecidea nitidula* var. *spuria* (Schaer.) Fries.

Diagnostic characteristics. The species is characterized by a crustose, areolate, white to whitish grey to dark grey thallus with a conspicuous black prothallus and hypothallus; medulla lacking calcium oxalate crystals (H_2SO_4 -); HNO_3 + violet epihymenium; hymenium without oil droplets; *aethalea*-type proper exciple; 8-spored asci; 1-septate, *Buellia*-type, oblong to ellipsoid ascospores with a narrow, non-thickened proper septum.

Chemistry. Thallus usually K+ yellow to red (crystals), C-, KC-, P- or + yellow; medulla I+ blue (amyloid); UV-; atranorin, chloroatranorin, norstictic and stictic acids.

Ecology. At the collection site, the species is found growing on rocks along coastal regions at an elevation of 10 m.

Geographical distribution. The species is common and widely distributed throughout the Northern Hemisphere [1, 10].

Remarks. The species is often confused with *B. stellulata* (Taylor) Mudd, but the latter contains atranorin, 2'-O-methylperlatolic and confluent acids and also has I medulla.

Specimens examined. South Korea, Jeonnam Prov., Geomun Island, N34°00'39.8" E127°19'01.9", alt. 10 m, on rocks, 24 March 2007, Hur 070087, 070088, 070094,

070102 (KoLRI).

***Buellia stellulata* (Taylor) Mudd.**

(Fig. 6)

Man. Brit. Lich.: 216 (1861).

Basionym: *Lecidea stellulata* Taylor, in Mack., Fl. Hibern. 2: 118, 1836.

Synonyms: *Buellia candidula* Arnold; *B. rimulata* (Nyl.) Zahlbr.; *Lecidea microtera* Nyl.; *L. stellulata* var. *macrior* Zahlbr.; *L. squamulosa* Fée.

Diagnostic characteristics. The species is characterized by a crustose, areolate white to whitish grey to dark grey thallus with a conspicuous black prothallus and hypothallus; medulla lacking calcium oxalate crystals (H_2SO_4 -); HNO_3 + violet epihymenium; hymenium without oil droplets; *aethalea*-type proper exciple; 8-spored asci; 1-septate, *Buellia*-type, oblong to ellipsoid ascospores with a narrow, non-thickened proper septum.

Chemistry. Thallus usually K+ yellow (sometimes weak), P- or + faintly yellow, C-, KC-; medulla I- (non-amyloid); UV-; atranorin, 2'-*O*-methylperlatolic and confluent acids.

Ecology. At the collection site, the species is found on coastal rocks at an altitude of 5 m, along with species of *Phylliscum*.

Geographical distribution. The species is common and widely distributed throughout the Northern Hemisphere [1-3].

Remarks. It is similar to *B. spuria* (Schaer.) Anzi, but the latter contain atranorin, chloroatranorin, norstictic and stictic acids and have I+ medulla.

Specimen examined. South Korea, Jeju Prov., Jeju Island, N33°22'20.5", E126°52'42.4", alt. 5 m, on shore rocks, 17

Figs 1–6. Habitus of *Buellia* species in South Korea. Fig. 1. *B. disciformis*. Fig. 2. *B. maritime*. Fig. 3. *B. polyspora*. Fig. 4. *B. punctata*. Fig. 5. *B. stellulata*. Fig. 6. *B. spuria*. Scale bars = 1 mm.

October 2006, Hur 061010 (KoLRI).

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