

A new species of *Fellhanera* (lichenized Ascomycota: *Pilocarpaceae*) from central North America

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Abstract: *Fellhanera crucitignorum*, a blastidiate crustose lichen with anthraquinones and submuriform ascospores, is described as new to science. The species is associated with exposures of non-calcareous sandstones in Kansas and Oklahoma, in the southern portion of North America's Great Plains. The anthraquinones are typically concentrated in the blastidia, creating a distinctive grey thallus with localized orange granules.

Key words: anthraquinones, Cross Timbers, Great Plains, Kansas, Oklahoma, saxicolous

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Introduction

The genus *Fellhanera* Vězda comprises more than 70 species of crustose lichens with small, thin-margined apothecia with a paraplectenchymatous exciple, branched and anastomosing paraphyses, *Byssoloma*-type asci (*sensu* Hafellner 1984), ellipsoid to cylindrical, septate ascospores typically constricted at the septa, and pycnidial conidiomata that produce bacilliform to pyriform conidia. The majority of species are foliicolous (Lücking 2008), although corticolous and saxicolous taxa are also known. Of the eleven species reported from the USA (Esslinger 2011), six are typically saxicolous (van den Boom 2004; Harris & Lendemer 2009). Continuing fieldwork by the authors in the south-eastern part of the Great Plains has revealed a blastidiate crustose lichen with anthraquinones associated with exposures of non-calcareous sandstones. The species was recently discovered with apothecia in Kansas and confirmed to belong to *Fellhanera*.

Materials and Methods

Specimens were studied dry using dissecting microscopes and subjected to chemical analysis using standard

spot tests (reagents are abbreviated following Brodo *et al.* 2001) and thin-layer chromatography (TLC). TLC was carried out at KANU using solvent systems A, B' and C following the methods of Orange *et al.* (2001). Mounts were prepared by hand with a razor blade and placed in water. Microscopic characters were observed on material mounted in water and images were captured and measured to the nearest hundredth μm using a Nikon Color View II soft imaging system camera with analySIS Imager 3.2. Illustrations were prepared using Adobe Photoshop. Measurements are presented as a simple range or, where sufficient material allowed, as the average (\bar{x}) \pm one standard deviation (SD), bounded by the smallest and largest observed values, and followed by the sample size (n) [i.e., (smallest observed) $\bar{x} - 1 \text{ SD} - x - \bar{x} + 1 \text{ SD}$ (largest observed) (n)].

Taxonomy

Fellhanera crucitignorum C. A. Morse & Ladd sp. nov.

MycoBank No: MB803253

Fellhanera species saxicola vel muscicola, thallo blastidiato crystallina rubra et K+ purpurea continenti, ascis 8-sporis, ascosporis submuriformibus 15.8–20.1 \times 6.6–8.2 μm , conidiis bacilliformibus vel lageniformibus, 3.3–4.7 \times 1.0–1.5 μm .

Typus: USA, Kansas, Woodson Co., 6 mi E of Toronto, Woodson Co State Fishing Lake & Wildlife Area on SE side, 37.79396°–37.79463°N, 95.83590°–95.83416°W, elevation 1020–1050 ft, upland, brushy to open Cross Timbers with frequent outcrops and boulders of non-calcareous sandstone on gentle, primarily W-facing slopes above artificial lake, on outcrops and small rocks and overgrowing bryophytes, occasionally on stabilized soil, 18 March 2012, C. A. Morse 23306 & K. J. Morse (KANU—holotypus).

(Fig. 1)

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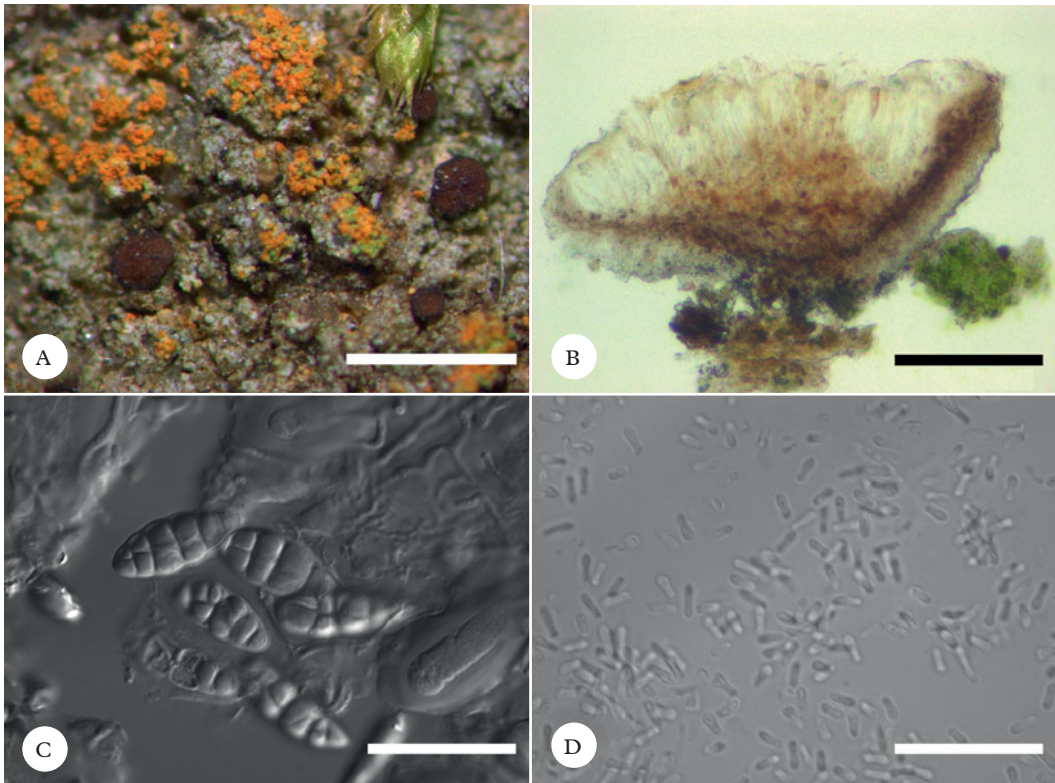


FIG. 1. *Fellhanera crucitignorum*. A, apotheciate thallus growing on rock; B, apothecial section (Morse 23306—holotype); C, ascospores after treatment with 10% KOH (Morse 23306—holotype); D, conidiospores (Morse 14523, KANU). Scales: A = 1 mm; B = 100 μ m; C & D = 20 μ m. In colour online.

Thallus to 20 cm diam., whitish grey, brownish grey, greyish green, yellowish green, or (typically in areas where blastidia are developing) mottled pale to dark orange, arising as small, convex, pale greenish or greyish granules, occasionally from a white hyphal weft or a scantily developed, finely fibrous, white prothallus, granules coalescing in older areas to form a thin, effuse, continuous, granular-verrucose thallus (especially over bryophytes) or forming thicker, verrucose areoles 0.5–2.0 mm wide, or the thallus poorly developed and essentially chasmolithic, especially on coarser saxicolous substrata; *blastidia* produced laminally and marginally on convex areoles, initiated in small punctiform to oblong patches *c.* 0.5 mm diam., often coalescing to cover large areas of the older part of the thallus, pale green, pale orange, or (usually) dark orange, fine

and soredia-like to coarser and globose, oblong or irregular in shape, 25–53 \times 18–35 μ m, budding apically and becoming somewhat coralloid; *soralia* and *isidia* absent. *Photobiont* chlorococcoid, the cells round to slightly oblong, (4.5–)6.4–8.2–9.9(–10.9) μ m in diam. ($n = 35$).

Apothecia rare (observed on three specimens), widely scattered, sessile, constricted at the base, 0.2–0.5 mm diam.; *disc* dark reddish brown to black, plane to convex, surface slightly roughened; *margin* prominent and slightly elevated above the disc or becoming excluded in convex apothecia, finely papillate, concolorous with the disc or paler; *epihymenium* pale; *hymenium* 50–70 μ m high, pale to yellowish, not interspersed; *paraphyses* moderately branched, slender, scarcely expanded distally, to *c.* 2.3 μ m wide; *proper exciple* paraplectenchymatous, of globose to

oblong cells 5.2–6.7 µm diam., the outer layer *c.* 36 µm thick, hyaline, the inner layer *c.* 19 µm thick, with dark reddish brown (K+ reddish) cell walls; *hypothecium* to 85 µm high, of globose cells with reddish brown or orange-brown walls, the orange pigments intensifying in K. *Asci* *Byssoloma*-type (outer wall I+/KI+ dark blue, tholus KI+ pale blue with a darker tubular structure), *c.* 43–61 × 13–16 µm; *ascospores* 8 per ascus, ellipsoid to narrowly ovoid, typically constricted at the septa and often somewhat irregular in outline, submuriform with 4 to 6 primary locules, the central 2 to 4 with (0–) 1 (–2) vertical septa, (14.1–) 15.8–18.2–20.1(–23.0) × (5.9–) 6.6–7.4–8.2(–9.1) µm (*n* = 29).

Pycnidia uncommon, partially immersed, black (walls charcoal grey to blue-grey, K–); *conidia* bacilliform to ± lageniform or somewhat biclavate, (2.4–) 3.3–4.0–4.7(–6.6) × (0.9–) 1.0–1.3–1.5(–1.9) µm (*n* = 56).

Chemistry. TLC: orange areas of thallus and blastidia contain two anthraquinones: 1) Rf class 7/6–7/7 (before charring pale yellow in daylight, UVL+ yellow to yellow-orange; after charring dull greenish yellow, UVL+ dark brownish orange in solvent A, faint yellowish, UVL+ yellowish orange in solvent B', and yellowish grey, UVL+ dark in solvent C); 2) Rf class 6/5–6/6 (before charring pale yellow in daylight, UVL+ pure orange; after charring brownish grey, UVL+ deep pinkish orange in solvent A, nearly colourless, UVL+ red-orange in solvent B', and brownish grey, UVL+ dark purplish in solvent C). The upper spot appears to be consistent with fragilin. Spot tests: greenish and greyish areas of thallus and apothecial discs and margins all K–, UV–; orange areas K+ magenta, UV+ deep reddish orange.

Etymology. The epithet *crucitignorum* is derived from the Latin words 'cruX' (cross) and 'tignum' (board, and by extension timber) and translated as 'of the Cross Timbers', the ecogeographical region in which the majority of specimens have been collected. The Cross Timbers contains some of the last expanses of old growth oak woodlands in North America (Clark & Hallgren 2004), and fieldwork is

revealing significant lichen discoveries (e.g. Ladd & Morse 2012).

Ecology and distribution. *Fellhanera crucitignorum* is known from the eastern part of the Central Mixed-Grass Prairie, Osage Plains/Flint Hills Prairie, and Cross Timbers ecoregions in eastern Kansas and central Oklahoma (The Nature Conservancy 2007), at elevations of 213–481 msm (Fig. 2), where it occurs in upland, Cross Timbers woodland or in mixed-grass and tallgrass prairie openings, often on open, south and west-facing slopes. Most specimens occurred directly on outcrops, boulders, and fragments of sandstone, or overgrowing bryophytes on sandstone. Two specimens were collected from stabilized sandy soil weathered from typical sandstone substratum. *Endocarpon pallidulum* (Nyl.) Nyl. and *Trapelia placodioides* Coppins & P. James appear to be common associates of *F. crucitignorum*. Other notable taxa found in close association include *Agonimia opuntella* (Buschardt & Poelt) Vězda, *Anisomeridium distans* (Willey) R. C. Harris, *Lepraria lobificans* Nyl., *Peltula patellata* (Bagl.) Swinscow & Krog, *Phaeophyscia adiantola* (Essl.) Essl., *Rinodina destituta* (Nyl.) A. Zahlbr., *R. oxydata* (Massal.) Massal., *R. tephrae* Tuck., *Thelenella muscorum* (Fr.) Vain. and *Thelidium minutulum* Körb.

The distributional pattern of *F. crucitignorum* in eastern Kansas tracks closely areas where surfacing sandstone is abundant, as it is throughout much of central Oklahoma; elsewhere in eastern Kansas, in the Flint Hills and eastern Osage Plains, the dominant substrata are comprised of surfacing limestones and highly calcareous soils. In combination with the relatively arid climate of the southern Plains, this surfacing sandstone gives rise to the distinctive vascular plant and lichen floras of the Cross Timbers and Smoky Hills Prairies. Mean annual precipitation across the known range of *F. crucitignorum* varies from *c.* 700–1200 mm. All of the region has a negative net evaporational value (open pan evaporation minus annual precipitation), typically ranging from 375 mm in the eastern portion of the range to 1550 mm in the west (based on Owenby *et al.*

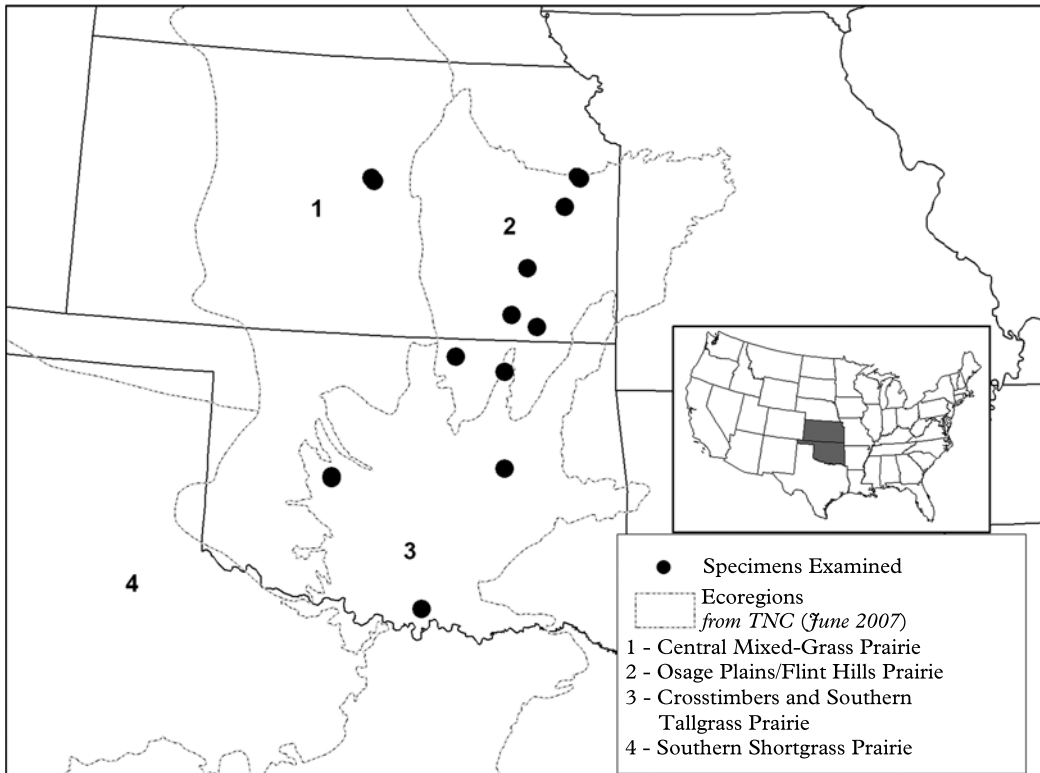


FIG. 2. Distribution of *Fellhanera crucitignorum*.

1992 and NOAA 1982). Interestingly, despite intensive fieldwork (e.g. Harris & Ladd 2005), the species has not been found in the higher net precipitation accumulation region of the adjacent Interior Highlands, which has similar vegetation and substrata.

Discussion. *Fellhanera crucitignorum* is characterized by the combination of a blastidiate thallus with localized areas of anthraquinone deposition, red-brown to black apothecia with concolorous proper margins, 8-spored asci with submuriform ascospores, bacilliform to lageniform conidia, and its association with non-calcareous sandstone. Several saxicolous members of the *F. silicis* group and *F. nashii* van den Boom regularly produce blastidia (van den Boom 2004; Harris & Lendemer 2009), which are characterized as granular to soredioid or isidioid, but those species produce narrower, transversely septate spores.

Secondary chemistry is unknown from members of the *F. silicis* group, but van den Boom (2004) reported atranorin and probably divaricatic acid from *F. nashii*.

Fellhanera borbornica Sérus. *et al.*, recently described from material collected from basalt on the island of La Réunion in the Indian Ocean (Lumbsch *et al.* 2011), differs in its slightly broader muriform spores, as well as features of the apothecia and pycnidia, does not produce vegetative diaspores, and evidently lacks chemistry. *Fellhanera* includes several foliicolous species with submuriform or muriform spores in the *F. fuscatula* aggregate, circumscribed by the presence of fusiform or bacilliform conidia and the absence of secondary chemistry (Lücking 1997, 2008). *Fellhanera crucitignorum* is not close to any one of them in thallus and apothecial morphology and chemistry.

Sterile specimens of *F. crucitignorum* are most likely to be confused with sorediate species of *Caloplaca*, such as *C. xanthostigmoidea* (Räs.) Zahlbr., a species producing isidioid protruberances bearing aggregations of soredia-like elements (Søchting & Tønsberg 1997). However, that species is typically corticolous, with a distinctly yellow to orange thallus and orange pycnidia, and occurs in cool temperate regions in North America (Wetmore 2001). Its range is not known to overlap with that of *F. crucitignorum*.

The presence of anthraquinones in the thallus of *Fellhanera crucitignorum* constitutes a first report for the genus and is of some interest. Various pigments have been reported from *Fellhanera*, including the xanthone asemone in *F. bouteillei* (Desm.) Vězda (Spier *et al.* 2002), an unknown orange pigment in the pycnidial wall of *F. ochracea* Sparrius & Aptroot (Sparrius & Aptroot 2000) and substances described as K+ purple or purplish brown in the hypothecium and exciple of other species (Lücking 2008; Harris & Lendemer 2009). Otherwise, secondary chemistry in this genus appears to be limited to usnic acid, isousnic acid, zeorin, and a few fatty acids or orcinol *para*-depsides (Lücking *et al.* 1994; Aptroot *et al.* 1998; Sérusiaux *et al.* 2001; van den Boom 2004; Lücking 2008).

Anthraquinones are known from some other genera of *Pilocarpaceae* and related taxa. Flavo-obscurin B1 has been isolated from the apothecial margins of *Byssoloma rubromarginatum* Messuti & de la Rosa (Messuti & de la Rosa 2007) and emodin, 7-chlor-emodin, and fragilin from *B. tricholomum* (Mont.) Zahlbr. (Santesson 1970). Although *Byssoloma* and *Fellhanera* are closely related (Lücking 2008), the majority of *Fellhanera* species, including *F. crucitignorum*, are readily distinguished from *Byssoloma* by differences in exciple structure (Lücking 1997, 2008). Members of the genus *Malmidea* Kalb *et al.* (*Malmideaceae*), a genus recently erected to accommodate the greater part of *Malcolmiella* Vězda, have been shown to produce norsolorinic acid and other anthraquinones (emodin, emodin bisanthron) and several additional constituents in the medullary tissue (Lücking 2008; Kalb *et al.* 2011). *Malmi-*

dea was found to occupy an isolated position within the *Lecanorales* in the study of Kalb *et al.* (2011), and its members are distinct from *F. crucitignorum* (and from other *Pilocarpaceae*) in features of the ascus, as well as in having a partially medullary exciple and simple spores. *Malcolmiella cinereovirens* Vězda, the type of the genus, which was found by Kalb *et al.* (2011) to be distinct from *Malmidea*, has an ascus structure similar to that of *Pilocarpaceae* but differs from the new species and other members of *Fellhanera* in having 0–1-septate ascospores with warty ornamentation (Kalb *et al.* 2011).

Specimens examined. **USA:** *Kansas:* Chautauqua Co., 3.0 mi N, 0.75 mi E Hale, West Liberty Cemetery and environs, 37.28°N, 96.04°W, 2007, *Morse* 15761 (KANU), 2009, *Morse* 20258 & *Logan* (KANU); Douglas Co., 1.75 mi N, 0.5 mi W junction of US Hwy 56 & Douglas Co. Rd 1057 in Baldwin City, University of Kansas Ecological Reserves: Breidenthal Biological Reserve, 38.81°N, 95.20°W, 2006, *Morse* 14539 & *Morse* (KANU); 2010, *Morse* 22126 & *Logan* (KANU), *Morse* 23189 & *Logan* (KANU, fertile specimen); c. 0.25–0.45 mi N, 1.75 mi E junction of Douglas Co. Rd 1055 & US Hwy 56 in Baldwin City, property of Ralph & Roma Earles, 38.78°–38.79°N, 95.15°W, 2012, *Morse* 23262 & *Morse* (KANU); Ellsworth Co., 2 mi S, 0.5 mi W Carneiro, Wildlife Management Area along E side 25th Ave, 2.5 mi S junction with KS Hwy 140, 38.70°N, 98.03°W, 2005, *Morse* 12189 (KANU, fertile specimen); 4 mi S, 2 mi E of Carneiro, Kanopolis State Park: Horsethief Canyon area, 38.67°N, 98.00°W, 2010, *Morse* 20357 & *Logan* (KANU); Franklin Co., 3 mi S, 1 mi E Homewood, Ottawa University Natural History Reservation, 38.47°N, 95.36°W, 2008, *Morse* 16346 & *Logan* (KANU); Montgomery Co., 0.5 mi N, 5.5 mi W Liberty, S side of Montgomery Co. State Lake, 37.16°N, 95.69°W, 2006, *Morse* 14367 (KANU); 2012, *Morse* 23343 & *Morse* (KANU); Woodson Co., 6 mi E Toronto, Woodson Co. State Fishing Lake and Wildlife Area on SE side, 37.79°N, 95.84°W, 2006, *Morse* 14523 & *Roth* (KANU); 2008, *Morse* 18045a & *Logan* (KANU); 2011, *Morse* 23098 & *Morse* (KANU). *Oklahoma:* Caddo Co., c. 2.5 mi S Hinton, Red Rock Canyon State Park, S end, 35.44°N, 98.35°W, 2007, *Morse* 14852 & *Ladd* (KANU); Red Rock Canyon State Park, N end, 35.46°N, 98.35°W, 2007, *Morse* 14900 & *Ladd* (KANU), *Ladd* 28568 & *Morse* (hb. Ladd), *Ladd* 28581 & *Morse* (hb. Ladd); Love Co., c. 8.5 mi N, 1 mi E of Marietta, Lake Murray State Park, 34.06°N, 97.09°W, 2009, *Morse* 18435 & *Ladd* (KANU); Okmulgee Co., 0.50–0.75 mi N, 6 mi W of junction of US Hwys 62 & 75 on S side of Okmulgee, Okmulgee State Park, 35.62°N, 96.07°W, 2009, *Morse* 20185 & *Logan* (KANU); Osage Co., c. 9 mi N of Pawhuska, Tallgrass Prairie Preserve, along Wild Hog Creek, 36.81°N, 96.77°W, 1996, *Ladd* 19888 (hb. Ladd); 7.5 mi N, 3

mi E Barnsdall, Woolaroc Wildlife Preserve, 36°66'N, 96°11'W, 2007, *Morse* 14632c & *Ladd* (KANU).

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