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Three new species of *Rinodina* (Physciaceae) and a new record from North America

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Abstract. *Rinodina campestris, R. megistospora* and *R. terricola* are described as new to science. *Rinodina boleana* is recorded for the first time from North America and is compared in detail to *R. pyrina* and *R. imshaugii* and all are shown to possess *Dirinaria*–type spores.

Keywords. Ascomycotina, Lecanorales, taxonomy, *Dirinaria*–type spores, phytogeography.

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A monographic treatment of *Rinodina* (Ach.) Gray for North America (Sheard 2010) recorded 96 species for the continent. Van den Boom et al. (2009) have shown that *R. aurantiaca* Sheard is most probably a synonym of *R. capensis* Hampe thereby reducing this number by one. Subsequently, *R. pityrea* Ropin & H. Mayrhofer has been reported (Sheard 2011) from the floristically well–known northeastern seaboard. Two rare species are described here from the Pacific region: *Rinodina megistospora* from southwestern Oregon and *R. terricola* from southern California. It had been predicted that additional species were likely to be found in the west (Sheard 2010) but it was not expected that new species would be found in the Central Plains, a region often considered to be of relatively low species diversity. A new species, *Rinodina campestris,* and a new record for North America, *R. boleana* Giralt & H. Mayrhofer, were discovered in the course of recent intensive collecting in the Central Plains by CAM and associates.

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Materials and Methods

The study is based on material from the following herbaria: FH, H, KANU, NY, SBBG, SASK and UCR. Surface observations of specimens were made using a Wild M5 stereomicroscope and measurements taken at 25× magnification and rounded to the nearest 0.05 mm. Internal ascomata measurements were made on vertical sections (20–25 μm thick), cut with a Leitz freezing microtome, at 50× magnification to an accuracy of 5 μm using a Wild M20 compound microscope.

Ascospore measurements were taken at 500× magnification using a Wild vernier micrometer (scale

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of 0.1 μm) to an accuracy of 0.5 μm. Ascospore measurements and length/width ratios are quoted as the range between the 25th and 75th percentiles with the 5th and 95th percentiles quoted in brackets, therefore excluding the most extreme values. Observations of ascospore wall structure were made with an oil immersion lens at a magnification of 1250×. Spore photographs were taken with a stand mounted Nikon Coolpix 950 digital camera using wide angle, aperture priority, macro and highest quality picture settings. A remote monitor was necessary to assure adequate focus control.

Ascospore structure is central to the taxonomy of *Rinodina* and accurate identification of spore type is therefore essential. Internal spore structure in freshly gathered specimens is typically obscured by oil globules. Clearing has previously been achieved with Melzer's reagent (Sheard 2010) and may take a few minutes. Gently heating an aqueous slide preparation over methylated spirits burner to the point of boiling clears the spores more quickly and without ill effects (as used by Wetmore 1994 for *Caloplaca*). Spores clear themselves in the herbarium over a period of one to three years.

The shape of the spore lumina changes during development in most spore types and their structure should therefore be assessed and their size measured at maturity. A quick scan of a hand section squash preparation will reveal a range of spore wall pigmentation. Mature spores are those with the darkest walls prior to the over mature stage when the internal lumina and finally the walls themselves show signs of collapse.

Chemical constituents were identified by thin layer chromatography following the standard methods for lichen products (Culberson 1972; Culberson & Johnson 1982; Culberson & Kristinsson 1970; Elix & Ernst–Russell 1993).

The species

Rinodina boleana Giralt & H. Mayrhofer, Mycotaxon 40: 435 (1991). Type: Spain. catalonia: Alt Camp, Querol, Esblada, on *Rosmarinus officinalis*, 21.II.1988, *M. Giralt, A. Gómez–Bolea & P. Navarro–Rosinés* (bcc – holotype, hb. Giralt, gzu!, sask! – isotypes).

Description. Thallus thin, dark grey sometimes brownish, rimose; surface plane, matt or scurfy; margin indeterminate, prothallus absent; vegetative propagules absent. Apothecia broadly attached, frequent, often contiguous, to 0.25–0.50 mm in diam.; disc dark brown to black, plane sometimes becoming slightly convex; thalline margin concolorous with thallus, entire, ca. 0.05 mm wide, persistent or becoming excluded; excipular ring absent.

Apothecial anatomy. Thalline exciple 40–70 μm wide laterally; cortex poorly defined, 5–10 μm in diam. laterally, epinecral layer usually present, ca. 5 μm wide; cortical cells to 4.5–6.5 μm wide, usually unpigmented; algal cells to 17.0–23.5 μm long; crystals absent in cortex and medulla; proper exciple hyaline, <5 μm wide, expanding to 10–15 μm wide at surface; hypothecium hyaline, 15–40 μm deep; hymenium 60–70 μm high, not inspersed; paraphyses 2.5–3.0 μm wide, not conglutinate, often terminally branched, apices to 5.0–7.5 μm wide, darkly pigmented forming a dark brown epihymenium, lacking dispersed pigment; asci 35–45 × 10–15 μm.

Ascospores 8/ascus, Type B development, *Dirinaria*–type (Giralt 2001 p. 19; Sheard 2010 p. 10; **Fig. 1**), (12.5–)13.0–14.5(–16.0) × (6.0–)6.5(–7.0) μm (n=98), l/w ratio (1.9–)2.0–2.3(–2.5), lumina *Physcia*–like at first, becoming rounded, *Pachysporaria*–like with relatively wide lateral walls in addition to thick apical and septal walls, rarely slightly inflated in KOH at septum; septal disc absent; torus absent but diffuse septal pigmentation present; walls not ornamented. Pycnidia immersed; conidia bacilliform, 5–7 × 1 μm.

Chemistry. Spot tests all negative; secondary metabolites not detected.

Substrate and distribution. Recorded on *Artemisia filifolia, Celtis occidentalis* twigs, *Populus deltoids, Salix amygdaloides* and weathered wood of *Juniperus monosperma* between 720 and 1180 m elevation in the high Central Plains of northeastern Colorado, western Kansas and southwestern Nebraska, west of approximately 99° longitude (**Fig. 2**). The species is widespread in the Mediterranean region of Europe (Giralt 2001) and has recently been recorded from New Zealand

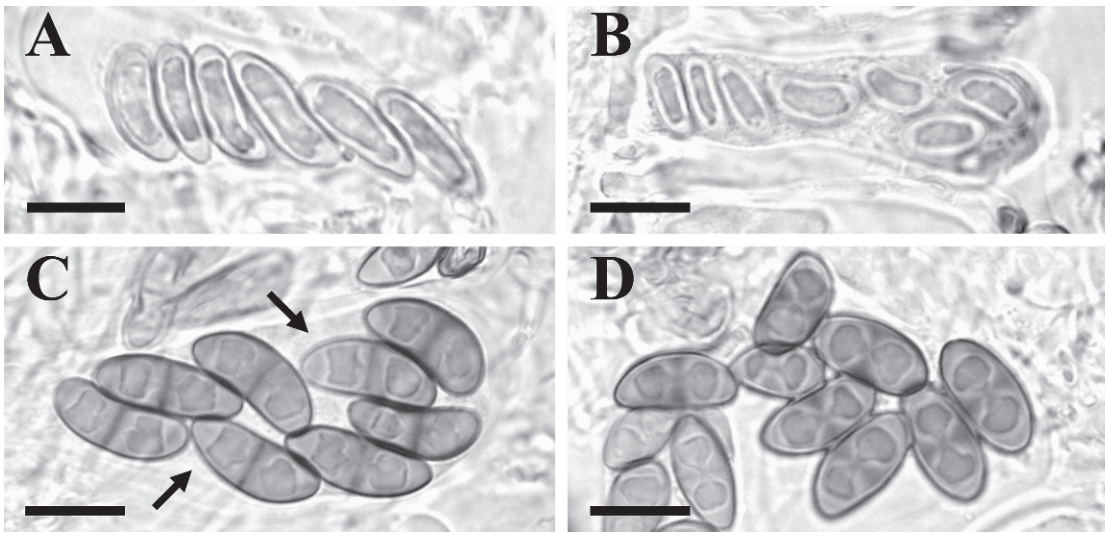

Figure 1. *Dirinaria*–type spores of *Rinodina boleana*. **A**. Immature ascus with delayed Type B spore development, *Morse 13416a*, Meade Co., Kansas (KANU). **B**. Immature ascus with typical Type B spore development, *Morse 13406a*, Stevens Co., Kansas (KANU). **C**. Submature spores with *Physcia*–like and acutely angled lumina (arrows) at one stage of development, *Morse 13406a*, Stevens Co., Kansas (KANU). **D**. Mature spores with typical, more rounded *Pachysporaria*–like lumina, *Morse 13343*, Morton Co., Kansas (KANU). All scales 10 µm.

(Mayrhofer et al. 2007) where it is thought to have been introduced on woody phanerogams.

Discussion. Specimens of *Rinodina boleana* were initially identified as *R. pachysperma* H. Magn. based on the shape of the spore lumina at maturity (*Pachysporaria*–like) but the spores of this species are larger and more broadly ellipsoid. *Pachysporaria*–type II spores may also be accompanied by Type B development in some species such as *R. maculans* Müll. Arg. (Sheard 2010) and this type of development has now been demonstrated in *R. pachysperma* (*Advaita 6890b*, KANU). The two species appear to be allopatric, *R. pachysperma* having a northeastern deciduous forest distribution does not occur west of 99° W longitude, whereas *R. boleana* is found in the high Central Plains (Canadian and northern Carolinian Provinces and Kansan Subprovince of McLaughlin 2007), respectively. *Rinodina boleana* will key out after couplet 95 or 112 in Sheard (2010) since the rare septal swelling in KOH will usually not be observed.

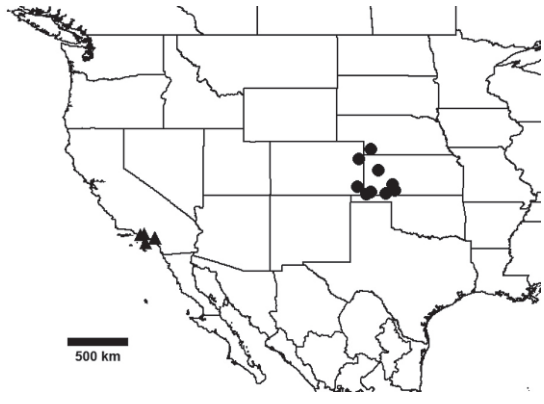

Figure 2. Distribution of *Rinodina boleana* ● and *Rinodina terricola* ▲.

95 Thallus ochraceous or grey–brown, never copper–brown; never of isolated convex verrucae; southern or eastern to central 95a

95a(95) Spores averaging 13.0–14.5 × ca. 6.5 µm .... *R. boleana*

95a Spores averaging >14.5 × ca. 6.5 µm 96

112 Thallus thin, matt; areoles absent or lacking upturned margins and vegetative propagules; apothecia never erumpent; margins and thallus lacking epinecral layer 112a

112a(112). Spores averaging 13.0–14.5 ca. 6.5 µm, lacking a prominent torus ..... *R. boleana*

112a Spores averaging >14.5 ca. 6.5 µm, with a prominent torus 113

Rinodina boleana possesses large algal cells, which together with the dark brown epihymenium immediately invites comparison with *R. pyrina*

(Ach.) Arnold (Mayrhofer & Moberg 2002) and *R. imshaugii* Sheard (Sheard 2010). The species is not distinguishable in habit from the morphologically rather variable *R. pyrina* except perhaps in having a less well developed and slightly darker thallus when the two species have been found together. Although similar in size, the spores of *R. boleana* are very different from those of *R. pyrina* (*Physconia*–like, **Table 1**), being characterized by very obvious Type B development (**Figs. 1A, B**), typically with *Physcia*–like lumina in the early stages of development (**Fig. 1C**), the lumina then rounding and becoming smaller and *Pachysporaria*–like (**Fig. 1D**). There is no more than a hint of septal inflation in a few spores on application of KOH, often a characteristic of the *Dirinaria*–type. However, a slight widening (no more than a micron) of the whole spore is often detectable after this treatment.

The spores of *R. boleana* have been designated as belonging to the *Dirinaria*–type, rather than *Pachysporaria*–type which they resemble at maturity, and to which they have previously been assigned (Giralt & Mayrhofer 1991, 1995; Mayrhofer et al. 2007), because of their obvious Type B development and acutely angled lumina apices in early development (**Fig. 1C**). This last feature is absent in the *Pachysporaria*–type but often seen during developmental stages of the *Dirinaria*–type spore. These apical angles are more acute than those typical of the *Physcia*–type spore, which they otherwise resemble, a feature that appears not have been previously noted.

Rinodina pyrina is a widespread and often abundant species in the Central Plains of North America (Sheard 2010) with spores hitherto described as belonging to the *Physconia*–type and an epihymenium lacking the dispersed red–brown pigment normally associated with *Physcia*– and *Physconia*–type spores (Giralt 2001; Mayrhofer & Moberg 2002; Sheard 2010). Its spores are similar in size and shape to *R. boleana* but longer spores are often curved, a state rarely found in *R. boleana*. Development through the single cell stage is normally rapid and therefore rarely observed but both Type A and Type B developments have been recorded in the present study, the latter for the first time (**Fig. 3A**). In immature septate spores, septal and particularly apical wall thickenings (*Physcia*–like) are often observed (Fig. 143A in Sheard 2010) but are of short duration in the development sequence. The spores typically possess a narrow torus at maturity (**Fig. 3B**), a frequent occurrence in the *Physconia*–type but in intermediate developmental stages a septal disc may sometimes be present (best observed in KOH, **Fig. 3D**), a character otherwise unknown in *Physcia*– and *Physconia*–type spores, with the

Table 1. Comparison of spores in *Rinodina boleana, R. pyrina* and *R. imshaugii.*

	immature structure / mature structure	development type	length × width (μm) 25th–75th percentiles	length/width ratio [1]	inflation in KOH	torus	septal disc [2]
R. boleana	*Physcia*–like *Pachysporaria*–like	B	13.0–14.5 × 6.5	2.0–2.3	in few spores	none – diffuse pigment	Not seen
R. pyrina	*Physcia*–like *Physconia*–like	A/B	12.0–13.5 × 6.0–6.5	1.9–2.3	none	narrow	yes [3]
R. imshaugii	*Physcia*–like *Physconia*–like [4]	A	15.0–17.5 × 7.0–8.0	2.1–2.3	yes in some	narrow	Not seen

[1] 25th–75th percentiles

[2] during development

[3] best seen in KOH

[4] *Physcia*–like state frequently retained

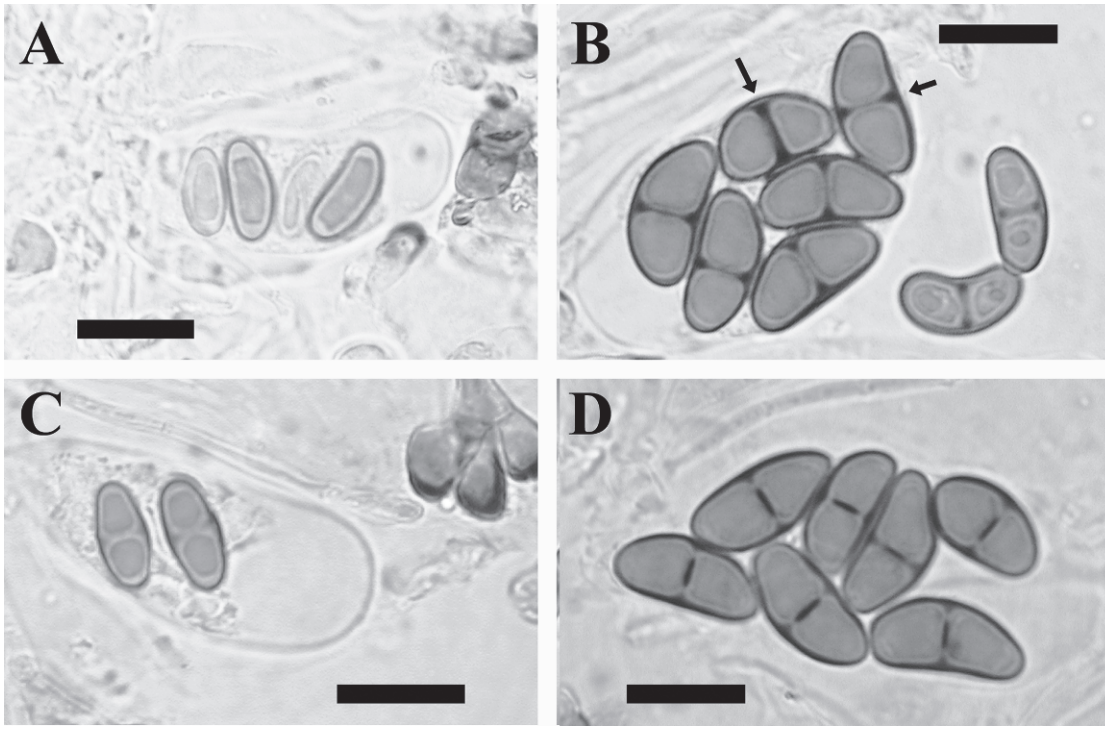

Figure 3. *Dirinaria*–type spores of *Rinodina pyrina*. **A**. Immature spores, Type B development, *Advaita 4969a*, McCook Co., South Dakota (KANU). **B**. Six mature spores with *Physconia*–like lumina and torus, large arrow in surface view, small arrow in septum section, and two immature spores each with forming torus. **C**. Two immature spores with slight inflation at the septum, terminally branched paraphyses upper right, both *Morse 16925b*, McCone Co., Montana (KANU). **D**. Submature spores in KOH showing refractive septal discs, *Morse 19770*, Perkins Co., South Dakota (KANU). All scales 10 μm.

exception of *R. roscida* (Sommerf.) Arnold and *R. terrestris* Tomin, both of which may also show Type B development (Sheard 2010). Finally, a hint of septal inflation may sometimes be seen in immature spores (**Fig. 3C**) although this is not enhanced in KOH as it typically is in the *Dirinaria*–type spore. The presence of Type B development, septal inflation, as well as a septal disc during development are all characters which indicate that the spores of *R. pyrina* are more closely related to the *Dirinaria*– rather than to the *Physconia*–type. These findings therefore agree with the molecular studies of Helms et al. (2003), Kaschik (2006) and Nadyeina et al. (2010), which suggest that *R. pyrina* is most closely related to two *Rinodina* species possessing *Dirinaria*–type spores.

Rinodina imshaugii is also similar to *R. pyrina* and *R. boleana* in possessing a dark brown epihymenium, which has branched paraphyses with broad apical cells and large algal cells (Sheard 2010). Type B development has not been observed in the spores of *R. imshaugii* but they possess relatively persistent apical wall thickenings with lumina that are acutely angular and therefore also belong to the *Dirinaria*–type. *Rinodina imshaugii* is well distinguished from both *R. pyrina* and *R. boleana* by its larger spores, which may inflate at the septum with KOH and by its apothecia, which quickly become convex, excluding the thalline margin and thereby giving the apothecia a lecideine appearance at maturity. *Rinodina imshaugii* has previously been considered to be strictly alpine (Sheard 2010) but now has been found in the high steppe at an elevation of 2195 m in Albany Co., Wyoming (*Morse 16515a, c*, KANU) accompanied by *R. pyrina* and *R. lobulata* Sheard. It has also been found at 1885–1930 m in Moffat Co., Colorado (*Morse 19149a, b,* KANU), also accompanied by *R. pyrina*.

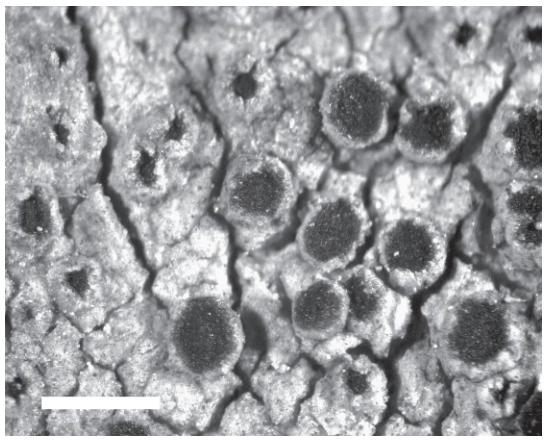

Figure 4. Habit of *Rinodina campestris*, *Morse 14826*, Caddo Co., Oklahoma (KANU). Rimose –areolate thallus with broadly attached apothecia with persistently plane discs and entire margins. Immature, erumpent apothecia are present to the left. Scale 1 mm.

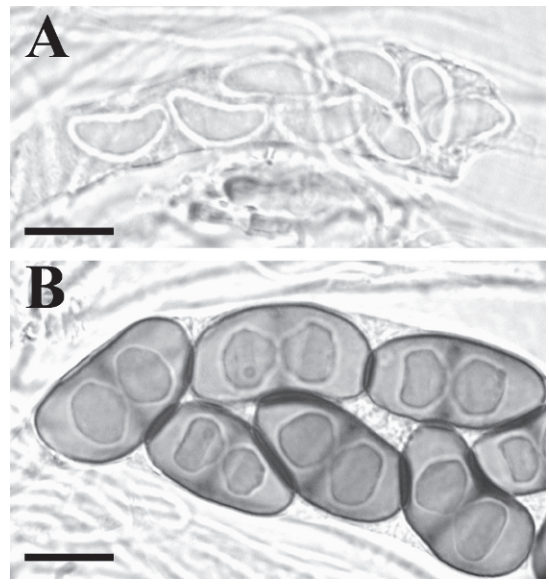

Figure 5. *Pachysporaria*–type I spores of *Rinodina campestris*, *Morse 10814a*, Comanche Co., Kansas, (KANU). **A**. Immature spores with Type A development, note their curved and reniform shape. **B**. Mature spores with *Physcia*–like, to irregularly rounded lumina. Both scales 10 μm.

Rinodina boleana, R. pyrina and *R. imshaugii* form a small unit within the *Dirinaria*–group of species characterized by relatively small spores, branched apices of the paraphyses, lack of secondary substances, and large algal cells. *Rinodina boleana* might be expected to be more widely dispersed latitudinally in the high country to the east of the Rocky Mountains than its presently known and relatively restricted distribution. The distribution of *R. boleana* and *R. pyrina* are centered on the Great Plains Province while *R. imshaugii* is found in the southern part of the Rocky Mountain Subprovince of McLaughlin (2007). Weber (2003) noted that the flora of the high Steppe country had affiliations with the Rocky Mountain alpine. The three species appear to form both a taxonomically and geographically cohesive unit.

Specimens examined. U.S.A. COLORADO: Baca Co., Two Buttes Reservoir, *Morse 21711;* Yuma Co., 4 mi N Idalia, *Morse 16069a, 16084b.* KANSAS: Clark Co., 1 mi W Ashland, *Morse 14009b*; Ford Co., 8.5 mi W Spearsville, *Morse 13958b*; Logan Co., 8 mi W Oakley, *Morse 12416c*; Meade Co., 6 mi N Meade, *Morse 13416a*; Morton Co., Elkhart, Cimarron Nat. Grassland, *Morse 13343*; Stevens Co., 4.5 mi N Hugoton, Cimarron Nat. Grassland, *Morse 13406a.* NEBRASKA: Chase Co., Enders Reservoir, *C.A. Morse 21010* (all KANU).

Rinodina campestris Sheard & C.A. Morse *sp. nov.* **Figs. 4–6**

Mycobank number: 519970

Thallus verruciformis; apothecia late affixa, aggregata, planis persistente discis. Ascosporae in modum "A" evolutae, formae Pachysporaria I, (19.0–) 21.0–23.5(–24.5) × (11.0–)12.0–13.5(–15.0) μm.

TYPE: U.S.A. KANSAS: Rooks Co., 2.5 mi S, 2 mi W jct of US hwys 24 & 183 in Stockton, Rooks County State Fishing Lake and Wildlife Area: NE side, 39.40202°N, 99.31607°W. Partially mowed park–like area and weedy floodplain forest along edge of lake, with *Celtis occidentalis, Fraxinus pennsylvanica, Populus deltoides* and *Ulmus pumila*, and brushy grassland with mixed grass prairie vegetation. Common on 20 in dbh *Populus* and 6–12 in dbh *Celtis*. 28 June 2010, *C.A. Morse 20961* (FH – holotype, BM, CANL, COLO, GZU, KANU, MIN, NY, SASK, UPS – isotypes).

Etymology. "Campestris" (Latin), pertaining to plains as in the Great Plains floristic province (McLaughlin 2007), the distribution area of this species.

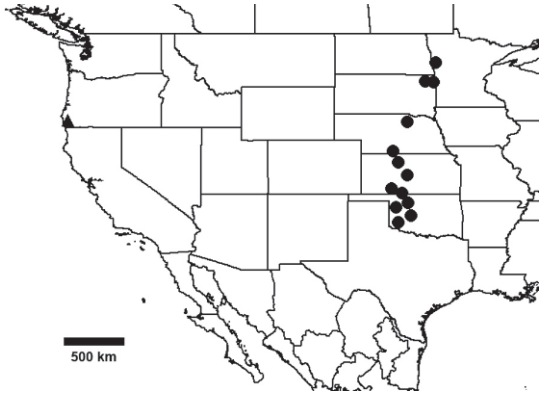

Figure 6. Distribution of *Rinodina campestris* ● and *Rinodina megistospora* ▲.

Description. Thallus thin to thick, dark grey to grey–brown to light brown, continuous, or cracked, frequently becoming rimose–areolate; areoles to 0.20–0.80 mm wide; surface verrucose or sometimes plane, matt or shining; margin indeterminate, prothallus absent. Apothecia often (**Fig. 4**) erumpent at first, then broadly attached, frequent, often contiguous, to 0.40–0.80 mm in diam.; disc black, persistently plane, thalline margin concolorous with or paler than thallus, rarely darkly pigmented in part, entire, ca. 0.10 mm wide, persistent; excipular ring usually absent but sometimes prominent, raised and associated with pigmented margin.

Apothecial anatomy. Thalline exciple 60–100 m wide laterally; cortex 10–20 µm wide, epinecral layer, sometimes present, ca. 10 µm wide; cortical cells 4.0–6.0 µm in diam., rarely darkly pigmented; algal cells 15.0–20.0 µm long; crystals absent in cortex and medulla; proper exciple hyaline, <5–10 µm wide, expanding to 15–30 µm at surface; hypothecium hyaline or yellowish, 60–70 µm deep; hymenium 120–140 µm high, not inspersed; paraphyses 2.5–3.0 µm wide, becoming conglutinate in older apothecia, apices to 4.0–5.0 µm wide, lightly pigmented forming a reddish brown epihymenium, lacking dispersed pigment, penultimate cells sometimes pigmented; mature asci infrequent, ca. 75 × 25 µm.

Ascospores 4–8/ascus, non–septate spores typically curved, Type A development, *Pachysporaria*–type I (Giralt 2001 p. 18; Sheard 2010 p. 11; **Fig. 5**), (19.0–)21.0–23.5(–24.5) × (11.0–) 12.0–13.5(–15.0) µm (n=108), l/w ratio (1.5–)1.7–1.9(–2.0), lumina *Physcia*–like at first but with thick lateral walls, becoming irregularly rounded, finally spherical, sometimes with small, apical satellite lumina, some spores slightly inflated at septum but not more so in KOH, very rarely *Mischoblastia*–like when over mature; septal disc absent; torus absent; walls ornamented at maturity. Pycnidia rarely observed but then abundant, conical, ca. 0.10 mm in diam., protruding above thallus; conidia bacilliform, ca. 5.5 × 1.0 µm.

Chemistry. Spot tests all negative; secondary metabolites not detected.

Substrate and distribution. *Rinodina campestris* has been collected on *Celtis occidentalis, Cornus drummondii, Populus deltoides, Tilia americana* and *Ulmus pumila* twigs, from 140–690 m elevation. It is apparently restricted to the Great Plains floristic province (McLaughlin 2007), being recorded from Minnesota southwards to Oklahoma (**Fig. 6**).

Discussion. This species is characterized by its verrucose thallus and crowded apothecia with plane discs that reflect a persistently thin hypothecium relative to the hymenium (Sheard 2010). Immature spores, prior to septation, are characteristically curved (**Fig. 5A**). The spore structure is rather variable during development (**Fig. 5B**), the lumina shape being *Physcia*–like at first before becoming rounded and retaining relatively thick lateral walls characteristic of the *Pachysporaria*–type. Small, apical satellite lumina develop in some mature spores and appear to be the precursors of germ tubes. Spore size is also rather variable depending on the proportion of asci with four spores sampled, eight spored asci having smaller spores. *Rinodina campestris* will key out after couplet 94 in the key of Sheard (2010).

94(93) Apothecia narrowly attached; spores averaging 24.5–27.0 × 13.5–15.0 µm; southeastern U.S.A. ..... *R. dolichospora*

94 Apothecia broadly attached; spores averaging < 27.0 × 15.0 µm; distribution otherwise 94a

94a(94) Apothecial disc becoming convex, margin excluded; spores averaging 19.5–20.0 × 10.0–11.0 µm, coastal California with outlier in Gulf Islands ..... *R. herrei*

94a Apothecial disc persistently plane, margin persistent, spores averaging 21.0–23.5 × 12.0–13.5 µm; Great Plains ..... *R. campestris*

Many mature spores show a dark pigmentation at the septum but the pigment is too diffuse to be considered a torus. The spores are at the lower end of

the size range of the *Pachysporaria*–type I spore cited by Sheard (2010), have a rather variable structure during development and do not show polygonal lumina at any stage of development. However, apical satellite lumina are not found in any other spore type. The spores show some similarity with those of *R. confusa* H. Mayrhofer and Kantvilas (Mayrhofer et al. 1999) but lack a torus and possess wall ornamentation. They also show similarities with the spores of *R. abolescens* H. Magn. but these differ in the presence of a well developed torus and are constricted at the septum (Giralt & Mayrhofer 1995).

Rinodina campestris and *R. boleana* belong to the Great Plains floristic Province of McLaughlin (2007), more specifically to the Saskatchewan and Kansan Subprovinces of the northern part. This area more or less corresponds to the northern part of the Central Grasslands floristic element of Brodo et al. (2001) but no species are restricted to this part of the region according to the distribution maps included in this flora. This type of distribution is therefore rare in lichens (but see Harris & Morse 2008; Wetmore 2009) and is certainly novel within the genus *Rinodina*.

Specimens examined. U.S.A.: KANSAS: Barton Co., Green Lake Pool, *Morse 21687*; Clark Co., Clark Co. State Lake, *C.A. Morse 14004b*; Comanche Co., Merrill Ranch, Sink Valley, *C.A. Morse 10814a* (all KANU); Rooks Co., Rooks Co. State Fishing Lake, *C.A. Morse 20961* (KANU, SASK). MINNESOTA: Clay Co., near Glyndon, *M.K. Advaita 6527, 6532a*. NEBRASKA: Furnas Co., 4.75 mi W Oxford, *C.A. Morse 20995*; Holt Co., near O'Neil, *M.K. Advaita 7432* (all KANU). OKLAHOMA: Caddo Co., 2.5 mi S Hinton, *C.A. Morse 14826* (KANU, SASK); Ellis Co., 10 mi W Camargo, *C.A. Morse 14948c*; SW Camargo, *C.A. Morse 15004*; Greer Co., 6 mi SE Granite, *C.A. Morse 15097*; Major Co., 6 mi W Orienta, *C.A. Morse 20425*. SOUTH DAKOTA: Day Co., 7 mi E Grenville, *M.K. Advaita 4459*; NE Waubay, *M.K. Advaita 6800*; Roberts Co., 10 mi E Wilmot, *M.K. Advaita 4505* (all KANU).

Rinodina megistospora Sheard & H. Mayrhofer *sp. nov.* **Figs. 7, 8**

Mycobank number: 519971

Thallus pallide griseus, atranorinum continens. Ascosporae in modum "A" evolutae, formae Pachysporaria "I", (36.0–)38.0–42.0(–44.5) × (18.5–)19.5–21.0(–22.0) µm.

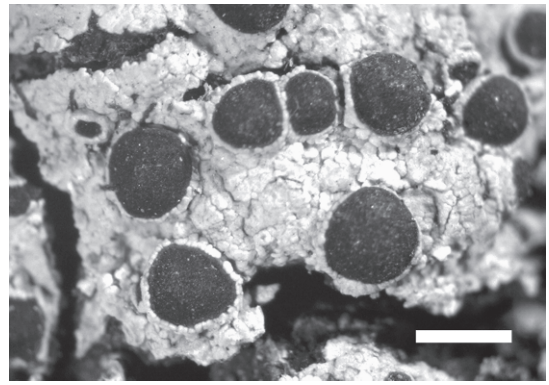

Figure 7. Habit of *Rinodina megistospora*, *Bratt 9969*, Curry Co., Oregon (SASK – isotype). Continuous thallus of overlapping, minute lobules with convex apothecial discs eventually excluding thalline margins. Lobules best seen at edge of crack in substrate at top left. Scale 1 mm.

TYPE: U.S.A. OREGON: Curry Co., Siskiyou Nat. Forest, Oak Flat off road along Rogue River, near Agness [probably on *Quercus*], 20 October 1996, *C.C. Bratt 9969* (SBBG – holotype, SASK – isotype).

Etymology. The species is named for its very large spores (Greek "megisto").

Description. Thallus thin to thick, light grey; initially of isolated areoles, ca. 0.40 mm wide, with minute, radiating lobules ca. 0.15 mm wide, quickly coalescing to become continuous (**Fig. 7**); surface with overlapping lobules, matt; margin determinate; prothallus absent; vegetative propagules absent. Apothecia broadly attached, frequent, sometimes contiguous, to ca. 1.0 mm in diam.; disc dark brown to black, quickly becoming convex, sometimes half globose; thalline margin concolorous with thallus, entire, 0.05–0.10 mm wide, becoming excluded; excipular ring usually present at first, raised.

Apothecial anatomy. Thalline exciple 70–85 µm wide laterally, cortex poorly organized, ca. 10 µm wide; epinecral layer absent; crystals present in cortex, absent in medulla; cortical cells 5.5–6.5 µm in diam., not pigmented; algal cells 12.5–14.5 µm long; thalline exciple ca. 90 µm wide below, cortex 15–20 µm wide; proper exciple lightly pigmented orange–brown, 10–15 µm wide laterally, expanding to ca. 50 µm at periphery, concolorous with epihymenium; hypothecium 80–120 µm deep, hyaline except lightly pigmented at base, inspersed; hymenium 150–160 µm high, some intrusion of

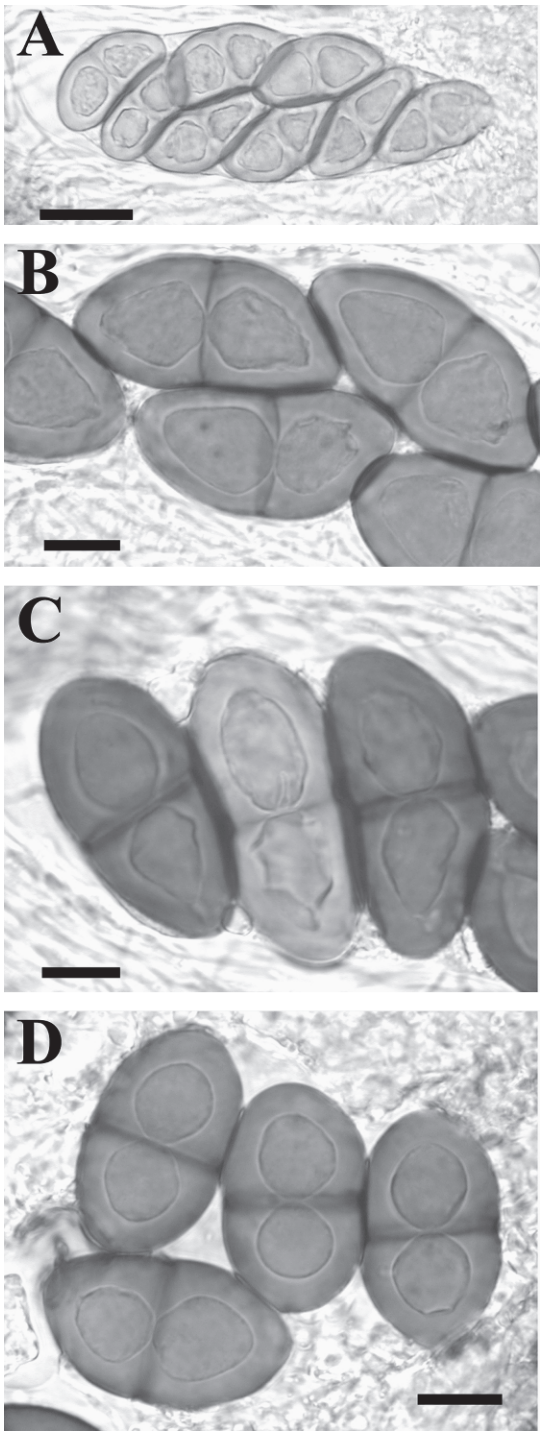

Figure 8. *Pachysporaria*–type I spores of *Rinodina megistospora*, Siskiyou National Forest, Curry Co., Oregon, *C.C. Bratt 9969* (SASK – isotype). **A**. Ascus with immature spores, walls hardly pigmented. **B**. Submature spores with more pigmented walls, locules of some cells irregular in outline and tori poorly formed. **C**. Two mature spores with darkly pigmented walls and well developed tori, another spore with delayed development, wall more lightly pigmented and the lumen of one cell with a polygonal shape. **D**. Mature spores with well developed tori, inflated lumina, and slightly constricted at the septum. All scales 10 µm.

hypothecial inspersion at base; paraphyses ca. 2.0 µm wide, branched, conglutinate, apices expanded to 3.5–4.0(–4.5) µm, lightly pigmented, immersed in a dispersed pigment forming a dark, orange–brown epihymenium; ascus with immature spores ca. 110 × 35 µm.

Ascospores '8/ascus, Type A' development, *Pachysporaria*–type I (Giralt 2001 p. 18; Sheard 2010 p. 11; **Fig. 8**), (36.0–)38.0–42.0(–44.5) × (18.5–)19.5–21.0(–22.0) µm (n=57), l/w ratio (1.8–)1.9–2.1(–2.2), some immature spores with transient polygonal lumina (**Fig. 8B, C**); torus narrow; walls very lightly ornamented. Pycnidia not seen.

Chemistry. Spot tests, K+ yellow, C−, P+ faint yellow; secondary metabolites, atranorin in cortex.

Substrate and Distribution. Only known from a *Quercus* stand at the type locality in southern Oregon in a high rainfall region close to the coast (**Fig. 6**).

Discussion. *Rinodina megistospora* is characterized by its very large, *Pachysporaria*–type I spores and will key out in couplet 69 in the key of Sheard (2010).

69(66) Spores averaging > 21 µm long; apothecia to >0.90 mm diameter 70a

69 Spores averaging < 21 µm long; apothecia to <0.90 mm diameter 71

70a(69) Spores averaging > 35 × 18 µm ..... *R. megistospora*

70a Spores averaging < 35 × 18 µm 70

In North America only four other species have spores averaging >30 µm in length (Sheard 2010): *Rinodina ascociscana* (Tuck.) Tuck., *R. macrospora* Sheard, *R. roscida* (Sommerf.) Arnold (all *Physcia*–type), and *R. oregana* H. Magn. (*Dirinaria*–type). *Rinodina isidioides* (Borrer) H. Olivier, reported from Mexico by Sheard (2004), has slightly shorter *Pachysporaria*–type I spores than these species. The light grey thallus, convex apothecia and general habit of *R. megistospora* are reminiscent of the terricolous *R. mniaraea* var. *mniaraeiza* (Nyl.) H. Magn., which also contains cortical atranorin. However,

R. mniaraea is an oro–arctic species with smaller, *Physcia*–type spores. Two other species that possess large *Pachysporaria*–type I spores are *R. brasiliensis* Giralt, Kalb and H. Mayrhofer and *R. dolichospora* Malme which, however, differ in lacking the transient polygonal lumina of *R. megistosopora* during development and are also characterized by their lumina being surrounded by oil globules at maturity (Giralt et al. 2009).

Many species with *Pachysporaria*–type I spores have tropical affinities and those ranging furthest north do so with the aid of vegetative propagules. For example, *Rinodina flavosoralifera* Tønsberg occurs further north than *R. megistospora* in Alaska but at this latitude reproduces vegetatively. Sheard (2010) has noted that it probably has southern origins since it has only been recorded with mature spores at its two southernmost localities in California and the Canary Islands. Other species with this spore type occurring in northwest North America are also poorly fertile: *R. griseosoralifera* Coppins, *R. sheardii* Tønsberg and *R. stictica* Sheard & Tønsberg all reproduce primarily by means of soredia. The isidiate species *R. isidioides* occurs furthest north in Europe being found in Argyll, western Scotland (Giavarini et al. 2009) and extreme southwestern Norway (Tønsberg 1994; Mayrhofer & Moberg 2002).

The locality where *Rinodina megistospora* occurs is near the junction of the Rogue and Illinois Rivers, on the boundary of the Californian and Vancouverian Floristic Subprovinces (McLaughlin 2007) and within the high rainfall coastal area. The region is well known for its large number of relict species and for its species diversity, of conifers in particular (Raven & Axelrod 1978; Coleman & Kruckberg 1999; Stein et al. 2000), remnants of an Arcto–Tertiary flora that was mostly extinguished to the south with the onset of the Mediterranean climate (Raven & Axelrod 1978). It is a more ancient landscape than the Coastal Ranges to the north and south that has been uplifted by the subduction of the offshore Gorda Plate (Coleman & Kruckberg 1999).

The origin of *Rinodina megistospora* and other species with *Pachysporaria*–type I spores in northwest North America remains an enigma but may be to the south. Present evidence suggests that *R. megistospora* survives further north in the Pacific coastal region than any other species with *Pachysporaria*–type I spores without the aid of vegetative reproduction. Perhaps this is made possible by its very large spores.

Rinodina terricola Sheard & K. Knudsen *sp. nov.* Mycobank number: 519973

Thallus atranorinum continens. Ascosporae in modum "A" evolutae, formae Mischoblastia, (23.0–)25.0–27.0(–29.5) × (12.0–)13.0–14.0(–15.0) µm.

Type: U.S.A. California: Orange Co., Peninsular Range, Santa Ana Mountains, Weir Canyon, 33° 49′ 53″ N, 117° 43′ 09″ W, 405 m, oak woodland with coastal sage scrub, on soil, 20 May, 2006, *K. Knudsen 6203* (FH – holotype, UCR – isotype).

Etymology. "Terricola" (Latin), growing on the ground.

Description. Thallus usually thick and continuous on soil, or thinner and areolate on rock, areoles sometimes with raised margins, to ca. 1.20 mm wide, light to dark grey; surface plane, matt; margin determinate; prothallus absent; vegetative propagules absent. Apothecia innate to broadly attached, frequent, sometimes contiguous, to 0.60–0.80 mm in diam.; disc dark brown (particularly when moist) to black, plane sometimes becoming slightly convex; thalline margin in terricolous material often pigmented brown at first, becoming concolorous with thallus or not, entire, 0.05–0.10 mm wide, confluent excipular ring sometimes present, margin sometimes finally merging with thallus at maturity, apothecia then innate and appearing lecideine; proper exciple not evident when thalline margin lost. Apothecia of saxicolous specimens relatively narrowly attached with margins mostly persistently pigmented, also appearing lecideine.

Apothecial anatomy. Thalline exciple 40–100 µm wide laterally, cortex poorly organized, 10–20 µm wide; epinecral layer 5–10 µm wide when present; crystals present in cortex, absent from medulla; cortical cells strongly pigmented or not, to 4.0–7.0 µm in diam.; algal cells to 10.0–16.0 µm long; thalline exciple 40–100 µm wide, same below when apothecia broadly attached, cortex ca. 10 µm wide when present, entire margin may become pigmented and algal cells excluded; proper exciple hyaline laterally, 5–15 µm wide, 25–50 µm wide at periphery,

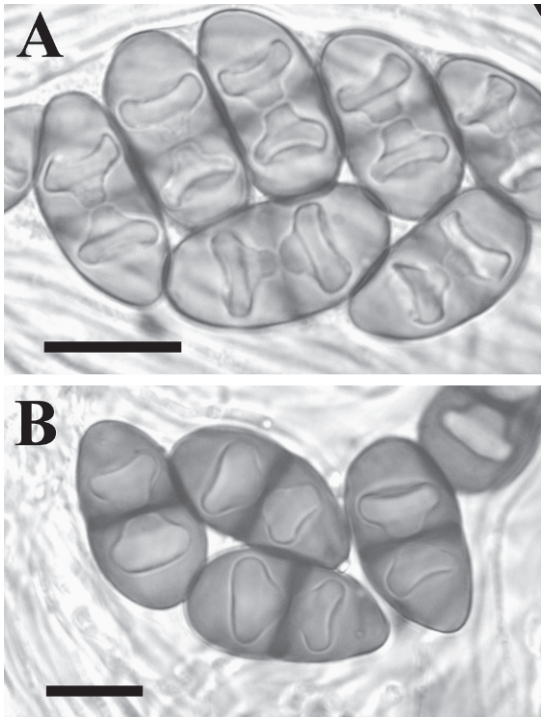

Figure 9. *Mischoblastia*–type spores of *Rinodina terricola*, Santa Ana Mountains, Orange Co., California, *K. Knudsen 6203* (FH – holotype). **A**. Fully grown but submature spores, walls and diffuse tori not fully pigmented. **B**. Mature spores with more darkly pigmented walls and tori, slightly constricted at the septum, and the lumina more inflated. Both scales 10 μm.

concolorous with epihymenium; hypothecium 40–80 μm deep; hymenium 100–140 μm high, not inspersed; paraphyses 2.5–3.5 μm wide, conglutinate, apices inflated to 5.0–5.5 μm and pigmented, forming a light to dark brown epihymenium; asci 70–90 × 20–27 μm.

Ascospores 8/ascus but sometimes 4 with very delayed development; Type A development, *Mischoblastia*–type (Giralt 2001 p. 18; Sheard 2010 p. 11; **Fig. 9**), (23.0–)25.0–27.0(–29.5) × (12.0–) 13.0–14.0(–15.0) μm (n=109), l/w ratio (1.7–)1.8–2.0(–2.2), slightly constricted at septum when mature, becoming inflated when over mature; torus narrow at maturity; walls not or lightly ornamented. Pycnidia not seen.

Chemistry. Spot tests, K+ yellow, C−, P+ faint yellow; secondary metabolites, atranorin in cortex.

Substrate and distribution. *Rinodina terricola* is found on soil or on friable, loosely compacted sandstone and is the taxon referred to under *Rinodina destituta* (Nyl.) A. Zahlbr. by Sheard (2004, 2010) occurring on these substrates in southern California. The species is apparently limited to mountain canyons of the greater Los Angeles region (**Fig. 2**). A few saxicolous records of *Rinodina oxydata* (A. Massal.) A. Massal. from southern California were incorrectly identified by Sheard (2004, 2010) since some saxicolous specimens of *R. terricola* have smaller than typical spores.

Discussion. This species is characterized by growing on soil or decaying sandstones that are easily eroded and also by its large spores, larger than those of *Rinodina destituta* (Nyl.) A. Zahlbr., which otherwise has the largest known *Mischoblastia*–type spores in the northern (Sheard 2010) or southern hemispheres (Kaschik 2006). Saxicolous specimens of *R. terricola* will key out in couplet 11, terricolous specimens under couplet 118 in the key of Sheard (2010).

11(10) Spores averaging 25.0–27.0 μm long ..... *R. terricola*
11 Spores averaging <25.0 μm long 11a
11a(11) Average spore l/w ratio ≥ 1.9, ± narrowly ellipsoid 12
11a Average spore l/w ratio > 1.9, broadly ellipsoid . 13
118(117) Apothecial discs becoming strongly convex, thalline margin excluded; oro–arctic ..... *R. mniaraea*
118 Apothecial discs remaining ± plane, thalline margin persistent; west coast and coastal ranges, north to Gulf Islands and Vancouver Islands 118a
118a(118) Spores averaging 22.5–24.0 × 11.0–12.0 μm ..... *R. bolanderi*
118a Spores averaging 25.0–27.0 × 13.0–14.0 μm ..... *R. terricola*

Terricolous species sometimes extend their habitat to lower stems of shrubs and trees. There are only two known corticolous species with *Mischoblastia*–type spores: *R. wetmorei* Sheard from Minnesota (Sheard 2010) and *R. euskadiensis* A. Crespo & B. Aguirre from Spain (Crespo & Aguirre 1984; Giralt 2001). The former species lacks atranorin in the cortex and the latter is thought to be a variant of *R. oxydata* (Giralt 2001). *Rinodina terricola* may be most closely related to *R. destituta* since this species has relatively large spores and some forms have areolae with similarly raised margins. The two species are allopatric, *R. destituta* being an eastern species in North America (Sheard 2010).

Matzer and Mayrhofer (1996) suggested that *Rinodina* species with *Mischoblastia*–type spores are in need of revision. The decision to describe the new species *R. terricola* was therefore made with some caution but the species appears to be as distinct, or more distinct, than other species in the group based on the characters discussed above and further below.

Rinodina terricola also has other unusual characters for a species with *Mischoblastia*–type spores. Bagliettoana–green which is frequently, although variably, present in the pigmented upper part of the proper exciple in species possessing *Mischoblastia*–type spores has not been observed. Also, the thalline margin may be pigmented in young apothecia and then becomes less pigmented, or even unpigmented, during development, which is the reverse of the usual sequence in this group of species. Finally, the thalline margin may be lost as it apparently merges with the thallus especially in terricolous specimens with a well developed thallus. In this state the apothecia are innate and appear to be lecideine and without an externally evident proper exciple. The general habit of the species is very variable, partly due to the different substrates on which it grows. Contrasting with the thick thalli and frequently innate apothecia of terricolous specimens, thalli growing on crumbling sandstone typically have a thin thallus and sessile apothecia with prominent pigmented margins, similar to many *R. oxydata* specimens, but mature apothecia are mostly larger. *Rinodina oxydata* occurs in the same area as *R. terricola* and although it is never terricolous there is some potential for confusion with specimens growing on rock despite the former species having much smaller spores.

Rinodina terricola now appears to be rare, probably due to the reduction of terricolous habitats by development and the degradation of remaining habitat by grazing, recreation, invasive weeds and fire. In addition, the substrate is inherently unstable and the population at the Latigo Canyon site subsequently has been eliminated by soil slumping. The modern populations on friable sandstone probably are small, relect populations. For example, in Fremont and Weir Canyons in the Santa Ana Mountains, over a century of cattle grazing probably has eliminated extensive biological soil crusts, dominated by lichens, from the valley floors. Several terricolous species, including *R. terricola*, are still found persisting on decaying sandstone outcrops (Knudsen & Kocourková 2009).

Specimens examined. U.S.A. CALIFORNIA: Los Angeles Co., Catalina Island, *H.E. Hasse* (NY); Santa Monica Mountains, *H.E. Hasse* (SBBG); 1897, *H.E. Hasse* (H); 1901, *H.E. Hasse* (MIN); 1913, *H.E. Hasse* (FH); Latigo Canyon, *K. Knudsen 1581* (UCR); Sullivan's Canyon, 1913, *H.E. Hasse* (FH); Orange Co., Fremont Canyon, *K. Knudsen 9320* (UCR); Weir Canyon, *K. Knudsen 6203* (FH, UCR).

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