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New records of *Rhizocarpon* from China

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Abstract – Four new lichen records are reported from China — *Rhizocarpon grande*, *R. infernulum*, *R. petraeum*, and *R. rubescens*. Detailed taxonomic descriptions with photos and comments are provided.

Key words – *Rhizocarpaceae*, Asia, taxonomy

Introduction

De Candolle originally established *Rhizocarpon* (*Rhizocarpaceae*) in 1805 (Kirk et al. 2008). The lichen genus, which is predominately distributed in temperate, alpine and polar regions, includes about 200 species worldwide (Feuerer & Timdal 2004; Ihlen 2004; Kirk et al. 2008). The genus is distinguished by its rock dwelling crustose thallus with black lecideine apothecia, branched and anastomosed paraphyses, *Rhizocarpon*-type asci, and 1-septate to muriform ascospores with a swollen perispore (halonate).

Traditionally *Rhizocarpon* is divided into taxa with a yellow thallus containing rhizocarpic acid (subgenus *Rhizocarpon*) and taxa with white, gray, or brown thalli lacking rhizocarpic acid (subgenus *Phaeothallus*) (Thomson 1967).

In China, 28 *Rhizocarpon* species have been reported (Wei 1991; Abbas & Wu 1998; Aptroot 2002; Aptroot & Sparrius 2003). During our study of *Rhizocarpon* in China, four additional species were found in subgenus *Phaeothallus*: *R. grande, R. infernulum, R. petraeum,* and *R. rubescens.*

Materials & methods

The examined specimens are preserved in SDNU (Lichen Section of Botanical Herbarium, Shandong Normal University). Their morphological and anatomical characters were examined under a stereomicroscope (COIC XTL7045B2) and a polarizing microscope (Olympus CX41). Lichen substances were identified using standardized thin layer chromatography techniques (TLC) with solvent system C (Orange et al. 2001). Photographs were taken under Olympus SZX16 and BX61 with DP72.

Taxonomy

Rhizocarpon grande (Flörke ex Flot.) Arnold, Flora 54: 149 (1871) Figs 1, 2

Thallus saxicolous, crustose, verrucose-areolate to bullate-verrucose, 0.15–0.2 mm thick, pale gray to gray-brown, epruinose; hypothallus prominent, black; cortex and medulla with obvious crystals; algal layer even. Apothecia lecideine, black, between the areolae, angular or rounded, 0.4–0.6 mm in diam; margin thin to disappearing; disc flat to convex; exciple brown, with crystals; epihymenium olivaceous brown, with crystals, usually K+ purple red; hymenium hyaline to pale brown in upper part, 110–135 μm tall; paraphysis

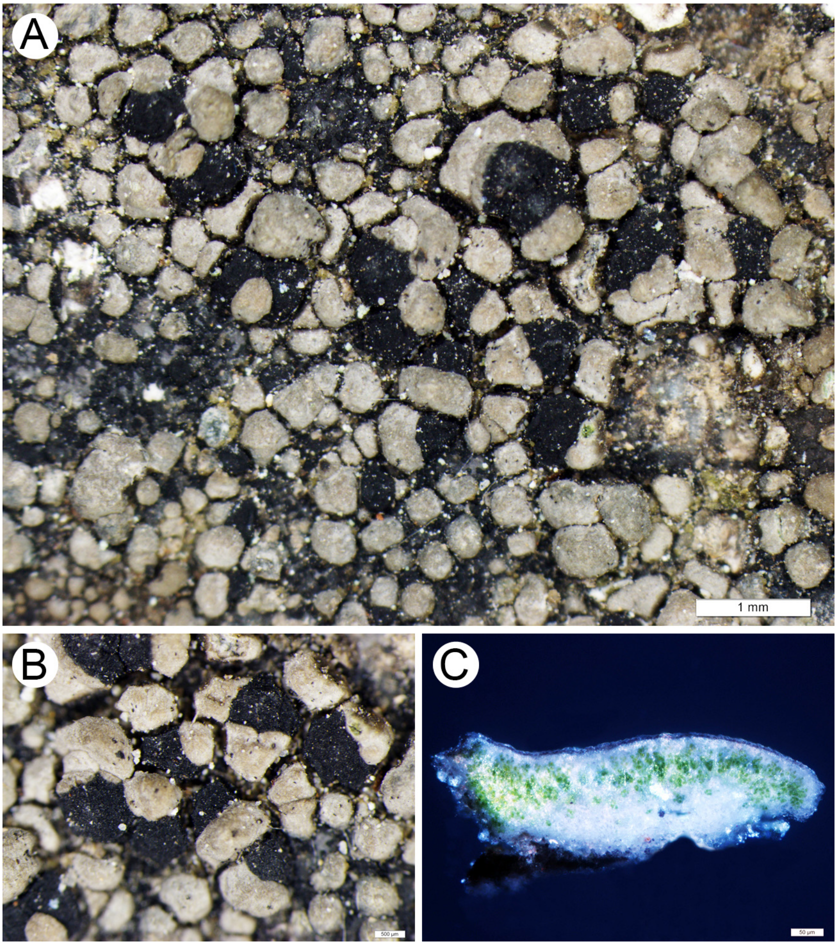

Figure. 1 *Rhizocarpon grande* (Fu 20124496, SDNU). A: Thallus; B: Apothecia; C: Crystals in thallus section. Scale bars: A = 1 mm; B = 500 μm; C = 50 μm.

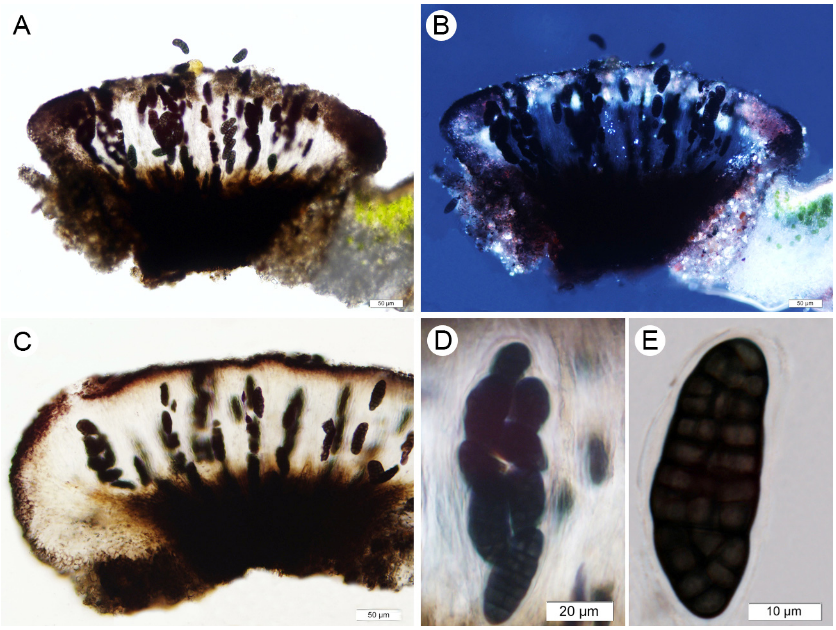

Figure. 2 *Rhizocarpon grande* (Fu 20124496, SDNU). A: Apothecium section; B: Crystals in apothecium section; C: K reaction; D: Ascus; E: Ascospore. Scale bars: A–C = 50 μm; D = 20 μm; E = 10 μm.

capitate, branched and anastomosing; hypothecium brown. Asci *Rhizocarpon*-type, 8-spored. Ascospores dark brown, muriform, ellipsoid, 25–40 × 10–16 μm.

Chemistry — Secondary metabolites: gyrophoric acid and stictic acid.

Specimen examined — **CHINA. Inner Mongolia**, Arxan city, Mt. Jiguan, alt. 1500 m, on rock, 29 Aug. 2011, H.D. Fu 20124496 (SDNU).

Comments — *Rhizocarpon grande* resembles *R. eupetraeum* in having a verrucose thallus, but *R. eupetraeum* contains norstictic acid, lacks gyrophoric acid, and has a K– epihymenium. *Rhizocarpon grande* is also similar to *R. geminatum*, which can be differentiated by its 2-spored asci, larger ascospores (35–60 × 18–30 μm; Thomson 1997), and absence of gyrophoric acid.

Distribution — *Rhizocarpon grande* has been reported from North America, Europe, Asia, and Antarctica (Thomson 1997, Galloway 2007, Golubkov & Matwiejuk 2009). New to China.

Rhizocarpon infernulum (Nyl.) Lynge, Rhodora 36:158 (1934) Figs 3, 4

Thallus saxicolous, crustose, rimose to cracked areolate, brown, 0.05–0.085 mm thick, epruinose; prothallus black, well developed; cortex without crystals,

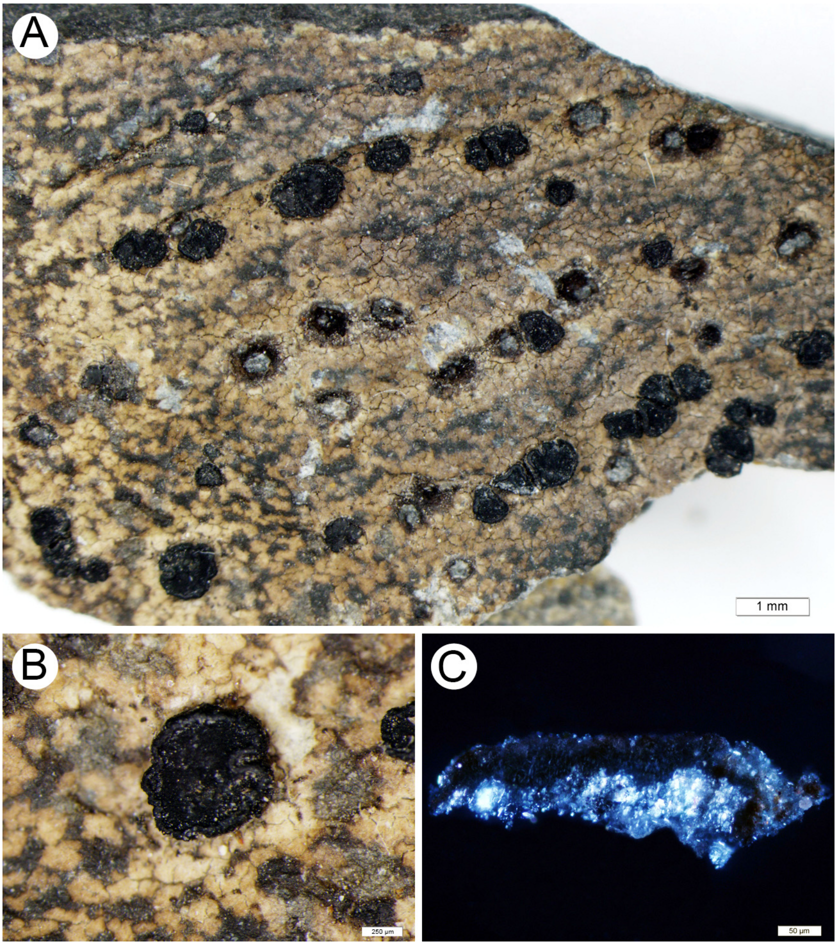

Figure. 3 *Rhizocarpon infernulum* (Zhang 20103078, SDNU). A: Thallus; B: Apothecium; C: Crystals in thallus section. Scale bars: A = 1 mm; B = 250 µm; C = 50 µm.

medulla with obvious crystals; algal layer even. Apothecia lecideine, black, innate, 0.3–0.7 mm in diam; disc flat; margin persistent, thin; exciple well developed, carbonaceous, without crystals; epihymenium usually with aeruginous blue to blue-black pigment, without crystals, N+ purple red; hymenium hyaline, 70–90 µm tall; paraphysis branched and anastomosing, scarcely swelling at apex, with sharply delimited, brown cap, although this is often masked by a blue-green epithecial pigment; hypothecium brown. Asci *Rhizocarpon*-type, 8-spored. Ascospores hyaline, 1-septate, ellipsoid, 15–18 × 7–8.5 µm.

Chemistry —No substances were detected by TLC.

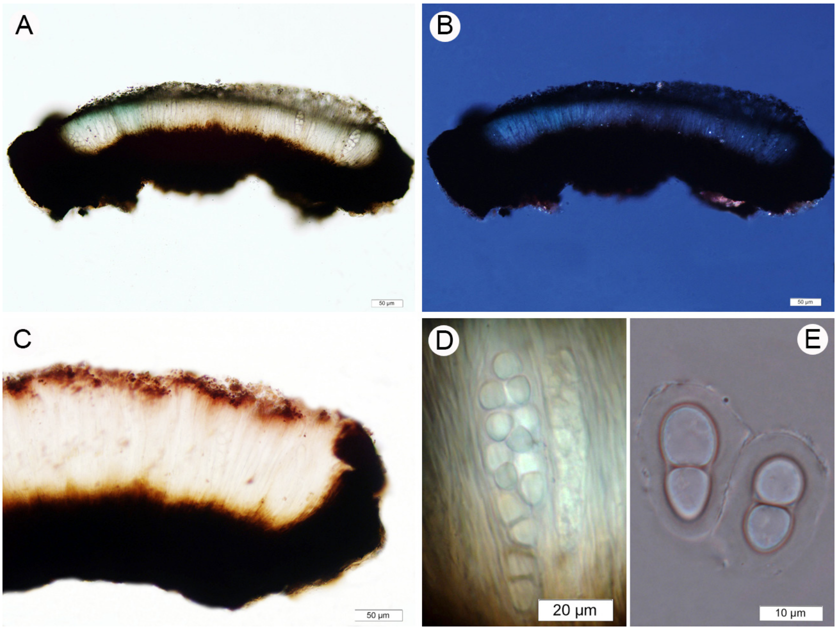

Figure. 4 *Rhizocarpon infernulum* (Zhang 20103078, SDNU). A: Apothecium section; B: Crystals in apothecium section; C: N reaction; D: Ascus; E: Ascospores. Scale bars: A–C = 50 µm; D = 20 µm; E = 10 µm.

Specimens examined — **CHINA. Guizhou**, Leishan county, Mt. Leigong, alt. 2700 m, on rock, 9 Nov. 2009, L.L. Zhang 20103078 (SDNU); alt. 2100 m, on rock, 1 Apr. 2011, X.R. Kou 20111813 (SDNU); alt. 1800 m, on rock, 2 Apr. 2011, Y.L. Cheng 20112591A (SDNU).

Comments — *Rhizocarpon infernulum* is morphologically close to *R. hochstetteri*, which can be separated by the thicker thallus (0.1–0.35 mm thick) and larger ascospores (21–25 × 10–12 µm) (Fryday 2002). *Rhizocarpon infernulum* is also similar to *R. cinereovirens*, which can be distinguished by its less well-developed exciple with a hyaline interior and the usual presence of norstictic acid or stictic acid.

Distribution — *Rhizocarpon infernulum* has been reported from Europe, Asia, and North America (Fryday 2002, Fletcher et al. 2009). New to China.

Rhizocarpon petraeum (Wulfen) A. Massal., Ric. Auton. Lich. Crost. 102 (1852) Figs 5, 6

Thallus saxicolous (usually on siliceous rock), crustose, continuous to rimose, areolate in part, often flat and polygonal, 0.14–0.2 mm thick, pruinose, when eroded, thallus surface gray to brown; when eroded, thallus surface gray

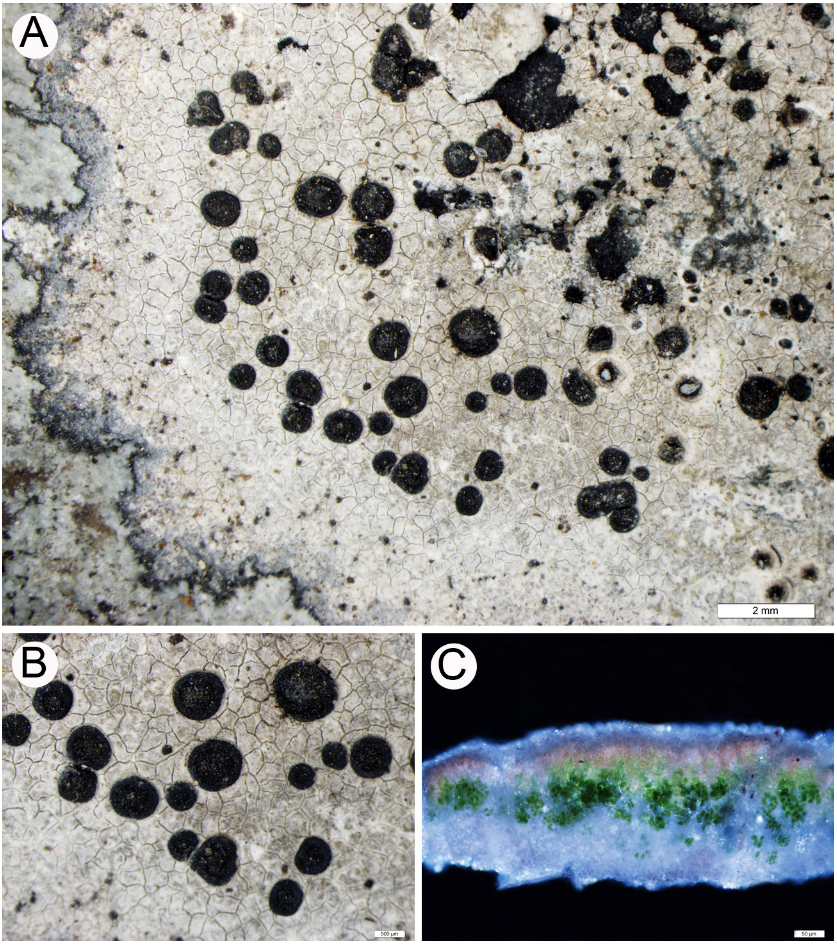

FIGURE. 5 *Rhizocarpon petraeum* (Li 20126494A, SDNU). A: Thallus; B: Apothecia; C: Crystals in thallus section. Scale bars: A = 2 mm; B = 500 µm; C = 50 µm.

to brown; prothallus distinct, black; cortex and medulla with obvious crystals; algal layer even. Apothecia lecideine, innate, irregularly arranged, 0.4–1 mm diam; disc flat, black, epruinose; margin distinct, persistent; exciple dark brown to dark blue-green at the rim, inner part colourless to brown, with crystals, N+ purple; epihymenium olivaceous, with obvious crystals; hymenium hyaline, 150–200 µm tall; paraphysis branched and anastomosing; hypothecium brown. Asci *Rhizocarpon*-type, 8-spored. Ascospores: hyaline, becoming dark when over-mature, narrowly ellipsoid to ellipsoid, eumuriform, 23–50 × 12–16 µm, with 12–21 cells in optical view.

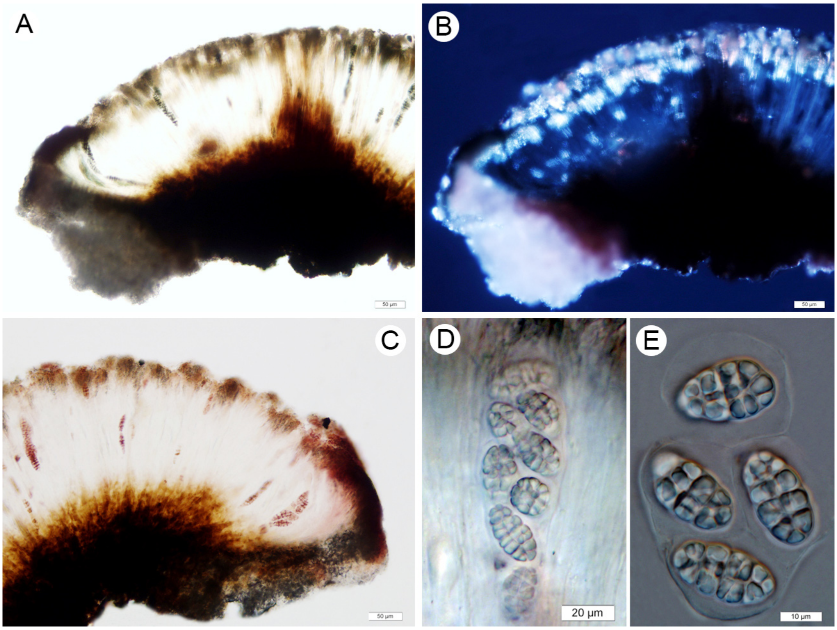

Figure. 6 *Rhizocarpon petraeum* (Li 20126494A, SDNU). A: Apothecium section; B: Crystals in apothecium section; C: N reaction; D: Ascus; E: Ascospores. Scale bars: A–C = 50 µm; D = 20 µm; E = 10 µm.

Chemistry — Secondary metabolites: stictic acid.

Specimens examined — **CHINA. Xinjiang**, Urumqi, Nanshan–Xiaoquzi, alt. 2700 m, on rock, 28 Aug. 2011, L. Li 20126494A (SDNU); 28 Aug. 2011, Z.L. Huang 20125928 (SDNU).

Comments — *Rhizocarpon petraeum* is morphologically close to *R. umbilicatum*, which can be distinguished by its smaller ascospores (22–27.5 × 11–15 µm) with 6–8 cells in optical view and usual growth on calcareous rock (Ihlen 2004). When the thallus is not distinctly covered with pruina, *R. petraeum* is also similar to *R. lavatum* and *R. reductum*, but *R. lavatum* lacks secondary metabolites, and *R. reductum* produces ascospores containing fewer cells (8–13 cells in optical view; Ihlen 2004).

Distribution — *Rhizocarpon petraeum* has been reported from Europe, North America, Australia, and Asia (Ihlen 2004, Fletcher et al. 2009, Golubkov & Matwiejuk 2009). New to China.

Rhizocarpon rubescens Th. Fr., Lich. Scand. 1: 631 (1874) Figs 7, 8

Thallus saxicolous, crustose, areolate, areoles convex, rounded, containing small granules, gray to gray-brown, 0.15–0.2 mm thick, epruinose; prothallus

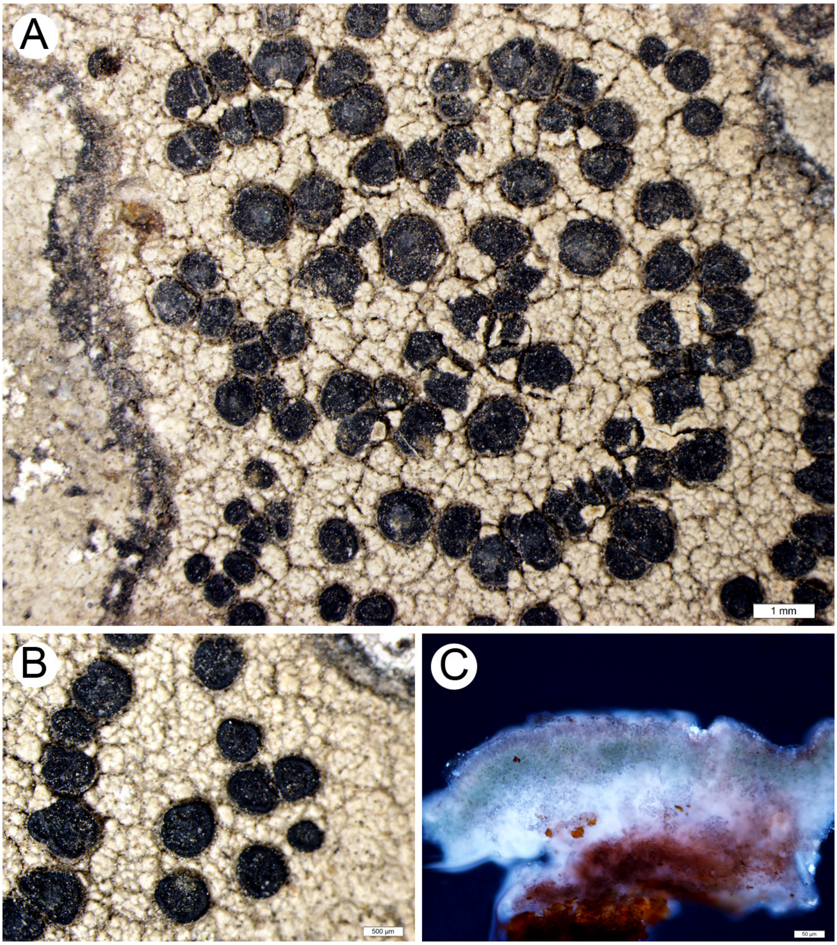

FIGURE. 7 *Rhizocarpon rubescens* (Shi 061473, SDNU). A: Thallus; B: Apothecium; C: Crystals in thallus section. Scale bars: A = 1 mm; B = 500 µm; C = 50 µm.

distinct, black; cortex and medulla with crystals; algal layer even. Apothecia lecideine, innate, irregularly arranged or sometimes arranged in a circular pattern, 0.5–1mm diam; disc flat, black; margin distinct when young; exciple dark brown, with obvious crystals, K+ purple; epihymenium dark green, with crystals; hymenium hyaline, often with a Macrocarpa-green tinge, 130–150 µm tall; paraphysis branched and anastomosing; hypothecium dark brown. Asci *Rhizocarpon*-type, 8-spored. Ascospores hyaline, ellipsoid, eumuriform, 25–38 × 12–15 µm.

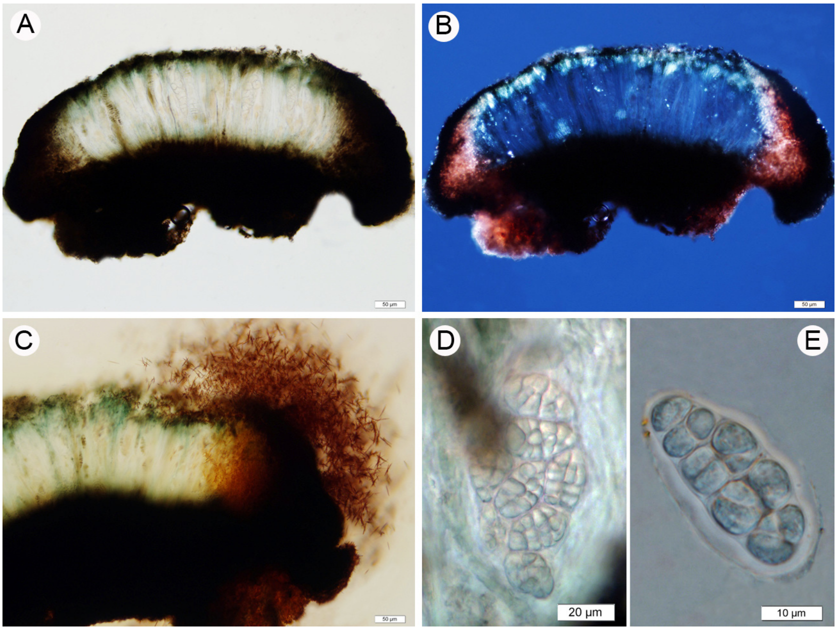

Figure. 8 *Rhizocarpon rubescens* (Shi 061473, SDNU). A: Apothecium section; B: Crystals in apothecium section; C: K reaction; D: Ascus; E: Ascospore. Scale bars: A–C = 50 µm; D = 20 µm; E = 10 µm.

Chemistry — Secondary metabolites: norstictic acid.

Specimens examined — **CHINA**. **Gansu**, Wenxian county, Qiujiaba, alt. 2250 m, on rock, 3 Aug. 2006, X.L. Shi 061473 (SDNU), 061475 (SDNU); **Yunnan**, Lijiang city, Mt. Laojun, alt. 3800 m, on rock, 5 Nov. 2009, H.Y. Wang 20100308A (SDNU).

Comments — *Rhizocarpon rubescens* resembles *R. suomiense* in having hyaline, muriform ascospores and norstictic acid, but *R. suomiense* has 2-spored asci and strongly muriform ascospores (31–54 cells in optical view; Ihlen 2004). *Rhizocarpon rubescens* is morphologically close to *R. reductum*, but *R. reductum* contains stictic acid and has a K+ blue epithecium and K+ yellow exciple.

Distribution — *Rhizocarpon rubescens* has been reported from Europe and North America (Fryday 2000, Ihlen 2004). New to China.

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