*The Lichenologist* **49**(6): 617–672 (2017) 
doi:10.1017/S0024282917000536

# The lichen genus *Rinodina* (*Physciaceae*, *Caliciales*) in north-eastern Asia

**John W. SHEARD, Alexander K. EZHKIN, Irina A. GALANINA, Dmitry HIMELBRANT, Ekaterina KUZNETSOVA, Akira SHIMIZU, Irina STEPANCHIKOVA, Göran THOR, Tor TØNSBERG, Lidia S. YAKOVCHENKO and Toby SPRIBILLE**

**Abstract:** *Rinodina* is a widespread, polyphyletic genus of crustose *Physciaceae* with *c*. 300 species worldwide. A major missing link in understanding its global biogeography has been eastern Asia where the genus has never been systematically revised. Here we review specimen and literature records for *Rinodina* for north-eastern Asia (Russian Far East, Japan and the Korean Peninsula) and recognize 43 species. We describe two species, *R. hypobadia* and *R. orientalis*, as new to science. *Rinodina hypobadia* is distinguished by its pigmented hypothecium, *Dirinaria*-type ascospores and pannarin in both thallus and epihymenium. *Rinodina orientalis* is characterized by its erumpent apothecia that remain broadly attached, with discs sometimes becoming convex and excluding the thalline margins, ascospores belonging to the *Physcia*-type and secondary metabolites absent. Nine other species are reported from the region for the first time. These include *R. dolichospora*, *R. freyi*, *R. metaboliza*, *R. sicula*, *R. subminuta* and *R. willeyi*. Of particular biogeographical interest are three additional new records that have western North American–eastern Asian distributions: the corticolous species *R. endospora*, *R. macrospora* and *R. megistospora*. Six species have the better known eastern North American–eastern Asian distributions: *R. ascociscana* (syn. *R. akagiensis*, *R. melancholica*), *R. buckii*, *R. chrysidiata*, *R. subminuta*, *R. tenuis* (syn. *R. adirondackii*) and *R. willeyi*, and two have eastern North American–eastern Asian–European distributions: *R. excrescens* and *R. moziana* (syn. *R. destituta*, *R. vezdae*). Our study begins to close one of the largest gaps in our knowledge of circumboreal species distributions in *Rinodina* and, together with previous studies in North America and Europe, provides new insights into circumboreal crustose lichen biogeography. *Rinodina cinereovirens* (syn. *R. turfacea* var. *cinereovirens*) is also reported as new to North America.

**Keywords:** biogeography, disjunctions, lichenized Ascomycetes, new species, synonyms, vicariance

*Accepted for publication 3 June 2017*

## Introduction

No crustose lichen genus in the Holarctic has been revised in every major sector of the boreal forest. Eastern Asia has long constituted a large knowledge gap in the biogeography of lichens, especially crustose lichens.

J. W. Sheard: Department of Biology, University of Saskatchewan, 112 Science Place, Saskatoon, SK S7N 5E2, Canada. Email: john.sheard@usask.ca
A. K. Ezhkin: Institute of Marine Geology and Geophysics, Nauki Str., 1B, Yuzhno-Sakhalinsk, 693022, Russia.
I. A. Galanina and L. S. Yakovchenko: Federal Scientific Center of East Asian Terrestrial Biodiversity, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok Str. 100-leta, Vladivostok 159, 690024, Russia.
D. Himelbrant, E. Kuznetsova and I. Stepanchikova: Department of Botany, St. Petersburg State University, Universitetskaya Emb. 7–9, St. Petersburg 199034, Russia; Laboratory of Lichenology and Bryology, Komarov Botanical Institute RAS, Professor Popov St. 2, St. Petersburg 197376, Russia.
A. Shimizu: Graduate School of Environmental Earth Science, Hokkaido University, Hokkaido, 060-0810, Japan.
G. Thor: Department of Ecology, Swedish University of Agricultural Sciences, P.O. Box 7044, SE-750 07 Uppsala, Sweden.
T. Tønsberg: Department of Natural History, University Museum, University of Bergen, Allégaten 41, P.O. Box 7800, N-5020 Bergen, Norway.
T. Spribille (co-corresponding author): Institute of Plant Sciences, Karl-Franzens-Universität Graz, Holteigasse 6, A-8010 Graz, Austria; current address: Biological Sciences CW405, University of Alberta, Edmonton, AB T6G 2E9, Canada. Email: spribill@ualberta.ca

This is all the more unfortunate due to the central role that eastern Asia is known to have played in the evolution of higher plants (Wen 1999; Xiang *et al.* 2000; Qian 2002), and the need for testable hypotheses in lichen biogeography that include eastern Asia.

*Rinodina* (Ach.) Gray is one of the better understood genera across the Holarctic, modern monographic treatments being available for the Iberian Peninsula (Giralt 2001), Scandinavia (Mayrhofer & Moberg 2002), North America (Sheard 2010) and the saxicolous species of the Old World (Mayrhofer 1984). Though polyphyletic (Helms *et al.* 2003; Kaschik 2006; Nadyeina *et al.* 2010; Resl *et al.* 2016), species-level concepts within *Rinodina* are becoming increasingly well established and clear outlines of species groups have begun to emerge in conjunction with a refined understanding of crustose-macrolichen transitions. Particularly clear patterns of biogeography have come into focus with the availability of molecular data from different parts of the world (Resl *et al.* 2016). The present paper is a first attempt at an inclusive treatment of the genus in north-eastern Asia.

The Japanese lichen biota has long been one of the most studied in Asia but its crustose lichen biota is still poorly known. Reports of 25 and 22 species of *Rinodina*, respectively, in two earlier checklists (Kurokawa 2003; Harada *et al.* 2004) were trimmed back in the synonymized list of Kurokawa & Kashiwadani (2006), who collated data showing that several taxa belong in other genera (e.g. *Buellia*) and accepted 18 species of *Rinodina* for Japan. Two new corticolous species have recently been added to the lichen biota of Japan, *R. chrysidiata* Sheard (Lendemer *et al.* 2012) and *R. buckii* Sheard (Sheard *et al.* 2012), bringing the total to 20 species. This compares to 33 species for the British Isles (Giavarini *et al.* 2009), to which should be added *R. intermedia* Bagl. (Mayrhofer *et al.* 2001), making a total of 34 species for a comparable maritime archipelago only 65% of the area of Japan.

Fewer species have been reported from Korea. *Rinodina membranifera* (Hue) Zahlbr. was the one *Rinodina* (except *Dimelaena oreina* (Ach.) Norman, which the authors included in *Rinodina*) reported in the only two Korean checklists published to date (Hur *et al.* 2005; Moon 2013). *Rinodina chrysidiata* and *R. buckii* were added to the list of known lichen biota by Lendemer *et al.* (2012) and Sheard *et al.* (2012), respectively. Joshi *et al.* (2013) reported *R. oleae* Bagl. as new to South Korea. Kondratyuk *et al.* (2013) reported *R. fimbriata* Körb., *R. oleae* (as new to Korea a second time), *R. polyspora* Th. Fr., *R. pyrina* (Ach.) Arnold, *R. sophodes* (Ach.) A. Massal. and *R. teichophila* (Nyl.) Arnold as new to South Korea. Aptroot & Moon (2014) reported a further four species: *R. cinereovirescens* (Harm.) Zahlbr. *R. laevigata* (Ach.) Malme, *R. placynthielloides* Aptroot and *R. xanthomelana* Müll. Arg. Finally, Kondratyuk *et al.* (2016) reported *R. xanthophaea* (Nyl.) Zahlbr., making a total of 14 species for Korea.

Twenty-three species of *Rinodina* are accepted as occurring in the three main sectors of the Russian Far East (arctic, northern and southern forested) in the most recent Russian checklist (Urbanavichus & Andreev 2010). However, this tally missed or discounted pre-2010 reports from the "far eastern" sectors of Russia of *R. gennarii* Bagl. (Bredkina *et al.* 1992; Chabanenko 2002), *R. polyspora* and *R. trevisanii* (Hepp) Körb. (Chabanenko 2002). Two further species, *R. kozukensis* (Vain.) Zahlbr. and *R. teichophila*, were added by Skirina (2010), while Galanina *et al.* (2011) reported *R. excrescens* Vain. from numerous localities in the Russian Far East, Sheard *et al.* (2012) reported *R. buckii* from the region, Lendemer *et al.* (2012) included Russian localities in their description of *R. chrysidiata*, and Urbanavichene & Palice (2016) reported *R. efflorescens* from the Stanovoye Nagor'e Mountains, making a total of 32 previously reported species.

## Materials and Methods

This study is based primarily on collections by the authors, with the exception of JWS. Type specimens of all corticolous species described from Japan have been examined. For Japan, the northern island of Hokkaido has been the region most densely sampled. In far eastern

Russia, collections have primarily been made from Zabaikalskiy Krai, Khabarovskiy Krai, Primorskiy Krai, Sakhalin Island and the Kamchatka Peninsula. The vast majority of collections examined were newly made. Unfortunately, it was not possible to freely borrow material that is the basis for previous reports in the literature, such as in Chabanenko (2002) or Skirina (2010), because of onerous restrictions on the mailing of scientific material by the Russian postal service.

Habit observations of specimens were made using a Wild M5 stereomicroscope. Thallus measurements were taken at ×25 magnification and rounded to the nearest 0·05 mm. Internal ascomatal measurements were made on vertical sections (*c.* 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 of 0·1 µm) to an accuracy of 0·5 µm. Ascospore (hereafter "spore") types are defined in Sheard (2010). Measurements are quoted as the range between the 25th and 75th percentiles with 5th and 95th percentile outliers indicated in brackets when full species descriptions are given. Observations of ascospore wall structure were made with an oil immersion lens at a combined magnification of ×1250. It is imperative to measure mature spores, which are determined by density of pigmentation and retention of internal lumen. Ascospore wall structure and lumen shape in freshly collected specimens (up to two or three years old) was revealed by heating slide preparations of water-mounted sections over a spirit burner. For species with a conglutinate hymenium this also has the effect of aiding the release of ascospores from the ascus on application of gentle pressure to the cover slip.

Standard reagents (K, C, P) were used sparingly when testing thalli for secondary product reactions. Polarized light (PL) is particularly useful in testing for low concentrations of cortical atranorin. It can also be used for locating crystals of gyrophoric acid and pannarin. Thin-layer chromatography (TLC) was carried out according to Culberson & Kristinsson (1970), Culberson (1972) and Menlove (1974). All three solvents were used, with glass plates in solvent C to allow for the detection of fatty acids.

Species occurrence mapping was performed on 2·5 min resolution global altitude base layer made available as part of WorldClim (Hijmans *et al.* 2005) using the *sp* (Pebesma & Bivand 2005) and *rasterVis* R packages (https://github.com/oscarperpinan/rastervis). Locality names from Russia were rendered using the BGN/PCGN romanization protocol. Locality lists for species do not include all specimens studied, with the exception of the paratype lists for the two newly described species.

## Results

We confirmed a total of 43 species as occurring in the study area, including two species new to science: *Rinodina hypobadia* Sheard (Japan and Russia) and *R. orientalis* Sheard (Japan, South Korea and far eastern Russia). Of these, we record nine species for the first time from the region: *R. dolichospora* Malme, *R. endospora* Sheard, *R. freyi* H. Magn., *R. macrospora* Sheard, *R. megistospora* Sheard & H. Mayrhofer, *R. metaboliza* Vain., *R. sicula* H. Mayrhofer & Poelt, *R. subminuta* H. Magn. and *R. willeyi* Sheard & Giralt. These are all corticolous species with the exception of *R. sicula*, which is saxicolous. We include four other species reported from our region by Mayrhofer (1984) in his monograph on saxicolous *Rinodina* species (*R. cervina* Vain., *R. compensata* (Nyl.) Zahlbr., *R. kozukensis* and *R. teichophila*), although we did not study them.

Our findings suggest that *Rinodina* species diversity has been underestimated in the countries of this region. Whereas 20 species had been reported previously for Japan, we now report 25. Two species have been reduced to synonymy (*R. akagiensis* Vain., *R. melancholica* Zahlbr. = *R. ascociscana* (Tuck.) Tuck.), one species accepted in the current checklist, *R. tsunodae* Yas. ex Räs., is a previously reported synonym of *R. kozukensis*, four are considered unconfirmed (*R. exigua* (Ach.) S. Gray, *R. milvina* (Wahlenb.) Th. Fr., *R. pyrina* and *R. sophodes*) and 11 are new for Japan (*Rinodina excrescens*, *R. freyi*, *R. gennarii*, *R. hypobadia*, *R. intermedia*, *R. megistospora*, *R. orientalis*, *R. polyspora*, *R. septentrionalis*, *R. subminuta* and *R. willeyi*). Fourteen species were previously reported for Korea and we also accept 14, albeit with modifications to the list. We reject reports of *R. laevigata* and *R. xanthomelana*, four other species are considered unconfirmed (*R. fimbriata*, *R. membranifera*, *R. pyrina* and *R. sophodes*) and six are new to South Korea (*R. ascociscana*, *R. moziana* (Nyl.) Zahlbr., *R. orientalis*, *R. subalbida* (Nyl.) Vain., *R. subminuta* and *R. subparieta* (Nyl.) Zahlbr.). Finally, while 32 species had previously been reported from the regions of the Russian Far East, we accept 35 species. One previous report is based on a misidentification, although we have found potentially authentic material (*R. oleae*). For 12 previously reported species, including several of the most widely reported names in the Russian Far East, no authentic material

https://doi.org/10.1017/S0024282917000536 Published online by Cambridge University Press

could be confirmed: *R. archaea* (Ach.) Arnold, *R. bischoffii* (Hepp) A. Massal., *R. calcarea* (Arnold) Arnold, *R. colobinoides* (Nyl.) Zahlbr., *R. confragosa* (Ach.) Körb., *R. exigua*, *R. melanconia* Vain., *R. milvina*, *R. olivaceobrunnea* Dodge & Baker, *R. pyrina*, *R. sophodes* and *R. trevisanii*. Fifteen more species are new to the Russian Far East, and 13 of these (all except those denoted by a ⋆) are new to the whole of Russia: *R. ascociscana*, *R. dolichospora*, *R. endospora*, *R. freyi*, *R. hypobadia*, *R. macrospora*, *R. megistospora*, *R. metaboliza*⋆, *R. orientalis*, *R. polyspora*⋆, *R. sicula*, *R. subalbida*, *R. subminuta*, *R. tenuis* Müll. Arg. and *R. willeyi*.

We place 14 previously published names on our list of species for which material has not been seen: *R. archaea*, *R. bischoffii*, *R. calcarea*, *R. colobinoides*, *R. confragosa*, *R. exigua* [incl. f. *laeviuscula*], *R. fimbriata*, *R. melanconia*, *R. membranifera*, *R. milvina*, *R. olivaceobrunnea*, *R. pyrina*, *R. sophodes* and *R. trevisanii*. In several of the latter cases, names have almost certainly been widely misapplied (e.g. *R. archaea*, *R. exigua*, *R. sophodes* and *R. trevisanii* were probably applied to species now shown to be common in the region such as *R. freyi* and *R. subminuta*), while in other cases the underlying reports may well be valid but specimens were not available for study. In two additional cases (*R. laevigata* and *R. xanthomelana*) we have studied the voucher material behind recent reports from the region and found them to be misidentified.

One of the striking patterns that emerges from the study of far eastern material of *Rinodina* is the close relationship with the genus in North America. Three of the new records reported here have western North American–eastern Asian distributions: the corticolous species *R. endospora*, *R. macrospora* and *R. megistospora*. Six species have the better known eastern North American–eastern Asian distribution, two of which are shown, based on this study, to provide older names than those currently in use. These species are *R. ascociscana* (syn. *R. akagiensis*, *R. melancholica*, Japan), *R. buckii*, *R. chrysidiata*, *R. subminuta*, *R. tenuis* (syn. *R. adirondackii* H. Magn., North America) and *R. willeyi*. *Rinodina cinereovirens* (Vain.) Vain. (syn. *R. turfacea* var. *cinereovirens* (Vain.) H. Mayrhofer) is also reported as new to North America.

## Key to the species of *Rinodina* from far eastern Asia

Species that were not examined from the area, but which have been reported by others or can be expected to occur, are marked with an asterisk (⋆).

1 Substratum rock . . . . . . . . . . 2
Substratum bark, wood, soil, decaying ground vegetation, bone or other lichens . . . . . . . . . . 15

2(1) Thalli with vegetative propagules . . . . . . . . . . 3
Thalli lacking vegetative propagules . . . . . . . . . . 4

3(2) Thallus effigurate, typically with isidia; when fertile spores belong to the *Physconia*-type; associated with seabird colonies; northern . . . . . . . . . . **R. balanina**
Thallus not effigurate, vegetative propagules blastidia with budding soredia; spores *Pachysporaria*-type II; not coastal; southern . . . . . . . . . . **R. placynthielloides**

4(2) Maritime, typically on coastal rocks; spores *Dirinaria*-type . . . . . . . . . . **R. gennarii**
Not coastal; spores belonging to a different type . . . . . . . . . . 5

https://doi.org/10.1017/S0024282917000536 Published online by Cambridge University Press

5(4) Medulla orange, K+ red-violet; spores *Pachysporaria*-type I, ultimately developing satellite apical lumina . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. cervina**
Medulla not orange, not K+ red-violet; spores of various types but never developing apical lumina . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6

6(5) Thallus and apothecium margins K+ yellow, atranorin in cortex . . . . . . . . . . . . 7
Thallus and apothecium margins K−, atranorin absent . . . . . . . . . . . . . . . . . . . 9

7(6) Spores with angular lumina, walls thickened at septum and apices, *Physcia*-type; proper exciple hyaline throughout, or if lightly pigmented not aeruginose (N−); thalline margin never pigmented . . . . . . . . . . . . . . . . . . . . . . . **R. confragosa***
Spores with 'hourglass'-shaped lumina, *Mischoblastia*-type; proper exciple typically aeruginose at periphery (N+ red under microscope); thalline margin often becoming pigmented . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8

8(7) Thallus plane; spores averaging <21·0 µm in length, rarely swollen at septum . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. oxydata**
Thallus verrucose; spores averaging >21·0 µm in length, often swollen at septum when mature . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. moziana** (syn. *R. destituta*)

9(6) Spores elongately ellipsoid, l/w ratio *c.* 2·0, *Pachysporaria*-type . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. cinereovirescens**
Spores broadly ellipsoid, l/w ratio <2·0, belonging to various types . . . . . . . . . 10

10(9) Spores 20·0–32·0 × 11·0–19·0 µm, *Teichophila*-type, often swollen at septum, more so in KOH . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. teichophila**
Spores <20 µm long, never swollen at septum, belonging to another type . . . . 11

11(10) Spores with broad pigmented band around septum, *Bischoffii*-type . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. bischoffii***
Spores lacking a broad pigmented band around septum, belonging to another type . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12

12(11) Spores with *Physcia*-like lumina when immature, becoming rounded especially at the apices, lateral walls thin . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13
Spores with rounded lumina from beginning, lateral walls relatively thick . . . . 14

13(12) Thallus thick, dark brown; spores constricted at septum when mature, *Milvina*-type; secondary metabolites absent . . . . . . . . . . . . . . . . . . . . . . . . . **R. milvina***
Thallus thin, grey to light brown; spores *Physconia*-type; thalline margin C+ red (under miroscope), gyrophoric acid in medulla . . . . . . . . . . . . . . . . . **R. sicula**

14(12) Apothecial discs pruinose; spores *Pachysporaria*-type . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. compensata**
Apothecial discs not pruinose; spores *Pachysporaria*- to *Milvina*-like . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. kozukensis**

15(1) On soil, decaying ground vegetation, wood, bone or lichenicolous . . . . . . . . . . 16
Strictly corticolous or lignicolous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 23

https://doi.org/10.1017/S0024282917000536 Published online by Cambridge University Press

16(15) Spores 3-septate or submuriform . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 17
Spores 1-septate, *Physcia*-type, rarely with apical satellite lumina . . . . . . . . . . . 18

17(16) Spores strictly 3-septate, type B development (apical wall thickened prior to septum formation); secondary metabolites absent . . . . . . . . . . . . . . . . . . .**R. conradii**
Spores 3-septate at first, typically becoming submuriform, type A development (apical wall thickening after septum formation); deoxylichesterinic acid present . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. intermedia**

18(16) Sphaerophorin crystals in medulla (sometimes lichenicolous) . . . . . .**R. turfacea**
Sphaerophorin lacking in medulla (never lichenicolous) . . . . . . . . . . . . . . . . . 19

19(18) Cortex K+ yellow or medulla orange, K+ red . . . . . . . . . . . . . . . . . . . . . . . . 20
Thalline reactions absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21

20(19) Thallus light grey; K+ yellow, atranorin in cortex . . . . . . . . . . . **R. mniaroeiza***
Thallus a shade of brown; medulla orange, K+ red, skyrin or other anthraquinones present . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .**R. cinnamomea***

21(19) Spores averaging <23·0 µm in length . . . . . . . . . . . . . . . . .**R. olivaceobrunnea***
Spores averaging >23·0 µm in length . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22

22(21) Thallus and apothecia not pruinose; apothecial discs becoming convex, thalline margin then excluded; spores averaging 24·5–25·5 µm in length, l/w ratio 2·0–2·2 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. mniaroea**
Thallus and apothecia typically pruinose; apothecial discs plane or concave, not convex, thalline margin never excluded; spores averaging 30·0–32·0 µm in length, l/w ratio 2·2–2·5 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. roscida**

23(15) Vegetative propagules present . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 24
Vegetative propagules absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 30

24(23) Thallus typically golden yellow . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 25
Thallus a shade of grey or brown . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 26

25(24) Thallus with small, dense isidia; very rarely with apothecia; spores *Pachysporaria*-type I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. chrysidiata**
Thallus with marginal, labriform soralia, sometimes becoming pustulate; frequently, but not always, with apothecia; spores *Physcia*-type **R. xanthophaea**

26(24) Thallus light grey; soralia labriform at first, soredia whitish; K+, P+ yellow, cortical atranorin present, pannarin absent . . . . . . . . **R. subparieta** (syn. *R. degeliana*)
Thallus darker grey; soredia never whitish; K−, P+ cinnabar, atranorin absent, pannarin present . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 27

27(26) Thallus usually of convex to bullate areoles; blastidia often present, sometimes breaking into soredia; zeorin typically absent, when fertile pannarin also in epihymenium . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .**R. excrescens**
Thallus never consisting of bullate areoles; soredia always present; zeorin typically present, pannarin never in epihymenium . . . . . . . . . . . . . . . . . . . . . . . . . . 28

28(27) Soredia typically yellowish, secalonic acid A present; spores *Physcia*-type when fertile, averaging <20 µm in length . . . . . . . . . . . . . . . . . . . . . . **R. efflorescens**
Soredia never yellowish, secalonic acid A absent; spores not *Physcia*-type, averaging >20 µm in length . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 29

29(28) Thallus minutely verrucose, verrucae central on areoles, quickly forming raised soralia, later spreading over thallus surface; soredia >40 µm diam.; spores *Teichophila*-type . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. buckii**
Thallus with plane areoles, soredia developing marginally on areoles, never raised centrally on verrucae, later spreading over thallus surface; soredia <40 µm diam.; spores *Pachysporaria*-type I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. willeyi**

30(23) Ascospores 3-septate or submuriform . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 31
Ascospores 1-septate, rarely with satellite apical cells . . . . . . . . . . . . . . . . . . . . 32

31(30) Spores strictly 3-septate, type B development (apical wall thickened prior to septum formation); secondary metabolites absent . . . . . . . . . . . . . . . . . . . .**R. conradii**
Spores 3-septate at first, becoming submuriform, type A development (apical wall thickening after septum formation); deoxylichesterinic acid present . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. intermedia**

32(30) Thallus brightly pigmented; xanthone present, UV+ orange . . . . . . . . . . . . . . 33
Thallus a shade of grey or brown; xanthone absent, UV− . . . . . . . . . . . . . . . . 34

33(32) Thallus citrine, thiomelin present; spores averaging 31·0–34·5 × 16·0–17·5 µm, *Pachysporaria*-type I; not sorediate; subtropical, Tsushima Island, Japan . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. luteonigra**
Thallus golden yellow, secalonic acid A present; spores averaging 23·5–28·5 × 2·0–15·0 µm, *Physcia*-type; frequently sorediate; temperate, widely distributed . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .**R. xanthophaea**

34(32) Thallus K+ yellow or P+ cinnabar, atranorin or pannarin present . . . . . . . . . 35
Thallus K−, P−, both atranorin and pannarin absent . . . . . . . . . . . . . . . . . . . 42

35(34) Thallus K+ yellow, atranorin present, pannarin absent . . . . . . . . . . . . . . . . . . . 36
Thallus P+ cinnabar, pannarin present, atranorin absent . . . . . . . . . . . . . . . . 38

36(35) Spores averaging >33·0 µm long, *Pachysporaria*-type I . . . . . . . **R. megistospora**
Spores averaging <33·0 µm long, *Physcia*- or *Physconia*-type . . . . . . . . . . . . . . . 37

37(36) Spores averaging >26·0 µm long, strictly *Physcia*-type; never sorediate; distribution limited to coastal foreshores . . . . . . . . . . . . . . . . . . . . . . . . . . **R. macrospora**
Spores averaging <26·0 µm long, *Physcia*- to *Physconia*-type; most frequently sorediate; distribution inland . . . . . . . . . . . . **R. subparieta** (syn. *R. degeliana*)

38(35) Hypothecium pigmented dark reddish brown; spores *Dirinaria*-type, (12·0–)14·0–16·5(–18·0) × (6·5–)7·0–8·5(–9·5) µm, lightly pigmented . . . . . . **R. hypobadia**
Hypothecium never strongly pigmented; spore type otherwise . . . . . . . . . . . . . 39

39(38) Spores averaging <20·0 µm in length, *Physcia*-type; thallus becoming bullate, often with minute blastidia . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. excrescens**
Spores averaging >20·0 µm in length, not *Physcia*-type; thallus sometimes verrucate but never bullate or blastidiate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 40

40(39) Thallus persistently plane; epihymenium lacking crystals, P−; spores averaging >29·0 µm . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. tenuis** (syn. *R. adirondackii*)
Thallus becoming verrucate; epihymenium with or without crystals, P+ or P−; spores averaging <29·0 µm . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 41

41(40) Epihymenium typically possessing pannarin crystals, P+ cinnabar; spores lacking apical canals; widely distributed in Japan and adjacent mainland . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. subalbida**
Epihymenium lacking pannarin crystals, P−; spores with very obvious apical canals; Cheju Island, Korea . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **Rinodina sp. A**

42(34) Spores 16 per ascus . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. polyspora**
Spores 4–8 per ascus . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 43

43(42) Medulla with sphaerophorin crystals, PL+ . . . . . . . . . . . . . . . . **R. cinereovirens**
Medulla lacking sphaerophorin crystals, PL− . . . . . . . . . . . . . . . . . . . . . . . . . . 44

44(43) Spores swollen at septum, more so in KOH, type B development (apical wall thickening prior to septum formation), *Dirinaria*-type . . . . . . . . . . . . . . . . . 45
Spores not swollen at septum, even in KOH, type A development (apical wall thickening after septum formation), various types . . . . . . . . . . . . . . . . . . . . 50

45(44) Spores averaging >21 µm long . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. endospora**
Spores averaging <21 µm long . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 46

46(45) Spores lacking wall thickening at maturity (septal and apical thickenings may be present briefly in immature spores) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 47
Spore lumina *Physcia*-like, with persistent apical wall thickening . . . . . . . . . . . 48

47(46) Thallus grey to ochraceous, rugose, areoles to 0·70 mm wide; apothecia to 0·80 mm in diam., discs plane, never convex; spores averaging 15·5–18·0 × 8·0–8·5 µm, l/w ratio 1·9–2·1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. mongolica**
Thallus grey, never ochraceous, continuous to rimose; apothecia to 0·30–0·50 mm in diam., discs often becoming convex; spores averaging 12·5–13·5 × 5·5–6·0 µm, l/w ratio 2·1–2·4 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. pyrina***

48(46) Apothecia not erumpent; spores averaging 17·5–21·5 × 9·0–11·0 µm . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. metaboliza**
Apothecia erumpent; spores smaller . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 49

49(48) Spores averaging 15·5–16·0 µm in length . . . . . . . . . . . . . . . . . . . **R. manshurica**
Spores averaging 16·5–18·0 µm in length . . . . . . . . . . . . . . . . . . . . . . . **R. aff. oleae**

50(44) Spores averaging >22·0 µm in length . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 51
Spores averaging <22·0 µm in length . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 52

51(50) Margins of apothecia often radially cracked; spores *Physcia*- to *Physconia*-type . . . . . . . . . . . . . . . . . . . . . . . . . **R. ascociscana** (syn. *R. akagiensis*, *R. melancholica*)
Margins of apothecia not radially cracked; spores *Pachysporaria*-type I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. dolichospora**

52(50) Spores *Physcia*- to *Physconia*-type, some lumina becoming rounded at apices, at maturity thin-walled . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 53
Spores strictly *Physcia*-type, apical walls remaining thick . . . . . . . . . . . . . . . . . . 56

53(52) Thallus dark brown, spores darkly pigmented at maturity, torus prominent; oro-arctic . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 54
Thallus a shade of grey, sometimes brownish, spores typically pigmented at maturity, torus present but not prominent; boreal . . . . . . . . . . . . . . . . . . . . . 55

54(53) Thallus of dispersed or contiguous areoles; apothecia mostly dispersed, narrowly attached, becoming markedly sessile (almost stipitate) . . . . . . . . . . **R. sibirica**
Thallus inconspicuous; apothecia mostly crowded, typically broadly attached . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. olivaceobrunnea***

55(53) Thallus thick, rugose, areolate; apothecia crowded, discs persistently plane, thalline margins persistent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. archaea***
Thallus thin, plane, continuous or rimose-areolate; apothecia dispersed, discs becoming convex, often excluding thalline margin . . . . . . . . . . . **R. trevisanii***

56(52) Spores averaging >18 μm long, zeorin present . . . . . . . . . . . . . . . . **R. subminuta**
Spores averaging <18 μm long, zeorin absent . . . . . . . . . . . . . . . . . . . . . . . . . . . 57

57(56) Apothecia erumpent at first, discs often becoming strongly convex; spores with lightly pigmented tori at maturity . . . . . . . . . . . . . . . . . . . . . . . . . . **R. orientalis**
Apothecia never erumpent, discs persistently plane; spores with very dark, prominent tori at maturity . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 58

58(57) Apothecia crowded, broadly attached; thalli associated with leaf scars or other mesic microhabitats; areoles plane, contiguous, to >0·20 mm in diam. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **R. freyi**
Apothecia mostly scattered, narrowly attached; thalli typically in more xeric microhabitats; areoles convex, scattered, to 0·20 mm in diam. . . . **R. septentrionalis**

## Annotated Species List

### Rinodina ascociscana (Tuck.) Tuck.

*Genera Lich.*: 124 (1872).—*Psoroma ascociscana* Tuck., *Amer. J. Arts & Sci., ser. 2* **25:** 424 (1858); type: USA: [New Hampshire: Grafton Co.,] very common on trunks in the White Mountains, 1843, *E. Tuckerman* s. n. (FH—lectotype; COLO, FH, UC, US—isolectotypes).

New synonyms: *Rinodina akagiensis* Vain., *Bot. Mag. Tokyo* **35:** 62 (1921); type: Japan, Kosuke Prov. [Gunma Pref.], Mons Akagi, 20 Dec 1918, *A. Yasuda* 348 (TUR-V 08741—holotype!).

*Rinodina melancholica* Zahlbr., *Bot. Mag. Tokyo* **41:** 361 (1927); type: Japan (Nippon media), [Nagano/Gifu Pref. borders] Mount Norikura, August 1905, *Faurie* 6865 (W—holotype!).

*Rinodina ascociscana* is characterized by its ochraceous to brown, usually continuous, glossy thallus surface, narrowly attached apothecia often with radially striate thalline margins at maturity, and particularly by its very large spores, up to 43·5 × 18·5 μm

https://doi.org/10.1017/S0024282917000536 Published online by Cambridge University Press

(*Thor* 32526, UPS) which belong to the *Physcia–Physconia*-type and are sometimes larger than those quoted by Sheard (2010). Zeorin is reported for the first time in one of thirteen specimens (*Kashiwadani* 38575, TNS).

The holotype of *R. akagiensis* is a relatively young specimen with a poorly developed thallus. The spores are entirely typical of *R. ascociscana* in their structure and size (29·0–39·0 × 14·5–18·0 µm, $n = 10$). The only characters that are somewhat atypical are the narrow margins and slightly convex discs of most of the apothecia. The brown thallus, narrowly attached apothecia with radially cracked margins and the large spores (28·0–32·0 × 15·0–18·0 µm, $n = 10$) of the *R. melancholica* holotype indicate that this taxon is also synonymous with *R. ascociscana*. Again, the thallus is not well developed and the spores are either immature or over-mature but fall within the range quoted by Sheard (2010).

The species occurs in mixed deciduous forest in Honshu, Japan from 380–1480 m, on Cheju Island, Korea from 750–1600 m, in Gangwon Province from 380 m to the sub-alpine zone at 1660 m, and in Primorskiy Krai, Russia at low elevations (Fig. 1A). *Rinodina ascociscana* has previously been considered endemic to eastern North America (Sheard 2010; Lendemer *et al.* 2014).

*Selected specimens examined*. **Japan:** *Hokkaido*: Iburi Prov., Muroran-shi, 42°18'N, 140°58'E, 1904, *U. Faurie* 6083 (TNS); Mount Tarumae, 42°41'N, 141°21'E, 1977, *H. Kashiwadani* 14478 (TNS); Ishikari Prov., near Mt. Arashiyama, Asahikana City, 43°47'N, 142°18'E, *A. Shimizu* 1541 (TNS with *R. subalbida*); Kitami Prov., Shari-gun, Mount Rausu, 44° 04'N, 145°12'E, on *Quercus crispula*, 1983, *H. Kashiwadani* 19950 (TNS); Kushiro Prov., Akan-gun, Lake Akan, 43°26'N, 144°08'E, on *Quercus crispula*, 1995, *Y. Ohmura* 1903 (TNS); Tokachi Prov., Ashoro-gun, Lake Onneto, 43°23'N, 143°59'E, on *Fraxinus mandshurica* var. *japonica*, 1995, *Y. Ohmura* 1776 (TNS). *Honshu*: Kozuke Prov., Mt. Akagi, 36°33'N, 139° 12'E, *K. Tsunoda* 463, 468, 508 (TNS); Etchu Prov. (Toyama Pref.), Nakashinkawa-gun (Nakaniikawa-gun), Tateyama-cho, 30 km ESE of Toyama, Syomyo-zaka, on deciduous tree, alt. 1160–1220 m, 36°34'N, 137°31'E, 1994, *G. Thor* 12608 (TNS & UPS); Mutsu Prov. (Aomori Pref.), Shimokita-gun, Sai-mura, Mt. Nuidoiwa-yama (Nuidoishi-yama), on *Fagus crenata*, alt. 380–626 m, 41°19'N, 140°51'E, 1994, *G. Thor* 11746 (TNS & UPS); Shimotsuke Prov. (Tochigi Pref.), Nikko City, 13 km NW of Nikko and 5 km ESE of Yumoto Village, elev. 1610 m, 36°47'56·3"N, 139°28'56·6"E (WGS84, ±30 m), 2015, *Thor* 32526 (UPS); Shinano Prov. (Nagano Pref.), Ohmachi-city, 16 km NW Shinano-Ohmachi, Ohgisawa, on deciduous tree, alt. 1420–1480 m, 36°33'N, 137°43'E, 1994, *G. Thor* 12728 (TNS & UPS).—**Russia:** *Primorsky Krai*: Vladivostok Botanical Gardens, 43°09'N, 131°53'E, on *Quercus mongolica*, 14 vii 2003, *I. A. Galanina* (VLA); Khasanskiy District, vicinity of Paset, 42°28'N, 130°48'E, on *Quercus mongolica*, 14 iv 2002, *I. A. Galanina* (VLA); Sikhote-Alin' Mountains, Sikhote-Alin'skiy Zapovednik, Terneyskiy Rayon, 54 km (air line) NW of Plastun, along brook Kaban', 45°08·286'N, 135°53·158'E, on *Abies nephrolepis*, 2007, *T. Spribille* 23861, 23865 (GZU); Sikhote Alin, Terney District, valley of Taratay brook, on the slope of mountain ridge, 45°44'42·03"N, 136° 36'11·29"E, on *Tilia amurensis*, 14 viii 2010, *E. Kuznetsova* (LECB 12-53).—**South Korea:** *Cheju Island*: Eorimok trail, NW slope of Mt. Halla, dead deciduous tree, alt. 1600–1000 m, 33°23'N, 126°31'E, 2001, *G. Thor* 17161 (AK & UPS); Namcheju-gun, Namwon-up, Songpanak trail, east slope of Mt. Halla, on dead deciduous tree, alt. 750–1500 m, 33°23'N, 126°37'E, 2001, *G. Thor* 17400, 17429 (on *Fraxinus*), 17444 (on Acer) (AK & UPS). *Gangwon Prov.*: Pyeonchang-gun, Mt. Odae, Odaesan Nat. Park, on *Quercus*, alt. 1560 m, 37°47'N, 128°32'E, 2014, *A. Aptroot* 72645 (ABL); Yangyang-gun, Ser-myun, Osaeck-ri, southern part of Sorak Mts, Sorak-san Nat. Park, south slope of Mt. Dachong, on deciduous tree. alt. 700–1400 m, 38°05·30–06·45'N, 128°27·00–30'E, 2006, *G. Thor* 20248 (AK & UPS); from 2·5 km NNE of Osaeck Village to timberline, *c.* 3·5 km NNE of Osaeck Village, subalpine, on dead *Abies* sp., alt. 1400–1600 m, 38°06·45–07·00'N, 128°27·30–28·00'E, 2006, *G. Thor* 20325 (AK & UPS with *R. buckii*); 38°07'N, 128° 27'E, on *Betula* in subalpine, 1400–1660 m, *G. Thor* 20300 (UPS, with *R. chrysidiata* and *R. xanthophaea*), 20318 (UPS, with *R. chrysidiata*); Inje-gun, Buk-myun, Yongdae-ri, inner part of Sorak Mts, Sorak-san Nat. Park, from Backdam (Paekdam) temple and along road in Backdam Valley towards Yongdae-ri Village on *Quercus* sp., alt. 450–550 m, 38°09·85–10·25'N, 128°22·50'E, 2006, *G. Thor* 20679, 20702 (AK, with fertile *R. chrysidiata*); on *Quercus* sp., alt. 380–420 m, 38°10·25–11·00'N, 128°22·30–22·00'E, 2006, *G. Thor* 20863 (AK & UPS).

## Rinodina balanina (Wahlenb.) Vain.

*Ark. Bot.* **8**(4): 69 (1909).—*Lichen balaninus* Wahlenb., *Flora Lappon.*: 426 (1812); type: [Norway, Finnmark] In petris insulae sinus Altensis, 13 [May]1802, *Wahlenberg* s. n. (UPS—lectotype, Mayrhofer & Moberg 2002).

*Rinodina balanina* is characterized by its brown, marginally effigurate, verrucose, often isidiate thallus and is always found on maritime ornithocoprophilous rocks, mostly north of the Arctic Circle (Mayrhofer & Moberg 2002). This species was first reported from the Arctic Ocean coast of Chukotka by Almquist (1879, from Tiapka near Cape Serdtse-Kamen),

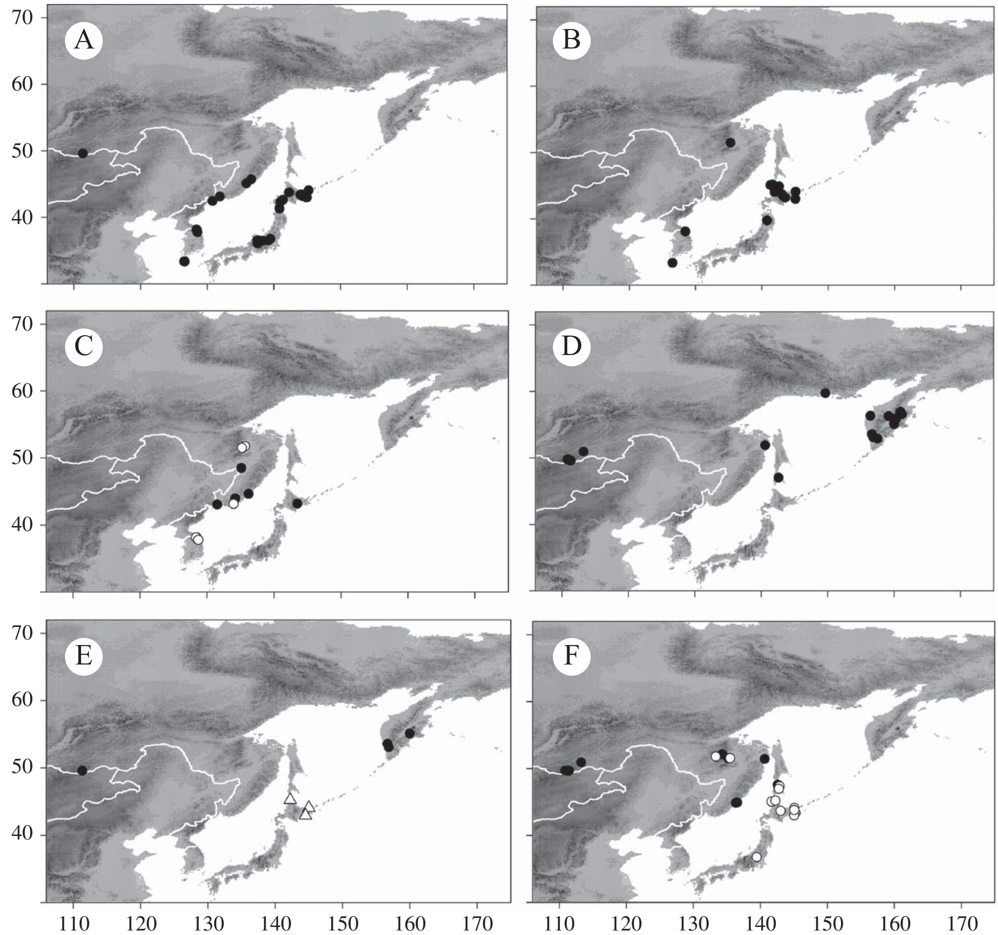


FIG. 1. Distribution of *Rinodina* species in north-eastern Asia. A, *R. ascociscana*; B, *R. buckii*; C, *R. chrysidiata* (solid circles: previous records; open circles: new records); D, *R. cinereovirens*; E, *R. conradii* (circles), *R. gennarii* (triangles); F, *R. excrescens* (solid circles: previous records; open circles: new records).

subsequently by Vainio (1909: "in rupe gneissacea in peninsula Jinretlen"), and perhaps based on these reports also by Andreev *et al.* (1996) and Urbanavichus & Andreev (2010). We have not been able to locate the specimens. These appear to be the only records for the Beringian region as the species has not been reported from Alaska or the North American Pacific coast (Sheard 2010).

## Rinodina buckii Sheard

*Herzogia* **25**(2): 126 (2012); type: USA, North Carolina, Swain Co., Great Smoky Mountains National Park, Hyatt Ridge Trail between Beech Gap Trail and Enloe Creek Trail, on fallen branch, 6 Aug. 2009, *J. C. Lendemer* 19269 & *E. A. Tripp* (NY—holotype).

This species was recently described from the Appalachian Mountains of eastern USA, Japan, South Korea and far eastern Russia (Sheard *et al.* 2012). Additional records for eastern North America were mapped in Lendemer *et al.* (2014). It was previously confused with *R. willeyi* Sheard & Giralt due to the similarly sized spores, sorediate thallus and chemistry (pannarin, usually with zeorin). The spores of *R. buckii*, however, belong to the *Teichophila*-type, are more heavily pigmented and possess a better developed torus. The margins of the thallus are characterized by small, discrete areoles that quickly develop central verrucae upon which the soredia develop. The soredia are, therefore, characteristically raised. They are also larger (40–65 µm in diam.) than those of *R. willeyi* (20–30 µm in diam.) and further differ in being initiated in the centre of the areoles rather than at their margins. As the areoles get larger and the soredia more dense, the two species become more similar in their vegetative characteristics, except for the smaller size and the often lighter coloured soredia of *R. willeyi*. This study of further Asian specimens does not change the spore size quoted in the type description of *R. buckii*.

The form of *Rinodina excrescens* with lobed areoles (Sheard *et al*. 2012) might also be mistaken for *R. buckii*, particularly when blastidia are present (characteristically minute and therefore easily confused with soredia). This form may develop bullate verrucae from the centre of the areoles, thereby mimicking the verrucae of *R. buckii*. In the case of fertile thalli, *R. excrescens* is easily distinguished from *R. buckii* by its smaller, *Physcia*-type spores. In addition, the thallus of *R. excrescens* typically has a glossy surface, a brownish tinge and rarely includes zeorin, whereas *R. buckii* has a matt surface, is always a shade of grey and typically contains zeorin. *Rinodina buckii* is related to *R. subalbida* by spore size, structure (*Teichophila*-type) and thallus chemistry but the latter species is never sorediate and its epihymenium typically contains crystals of pannarin which are not present in *R. buckii*.

In eastern North America, *Rinodina buckii* occurs at low to middle elevations (225–1535 m). In Hokkaido it is found from close to sea level to 750 m, at higher elevations (1300–1600 m) in South Korea and at 340 m for the single Russian record (Sheard *et al*. 2012). Its distribution in Asia is shown in Fig. 1B.

*Specimens not previously reported*. **Japan:** *Hokkaido*: Kitami Prov., Esashi-gun, Esashi-cho, 2 km S of Honcho, on *Larix*, alt. 10–20 m, 44°55'N, 142°35'E, 1995, *G. Thor* 14251 (UPS with *R. subparieta*); Shari-gun, Shari-cho, Shiretoko Nat. Park, path along small stream NE of Iwaobetsu hot-spring hotel (Onsen), 44°07'N, 145°05'E, alt. 240 – 280 m, on ± mossy, horizontal log, 1995, *T. Tønsberg* 22845 (BG with *R. tenuis*, *R. excrescens*); 9 km NE of Utoro Village, along trail around Shiretoko-goko Lakes, on *Taxus cuspidata*, alt. 260 m, 44°07'N, 145°05'E, 1995, *G. Thor* 14294 (UPS); Teshio Prov., Rumoi-gun, Obira-cho, 21 km ENE of Obira at coast, along E and upper trail from Tengunotaki Waterfall to parking area, 44°04'N, 141°55'E, alt. 130 – 150 m, on *Abies sachalinensis*, 1995, *T. Tønsberg* 21985 (BG with *R. willeyi*), 21997 (BG with type of *R. hypobadia*); Teshio-gun, Toyotomi-cho, 35 km NNW of Teshio, along small road 2·5 km from coast, 45°12'N, 141°36'E, alt. 10–20 m, on *Quercus serrata* var. *grosseserrata*, 1995, *T. Tønsberg* 22224 (BG); Toyotomi-cho, Rishiri-Rebun-Sarobetsu Nat. Park, 23 km NNW of Teshio at coast, Wakasakanai area, S of the road from coast to Toyotomi, on *Abies sachalinensis*, alt. 20 m, 45° 05'N, 141°39'E, 1995, *G. Thor* 13636 (UPS with *R. excrescens*); Tokachi Prov., Kato-gun, Kamishihoro-cho, just W of road 273, 6 km S of Mikuni tunnel through Mt. Mikuni-yama, 43°32'N, 143°09'E, alt. 680 m, on *Abies sachalinesis*, 1995, *T. Tønsberg* 23050 (with *R.* aff. *oleae*; BG). *Honshu*: Prov. Tohoku (Prefecture Akita), 11 km NE of Lake Tazawa, 2 km SSW Tsuru-no-yu Onsen, on old *Quercus*, alt. 616 m, 39° 47·303'N, 140°46·405'E (WGS84, ±3 m), 2013, *G. Thor* 29792 (UPS).—**South Korea:** *Gangwon Prov*.: Yangyang-gun, Ser-myun, Osaeck-ri, southern part of the massif Sorak Mts, Sorak-san Nat. Park, south slope of Mt. Dachong subalpine, on dead *Abies* sp., alt. 1400–1600 m, 38°06·45–07·00'N, 128°27·30–28·00'E, 2006, *G. Thor* 20325 (AK & UPS with *R. ascociscana*).

## Rinodina cervina Vain.

*Bot. Mag*. (*Tokyo*) **35:** 61 (1921); type: Japan, Prov. Kozuke, in rupe, 9. 3. 1918, *Yasuda* 359 (TUR-V 8650— holotype, Mayrhofer 1984).

This is a saxicolous species known only from Japan and not seen by us. The spores are probably *Pachysporaria*-type I (Sheard 2010), as indicated by the apical satellite lumina found in the most mature spores illustrated by Mayrhofer (1984). The species is otherwise distinguished by an orange pigment in the medulla, K+ red-violet.

## Rinodina chrysidiata Sheard

*Lichenologist* **44:** 179 (2012); type: USA, North Carolina, Clay Co., Nantahala National Forest, 1–1·5 mi N of US 64 on Buck Creek Rd, *c*. 5 mi NE of Shooting Creek, mesic upland forest, on *Liriodendron*, 10 November 2007, *J. C. Lendemer* 10425 (NY—holotype; BG—isotype).

New synonym: *Rinodina xanthophaea* f. *isidiosa* Pczelkin, *Novosti sistematiki nizshikh rastenii* **24:** 166 (1987); type: USSR Far East [Russia: Primorsky Krai:]

Sikhote-Alin Nature Reserve, [45°02'N, 136°20'E], oak stand near the seashore in the surroundings of Lake Khuntam, on oak bark, 1982, *A. V. Pczelkin* (LE—holotype!; KW—isotype not seen).

This recently described, golden yellow, xanthone-containing species reproduces vegetatively by means of isidia and has only rarely been found fertile (Lendemer *et al.* 2012). The type of *R. xanthophaea* f. *isidiosa* is enigmatic. Its thallus is densely isidiate and typical of *R. chrysidiata* in every respect. However, three large apothecia are present, *c.* 0·60 mm diam., and typical of *R. xanthophaea* in their external morphology. Two relatively thick (hand, not microtome) sections were taken from the one, previously sampled apothecium. Anatomical measurements were all within the range quoted for *R. xanthophaea* by Lendemer *et al.* (2012). The *Physcia*-type spores were also typical of *R. xanthophaea*, their measurements, (21·5–)23·5–26·5(–28·5) × 12·0–13·5 µm ($n = 20$), falling within the range of *R. xanthophaea* quoted by Lendemer *et al.* (2012) and possessing identical l/w ratios of (1·6–)1·8–2·1(–2·2). These spores have a very different lumen structure from those of the single poorly fertile specimen examined of *R. chrysidiata*, belonging to *Pachysporaria*-type I, newly reported here (*Thor* 20702) from South Korea.

Pczelkin (1987) states that *R. xanthophaea* f. *sorediosa* and f. *isidiosa* grow together in the Sikhote-Alin Nature Reserve "but do not establish intermediate forms", and further that the f. *isidiosa* is the more common. The lack of intermediate forms is supported by our observation (JWS) that in one of the apothecial sections taken from the type, the isidiate thallus could be seen to be growing on top of the thallus supporting the apothecium and separated from it by a dark tissue, suggestive of a prothallus. Our interpretation of these facts is that the holotype of the f. *isidiosa* is a mixed specimen of *R. xanthophaea* and *R. chrysidiata*, the thallus of the former having been overgrown by the latter. Since the isidiate thallus predominates in the holotype of *R. xanthophaea* f. *isidiosa*, and the isidia are clearly identified in the name of the forma, it is here synonymized with *R. chrysidiata*.

One poorly fertile specimen has previously been reported from North America with immature spores, tentatively identified as belonging to *Pachysporaria*-type I (Sheard *et al.* 2012). Another fertile specimen is reported here (*Thor* 20702) and is again small. The fertile part of the collection occupies a crevice of the bark substratum (*Quercus* sp.) and possesses a grey thallus with incipient isidia. The grey colour presumably reflects a shaded microhabitat and is accompanied by darkly coloured (with a hint of yellow pigmentation) and isidiate, sterile thalli on more exposed surfaces. Xanthones were not found by TLC in either thallus type (presumably because of their absence in the fertile material and very low concentrations in the isidiate material). A hand-cut section of the apothecium confirms the *Pachysporaria*-type I spore designation for this species. The great majority of spores were over-mature. The five mature spores found measured 23·0–27·0 × 13·5–14·5 µm and possessed prominent tori, consistent with the type description of *R. chrysidiata*. These spores are larger than the immature spores recorded by Lendemer *et al.* (2012) and should be considered more representative of the spore size for this species. The few other apothecia present appeared to be over-mature and it was not considered appropriate to sacrifice a second apothecium for microtome sectioning, given the likely outcome of a poor result.

*Rinodina citrinisidiata* Aptroot & Wolseley from Thailand (Aptroot *et al.* 2007) is probably very closely related to *R. chrysidiata*. It is reported to have similar-sized isidia with brown tips and *Pachysporaria*-type spores of similar size, though apparently more elongately-ellipsoid. It differs, however, in the presence of the xanthone thiomelin, rather than secalonic acid A, in the thallus.

*Rinodina chrysidiata* is previously known from the island of Hokkaido, South Korea and far eastern Russia (Lendemer *et al.* 2012). It occurs at 550 m elevation in the Russian localities and up to 1600 m in the mountains of South Korea (see Fig. 1C).

*Specimens not previously recorded.* **Russia:** *Khabarovskiy Krai*: foothills of Etkil'-Yankanskiy Mountains, Amgun' River region, 9·7 km N of Berozovyy, on *Picea*, elev. 550 m, 51°46·203'N, 135°41·010'E, 2009, *C. Printzen* 11801 (FR); Sonakh River, Amgun' River region, *c.* 10 km NW main Berezovyy-Badzhal route, on *Quercus mongolica*, elev. 340 m, 51°31·345'N, 135°13·304'E, 2009, *C. Printzen* 11918 (FR). *Primorsky Krai*: Lazo Nature Reserve, Tretylog, along the River Perekatnaya, 43:11N 13:58E, 500 m, on *Quercus*, *R. Moberg* 9746 (with *R. xanthophaea*, UPS).—**South Korea:** *Gangwon Prov.*: Gangrun City, Mt. Odae, Odaesan Nat. Park, alt. 240 m, 37°49·25'N, 128°42'E, 2014, *A. Aptroot* 72642 (ABL); Inje-gun, Buk-myun, Yongdae-ri, inner part of the massif Sorak Mts, Sorak-san Nat. Park, *c.* 1·5 km NW Backdam (Paekdam) temple, on *Quercus* sp., alt. 550–450 m, 38°09·85–10·25'N, 128°22·50'E, 2006, *G. Thor* 20702 (AK, UPS fertile with *R. ascociscana*); alt. 420–380 m, 38° 10·25–11·00'N, 128°22·30–22·00'E, 2006, *G. Thor* 20863 (AK & UPS); Yangyang-gun, Ser-myun, Osaeck-ri, southern part of the massif Sorak Mts, Sorak-san Nat. Park, south slope of Mt. Dachong, on *Quercus* sp., alt. 1600–1400 m, 38°07·10–06·45'N, 128°27·25–26·00'E, 2006, *G. Thor* 20475 (AK & UPS); *c.* 3–5 km SW of the shelter, on dead *Abies* sp., alt. 1400–1350 m, 38°06·45–28'N, 128°26·00–25·10'E, 2006, *G. Thor* 20621 (AK with *R. subalbida*).

## Rinodina cinereovirens (Vain.) Vain.

*In Nyl. & Norrl., Herb Lich.Fenn.* 560 (1921) (UPS—neotype, Mayrhofer & Moberg (2002); H—isoneotype). *Lecanora sophodes* var. *cinereovirens* Vain., *Meddeland. Soc. Fauna Fl. Fenn.* **2:** 56 (1878); type: Finland, Tavastia australis, Asikkala, Kailanneimi, prope Tuomisoja, 1863, *J. P. Norrlin* s. n. (not found); *Rinodina turfacea* var. *cinereovirens* (Vain.) H. Mayrhofer, Mayrhofer & Moberg *Rinodina - Nordic Lichen Flora* **2:** 68 (2002).

New synonym: *Rinodina turfacea* var. *ecrustacea* (Vain.) H. Olivier, *Mem. Soc. Sci. Nat. Cherbourg* **37:** 163 (1909). *Lecanora turfacea* var. *archaea* f. *ecrustacea* Vain., *Meddeland. Soc. Fauna Fl. Fenn.* **6:** 153 (1881); type: [Russia: Karelia], ad corticem salicis in regione abietina montis Päänuorunen, 1878, *E. A. Vainio* (TUR-V 8803—holotype, Mayrhofer & Moberg 2002).

*Thallus* thin, light grey or sometimes brownish grey, of scattered, convex verrucae, to 0·2–0·3 mm diam., rarely merging to form larger areoles; surface plane, matt; margin indeterminate; prothallus lacking; vegetative propagules absent.

*Apothecia* quickly differentiating on scattered areoles, rarely contiguous, becoming narrowly attached, sometimes almost stipitate, to 0·60–1·00 mm diam.; *disc* black, rarely light grey or orange pruinose, plane, rarely concave but sometimes becoming convex or half-globose; thalline margin concolorous with thallus, to *c.* 0·10 mm wide, entire and typically persistent; excipular ring absent. *Thalline exciple* 40–70 µm wide laterally; cortex 5–10 µm wide; epinecral layer sometimes present, *c.* 5 µm wide; crystals absent in cortex, present in medulla (sphaerophorin); cortical cells 4·5–7·0 µm wide, pigmented or not; algal cells 11·0–14·5 µm diam.; thalline exciple 80–120 µm wide below; cortex expanded to 20–60 µm wide, hyphae intricate, very rarely becoming somewhat columnar; *proper exciple c.* 10 µm wide laterally, expanding to 20–40 µm wide above, often pigmented light brown. *Hymenium* 90–120 µm high, not inspersed; *paraphyses* 2·0–2·5 µm wide, not strongly conglutinate, apices expanded to 4·0–6·0 µm wide, dark brown capitate, immersed in diffuse pigment forming a dark red-brown epihymenium, rarely with surface crystals. *Asci* 60–80 × 17–24 µm; *ascospores* 4 or 8 per ascus, type A development, *Physcia*-type, (21·5–)23·0–25·5(–27·5) × (10·0–)11·5–13·5(–14·0) µm, l/w ratio (1·7–)1·8–2·1(–2·3), $n = 235$, lumina angular, becoming less so but apical walls remaining thick; torus well developed (Fig. 2); walls not or hardly ornamented. *Hypothecium* hyaline, 30–45 µm deep.

*Pycnidia* not observed.

*Chemistry*. Spot tests all negative, medulla UV (lw) + blue-white. Secondary metabolites: sphaerophorin and satellites in medulla by TLC.

*Rinodina cinereovirens* is closely related to *R. turfacea* but has been raised to the level of species because it is distinguished by spores that are frequently only 4 per ascus, possess a shorter median length, a more broadly ellipsoid shape and more bluntly rounded apices (Fig. 2). Upper extremes of spore size for *R. cinereovirens*, nevertheless, overlap with those of *R. turfacea*. Apothecia of *R. cinereovirens* tend to be smaller, possessing discs that are rarely concave but which may often become convex, a character never found in healthy *R. turfacea*. Rarely, this species may also possess apothecia with orange pruina, as occasionally found in *R. turfacea*. *Rinodina cinereovirens* is also similar to *R. turfacea* in its expanded lower cortex which, however, is usually less deep and has an intricate rather than columnar structure (but note that

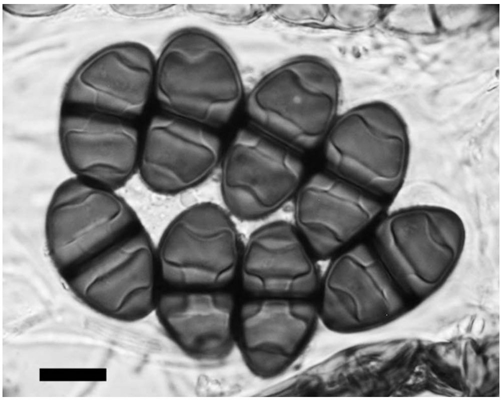

FIG. 2. *Physcia*-type ascospores of *Rinodina cinereovirens*, Zabaikal'skiy Krai, Sokhondinskiy Biosphere Zapovednik, 23 July 2006, *L. S. Yakovchenko* (VLA). Note the broadly ellipsoid spore shape and prominent torus in this 8-spored ascus. Compare with *Rinodina turfacea*, Fig. 172 in Sheard (2010). Scale = 10 μm.

Mayrhofer & Moberg (2002) described the lower cortex of *R. turfacea* as being intricate). The species is further differentiated by being limited to corticolous or lignicolous habitats rather than being found primarily on moss and decaying vegetation on the ground.

Magnusson (1947) remarked that the apothecium margins of *R. cinereovirens* were wider than those of *R. turfacea* but our observations suggest that they appear relatively broad only because of the mostly smaller size of their apothecia. In comparing the two species, it must also be recognized that immature spores of *R. cinereovirens* (i.e. those that are not fully pigmented) are frequently more elongately-ellipsoid than fully mature spores, which are more darkly pigmented. Furthermore, over-mature spores in which the lumen structure begins to deform, unaccountably, appear to shrink in length, thus making them even more broadly-ellipsoid. It is, therefore, imperative when comparing spore dimensions to control for spore development stage by measuring only those spores that are fully developed and pigmented but not over-mature.

Four-spored asci are also frequent in the western North American corticolous species *Rinodina badiexcipula* which Sheard (2010) suggested might be related to *R. turfacea* on account of its relatively large, *Physcia*-type spores, pigmented proper exciple and similar chemistry. This species, however, is distinct from *R. cinereovirens* in its darker thallus colour, thicker apothecial margins and its unusual type of spore development, which is unique within the genus, in that apical wall thickening is delayed until after pigmentation is initiated. This is well illustrated in Figure 21 of Sheard (2010), as is the asynchronous spore development, another frequent feature of this species.

The combination *R. cinereovirens* (Vain.) Vain. was listed as a *nomen nudum* by Lamb (1963) because neither a basionym nor a description was given in Nyl. & Norrl. *Herb. Lich. Fenn*. 560. However, in using the name at species rank Vainio was clearly, if indirectly, referencing his own previous variety that he described in 1878, and a reference to the protologue was not required at the time (T. Ahti & A. Sennikov, pers. comm. 2016). The combination as (Vain.) Vain. should therefore be regarded as valid.

*Rinodina cinereovirens* has a boreal distribution in the study area (Fig. 1D). In the east it occurs into the dwarf shrub tundra as high as 1290 m and in the west at 885–1795 m, the highest elevations being in the subalpine zone. It has previously been reported in our study area from Kamchatka by Himelbrant *et al.* (2009), the central Russian Far East by Urbanavichus & Andreev (2010) and the Stanovoye Nagor'e highlands by Chesnokov & Konoreva (2015). It was also reported from Baikal Zapovednik, which is west of our study area, by Urbanavichene & Urbanavichus (1998). The species was not separated from *R. turfacea* by Sheard (2010) in North America but is now known to occur in Newfoundland (*Ahti* 33943b, 34963a, H), New Brunswick (*Clayden* 18111, NBM), Wapusk National Park, northern Manitoba (*Piercey-Normore* 9832, WIN), northern Ontario (*Brinker* 42159a, SASK) and Alaska (*Tønsberg* 43542, 43762, 43948, 44056, 44106a, 44140, BG).

*Selected specimens examined*. **Russia:** *Kamchatka Krai*: Bystrinsky District, Bystrinsky Nat. Park, "Oxinskye" hot springs, 56°17'06"N, 159°11'07"E, alt. 656 m, on lignum, 19

https://doi.org/10.1017/S0024282917000536 Published online by Cambridge University Press

vii 2003, *E. Kuznetsova* (LECB 12–059); Mil'kovo District, Kamchatka River basin, SW slope of Tolbachik Volcano, *c.* 40–43 km SE of Kozyrevsk, 55°43'59"N, 160°11'33"E, alt. 683 m, on lignum of *Larix cajanderi*, 10 viii 2006, *D. Himelbrant* (LECB 12-066); Mil'kovo District, Kronotsky Nature Reserve, Levaya Schapina River basin, 55°08'19"N, 159°59'07"E, alt. 330 m, on *Sorbus sibirica*, 5 viii 2009, *D. Himelbrant* & *I. Stepanchikova* (LECB 12-018); Ust'-Bol'sheretsk District, Bannaya River basin, bank of the Bannaya River, 52°54'25"N, 157°30'12"E, alt. 244 m, on *Alnus hirsuta*, 6 viii 2002, *D. Himelbrant* & *E. Kuznetsova* (LECB 12-021); Ust'-Kamchatsk District, Kamchatka river basin, *c.* 24 km SE of Kozyrevsk, SW slope of Ushkovsky Volcano, *c.* 6 km N to Studenaya River, 55°57'39"N, 160°16'34"E, alt. *c.* 1290 m, on lignum, 16 viii 2004, *D. Himelbrant* & *E. Kuznetsova* (LECB 12-057); Kamchatka river basin, WSW slope of Shiveluch Volcano, *c.* 30 km NE of Kluchi, right bank of dry river Baydarnaya, 56°34'12"N, 161° 12'23"E, alt. 805 m, on *Alnus fruticosa*, 24 viii 2002, *D. Himelbrant* & *E. Kuznetsova* (LECB 12-011); Kamchatka river basin, W slope of Ushkovsky Volcano, *c.* 24 km E of Kozyrevsk, 7·8 km N of Studenaya River, 55°57'39"N, 160°14'42"E, alt. 1042 m, on *Salix pulchra*, 14 viii 2004, *D. Himelbrant* & *E. Kuznetsova* (LECB 12-047); Ust'-Kamchatsk District, Yelovka River basin, right bank of Yelovka River near estuary of Levaya River, 56°53'00"N, 160°55'06"E, alt. 160 m, 25 viii 2003, *D. Himelbrant* & *E. Kuznetsova* (LECB 12-051, 12-012). *Khabarovskiy Krai*: Bogorodskoe-De Kastri route, 12 km ESE of town of Bulava, on short spur road leading to Kadi Lake, arm of Amur River, on twigs of *Picea*, elev. 114 m, 51°55·219'N, 140°35·682'E, 2009, *C. Printzen* 11666 (FR). *Magadanskaya Oblast'*: Olskiy District, the foot of Kamenniy Ridge, near the tourist base Magtur, 59°45'24·5"N 149° 39'17·9"E, 9 m alt., on *Alnus*, base of the oldest trunk, 2013, *I. A. Galanina* M-13-178-3 (VLA). [*Sakhalinskaya Oblast'*:] Sakhalin Island, vicinity of Yuzhno-Sakhalinsk, mud volcano, mixed forest, 47°04'7·8"N, 142°36'30·6"E, 194 m alt., on *Abies*, 2012, *A. K. Ezhkin* R16\13 (VLA). *Zabaikal'skiy Krai*: Sokhondinskiy Biosphere Zapovednik, 2 km N of Agutsakan forest station, 49°36·611'N, 111°19·477'E, alt. 1125 m, 23 vii 2006, *L. S. Yakovchenko* (VLA); Sokhondinskiy Biosphere Zapovednik, road between forest stations Shergen-Daban and Ust'-Bablashniy, right bank of Burecha River valley, on *Picea* and *Salix*, 49°44·945'N, 110°50·822'E, alt. 1464 m, 2 vii 2007, *L. S. Yakovchenko* (VLA); Aginskiy Buryatskiy Autonomous Okrug, Alkhanay Nat. Park, 3·5 km E of ranger station 'Ara-Ilya', fold 'Niznyaya Tangaya', on *Pinus*, 50°56'35"N, 113°14'32"E, alt. 883 m, 6 vii 2006, *L. S. Yakovchenko* (VLA).

## Rinodina cinereovirescens (Harm.) Zahlbr.

*Cat. Lich. Univ.* **7:** 496 (1931).—*Lecanora cinereovirescens* Harm., *Ann. Cryptog. Exot.* **1:** 329 (1928); type: "Indochina", Ba-Lang, Demange (M—lectotype, Mayrhofer 1984).

This saxicolous species is distinguished by its *Pachysporaria*-type II spores, 14·5–18·0 × 7·0–8·5 µm, with very narrow tori, irregularly shaped lumina becoming ± rounded, and with unornamented walls (Mayrhofer 1984). It was reported from Korea by Aptroot & Moon (2014).

*Specimen examined.* **South Korea:** *Gyeongsangbuk-do*: Cheongsong-gun Distr., Budong-myeoun, Sangui-ri, Mt. Juwang, from Jaha bridge to Juwang Cave, 36°23'42"N, 129°09'0635"E, 330–520 m alt., siliceous rock, *A. Aptroot* 71005 (M).

## Rinodina compensata (Nyl.) Zahlbr.

*Cat. Lich. Univ.* **7:** 499 (1931).—*Lecanora compensata* Nyl. *Lich. Japon.*: 41 (1890); type: Japan, Mitso, Oct. 1879, *Almquist* s. n. (S—lectotype, Mayrhofer 1984).

This is another saxicolous species from Japan that was not seen by us except the specimen accompanying the lectotype of *Rinodina subalbida* (Nyl.) Vain. (Nagasaki, 1979, *Almquist*, S) referred to by Mayrhofer (1984). Its apothecia are characterized by possessing a fine-grained episamma and the spores have a clear but narrow torus belonging to the *Pachysporaria*-type (I?).

## Rinodina conradii Körb.

*Syst. lich. Germ.*: 123 (1855); type: [Poland], Conradsthal near Salzbrunn, near Hirschberg and on the south slope of Gellhornberges, s.d., *J. Flotow* s. n. (L—lectotype, Mayrhofer & Moberg 2002).

This species is primarily ground dwelling on moss or plant remains and is characterized by its type B spore development and persistently 3-septate spores (Mayrhofer & Moberg 2002; Sheard 2010). It can only be mistaken for *R. intermedia*, which possesses type A spore development and 3-septate spores that mature to become submuriform. *Rinodina intermedia* also has a complex chemistry whereas *R. conradii* lacks secondary metabolites (Mayrhofer *et al.* 2001). The distribution of *R. conradii* in the study area is shown in Fig. 1E. It has previously been recorded for far eastern Russia from Popov Island in Primorskiy Krai (Skirina 1996; Chabanenko 2002), from Kamchatka (Himelbrant *et al.* 2009) and from the Stanovoye Nagor'e highlands (Chesnokov & Konoreva 2015).

*Specimens examined.* **Russia:** *Kamchatka Krai*: Ust'-Bol'sheretsk District, Bystraya Bol'shaya River basin, 53°05'42"N, 156°53'06"E, alt. 140 m, on *Betula ermanii* lignum, 18 viii 2002, *D. Himelbrant & E. Kuznetsova* (LECB k-404); Pravyy Kikhchik river basin, Kuev River valley, on *S. udensis*, alt.140 m, 53°34'16"N, 156°40'58"E, 26 vii 2004, *D. Himelbrant* (LECB k-406); Mil'kovo District, Kronotsky Nature Reserve, Levaya Schapina river basin, SW part of Askhachny Ridge, S slope, 55°08'29"N, 159°58'17"E, alt. 340 m, 12 viii 2009, *D. Himelbrant* & *I. Stepanchikova* (LECB 12-006). *Zabaikal'skiy Krai*: Sokhondinskiy Biosphere Zapovednik, 2 km N of Agutsakan forest station, on *Betula*, 49°36·611'N, 111°19·477'E, alt. 1125 m, 23 vii 2006, *L. S. Yakovchenko* (VLA).

## Rinodina dolichospora Malme

*Bihang. Kongl. Svenska Vetensk.-Akad. Handl.* **28**(1)**:** 28 (1902); type: Brazil, Matto Grosso, Morro Grande, 20 December 1893, *G. Malme* 2159 (S—lectotype, Mayrhofer *et al*. 1999).

*Rinodina confinis* Sampaio, *Bolet. Soc. Broter. Ser. 2* **2:** 177 (1924); type: Portugal, Minho, Póvoa do Lanhoso, S. Gens, August 1919, *G. Sampaio* s. n. (UPS—syntype, Giralt *et al*. 2009).

An ochraceous, subsquamulose thallus and *Pachysporaria*-type I spores measuring 23·0–28·5 × 12·5–16·5 µm ($n = 20$) characterize the single collection. Polygonal lumina are present in the early stages of spore development but neither oil globules, as reported by Mayrhofer *et al.* (1999), nor apical satellite lumina were observed. The erumpent apothecia of the single specimen seen may relate to its relatively thick thallus. Such apothecia were not commented on by either Sheard (2010) or Mayrhofer *et al.* (1999) but the latter authors also report rather thick thalli. The erumpent apothecia are similar to the description of those for *R. elixii* H. Mayrhofer *et al*. but the spores of that species, although large, belong to the *Physcia*-type (Mayrhofer *et al.* 1999).

The single record is from the extreme south of far eastern Russia, close to the short border with Korea, and represents a new record for Russia (Kotlov 2008). The species has a widespread but very scattered distribution around the world, being known from its type and other localities in Brazil, south-western Europe (as *R. confinis*, Giralt *et al.* 2009), the Mississippi Delta region and southern Appalachians in the USA (Sheard 2010), and also from coastal New South Wales, Australia (Mayrhofer *et al.* 1999). Most recently, the species has been found at higher elevations in the Great Smoky Mountains, southern Appalachians, USA (Lendemer *et al.* 2013, 2014). The species seems to have a wide ecology, which might help explain its worldwide distribution.

*Specimen collected.* **Russia:** *Primorsky Krai*: Khasanskiy District, vicinity of Paset, 42°28'N, 130°48'E, oak forest (*Quercus mongolica*) on *Q. mongolica*, 14 iv 2010, *I. A. Galanina* (VLA).

## Rinodina efflorescens Malme

*Svensk Bot. Tidskr.* **21:** 251 (1927); type: Sweden, Västergötland, Habo, St. Kärr, cort. *Fagi*, 11 July 1923, *G. O. Malme* s. n. (S—holotype [online image!], studied by T. Tønsberg).

This corticolous species is characterized by its discrete soralia, *Physcia*-type spores (when fertile) and the presence of pannarin, zeorin and secalonic acid A. The soralia are typically yellowish in colour due to the pigment secalonic acid A.

Although we have not seen any specimens, *R. efflorescens* was recently reported from within the western limits of our study area by Makryy and Lishtva (on Kodar Ridge in the Vitimsky Zapovednik, Stanovoye Nagor'e Mountains, cited by Urbanavichene & Palice 2016) and in the Baikal Reserve (*op. cit.*, citing fertile material). We expect that it will be found to be more widespread in our study area, this notion possibly being strengthened by the presence of species such as *R. subparieta* and *R. excrescens*, with which it occurs in North America (Sheard 2010).

## Rinodina endospora Sheard

*Bryologist* **105:** 658 (2002); type: USA, California, Santa Clara Co., Mount Hamilton Range, San Antonio Valley, on *Quercus lobata* with *R. santae-monicae*, 4 August 1968, *Alice Howard* s. n. (UC—holotype).

*Rinodina endospora* is characterized by its relatively large *Dirinaria*-type ascospores. Typical of this spore type, the spores show type B development, are often swollen at the septum (more so in KOH) and possess septal discs. The spore size of (20·5–)22·0–24·0 × (9·0–)

9·5–10·5(–11·5) µm ($n = 40$) agrees with that of specimens from western North America (Sheard & Mayrhofer 2002; Sheard 2010) but they become more elongately-ellipsoid (l/w ratio (2·0–)2·1–2·6(–2·7)). The spores may be quite pointed at intermediate stages of development. The asci are also primarily 4-spored. In view of the asynchronous spore development reported in the original species description, this new finding is not surprising. The characteristic flecking of the epinecral layer on the dark brown apothecium margins in North American collections is poorly developed. However, we consider this unimportant because the development of an epinecral layer is one of the most variable morphological characters in the genus. There were no other detectable anatomical differences between the present material and North American collections.

*Rinodina endospora* is probably related to *R. metaboliza* which also has *Dirinaria*-type spores and is present in the same collection. In addition to possessing larger spores, *R. endospora* generally has a better developed thallus that is also darker and typically has a brownish tinge. Previously considered to be a western North American endemic species, *R. endospora* is now reported from Russia for the first time. It is the first of three western North American–East Asian disjunct species listed here.

*Specimens collected.* **Russia:** *Kamchatka Krai*: Ust'-Bol'sheretsk District, Pravyy Kikhchik river basin, vicinity of Mokushka River, 53°32'56"N, 156°41'07"E, alt. 235 m, floodplain forest, *Chosenia arbutifolia*, 22 vii 2004, *Himelbrant* (LECB 12-010 with *R. metaboliza*, *R. subminuta*).

## Rinodina excrescens Vain.

*Ann. Acad. Sci. Fenn., Ser. A* **27:** 84 (1928); type: Russia, (Siberia Occidentali) Konda, ad lignum putridum in pineto prope Leunsk, s. d., *E. Vainio* s. n. (TUR-V 08798—holotype).

The thallus morphology of the *Rinodina excrescens* collections exhibits the same range of variation as the species in eastern North America; from bullate areoles, which may be blastidiate/sorediate, to plane areoles with sublobate margins (Sheard 2010). The apothecia usually become narrowly attached, their discs are often pruinose (pannarin crystals) and the lecanorine margins are often flexuose and sometimes incomplete (crenulate). When fertile, the species has *Physcia*-type ascospores that are quite variable in size, as is often the case with species that may also reproduce by vegetative means. The spore measurements overlap with those from North American material but tend to be longer, (16·0–)17·5–19·5 (–21·5) × (8·0–)8·5–9·5(–10·0) µm ($n = 75$), l/w ratio (1·8–)1·9–2·2(–2·4). The species has previously been characterized by the presence of pannarin as the single detectable secondary metabolite, which is also present in the epihymenium. A new finding is that, very occasionally, zeorin accompanies pannarin in the thallus (*Thor* 14292, *Tønsberg* 22845a, 22904).

In its typical form, *Rinodina excrescens* is difficult to confuse with other species because of the bullate nature of the thallus. The species has been compared to the recently described eastern North American species, *R. bullata* Sheard & Lendemer (Sheard *et al.* 2012), but the bullate areoles of that species are smaller, loosely attached to the substratum and contain atranorin rather than pannarin. Lobate specimens may mimic young, presorediate stages of species such as *R. subparieta*, *R. buckii* and *R. willeyi*, but these are distinguished by their grey rather than brownish colour, presence of atranorin rather than pannarin in the first species and, typically, the additional presence of zeorin in the latter two.

*Rinodina excrescens* is a new record for Japan where it occurs at elevations of up to 720 m in Hokkaido. It was recently reported as widely distributed in the Russian Far East by Galanina *et al.* (2011) and Yakovchenko *et al.* (2013). Its range within the study area is substantially expanded by the records reported here (Fig. 1F). The species is elsewhere known from the Great Lakes region and eastern North America, where it is widely distributed but not common (Sheard 2010), and from southern Europe where it is scattered and very rare (Galanina *et al.* 2011).

*Specimens examined and not previously published.* **Japan:** *Hokkaido*: Ishikari Prov., Kamikawa-gun, Kamikawa-cho, Obako River valley, E of Obako Gorge Tourist Centre, 43°42'N, 143°01'E, alt. 710–720 m, on *Alnus*, 1995, *T. Tønsberg* 23122 (BG); Kitami Prov., Soya-gun, Sarufutsu-mura, 12 km NW of Hamatonbetsu Town, 8 km SE of Poronuma Lake, 1·5 km from sea, on *Picea glehnii*, alt. 30 m, 45°13'N, 142°15'E, 1995, *G. Thor* 14188 (UPS); Shari-gun, Shari-cho, Shiretoko Nat. Park, 7 km NE of Utoro Village, N and S of small road to Iwaobetsu hot-spring hotel (Onsen) 2 km (road distance) from jct to Shiretoko-goko Lakes, 44°06'N, 145°05'E, alt. 130 m, on *Abies sachalinensis*, 1995, *T. Tønsberg* 22775a, 22775b (BG); Shiretoko Nat. Park, 9 km NE of Utoro Village, along trail around Shiretoko-goko Lakes, on *Abies sachalinensis*, alt. 260 m, 44°07'N, 145°05'E, 1995, *G. Thor* 14292 (UPS); Kushiro Prov., Akkeshi-gun, Hamanaka-cho, 55 km E of Kushiro City, 3 km E of Hichirripputo Lake, just S of road following coast, on *Betula* sp., alt. 60 m, 43°02'N, 145°03'E, 1995, *G. Thor* 14440 (UPS with *R. subparieta*); on *Alnus* sp., *G. Thor* 14450 (UPS with *R. xanthophaea* and *R. buckii*); Nemuro Prov., Notsuke-gun, Betsukai-cho, 100 km ENE of Kushiro City, N shore of Furenko Lake, just NW of road 244, on *Betula* sp., alt. 5–10 m, 43°22'N, 145°15'E, 1995, *G. Thor* 14425 (UPS with *R. willeyi*); Shiretoko Peninsula, Menashi-gun, Rausu-cho, 15 km SW of Sakae City, on *Quercus mongolica*, alt 30 m, 43°49'N, 145°04'E, 1995, *T. Tønsberg* 22904 (BG); Teshio Prov., Teshio-gun, Toyotomi-cho, Rishiri-Rebun-Sarobetsu Nat. Park, 23 km NNW of Teshio at coast, Wakasakanai area, 1 km from coast, on *Abies sachalinensis*, alt. 20 m, 45°05'N, 141°39'E, 1995, *G. Thor* 13636 (UPS with *R. buckii*). *Honshu*: Shimotsuke Prov. (Tochigi Pref.), Nikko City, 14 km WNW of Nikko and 4 km SE of the village Yumoto, field station Nikko Shizen Fureai House, on old *Larix kaemperi*, elev. 1400 m, 36°46'11·2"N, 139°27'21·8"E (WGS84, ± 100 m), 2015, *Thor* 32286 (UPS).—**Russia:** *Khabarovskiy Krai*: Chegdomyn-Sofiysk route, *c.* 19 km NE of the Bureya River ferry crossing at Shakhtinskiy, 76 km (air line) NNE of Chegdomyn, between Umal'ta and Nimakan Rivers, 51°47·546'N, 133°21·122'E, lignicolous on snag, 658 m elev., 2009, *T. Spribille* 31600 (GZU); Amgun' River region, 18·7 km SW of Berezovyy, on *Larix gmelinii*, elev. 222 m, 51°33·598'N, 135° 28·956'E, 2009, *C. Printzen* 11870 (FR). [*Sakhalinskaya Oblast'*:] Sakhalin Island, Dolinsk District, Pchelinnaia River, 47°21'06·1"N, 142°52'28·6"E, 10 m alt., on *Abies*, 2012, *A. K. Ezhkin* R20\13 (VLA); Sakhalin Island, Susunayskiy Ridge, vicinity of Yuzhno-Sakhalinsk, Parkovaia Mountain, 46°58'23·6"N, 142°45'30·9"E, 207 m alt., on *Abies*, 2012, *A. K. Ezhkin* R21\13 (VLA); 46°58'26·15"N, 142°45'26·12"E, 198 m alt., on *Picea*, 2010, *A. K. Ezhkin* 11R/11 (VLA).

## Rinodina freyi H. Magn.

*Acta Horti Gotob.* **17:** 236 (1947); type: Switzerland, Graubünden, Engadin, Zernez, alte Zaunlatten, 1500 m, 16.VIII.1924, *E. Frey* s. n. (G—holotype); Berner Oberland, Diemtigtal, Grimmialp, 1280 m, 8 July 1934, *E. Frey* s. n. (G—paratype).

*Rinodina glauca* Ropin, *Herzogia* **9:** 807 (1993); type: [Italy: Südtirol:] Ehrenburg, Bruneck, on *Populus tremula* - Arnold *Lich. exs.* 1654 (M pro parte—lectotype as *R. ramulicola* Kernstock ex Arnold, *Verh. K. K. Zool.-Bot. Ges. Wien* **46:** 132 (1896) - nom. illeg.).

This species new to Japan and Russia is characterized by its relatively small, darkly pigmented, *Physcia*-type ascospores with a heavy torus and lack of secondary substances. The spore measurements from the specimens examined from Hokkaido are often larger ((15·5–)16·0–18·5(–20·5) × (7·5–)8·0–9·0(–9·5) µm ($n = 40$)) but overlap with those published for North American material ((12·0–)15·0–16·0 (–18·5) × (6·0–)7·5–8·0(–9·0) µm (Sheard 2010)). The species is further characterized by its contiguous, broadly attached apothecia and plane areoles.

In North America, the species is very common and a characteristic pioneer of the twigs of a wide range of shrubs and trees across the southern boreal zone (Sheard 2010). It is typically located in the axils of twig branches and on leaf scars, and other substratum sites that retain moisture. The species has been confused with *Rinodina septentrionalis* Malme (Giralt & Mayrhofer 1995; Sheard 2010), which has very similar spores, but the apothecia of that species are more scattered and more narrowly attached. The thallus of *R. septentrionalis* typically consists of small, usually isolated, convex areoles. Despite the differences between mature thalli, the two species are difficult to separate when immature. *Rinodina freyi* is widespread in Central Europe (Giralt & Mayrhofer 1995) and, as reported here, in the northern half of north-eastern Asia (Fig. 3A). It has also been reported from a site in western Mongolia, just west of the mapping area, by Hauck *et al.* (2013).

*Specimens examined.* **Japan:** *Hokkaido*: Kitami Prov., Esashi-gun, 9 km S of Homatonbetsu, on *Alnus* sp., alt. 50 m, 45°03'N, 142°23'E, 1995, *G. Thor* 14200 (TNS & UPS); on *Salix*, *G. Thor* 14208 (TNS with *R. polyspora*); Rishiri-to Island, Rishiri-gun, Rishirifuji-cho, Oniwaki area, 500 m N of Numaura Village, on *Abies sachalinensis*,

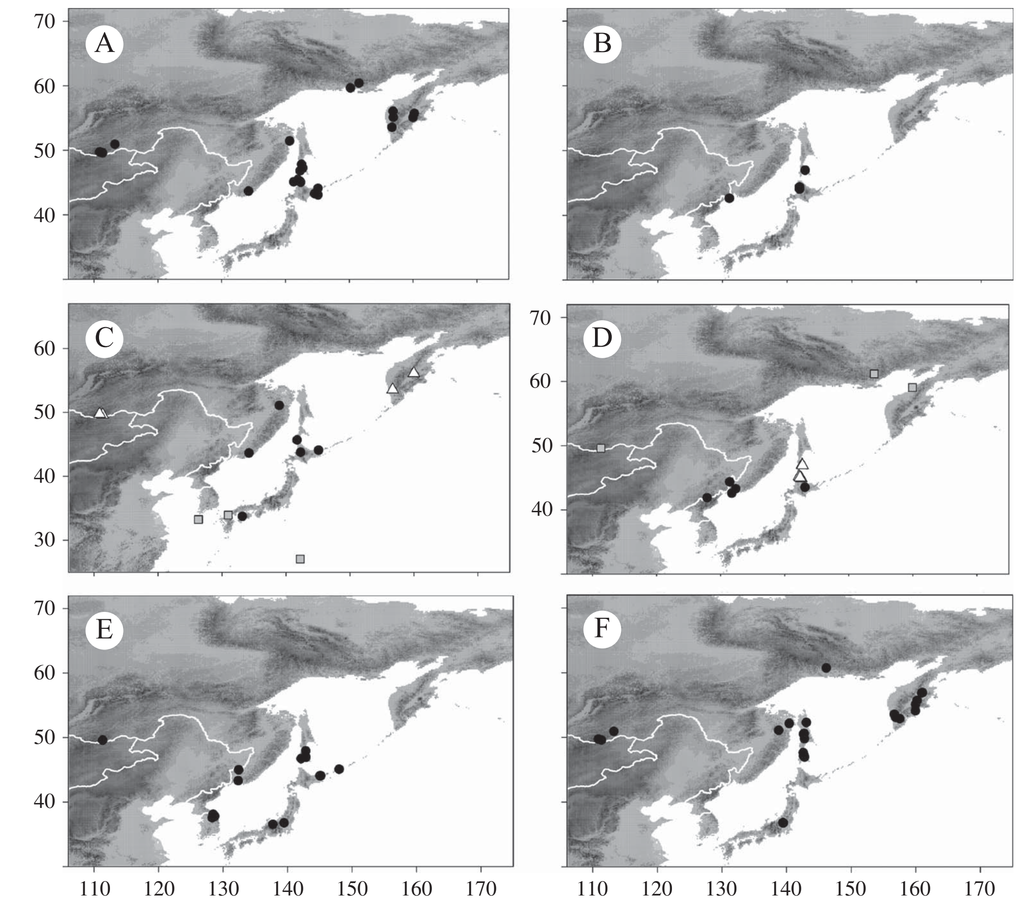


FIG. 3. Distribution of *Rinodina* species in north-eastern Asia (cont.). A, *R. freyi*; B, *R. hypobadia*; C, *R. megistospora* (circles), *R. metaboliza* (triangles), *R. moziana* (squares); D, *R. oleae* (circles), *R. polyspora* (triangles), *R. sicula* (squares); E, *R. orientalis*; F, *R. septentrionalis*.

alt. 15 m, 45°07'N, 141°17'E, 1995, *G. Thor* 13943 (UPS with *R. buckii* and *R. subparieta*); Shari-gun, Shari-cho, Shiretoko Nat. Park, NW slope of Shiretoko Peninsula *c.* 10 km NE Utoro Town, along trail from Iwaobetsu hot-spring hotel (Onsen) to Mt. Rausu-dake, on *Abies sachalinensis* twigs, alt. 395 m, 44·1065°N, 145·09207°E, 2010, *G. Thor* 23686 (UPS with *R. subalbida* and *R. subminuta*); Wakkanai City admin. area, 45°28'N, 141°57'E, on *Alnus, G. Thor* 14014 (TNS, UPS); Kushiro Prov., Akkeshi-gun, 2 km S Sakaki-machi, 43°06'N, 145°06'E, on *Quercus, K. H. Moon* 4195 (TNS); Kawakami-gun, around Kayanuma Hot Springs, 43°00'N, 1425°00'E, on *Abies, H. Kashiwadani* 39036 (TNS).—**Russia:** *Kamchatka Krai*: Mil'kovo District, Kamchatka River basin, SW slope of Tolbachik Volcano, *c.* 40–43 km SE of Kozyrevsk, 55°43'56"N, 160°11'39"E, alt. 689 m, on *Populus suaveolens*, 9 viii 2006, *D. Himelbrant* (LECB 12-036); Mil'kovo District, Kronotsky Nature Reserve, Levaya Schapina River basin, right bank of Ipuin River, 55°06'05'N, 159°59'22"E, alt. 280 m on *Crataegus chlorosarca*, 10 viii 2009, *D. Himelbrant* & *I. Stepanchikova* (LECB 12-034 with *R. metaboliza*); Ust'-Bol'sheretsk District, Pravyy Kikhchik River basin, 53°34'39"N, 156°41'17"E, alt. 229 m, on *Crataegus chlorosarca* branch, 26 vii 2004, *D. Himelbrant* (LECB 12-060). *Khabarovskiy Krai*: Komsomolsk-De Kastri route, Sushko Mountain, 9 km SW of De Kastri, 51°26·743'N, 140°38·357'E, 53 m elev., on *Alnus* at seashore, 2009, *T. Spribille* 30686 (GZU). *Magadanskaya Oblast'*: Ola District, vicinity of Arman, bridge over River Armani, 59°40'17·5"N, 150°10' 05·8″E, 45 m alt., on *Chosenia*, 2013, *I. A. Galanina* M-13-186-1 (VLA); Ola District, vicinity of Magadan City, 60°24'49·5"N, 151°30'49·04"E, 13 m alt., on *Chosenia*, 2013, *I. A. Galanina* M-13-210-1 (VLA). *Primorskiy Krai*: Sikhote-Alin' Mountains, Oblachnaya

Mountain, 20 km (air line) E of Yasnoye, 43°40·519'N, 134°12·855'E, on *Rhododendron mucronulatum*, 2007, *T. Spribille* 23578 (GZU). [*Sakhalinskaya Oblast'*:] Sakhalin Island, Dolinsky District, Makuy stream, 47°16'N, 142°42'E, twig of *Picea*, 2008, *N. A. Tsarenko & S. V. Nesterova* S-W-25-02E-2 (VLA); Sakhalin Island, Dolinsky District, 107 km of federal highway north of Firsovo, 47°49'17"N, 142°30'17·62"E, 12 vii 2008, *A. V. Bogacheva & N. A. Tsarenko* (VLA); Sakhalin Island, Dolinsky District, Makuy stream, 47°16'N, 142°42'E, on *Betula*, 2008, *S. V. Nesterova & N. A. Tsarenko* W-2008-25-03E (VLA); Sakhalin Island, Lyutoga River, 48 km west of Yuzhno-Sakhalinsk, 46°49'N, 142°18'E, on *Betula*, 10 viii 2006, *I. A. Galanina* (VLA). *Zabaikal'skiy Krai*: Sokhondinskiy Biosphere Zapovednik, 2 km N of Agutsakan forest station, on *Betula*, 49°36·611'N, 111° 19·477'E, alt. 1125 m, 23 vii 2006, *L. S. Yakovchenko* (VLA); Sokhondinskiy Biosphere Zapovednik, road between forest stations Shergen-Daban and Ust'-Bablashniy, right bank Burecha River valley, on *Picea*, 49°44·945'N, 110°50·822'E, alt. 1464 m, 2 vii 2007, *L. S. Yakovchenko* (VLA); Aginskiy Buryatskiy Autonomous Okrug, Alkhanay Nat. Park, 3·5 km E of ranger station 'Ara-Ilya', fold 'Niznyaya Tangaya', on *Pinus*, 50° 56'35"N, 113°14'32"E, alt. 883 m, 6 vii 2006, *L. S. Yakovchenko* (VLA).

## Rinodina gennarii Bagl.

*Comment. Soc. Crittog. Ital.* **1:** 17 (1861); type: Italy, Liguria, Mte. Faiallo nell' Apennino di Voltri, s. d., *F. Baglietto* s. n. (MOD—lectotype, Mayrhofer & Moberg 2002).

This saxicolous species is well characterized by its relatively small ascospores with type B development (but the development type is often difficult to find) and septal swelling in KOH, therefore belonging to the *Dirinaria*-type (Sheard 2010). The records reported here represent a new addition to the lichen biota of Japan for this primarily coastal species with a worldwide distribution (Trinkaus *et al.* 1999). The species was previously reported from Kunashir Island (Kuril Islands, Russia) off the north tip of Hokkaido (Bredkina *et al.* 1992; Chabanenko 2002). Kotlov (2008) refers to specimens on bark and rock and therefore a mixture of two species. *Rinodina gennarii* is now often included in *R. oleae* (Kaschik 2006; Giavarini *et al.* 2009) but in our opinion this species is restricted to corticolous substrata. *Rinodina gennarii* is primarily a species of maritime rocks but also occasionally grows on lignicolous maritime pilings. These lignicolous specimens have a different habit to *R. oleae* (Sheard 2010) but are also relatively infrequent so that their variability is not well known. According to our records, *Rinodina gennarii* is infrequent in north-eastern Asia; we have verified specimens only from Japan (Fig. 1E) but it is likely under-documented.

*Specimens examined.* **Japan:** *Hokkaido*: Kitami Prov., Rishiri-to Island, 1 km SW of Hondomari, 45°15'N, 142°13'E, on maritime rocks, *G. Thor* 13933 (TNS); Shari-gun, Shari-cho, Utoro Town, downtown Utoro, on vertical rock 100 m from the seashore, alt. 5–10 m, 44°04·2110'N, 144°59·3293'E, 2010, *G. Thor* 23795 (UPS); Kushiro Prov., Kushiro-cho, 14 km ESE of Kushiro City, small fishing village at seashore, on mortar, alt. 2 m, 42°56·2938'N, 144°29·4431'E, 2010, *G. Thor* 25904 (UPS).

## Rinodina hypobadia Sheard sp. nov.

MycoBank No.: MB 819994

Thallus thin, light to dark grey. Apothecia erumpent, then broadly attached. Hypothecium reddish or chestnut brown; vegetative propagules absent. Ascospores *Dirinaria*-type, (12·5–)14·5–16·5(–18·5) × (6·5–)7·0–8·5 (–10·0) µm, lumina *Physcia–Physconia*-like, spores mostly lightly pigmented at maturity, a few immature spores inflated at septum, others inflated on application of KOH; torus absent; walls not ornamented. Secondary metabolites pannarin and zeorin by TLC, pannarin crystals also present in epihymenium.

Type: Japan, Hokkaido, Teshio Prov., Rumoi-gun, Obira-cho, 21 km ENE of small town of Obira at coast, along E and upper trail from Tengunotaki Waterfall to parking area, 44°04'N, 141°55'E, alt. 130–150 m, mixed deciduous/*Abies sachalinensis* forest, on *A. sachalinensis*, 28 May 1995, *T. Tønsberg* 21997, with *Rinodina buckii* (BG—holotype).

(Figs 3B & 4)

*Thallus* thin, light to dark grey, continuous, becoming rimose but not areolate; surface plane, matt; margin determinate, in part delimited by a narrow, dark brown, fimbriate prothallus; vegetative propagules absent (Fig. 4A).

*Apothecia* erumpent, then broadly attached, finally slightly constricted at base; mostly not contiguous, to 0·40–0·80 mm diam.; *discs* black, slightly pruinose (more obvious when moist), persistently plane;

https://doi.org/10.1017/S0024282917000536 Published online by Cambridge University Press

thalline margin concolourous with thallus, 0·05–0·10 mm wide; excipular ring absent. *Thalline exciple* 40–80 µm wide; cortex poorly organized, *c.* 10 µm wide; epinecral layer 5–15 µm wide; crystals present in cortex and medulla; cortical cells obscured by crystals, to 3·5–5·5 µm wide, hyaline; algal cells to 8·0–14·0 µm long; *proper exciple* 5–10 µm wide laterally, mostly red-brown pigmented, expanded to 10–20 µm wide above. *Hymenium* (25–)60–100(–120) µm high, not inspersed; *paraphyses* 2·0–2·5 µm wide, conglutinate, apices expanded to 3·0–4·0 µm wide, lightly capitate, immersed in a dispersed pigment forming a red-brown epihymenium with crystals present. *Asci Lecanora*-type, 30–60 × 13–20 µm; *ascospores* 8 per ascus, type A or B development, *Dirinaria*-type, (12·5–)14·5–16·5(–18·5) × (6·5–) 7·0–8·5(–10·0) µm ($n = 110$), l/w ratio (1·7–) 1·8–2·1(–2·3); lumina *Physcia*- to *Physconia*-like (Fig. 4B), spores mostly immature and hyaline, rarely becoming dark brown, a few immature spores inflated at septum, others inflated only after application of KOH, finally lightly pigmented, darker when over-mature, then strongly constricted at the septum; torus absent; walls not ornamented. *Hypothecium* reddish or chestnut brown (Fig. 4C & D), (25–)50–80 µm deep.

*Pycnidia* raised, asymmetric, to 0·30 mm wide. *Conidia* bacilliform, *c.* 3·5 × 1·0 µm.

*Chemistry.* Spot tests K−, C−, P+ cinnabar (red needles under the microscope). Secondary metabolites: pannarin and zeorin in thallus by TLC, pannarin crystals also present in epihymenium (Fig. 4D).

*Etymology.* The species is named for its pigmented hypothecium ('hypo-', Greek for below; 'badius', Latin for chestnut brown).

This new species is characterized by its erumpent apothecia, strongly pigmented hypothecium, *Dirinaria*-type spores and the presence of pannarin in the thallus and epihymenium. The only other *Rinodina* species known with a pigmented hypothecium is *R. sheardii* Tønsberg but this species has *Pachysporaria*-type I spores, a very different chemistry (Elix & Tønsberg 1999) and is also sorediate (Sheard 2010). The spores of *R. hypobadia* are extremely variable in shape and size, and most examined were probably immature because they were unpigmented. Over-mature spores are mostly strongly constricted and are not included in the measurements quoted above. Rather few specimens have been examined so the above description should be regarded as preliminary. *Rinodina hypobadia* is infrequent in north-eastern Asia, where we have recorded it only from Hokkaido, Primorskiy Krai and southern Sakhalin Island (Fig. 3B).

*Paratypes examined.* **Japan:** [*Hokkaido*:] Teshio Prov., Rumoi-gun, Obira-cho, 21 km ENE of small town of Obira at coast, along E and upper trail from Tengunotaki Waterfall to parking area, 44°04'N, 141°55'E, alt. 130–150m, mixed deciduous/*Abies sachalinensis* forest, on *A. sachalinensis*, 1995, *T. Tønsberg* 21995 with *R. subparieta* (BG); Tomamae-gun, Shosanbetsu-mura, 16 km NE of the small town of Haboro at coast, along Wakabanosawa stream at Wakaba bridge, marsh dominated by *Alnus* and *Salix*, on *Salix* sp., alt. 100 m, 44° 24'N, 141°54'E, 1995, *G. Thor* 13538 (TNS & UPS).—**Russia:** *Primorsky Krai*: Khasanskiy District, Zarubino, 42°38'N, 141°44'E [sic; should be 131°04'E!], on *Tilia*, 10 v 2010, *I. A. Galanina* (VLA). *Sakhalinskaya Oblast'*: Sakhalin Island, Susunayskiy Ridge, vicinity of Yuzhno-Sakhalinsk, Ostraia Mountain, mixed forest, south-eastern exposure, 46°58'38·85"N, 142°46'37·41"E, 344 m alt., on *Populus*, 2011, *A. K. Ezhkin* 20R-11 (VLA).

### Rinodina intermedia Bagl.

*Comment. Soc. Crittog. Ital.* **1:** 315 (1863); type: [Switzerland], Sulle rupi conferte da leg. strato di muschi alla Madonna del Sasso, Locarno, Aug. 1862, *F. Baglietto* s. n. (MOD—holotype).

This ground-dwelling species is easily recognized by its subsquamulose thallus, 3-septate to submuriform ascospores with type A development, and a unique chemistry (Mayrhofer *et al.* 2001; Sheard 2010). These authors compared *Rinodina intermedia* with *R. conradii*, which has strictly 3-septate spores with type B spore development and an absence of secondary metabolites. The two species were considered to be allopatric in North America, being separated by their distribution but also by elevation where their distributions overlap in Colorado. *Rinodina*

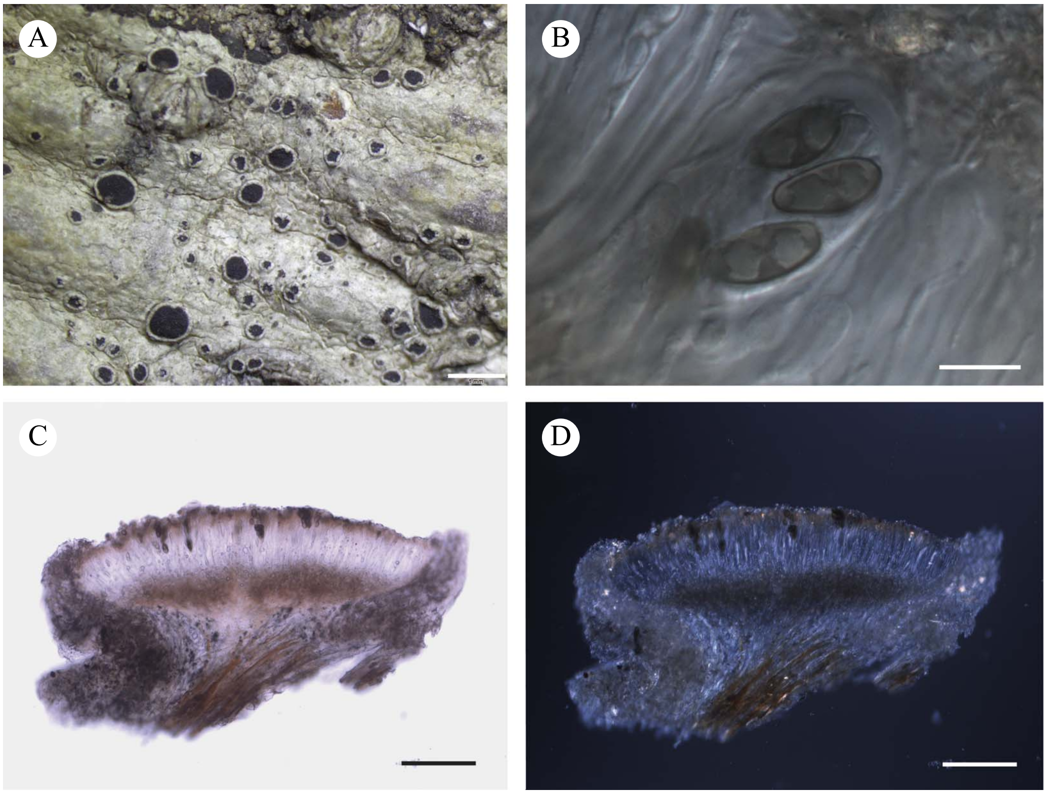


FIG. 4. *Rinodina hypobadia*, Japan, Hokkaido, Teshio Prov., Rumoi-gun, Obira-cho, *T. Tønsberg* 21997 (BG—holotype). A, habit, note the continuous thallus and erumpent young apothecia; B, *Dirinaria*-type ascospores; C, section through apothecium in transmitted light; D, the same section viewed in polarized light, the pigmented hypothecium prominent in both. Scales: A = 1 mm; B = 10 µm; C & D = 50 µm. In colour online.

*intermedia* occurs at lower elevations in this state than *R. conradii*, as it also does in the Himalayas. Interestingly, the two species have now been found together in one locality south of Lake Baikal and when seen side by side their morphologies are distinguished by the thinner thallus and smaller, more clustered apothecia of *R. conradii*.

Sheard (2010) considered *R. intermedia* to have a Sonoran distribution with northern outliers in North America but it is widespread across the world in xeric habitats at low latitudes and is absent from high latitudes in both the Northern and Southern Hemispheres where *R. conradii* is typically found (Mayrhofer *et al.* 2001). The species has previously been recorded from Russia (Kotlov 2008; including reports from Ol'khon Island in Lake Baikal by Makryy (2008) and from Buryatia by Urbanavichene & Urbanavichus (2008)) and is a new addition to the lichen biota of Japan (Kurokawa & Kashiwadani 2006). Although this species is usually terricolous, the Japanese record is corticolous; this substratum is otherwise known for this species only from the Himalayas (Mayrhofer *et al.* 2001).

*Specimens examined.* **Japan:** *Honshu*: Shimotsuke Prov. (Tochigi Pref.), Nikkoyumoto, on *Quercus magnolia*, 1400 m, *A. Henssen* 29254j (H).—**Russia:** *Zabaykal'skiy Krai*: Sokhondinskiy Biosphere Reserve, surroundings of the Agutsa patrol cabin, valley of the River Kumyl-Aliya, below Glubokaya on the right bank of the river, 49°41'12·6"N, 111°26'0·04"E, 1180 m elev., on mossed-over rock, 2009, *L. S. Yakovchenko* 101 (VLA); *ibid.*, upper reaches of the River Ingod, left bank of the river, 3 km above the winter shelter hut "Ingod" on the bank, deep canyon at woodland edge, facing river, 49°56'47"N, 111°11'03·9"E, 1307 m elev., on soil accumulations in depressions of walls, in lower (more xerophytic) part of canyon, 2009, *L. S. Yakovchenko* 131 (VLA).

## Rinodina kozukensis (Vain.) Zahlbr.

*Cat. Lich. Univ.* **7:** 524 (1931).—*Melanaspicilia kozukensis* Vain. *Bot Mag.* (*Tokyo*) **35:** 61 (1921); type: Japan, Prov. Kozuke, in rupe, 26 Feb 1918, *Yasuda* (TUR-V 9106—holotype, Mayrhofer 1984).

*Rinodina tsunodae* Yas. ex Räs., *J. Jap. Bot.* **16:** 141 (1940); type: Japan, Prov. Kozuke, saxicola, 21 Jan. 1920, *Yasuda* 442 (H—holotype, Mayrhofer 1984).

A saxicolous species described from Japan with spores of the *Pachysporaria*- to *Milvina*-type, according to Mayrhofer (1984). Its thallus is thin, continuous to rimose-areolate and light to middle grey. The species has not been seen by us but was recently reported as new to Russia by Skirina (2010) from two islands in Peter the Great Bay in the Sea of Japan.

## Rinodina luteonigra Zahlbr.

*Bot. Mag. Tokyo* **41:** 360 (1927); type: Japan, [Nagasaki Pref.:] Tsushima [Island], May 1901, *Faurie* 3952 (W—holotype!, accompanied by *R. subalbida* (Nyl.) Vain.).

*Thallus* thin at margin, continuous, thicker in centre, golden yellow; surface plane becoming rugose, matt; prothallus not seen; vegetative propagules absent.

*Apothecia* erumpent remaining broadly attached, frequent but mostly not contiguous, to *c.* 0·60 mm diam.; *disc* black, slightly concave to persistently plane; thalline margin concolourous with thallus, entire, persistent, *c.* 0·10 mm wide; excipular ring dark brown, confluent to raised (best seen when moist). *Thalline exciple c.* 80 µm wide, hyaline; cortex and epinecral layer not evident; crystals filling margin; marginal hyphae not pigmented, to *c.* 5·5 µm wide; algal cells to *c.* 10·5 µm wide; thalline exciple to *c.* 110 µm wide below; *proper exciple* lightly pigmented, *c.* 10 µm wide laterally, expanding to *c.* 50 µm wide at periphery. *Hymenium c.* 160 µm high, not inspersed; *paraphyses c.* 2·0 µm wide, conglutinate, apices to *c.* 3·5 µm wide, lightly pigmented, immersed in a dispersed pigment forming a dark, red-brown epihymenium. *Asci* 80–100 × 27–42 µm; *ascospores* 8 per ascus, type A development, *Pachysporaria*-type I, (29·5–)31·0–34·5(–37·5) × (15·0–)16·0–17·5(–18·5) µm ($n = 40$), l/w ratio (1·7–)1·9–2·1(–2·2); lumina somewhat angular to subpolygonal during development, becoming ± spherical, lacking well-defined canals, walls persistently thick, some mature spores developing apical satellite lumina; torus well developed at maturity (Fig. 5); walls not ornamented. *Hypothecium c.* 35 µm deep, hyaline.

*Pycnidia* not seen.

*Chemistry.* Thiomelin and zeorin detected by TLC.

A full description is given above since the species is otherwise known only from Zahlbruckner's original, brief type description. *Rinodina luteonigra* has a similar habit to *R. lepida* (Nyl.) Müll. Arg. (syn. *R. flavonigella* Tuck.) and like the synonym of the latter species it is named for the contrast between the pigmented thallus and black apothecial discs. The major secondary substances for the two species are also the same. The ascospores of both belong to *Pachysporaria*-type I but those of *R. luteonigra* (Fig. 5) are much larger than those of *R. lepida* and some older spores also develop apical satellite lumina. The spores are also larger than those of *R. adirondackii,* once thought to be the species with the largest ascospores belonging to this spore type (Sheard 2010), although the spores of neither species are as large as those of the subsequently described *R.*

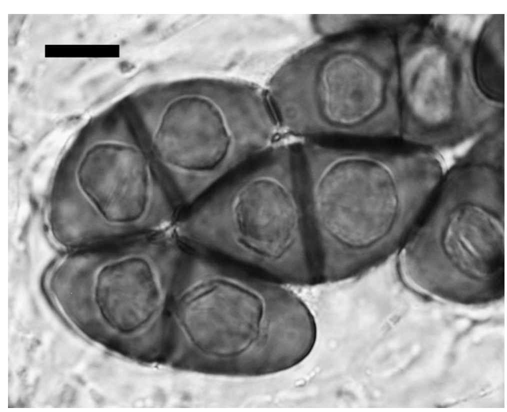

FIG. 5. *Pachysporaria*-type I ascospores of *Rinodina luteonigra*, Japan, Nagasaki Pref., Tsushima Island, May 1901, *Faurie* 3952 (W—holotype). Note the large size and heavy tori of these spores. Scale = 10 µm.

https://doi.org/10.1017/S0024282917000536 Published online by Cambridge University Press

*megistospora* Sheard & H. Mayrhofer (Sheard *et al.* 2011). The pigmentation and spore type of *R. luteonigra* and *R. lepida* both suggest a relationship with the Southern Hemisphere saxicolous species *R. thiomela* (Nyl.) Müll. Arg. and *R. xanthomelana* Müll. Arg.

The distribution of *R. luteonigra* is not known but given its type locality on Tsushima Island it is likely to be subtropical. This would appear to echo the over-representation of species with *Pachysporaria*-type I spores in the lichen biota of the southern part of continental USA (Sheard 2010).

## Rinodina macrospora Sheard

*Bryologist* **105**(4)**:** 665 (2002); type: Canada, British Columbia, Vancouver Island, Botanical Beach, 4 km SW of Port Renfrew, on *Picea sitchensis* behind beach, 14 August 1975, *W. J. Noble* 5371 (UBC—holotype; SASK—isotype).

This species is characterized by its large *Physcia*-type spores, cortical atranorin and its habitat which is limited to either driftwood or conifer trees on maritime foreshores. The ascospores of this single collection are of similar length but are more narrowly ellipsoid ((26·5–)28·0–32·0(–33·0) × (12·5–)13·0–13·5 (–14·0) µm ($n = 20$), l/w ratio 2·1–2·4(–2·5)) than North American collections (Sheard & Mayrhofer 2002; Sheard 2010). The spore walls are also less heavily ornamented. These differences might be due to the relatively early developmental stage of the single sample we collected and report here.

New to far eastern Asia in coastal Khabarovskiy Krai. This is the second example of a species with a western North American–East Asian disjunct distribution. It should be searched for on Sakhalin Island and Hokkaido.

*Specimen examined.* **Russia:** *Khabarovskiy Krai*: Sea of Japan, Tabo Bay (Bukhta Tabo), north of De Kastri, rocky promontory on north side of bay, 51°37·685'N, 140°53·098'E, 26 m, corticolous on exposed *Picea jezoensis* on coastal cliff, 2009, *T. Spribille* 30831 (GZU).

## Rinodina manshurica Räsänen

*Arch. Soc. Zool. Bot. Fenn. 'Vanamo'* **5:** 27 (1950); type: [China], Manshuria (Mantšukuo), Schitonhzusik, on *Tilia manshuricae*, 9 Oct. 1923, *I. Korejev* (H—holotype!).

*Thallus* thin, grey-brown, rimose, becoming rimose-areolate; areoles to *c.* 0·80 mm wide; surface plane, matt; margin indeterminate; prothallus absent; vegetative propagules absent.

*Apothecia* erumpent, remaining broadly attached, frequent but mostly not contiguous, to *c.* 0·50 mm in diam.; *disc* black, becoming convex; thalline margin concolourous with thallus, entire, *c.* 0·05 mm wide, becoming excluded; excipular ring absent. *Thalline exciple c.* 30 µm laterally; cortex not evident; epinecral layer *c.* 5 µm wide; crystals absent in medulla; algal cells to 13·5 µm long; thalline exciple *c.* 20 µm wide below; epinecral layer *c.* 10 µm wide; *proper exciple* not distinguishable laterally, to *c.* 20 µm wide at periphery. *Hymenium c.* 70 µm high, not inspersed; *paraphyses c.* 2·0 µm wide, apices to *c.* 3·0 µm, lightly capitate forming a light brown epihymenium, lacking a dispersed pigment. *Asci c.* 50 × 20 µm; *ascospores* 8 per ascus, development type not observed, *Dirinaria*-type, (14·0–)15·5–16·0(–16·5) × (7·5–)8·0–8·5 µm ($n = 20$), l/w ratio (1·7–)1·9–2·0(–2·1), some slightly swollen at septum, more so in KOH; lumina *Physcia*-like, septal disc more conspicuous in KOH, sometimes becoming pigmented; torus absent; walls not ornamented.
*Hypothecium c.* 40 µm deep, hyaline.

*Pycnidia* not seen.

*Chemistry.* Spot tests all negative; secondary metabolites not tested by TLC.

*Rinodina manshurica* is known only from its type and is characterized by small, erumpent apothecia and small spores with *Physcia*-like lumina. The apothecial characters are reminiscent of *R. subminuta* H. Magn. but on close examination the spores belong to the *Dirinaria*- rather than to the *Physcia*-type, and they are also smaller. The spores of *R. manshurica* are very slightly swollen at the septum and slightly more so in KOH. Additionally, the spores lack a torus and many possess septal discs, all characters of the *Dirinaria*- rather than *Physcia*-type spores. The spore development type would be expected to be type B but immature, non-septate spores were not observed. *Rinodina metaboliza* also has *Dirinaria*-type spores with *Physcia*-like lumina but its spores are larger and have more obvious septal swellings, and its apothecia are never erumpent. *Rinodina manshurica* is almost certainly closely related to *R. oleae* and may ultimately come to be included within that species. At present, *R. manshurica* can be distinguished from the material assigned here to *R.* aff. *oleae* by the smaller mean spore size in the single sample of *R. manshurica* based on a relatively small number of measurements from local material ($n = 20$ in *R. manshurica* and $n = 33$ in *R.* aff. *oleae*). The small erumpent apothecia also bring to mind *R. orientalis*, but the slightly longer spores of this species develop a torus and possess lumina that can sometimes mimic the *Pachysporaria*-type II spores in shape, although they are more angular and belong to the *Physcia*-type.

## Rinodina megistospora Sheard & H. Mayrhofer

*Bryologist* **114**(3)**:** 460 (2011); type: USA, Oregon, Curry Co., Siskiyou National Forest, Oak Flat off road along Rogue River, near Agness [probably on *Quercus*], 20 Oct 1996, *C. C. Bratt* 9969 (SBBG—holotype; SASK—isotype).

*Thallus* thin to thick, light grey, initially of isolated areoles, 0·25–0·55 mm wide, with minute, radiating lobules 0·15–0·20 mm wide, areoles quickly coalescing to become continuous; surface verrucose, with overlapping, minute lobules, matt; margin determinate; prothallus absent; vegetative propagules absent.

*Apothecia* broadly attached, frequent, sometimes contiguous, to 0·70–1·0 mm diam.; *disc* dark brown to black, becoming convex to half globose; thalline margin concolourous with thallus, entire, 0·05–0·10 mm wide, becoming excluded; excipular ring usually present at first, raised. *Thalline exciple* 55–90 µm wide laterally, cortex poorly organized, 10–15 µm wide; epinecral layer typically absent; crystals present in cortex (atranorin), absent in medulla; cortical cells 3·0–6·5 µm diam., not pigmented; algal cells 9·0–14·5 µm long; thalline exciple 65–90 µm wide below, cortex 15–20 µm wide; *proper exciple* lightly pigmented orange-brown, 10–20 µm wide laterally, expanding to 15–30(–50) µm at periphery, concolourous with epihymenium. *Hymenium* 120–160 µm high, some intrusion of hypothecial inspersion at base; *paraphyses* 2·0–2·5 µm wide, branched, conglutinate, apices expanded to 3·5–4·5 µm, lightly pigmented, immersed in a dispersed pigment forming a dark, orange-brown epihymenium. *Asci* with immature spores, 90–120 × 30–35 µm, spores easily released; *ascospores* 4–8 per ascus, type A development, *Pachysporaria*-type I, (34·5–)37·0–40·5(–43·0) × (17·0–)18·0–20·5(–21·5) µm ($n = 175$), l/w ratio (1·7–)1·9–2·1(–2·3), some immature spores with transient polygonal lumina, over-mature spores may possess apical satellite lumina; torus narrow; walls very lightly ornamented. *Hypothecium* 60–120 µm deep, hyaline except lightly pigmented at base, inspersed.

*Pycnidia* not seen.

*Chemistry.* Spot tests K+ yellow, C−, P+ faint yellow. Secondary metabolites: atranorin confirmed by TLC and two unknown compounds, A5, B5, C6 & A5, B6, C6.

A new description is given above to provide a better measure of character range than was possible in the original description, which was based on the type specimens alone (Sheard *et al.* 2011). The original description is not changed in any substantive way by the addition of new data from far eastern Asia. *Rinodina megistospora* is characterized by its very large, *Pachysporaria*–type I spores, the presence of atranorin in the cortex and two unknown substances which are consistently present. The light grey thallus, convex apothecia and general habit of *R. megistospora* are reminiscent of the terricolous *R. mniaroeiza* (Nyl.) Arnold, which also contains cortical atranorin. However, *R. mniaroeiza* is an oro-arctic, terricolous species with smaller, *Physcia*-type spores (Mayrhofer & Moberg 2002; Sheard 2010).

Only six other *Rinodina* species have ascospores averaging >30 µm in length (Sheard 2010). These are *R. ascociscana*, *R. macrospora* Sheard, *R. roscida* (Sommerf.)

Arnold (all with *Physcia*-type spores), *R. oregana* H. Magn. (*Dirinaria*-type spores) and *R. tenuis* (*Pachysporaria*-type I spores). The first three and the last of these species are reported here for far eastern Asia. *Rinodina tenuis* is distinguished from *R. megistospora* by its thin, plane thallus and presence of medullary pannarin rather than cortical atranorin. *Rinodina luteonigra* from southern Japan also has *Pachysporaria*-type I spores in this size range but is easily distinguished by its yellow pigmented thallus.

Previously known only from a *Quercus* stand at the type locality in southern Oregon, in a relatively high rainfall region close to the coast, *Rinodina megistospora* is now also recorded from near coastal localities at low elevations in Hokkaido, Japan (on unknown phorophytes) and on *Fagus* on Shikoku Island, Kochi Prov. The species also occurs on *Betula* and *Picea* in the Sikhote Alin' Mountains, Primorsky Krai and in the Khomi Mountains, Khabarovskiy Krai, suggesting that it might be widespread but infrequent on the mainland (Fig. 3C). Rather than being a western North American endemic as originally thought, *R. megistospora* must now be regarded as a disjunct species of the Klamath-Siskiyou Mountain region, a region well known for its floristic diversity (Coleman & Kruckeberg 1999). It is the third species in this study belonging to the Eastern Asiatic–western North American group of disjunct species.

*Specimens examined.* **Japan:** *Hokkaido*: Ishikari Prov., Mt. Arashiyama, Asahikawa City, 43°47'N, 142°18'E, on *Quercus crispula*, 2004, *A. Shimizu* 1559 (TNS); Kitami Prov., Shari-gun, Shari-cho, Shiretoko Nat. Park, NW slope of Shiretoko Peninsula *c.* 10 km NE of Utoro Town, along trail from Iwaobetsu hot-spring hotel (Onsen) to Mt. Rausu-dake, on deciduous tree, alt. 388 m, 44·10611°N, 145·09242°E (WGS84, by GPS), 2010, *G. Thor* 23974 (UPS); Shiretoko Nat. Park, NW slope of Mt. Rausu along trail from Iwaobetsu hot-spring hotel (Onsen) to summit, alt. 600 m, 44°06·000'N, 145°06·300'E, 2010, *A. Frisch* 10/Jp56, 10/Jp84 (UPS); Teshio Prov., Teshio-gun, Wakasakanai, 45°42'N, 141°44'E, 1980, *H. Kashiwadani* 16169 (TNS). *Shikoku*: Kochi Pref., Ino-cho Town, along path from road to small and steep hill Mt. Komochi-gon'gen, on *Fagus crenata*, alt. 1610–1630 m, 33°46'49–54"N, 133°11'16–19"E (WGS84), 2006, *G. Thor* 21398 (UPS).—**Russia:** *Khabarovskiy Krai*: Komsomolsk-De Kastri route, Khomi Mountains, about halfway between Chernyy Mys and Tsimmermannovka, 51°05·418'N, 138°57·113'E, on *Betula costata*, 529 m elev., 2009, *T. Spribille* 30550 (GZU). *Primorskiy Krai*: Sikhote-Alin' Mountains, Oblachnaya Mountain, 20 km (air line) E of Yasnoye, 43°40·435'N, 134°12·759'E, on *Picea jezoensis*, 2007, *T. Spribille* 23515 (GZU, with *R. xanthophaea*).

## Rinodina metaboliza Vain.

*Ann. Acad. Sci. Fenn., Ser. A* **27:** 87 (1928); type: [Russia:] Siberia, Tobolsk, Levusch ad corticem Salicis, 1880, *E. Vainio* s. n. (TUR-V 8490—holotype).

This species is characterized by its type B ascospore development, *Dirinaria*-type ascospores measuring 17·5–21·5 × 9·0–11·0 µm ($n = 30$) with septal swelling, enhanced in KOH. The spores can very easily be mistaken for the *Physcia*-type on first sight because of their relatively angular lumina. The species also lacks detectable secondary substances.

*Rinodina metaboliza* is a boreal species known from North America (Sheard 2010), Russia (Magnusson 1947; Kotlov 2008) and Scandinavia (Mayrhofer & Moberg 2002) but has not previously been reported from far eastern Asia. We report it from Kamchatka and the Transbaikal region (Fig. 3C).

*Specimens examined.* **Russia:** *Kamchatka Krai*: Mil'kovo District, Kronotsky Nature Reserve, Levaya Schapina River basin, right bank of Ipuin River, 55°06'05"N, 159°59'22"E, alt. 280 m, on *Crataegus chlorosarca*, 10 viii 2009, *D. Himelbrant* & *I. Stepanchikova* (LECB 12-034 with *R. freyi*); Ust'-Bol'sheretsk District, Pravyy Kikhchik River basin, vicinity of Mokushka River, 53°32'56"N, 156°41'07"E, alt. 235 m, on *Chosenia arbutifolia*, 22 vii 2004, *D. Himelbrant* (LECB 12-010 with *R. endospora* and *R. subminuta*). *Zabaikal'skiy Krai*: Sokhondinskiy Biosphere Zapovednik, 2 km N of Agutsakan forest station, on *Larix*, 49°36·611'N, 111°19·477'E, alt. 1125 m, 23 vii 2006, *L. S. Yakovchenko* (VLA); Sokhondinskiy Biosphere Zapovednik, road between forest stations Shergen-Daban and Ust'-Bablashniy, right bank of Burecha River valley, on *Picea*, 49°44·945'N, 110°50·822'E, alt. 1464 m, 2 vii 2007, *L. S. Yakovchenko* (VLA with *R. septentrionalis*).

## Rinodina mniaroea (Ach.) Körb.

*Syst. Lich. Germ.*: 126 (1855).—*Lecanora mniaroea* Ach., *Syn. Lich.*: 339 (1814); type: [Switzerland:] Helvetia, supra muscos, *J. C. Schleicher* 91a (H-ACH 1136A—lectotype, Mayrhofer & Moberg 2002).

This species was reported for all sectors of the Russian Far East by Urbanavichus &

https://doi.org/10.1017/S0024282917000536 Published online by Cambridge University Press

Andreev (2010). Although we have not seen any specimens from our study area, the species is widespread across oro-arctic regions of the Northern Hemisphere. *Rinodina mniaroea* is characterized by apothecia that become convex, excluding the thalline margins, and by its large *Physcia*-type spores (Mayrhofer & Moberg 2002; Sheard 2010). Three chemotypes have previously been recognized as varieties (Moberg & Mayrhofer 2002) but as a result of molecular studies (Resl *et al.* 2016) these have recently been raised to species status as *R. cinnamomea* (Th. Fr.) Räsänen with skyrin and other anthraquinones in the lower medulla, *R. mniaroeiza* (Nyl.) Arnold with cortical atranorin, and *R. mniaroea* lacking a diagnostic secondary chemistry although variolaric acid is often present. All might be expected to occur in the study area. *Rinodina turfacea* is distinguished by its persistently plane apothecial discs, persistent margins and the presence of sphaeophorin. *Rinodina roscida* is another oro-arctic species similar to *R. mniaroea* and *R. turfacea* but typically has a pruinose thallus and apothecial discs, larger spores, lacks sphaerophorin and occurs in calcareous rather than acidic terrain (Mayrhofer & Moberg 2002; Sheard 2010).

The specific epithet has usually been cited as 'mniaraea' in the belief that the name 'mniaroea' was an error made by Acharius. However, there is no evidence that this is the case and Acharius was consistent in his usage. Original orthography may not be changed other than through conservation and so Acharius' original spelling must be used (Coppins & Kirk 2017, pers. comm.). This also applies to the name 'mniaroeiza'.

### Rinodina mongolica H. Magn.

Lichens from central Asia II. *Sino-Swedish Expedition Publ. 22. XI Botany* **2:** 36 (1944); type: Mongolia australis, Beli-miao, [on cortex accompanied by *Candelariella aurella*], 41°30'N, 110°10'E, 24 Oct. 1929, *B. Bohlin* 109a (S—lectotype, designated here).

*Thallus* mostly thin, grey to ochraceous, areolate; areoles to 0·70 mm wide; surface rugose, matt; margin indeterminate; prothallus not seen.

*Apothecia* broadly attached, becoming somewhat sessile, scattered or contiguous, up to 0·80 mm diam.; *disc* black, slightly concave at first, becoming plane, never convex; thalline margin concolourous with thallus, to 0·10 mm wide, entire; excipular ring absent. *Thalline exciple c.* 80 µm wide laterally; cortex *c.* 10 µm wide; epinecral layer *c.* 10 µm wide; crystals absent in cortex and medulla; cortical cells to *c.* 6·5 µm wide, pigmented; algal cells large, to 26·5 µm long; thalline exciple *c.* 100 µm wide below, cortex not expanded; *proper exciple c.* 10 µm wide laterally, expanded to 25–40 µm wide above. *Hymenium c.* 100 µm high, not inspersed; *paraphyses* 2·5–3·0 µm wide, apices to 5·5–6·5 µm wide, reddish brown capitate, without dispersed pigment, forming a reddish brown epihymenium. *Asci c.* 50 × 15–20 µm; *ascospores* type A development (very rarely type B), *Dirinaria*-type, (15·0–)15·5–18·0 (–9·0) × (7·5–)8·0–8·5(–9·0) µm ($n = 40$), l/w ratio (1·8–)1·9–2·1(–2·3), few immature spores seen, then slightly swollen at septum, more so in KOH, some with septal wall thickening; lumina *Physconia*-like, without septal wall thickening at maturity, darkly pigmented at septum but torus absent; walls not ornamented. *Hypothecium c.* 80 µm deep, hyaline.

*Pycnidia* not seen.

*Chemistry.* Spot tests all negative.

This new description agrees with that of Magnusson (1944) but is more complete. The lectotype is abundantly fertile but the ascospore structure was initially difficult to determine due to dehydration. After soaking an apothecium in water overnight and heat treatment of a squash preparation, the spores were observed to be *Physconia*-like, without wall thickening at the septum or apices at maturity. The few young spores were observed to be swollen at the septum, the swelling becoming more apparent after treatment with KOH. The spore structure is therefore similar to *Rinodina pyrina* and a taxonomic relationship is further suggested by the large algal cells (Mayrhofer & Moberg 2002; Sheard 2010; Sheard *et al.* 2011). Magnusson does not make the comparison with *R. pyrina* but states that he ventured to describe the species "because of its pale yellowish grey, velvety thallus and thin walled, uniform spores". The thallus is thicker than is typical for *R. pyrina* and the ochraceous colour is also unusual for that species. The epihymenium is reddish brown but the pigment is present in the capitate apical cells rather than being diffuse around the apical cells as in species with *Physcia*- and *Physconia*-type spores.

The spores of *Rinodina mongolica* are longer than is typical for *R. pyrina* and more comparable in this respect to *R. imshaugii* (see Table 1 in Sheard *et al.* 2011). However, they lack the persistent apical thickening that is often found in *R. imshaugii* and their l/w ratio includes broadly-ellipsoid spores (like *R. pyrina*). The thallus and apothecium morphology is also quite unlike that of *R. imshaugii* and it therefore seems likely that *R. mongolica* is a good species, although poorly known since it is based on the type alone. A second specimen (*Bohlin* 109b, S) is poorly fertile and therefore unhelpful.

## Rinodina moziana (Nyl.) Zahlbr.

*Cat. Lich. Univ.* **7:** 544 (1931). *Lecanora moziana* Nyl., *Lich. Japon.*: 40 (1890); type: Japan, [Kyushu], Mitso ( = Mozi or Moji), 20 Oct 1879, *Almquist* (H-Nyl 28851 as *L. mitsoana*, Mayrhofer 1984—lectotype!, H-Nyl 28859 as *L. mitsoana*—topotype!).

= *Rinodina destituta* (Nyl.) Zahlbr. *Cat. Lich. Univ.* **7:** 510 (1931).—*Lecidea destituta* Nyl., *Sertum Lich. Trop. Labuan et Singapore, Accedunt Observ.*: 41 (1891); type: USA, Illinois, super saxa arenaria, s. d., *J. Wolf* s. n. (H-NYL 10210—holotype!). See Sheard (2010) for other synonyms listed under this name.

*Rinodina discolorans* var. *japonica* Räsänen. *J. Jap. Bot.* **16:** 141 (1940); Lamb, *Ind. Nom. Lich.*: 646 (1963) = *Rinodina discolor* var. *japonica* (Räsänen.) Sato, *Ind. Plant. Nippon.* **4:** 116 (1943); type: Japan, Kosuke Prov., 7 Dec. 1920, *Tsunoda* 444 (H—holotype), 9 Mar 1921, *Tsunoda* 445 (H—paratype).

*Rinodina vezdae* H. Mayrhofer, *J. Hattori Bot. Lab.* **55:** 473 (1984); type: Vězda *Lich. Bohem. exs.* 113 (as *R. discolor*) ČSSR: Moravia occid., Vev. Bitýška, ad saxa dioritica in valle fluvii Svratka, *c.* 350 m, 12. 12. 1956, *A. Vězda* s. n. (M—holotype!).

*Rinodina moziana* is one of only five saxicolous species recorded by us for the region. The original collections of *R. moziana* are very similar to specimens of *R. destituta* (including *R. vezdae*) as understood by Sheard (2010). Consequently *R. destituta* is here reduced to synonymy with *R. moziana*. Both original collections are very small, the lectotype being similar to the 'ochrocea' morphotype of *R. destituta* as described by Sheard (2010). The topotype is closest to the most typical state of *R. destituta*, the 'vezdae' morphotype. They both possess cortical atranorin, a thalline apothecial margin becoming partly or completely carbonized, a proper exciple with an aeruginose pigment at its upper margin, and relatively large *Mischoblastia*-type spores. Spore measurements, and their other characteristics, also correspond well with *R. destituta*: (20·0–)21·5–23·0(–24·0) × 12·0–12·5 (–13·0) µm ($n = 30$), l/w ratio (1·6–)1·7–1·8 (–2·0). The larger spores are swollen at the septum, with a narrow torus at maturity, and their walls are unornamented.

*Rinodina moziana*, now known from both Japan and Korea (including a specimen reported as *R. teichophila*; Aptroot & Moon 2014), has a wide distribution in eastern North America (as *R. destituta*, Lendemer *et al.* 2014) and is also found in Central and Southern Europe (reported as *R. vezdae*, H. Mayrhofer 1984; Giralt 2010). The species is also rather common in Australia (Kaschik 2006). Its distribution in far eastern Asia is southern and so far confined to islands (Fig. 3C).

*Specimens examined.* **Japan:** *Bonin Island*: Chichi-jima Island, Mt. Yoake, on exposed siliceous rocks, elev. 300 m, 27°4'58·404"N, 142°13'22·511"E, 2013, *A. Frisch, Y. Ohmura & H. Kashiwadani* 13/Jp62 (UPS).—**South Korea:** *Cheju Island*: Namcheju-gun, Andok-myon, 20 km west of town of Sogwip'o, south of Road 12, Andok Valley, on rock in stream, alt. 85 m, 33°16'N, 126°21'E, 2001, *G. Thor* 17305 (UPS); Andok-myon, Sagye-ri, Mt. Dansan, steep exposed hill, alt. 50 m, 33°14'N, 126°17'E, 2001, *G. Thor* 17377 (UPS).

## Rinodina aff. oleae Bagl.

*Mem. Reale Accad. Sci. Torino, Ser. 2,* **17:** 403 (1857); type: Italy, Liguria, Granarolo, 1855, *F. Baglietto* s. n. (MOD—lectotype, Kaschik 2006).

The thallus of this corticolous species is continuous, becoming rimose-areolate, and the apothecia are erumpent at first and reminiscent of *R. subminuta* but with smaller apothecia and ascospores, (15·5–)16·5–18·0 (–19·0) × (6·5–)8·0–9·0(–9·5) µm ($n = 33$), l/w ratio (1·8–)1·9–2·3(–2·6). Some spores are inflated at the septum, and more so in KOH. The absence of a torus and presence of a septal disc with *Physcia*-like lumina suggest that the spores belong to the *Dirinaria*-type. However, type B spore development was not observed in our material. The very obvious erumpent apothecia and relatively large spores are not typical of *R. oleae* (Giralt 2001) and there is, therefore, some doubt about this identification. As noted previously, the saxicolous *R. gennarii* is sometimes included in *R. oleae* (Kaschik 2006; Giavarini *et al.* 2009).

The corticolous *Rinodina oleae* is widespread in southern Europe (Giralt 2001). In North America the species is not well known and has a widely scattered distribution (Sheard 2010). The species was previously reported from the southern Russian Far East by Urbanavichus & Andreev (2010) but these records belong to the saxicolous *R. gennarii*; the vouchers behind a more recent report, from Khabarovskiy Krai (Yakovchenko *et al.* 2013), were not available for this study. It has also been reported from Korea by Joshi *et al.* (2013). Four of the five East Asian records, including one new to China, are found in a narrow region near the three-corners area where Russia, China and North Korea meet; we also report the species as new to Japan from Hokkaido (Fig. 3D).

*Specimens examined.* **China:** *Jilin Prov.*: Changbaishan Nat. Park, 41°54'N, 127°53'E, on *Larix*, 22 vi 2010, *I. A. Galanina*; on *Betula*, 27 vi 2010, *I. A. Galanina* (both VLA).—**Japan:** *Hokkaido*: Tokachi Prov., Kato-gun, Kamishihoro-cho, just W of road 273, 6 km S of Mikuni tunnel through Mt. Mikuni-yama, 43°32'N, 143°09'E, alt. 680 m, on *Abies sachalinensis*, 1995, *T. Tønsberg* 23050 (BG with *R. buckii*).—**Russia:** *Primorskiy Krai*: Hankayskiy District, vicinity of Pogranichniy, 44°23'N, 131°25'E, on *Q. mongolica*, 11 viii 2010, *I. A. Galanina* (hb. VLA); Khasanskiy District, vicinity of Zarubino, 42°37'N, 131°04'E, on *Q. mongolica*, 20 v 2001, *I. A. Galanina*; 10 v 2010, *I. A. Galanina* (both VLA); Shkotovsky District, vicinity of Shkotovo, 43°19'N, 132°21'E, on *Fraxinus*, 28 v 2010, *I. A. Galanina* (VLA).

## Rinodina orientalis Sheard sp. nov.

MycoBank No.: MB 819995

Thallus grey to dark grey-brown, thin, continuous, rarely becoming thick, rimose-areolate. Apothecia erumpent, remaining broadly attached, margins often poorly formed; disc black, plane, often becoming strongly convex excluding the thalline margin. Ascospores (rarely 4) 8 per ascus, *Physcia*-type, (14·5–)16·0–18·0 (–19·5) × (6·5–)7·0–8·5(–9·0) µm, lumina often with relatively rounded angles (*Pachysporaria*-like); torus developing late. Secondary metabolites absent.

Type: Japan, Hokkaido, Kitami Prov., Shari-gun, Shari-cho, Shiretoko National Park, NW slope of Shiretoko Peninsula *c.* 10 km NE of Utoro Town, along the trail from Iwaobetsu hot-spring hotel (Onsen) to Mt. Rausu-dake, old-growth montane forest dominated by *Quercus crispula* (syn. *Q. mongolica*) but also with *Acer mono*, *Betula ermanii*, *Prunus nipponica* and *Sorbus* sp., on *Sorbus* sp. (close to plot A2), alt. 611 m, 44·10228°N, 145·10025°E (WGS84, by GPS), 12 July 2010, *G. Thor* 24138 (UPS—holotype).

(Figs 3E & 6)

*Thallus* grey to dark grey-brown, thin, continuous, rarely becoming thick, rimose-areolate (Fig. 6A); areoles to 0·50–0·80 mm wide; surface plane or scabrid becoming rugose, matt; margin indeterminate; prothallus not seen; vegetative propagules absent.

*Apothecia* erumpent (Fig. 6A), remaining broadly attached, to 0·30–0·65(–0·80) mm diam., margin *c.* 0·05 mm wide, often poorly formed; *disc* black, plane, often becoming strongly convex, excluding the thalline margin (Fig. 6B); excipular ring rarely evident, then lighter brown than disc and confluent with thalline margin. *Thalline exciple* 40–80 µm wide; cortex 5–15 µm wide, typically with epinecral layer 5–10 µm wide; crystals absent in cortex and medulla; cortical cells to 3·5–4·5(–6·0) µm wide, typically pigmented; algal cells to 10·0–15·0(–20·5) µm long; *proper exciple* 5–10 µm wide laterally, sometimes pigmented, expanded to 20–40 µm above. *Hymenium* 70–100 µm high, typically conglutinate; *paraphyses* 2·0–3·0 µm wide, apices lightly capitate, immersed in dispersed pigment forming a dark, red-brown epihymenium. *Asci* 55–60 × 12–15(–18) µm, *Lecanora*-type; *ascospores* 8 per ascus (rarely 4), type A development, *Physcia*-type (Fig. 6C), (14·5–)16·0–18·0 (–19·5) × (6·5–)7·0–8·5(–9·0) µm ($n = 118$), l/w ratio (1·9–)2·0–2·4(–2·6), sometimes slightly inflated at the septum at first, not more so in KOH, later rarely slightly constricted; lumina often with relatively rounded angles (*Pachysporaria*-like); torus developing late; walls not

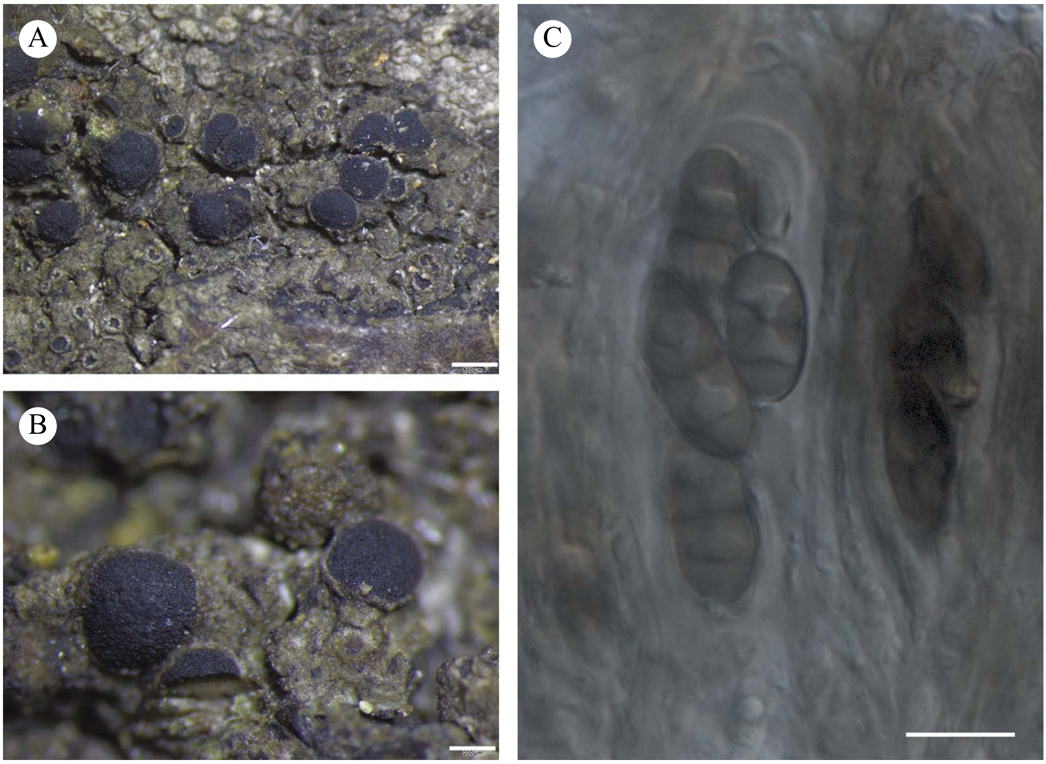


FIG. 6. *Rinodina orientalis*, Japan, Hokkaido, Kitami Prov., Shari-gun, Shari-cho, Shiretoko National Park, *G. Thor* 24138 (UPS— holotype). A & B, habit: A, showing young erumpent apothecia with plane discs; B, broadly attached apothecia with convex discs. C, *Physcia*-type ascospores. Scales: A = 500 µm; B = 200 µm; C = 10 µm. In colour online.

ornamented. *Hypothecium* hyaline, 30–50 µm deep, to 80 µm deep when disc convex.

*Pycnidia* not seen.

*Chemistry*. Spot test all negative. Secondary metabolites absent by TLC.

*Etymology*. Named after its wide distribution in far eastern Asia.

This new corticolous species is characterized by its *Physcia*-type spores with a narrow torus developing late and lacking wall ornamentation. Due to the rounded nature of the spore lumina, particularly in early development, and rare swelling at the septum, it was first thought that the spores might belong to the *Dirinaria*-type. However, the spores do not inflate further in KOH, and possess type A development. Asci may rarely develop only four spores, as in the holotype (Fig. 6C). The late developing torus and red-brown colour of the epihymenium both suggest that the spores should be interpreted as belonging to the *Physcia*-type (Sheard 2010). The apothecia are initially erumpent and very reminiscent of *Rinodina subminuta* H. Magn. but the discs of mature apothecia often become strongly convex excluding the thalline margin, characters that are absent in healthy *R. subminuta*. In addition, the spore structure of *R. subminuta* is more typical of the *Physcia*-type, with more angular lumina during development, a more obvious torus and larger spore size (averaging 18·5–20·0 µm long; Sheard 2010).

*Rinodina orientalis* is found in montane to subalpine forest in Japan which, together with the tendency for some spores to be inflated at the septum, immediately invited comparison with the European *R. ventricosa* Hinteregger &

Giralt (Hinteregger 1994). However, this species does not have erumpent apothecia and its spores are larger ((18·0–)18·5–20·0 (–21·0) × 8·5–9·5(–10·5) μm ($n = 40$)) with persistently very angular lumina, and more frequent and more obvious septal swelling. The two specimens (28 May 2010, *I. A. Galanina*; 10 May 2010, *I. A. Galanina*, both VLA) from southern Primorsky Krai, Russia do not have obvious erumpent apothecia and should be regarded as tentative identifications of this species. In addition to the morphological similarities with *R. subminuta*, *R. orientalis* also has a similar elevational range, except that it has not been found below 600 m on Hokkaido, Japan. This new species is widespread in eastern Asia as far west as the Mongolian border region (Fig. 3E).

*Paratypes examined.* **Japan:** *Hokkaido*: Kitami Prov., Shari-gun, Shari-cho, Shiretoko National Park, NW slope of Shiretoko Peninsula *c.* 10 km NE of Utoro Town, along trail from Iwaobetsu hot-spring hotel (Onsen) to Mt. Rausu-dake, on *Sorbus commixta*, alt. 1021 m, 44·08942°N, 145·11675°E (WGS84, by GPS), 2010, *G. Thor* 24529, 24532 (UPS); on *Weigela middendorffiana* at trail, alt. 840 m, 44·05447°N, 145·06740°E (WGS84, by GPS), 2010, *G. Thor* 24793 (UPS); on *Betula ermannii*, alt. 1000 m, 44·09°N, 145·12°E (WGS84, estimated from GPS), 2010, *G. Thor* 25600 (UPS); Shiretoko N.P., NW slope of Mt. Rausu along trail from Iwaobetsu hot-spring hotel (Onsen) to summit, alt. 600 m, 44°06·000'N, 145°06·300'E, 2010, *A. Frisch* 10/Jp21 (UPS); alt. 1200 m, 44°04·940'N, 145°07·682'E, 2010, *A. Frisch* 10/Jp26 (UPS). *Honshu*: Shimotsuke Prov. (Tochigi Pref.), Nikko City, 14 km WNW of Nikko and 4 km SE of Yumoto Village, the property surrounding the field station Nikko Shizen Fureai House, on *Malus toringo*, elev. 1400 m, 36°46'11·2"N, 139°27'21·8"E (WGS84, ±100 m), 2015, *Thor* 32262 (UPS); Shinano Prov. (Nagano Pref.), Ohmachi-city, 16 km NW Shinano-Ohmachi, Ohgisawa, along path near river 100 m S to 500 m W of Ohgisawa, on *Salix* sp., alt. 1420–1480 m, 36°33'N, 137°43'E, 1994, *G. Thor* 12723 (TNS & UPS).—**Russia:** *Primorsky Krai*: Chkotovskiy District, Chkotovo, 43°19'N, 132°21'E, 28 v 2010, *I. A. Galanina*; Khankaiskiy District, shore of Lake Khanka, near Turiy Rog, 45°00'N, 132°25'E, on *Quercus dentata*, 24 vi 2005, *L. S. Yakovchenko*; on *Quercus mongolica*, 10 v 2010, *I. A. Galanina* (both VLA). [*Sakhalinskaya Oblast'*:] Kuril Islands, Iturup Island, vicinity of Baranski Volcano, 45°5'26·57"N, 147°58'56·75"E, 461 m alt., on *Acer*, 17 viii 2013, *A. K.Ezhkin* (VLA); Sakhalin Island, Nevelskiy Pass, 46°44'35·92"N, 142°6'21·02"E, 425 m alt., on *Sorbus*, 6 xi 13, *A. K. Ezhkin* (VLA); Sakhalin Island, vicinity of Yuzhno-Sakhalinsk, Susunayskiy Ridge, Mt. Bolshevik, 47°56'31·7"N, 142°48'21·1"E, 95 m alt., on *Fraxinus*, 2012, *A. K. Ezhkin* R26\13 (VLA); Sakhalin Island, vicinity of Yuzhno-Sakhalinsk, Novo-Aleksandrovka, valley of stream Krasnosel'skiy, on *Salix*, 47°02'4·2"N, 142°43'34·8"E, 48 m alt., 2012, *A. K. Ezhkin* R18\13 (VLA); Sakhalin Island, vicinity of Yuzhno-Sakhalinsk, Susunayskiy Ridge, Ostraia Mountain, 46°58'39·2"N, 142°46'24·4"E, 237 m alt., on *Populus*, 2011, *A. K. Ezhkin* R3/13 (VLA); Sakhalin Island, vicinity of Yuzhno-Sakhalinsk, Susunayskiy Ridge, River Rogatka, 46°58'36·6"N, 142°49'07·4"E, 282 m alt., on *Salix*, 2011, *A. K. Ezhkin* R4/13 (VLA); Sakhalin Island, vicinity of Yuzhno-Sakhalinsk, Susunayskiy Ridge, Krasnaia Mountain, 46°56'8·5"N, 142°49'50·3"E, 737 m alt., on *Acer*, 2012, *A. K. Ezhkin* R6/13 (VLA); Sakhalin Island, Susunayskiy Ridge, vicinity of Yuzhno-Sakhalinsk, Parkovaia Mountain, 46°58'26·15"N, 142°45'26·12"E, 100 m alt., on *Acer*, 2011, *A. K. Ezhkin* 22R-11 (VLA); on *Populus*, 2011, *A. K. Ezhkin* 23R-11 (VLA); Sakhalin Island, Susunayskiy Ridge, vicinity of Yuzhno-Sakhalinsk, Turgenev Mountain, 47°00'33·6"N, 142°48'35·7"E, 592 m alt., on *Salix*, 2012, *A. K. Ezhkin* R9/13 (VLA). *Zabaikal'skiy Krai*: Sokhondinskiy Biosphere Zapovednik, 2 km N of Agutsakan forest station, Agutsakan River flood plain, on *Larix*, 49°36·611'N, 111°19·477'E, alt. 1125 m, 23 vii 2006, *L. S. Yakovchenko* (VLA with *R. metaboliza* and *R. endospora*).—**South Korea:** *Gangwon Prov.*: Gangrun City, Mt. Odae, Odaesan Nat. Park, on *Fraxinus*, alt. 240 m, 37°49'N, 128°42'E, 2014, *A. Aptroot* 72654 (ABL); Pyeonchang-gun, Mt. Odae, Odaesan Nat. Park, on *Quercus*, alt. 1230–1560 m, 37°47'N, 128°32'E, 2014, *A. Aptroot* 72750; Phoenix Park, on *Quercus*, alt. 650 m, 37°35'N, 128°19'E, 2014, *A. Aptroot* 72606 (both ABL); Yangyang-gun, Ser-myun, Osaeck-ri, southern part of the massif Sorak Mts, Sorak-san National Park, south slope of Mt. Dachong, along trail from shelter *c.* 500 m WNW of the top of Mt. Dachong to village at Hangyeryong Pass, *c.* 1–3 km SW of the shelter, on *Acer palmatum*, alt. 1600–1400 m, 38°07·10–06·45'N, 128°27·25–26·00'E, 2006, *G. Thor* 20390, 20416 (on *Quercus* sp.) (AK & UPS); 500 m SW of shelter, on dead shrub in alpine heath, alt. 1600 m, lat. 38·11833, long. 128·45417, *G. Thor* 20365 (UPS).

## Rinodina oxydata (A. Massal.) A. Massal.

*Neag. Lich.*: 19 (1854).—*Mischoblastia oxydata* A. Massal. *Ric. Lich. Crost.*: 42 (1852); type: Italy, Verona, in oppido Lavagno (ad saxa basalti), s. d., *A. Massalongo* s. n. (VER—holotype).

The only specimen of this species examined from the region was very small but possessed the typically thin thallus, pigmented apothecial margins and *Mischoblastia*-type ascospores (immature, 16·0–18·5 × 9·5–10·5 μm, $n = 5$) characteristic of *Rinodina oxydata*. The apothecial section showed crystals under PL suggestive of atranorin but they could not be specifically located to the cortex. The specimen was too small to be sampled for TLC. *Rinodina moziana* is similar but is distinguished by its larger spores and thicker thallus.

*Rinodina oxydata* is widely distributed throughout the world, being recorded from Europe, southern Africa, Australasia, South America (Kaschik 2006) and North America (Sheard 2010; Lendemer *et al.* 2014). The species was previously reported from Japan (Kurokawa & Kashiwadani 2006) and Russia (Kotlov 2008) and it was listed for the southern Russian Far East by Urbanavichus & Andreev (2010).

*Specimen examined.* **Russia:** *Primorskiy Krai*: Shkotovsky District, vicinity of Shkotovo, oak forest (*Quercus mongolica, Betula dahurica, Fraxinus mandshurica*), 43°19'N, 132°21'E, on tufa, 28 v 2010, *I. A. Galanina* (VLA).

## Rinodina placynthielloides Aptroot

*Fungal Diversity* **14:** 40 (2003); type: Taiwan, Taichung Co., 30 km ENE Taichung, 5 km NW Kukwan, along mountain trail, 1000–1300 m alt., 51RTG9279, on granite of wall along path, 22 Oct 2001, *Aptroot* 53541 (B—holotype).

*Thallus* thin, grey-brown, areolate, areoles to *c.* 0·60 mm wide; surface plane, matt; prothallus very thin, black, entire to fimbriate; vegetative propagules abundant, blastidia, darker brown than thallus, quickly covering surface of areoles, (30 × 60–) 55 × 80(–70 × 100) µm, budding soredia, (30–)35–40(–50) µm.

*Apothecia* broadly attached, infrequent, some contiguous, *c.* 0·45 mm diam.; *disc* dark brown, persistently plane; margin concolorous with thallus, entire, *c.* 0·05 mm wide; excipular ring not evident. *Thalline exciple c.* 60 µm wide laterally; cortex *c.* 10 µm wide, epinecral layer absent; crystals absent in cortex and medulla; cortical cells *c.* 4·5 µm wide, pigmented; algal cells *c.* 11 µm wide; thalline exciple 90–100 µm wide below; *proper exciple* not evident laterally, *c.* 30 µm wide at surface. *Hymenium c.* 80 µm high, not inspersed; *paraphyses c.* 2·5 µm wide, not conglutinate, apices to *c.* 4·0 µm wide, forming a brown epihymenium. *Asci c.* 60 × 19 µm; *ascospores* (4–)8 per ascus, development type not observed, *Pachysporaria*-type II, (13·0–)13·5–14·5(–18·0) × (7·0–) 7·5–8·5(–11·5) µm ($n = 22$), l/w ratio (1·6–) 1·7–1·8(–1·9), development often asynchronous; lumina rounded from start, torus present, walls not ornamented. *Hypothecium* hyaline, *c.* 60 µm deep.

*Pycnidia* not seen.

*Chemistry.* Spot tests all negative. Secondary metabolites absent by TLC (Aptroot & Sparrius 2003).

The measurements cited above were taken from a hand-cut section, rather than a microtome section, in order to conserve the limited number of apothecia present. The type description states that the asci are 4-spored. Only one such ascus was seen and represents the extreme state of the frequently asynchronous spore development in the asci. This ascus had spores at the maximum of the size range quoted above and they were also pointed as opposed to their more typical bluntly-ellipsoid shape. The type description also mentions lecideine apothecia, but these apothecia belong to a small thallus of *Rinodina moziana* with *Mischoblastia*-type spores that is also present on the type specimen. The spore measurements might also have been taken from these apothecia since they are mostly larger than those quoted above for *R. placynthielloides*. The thallus of *R. moziana* is a light grey colour and contains atranorin crystals but it also hosts abundant germinating soredia from the surrounding thalli of *R. placynthielloides*, thus explaining the apparent confusion between the two species. Although the holotype is a mixture of two species, the blastidiate thalli are dominant and there can be little doubt that the type description refers to *R. placynthielloides* rather than *R. moziana*.

Aptroot & Sparrius (2003) refer to the vegetative propagules as isidia but, when viewed under the compound microscope, these can clearly be seen to bud off soredia and are more typical of blastidia. These blastidia quickly cover the surface of the areoles and are the defining character of this interesting species. As demonstrated by their presence on the surface of the accompanying *R. moziana* thallus, the blastidia and their soredia are clearly very effective at colonizing adjacent substrata.

*Rinodina placynthielloides* was reported from South Korea by Aptroot & Moon (2014).

*Additional specimen examined.* **South Korea:** *Prov. Chungchongbuk-do*: Danyang-gun, Daegang-myun, Sonam Valley, 36°54'N, 128°20'E, 230 m alt., siliceous rock, 2007, *Aptroot* 67688 (ABL).

## Rinodina polyspora Th. Fr.

*Nova Acta Reg. Soc. Sci. Uppsala, Ser. 3*, **3:** 226 (1861); type: Switzerland, bei Zurich, 1853, *P. Hepp* s. n. (Hepp *Fletchen Eur.* 77 as *Psora sophodes* (UPS—lectotype [Giralt & Mayrhofer 1994]; BERN—isotype).

The 16-spored ascus is characteristic for this species although asci with 8 spores are also rarely found (Sheard 2010). The ascospores belong to the *Physcia*-type but are often over-mature, then lose their internal structure. The thallus is usually grey-brown and the apothecia are broadly attached, often becoming convex. The species is not to be confused with *R. polysporoides* which also possesses 16-spored asci but has *Dirinaria*-type spores (Giralt & Mayrhofer 1994).

*Rinodina polyspora* has recently been reported from Korea by Joshi *et al.* (2013). This species is new to the lichen biota of Japan (Fig. 3D). The species was previously recorded from the Russian Far East by Chabanenko (2002). It is also found in western and eastern North America (Sheard 2010) and Europe (Mayrhofer & Moberg 2002).

*Specimens examined.* **Japan:** *Hokkaido*: Kitami Prov., Esashi-gun, Hamatonbetsu-cho, 9 km S of Hamatonbetsu, on *Salix* sp. at the river, alt. 50 m, 45°03'N, 142°23'E, 1995, *G. Thor* 14208 (TNS & UPS); Soya-gun, Sarufutsu-mura, 12 km NW of Hamatonbetsu, 8 km SE of Poronuma Lake, 1·5 km from the sea, 45°13'N, 142°15'E, alt. 30 m, on *Picea glehnii*, 1995, *T. Tønsberg* 22756 (BG with *R. subminuta*); Esashi-gun, Esashi-cho, 2 km S of Honcho, 44°55'N, 142°35'E, alt. 10–20 m, on *Acer*, 1995, *T. Tønsberg* 22753 (BG with *R. subminuta*).—**Russia:** *Sakhalinskaya Oblast'*: Yuzhno-Sakhahlinsk District, Yuzhno-Sakhalinsk, Botanical Garden, on *Salix hultenii*, elev. 80–90 m, 46° 56'37·1"N, 142°45'54·1"E, 2004, *C. Printzen* 9107 (FR).

## Rinodina roscida (Sommerf.) Arnold

*Verh. K. K. Zool.-Bot. Ges., Wien* **37:** 133 (1887). Basionym: *Lecanora roscida* Sommerf., *Suppl. Flora Lappon.*: 97 (1826); type: [Norway: Nordland], Saltdalen, moss on calcareous rocks, 1824, *S. C. Sommerfelt* s. n. (O—lectotype, Mayrhofer & Moberg 2002).

This species is reminiscent of *Rinodina turfacea* in its oro-arctic distribution, its presence among mosses or on decaying vegetation on the ground and its large *Physcia*-type spores. It differs in its light grey thallus lacking sphaerophorin, pruinose apothecial discs and being limited to calcareous habitats. Its spores are also significantly larger than those of *R. turfacea* (Sheard 2010). *Rinodina roscida* is widespread in the oro-arctic of the Northern Hemisphere (Mayrhofer & Moberg 2002) and has previously been recorded from the arctic portion of the Russian Far East (Makarova & Katenin 1983; Urbanavichus & Andreev 2010).

*Specimens examined.* **Russia:** *Magadanskaya Oblast'*: Omsukchanskiy District, *c.* 500 km north-eastward from Magadan, foothills of Kilganskie Range, vicinity of mining camp Dzuletta, 61°11'39·8"N, 153°58'49·8"E, alt. 1480 m, upper part of the slope with calcareous rocks, on mosses, 2012, *Yakovchenko* M-12-Ca-1, M-12-Ca-2 (VLA).

## Rinodina septentrionalis Malme

*Svensk Bot. Tidskr.* **6:** 920 (1913); type: Sweden, Jämtland, Undersåker, 1912, *G. O. Malme* s. n., on *Salix* and *Alnus*, Malme, *Lich. Suec. Exs.* 290 (UPS—lectotype, Mayrhofer & Moberg 2002; COLO—isolectotype!).

This species is characterized by its scattered, narrowly attached apothecia, its small, scattered, convex areoles and by its relatively small, *Physcia*-type ascospores measuring (15·5–)16·5–18·5(–19·5) × (7·0–)7·5–8·0(–8·5) μm ($n = 40$), l/w ratio (1·9–)2·1–2·4(–2·6), with prominent tori. The spore size of our collections is comparable to that quoted by Mayrhofer & Moberg (2002) and Sheard (2010), and as indicated previously the spores cannot be separated from those of *R. freyi.* Thalli of this last species consist of plane areoles and are mostly found associated with leaf scars and twig axils or other sites where water tends to be retained on the bark substratum. Nevertheless, immature thalli of these two species are difficult to separate.

*Rinodina septentrionalis* was previously recorded in our study area from the Sikhote-Alin' Mountains by Chabanenko (2002, based on an earlier unpublished report by Insarov & Pchelkin, specimen in herbarium "MGU", not seen), Kamchatka (Himelbrant *et al*. 2009), the lower reaches of the Amur (Yakovchenko *et al*. 2013) and the Stanovoye Nagor'e highlands (Chesnokov & Konoreva 2015). It is an oro-arctic species in North America (Sheard 2010), Scandinavia and Siberia (Mayrhofer & Moberg 2002). The records reported here are the first from Japan and it is significant that they are from relatively high elevations. The species is widely distributed in the study area, especially north of 45° (Fig. 3F) and has also been reported from Mongolia (Hauck *et al*. 2013).

*Selected specimens examined.* **Japan:** *Honshu*: Shimotsuke Prov. (Tochigi Pref.), Nikko City, 20 km WNW of Nikko, SW shore of Lake Karikomi, on branch found on the ground, elev. 1635 m, 36°49'26·1"N, 139°25'53·8"E, 2015, *G. Thor* 32127; 13 km NW of Nikko and 5 km ESE of Yumoto Village, 40 m SE of the end of the dirt road, on *Alnus* sp. at small stream, elev. 1610 m, 36°47'56·3"N, 139°28'56·6"E, 2015, *G. Thor* 32537 (both UPS).—**Russia:** *Kamchatskyi Krai*: Elizovo District, Kronotsky Nature Reserve, Pikhtovaya Growe, 54°08'N, 159°56'E, alt. 25–50 m, *Abies gracilis*, 2009, *L. I. Rassokhina* (LECB 12-055); Mil'kovo District, Kamchatka River basin, SW slope of Tolbachik Volcano, *c.* 40–43 km SE of Kozyrevsk, near Bubochka hill, 55°43'54"N, 160°11'27"E, alt. 680 m, on *Alnus fruticosa*, 10 viii 2006, *D. Himelbrant* (LECB 12-016 with *R. sibirica*); Mil'kovo District, Kronotsky Nature Reserve, Levaya Schapina River basin, mouth of Ipuin River, 55°06'55"N, 159°57'45"E, alt. 280 m, old *Crataegus chlorosarca*, 8 viii 2009, *D. Himelbrant* & *I. Stepanchikova* (LECB 12-058 with *R. sibirica*); Ust'-Bol'sheretsk District, Bannaya River basin, bank of Bannaya River, 52°54'25"N, 157°30'12"E, alt. 244 m, *Alnus hirsuta*, 6 viii 2002, *D. Himelbrant* & *E. Kuznetsova* (LECB 12-056); Ust'-Bol'sheretsk District, Bystraya Bol'shaya River basin, 53°04'51"N, 156°54'38"E, alt. 61 m, on *Betula ermanii* branch, 18 viii 2002, *D. Himelbrant* & *E. Kuznetsova* (LECB 12-049); Ust'-Bol'sheretsk District, Pravyy Kikhchik River basin, 53°34'23"N, 156°41'05"E, alt. 236 m, on *Crataegus chlorosarca* branch, 4 viii 2004, *D. Himelbrant* & *E. Kuznetsova* (LECB 12-043); Ust'-Kamchatsk District, Yelovka River basin, right bank of Yelovka River near the estuary of Levaya River, 56°53'00"N, 160°55'06"E, alt. 160 m, on *Picea ajanensis* branch, 25 viii 2003, *D. Himelbrant* & *E. Kuznetsova* (LECB 12-044). *Khabarovskiy Krai*: Bogorodskoe-De Kastri route, 200 m N of junction to Savinskoe, 2·7 km E of Amur River bank, on *Larix gmelinii*, elev. 64 m, 52°09·954'N, 140°24·597'E, 2009, *C. Printzen* 11641 (FR); Komsomolsk-De Kastri route, Khomi Mountains, *c.* 20 air km E of Chernyy Mys, hills on north bank of Salasu River, 51°05·896'N, 138°46·303'E, on *Picea* twig, 316 m elev., 2009, *T. Spribille* 30496 (GZU). *Magadanskaya Oblast'*: Magadan Reserve, 60°44'26"N, 146°08'17"E, on *Alnus*, 17 vii 2010, *E. A. Zheludeva* (VLA). [*Sakhalinskaya Oblast'*]: Sakhalin Island, road to mud volcanoes near village of Klyuchi, top of the ridge, 47°11'N, 142°35'E, on *Larix*, 2005, *A. V. Galanin* S-C1-05, *I. A. Galanina* S-06-C1-1 (VLA); Sakhalin Island, Susunayskiy Ridge, near Yuzhno-Sakhalinsk, Ostraia Mountain, 46°58'38·29"N, 142°46'14·43"E, 350 m alt., on *Sorbus*, 2011, *A. K. Ezhkin* 17R-11 (VLA); Sakhalin Island, Dolinsky District, N of Firsovo, 47°38'N, 142°34'E, on dry twig, 2008, *N. A. Tsarenko* & *S. V. Nesterova* S-W-27-02E-3 (VLA); Sakhalin Island, Nogliksky District, vicinity of Val, bank of River Evay, 52°19'N, 143°03'E, 2009, *A. V. Bogacheva* & *V. Y. Barkalov* S-09-83-1 (VLA); Sakhalin Island, Smirnihovsky District, vicinity of Pobedino, 49°49'N, 142°46'E, on twig, 2009, *N. A. Tsarenko* S-W08-18-02NW-6 (VLA); Sakhalin Island, Tymovsky District, S of Palevo, 50°36'33"N, 142°41'27"E, 20 ix 2008, *N. A. Tsarenko* (VLA). *Zabaikal'skiy Krai*: Aginskiy Buryatskiy Autonomous Okrug, Alkhanay Nat. Park, 3·5 km E of ranger station 'Ara-Ilya', fold 'Niznyaya Tangaya', on *Pinus*, 50°56'35"N, 113°14'32"E, alt. 883 m, 6 vii 2006, *L. S. Yakovchenko* (VLA); Sokhondinskiy Biosphere Zapovednik, 2 km N of Agutsakan forest station, on *Betula*, 49°36·611'N, 111°19·477'E, alt. 1125 m, 23 vii 2006, *L. S. Yakovchenko* (VLA); Sokhondinskiy Biosphere Zapovednik, road between forest stations Shergen-Daban and Ust'-Bablashniy, right bank Burecha River valley, on *Picea*, 49°44·945'N, 110°50·822'E, alt. 1464 m, 2 vii 2007, *L. S. Yakovchenko* (VLA).

## Rinodina sibirica H. Magn.

*Svensk Bot. Tidskr.* **30:** 261 (1936); type: [Russia:] Siberia, Jenisejsk, Kolmogorova, 59°30'N lat., 3 Oct 1876, *M. Brenner* 462c (S—lectotype (f. *typica* H. Magn.) Sheard 2010).

*Rinodina sibirica* is characterized by apothecia that may be erumpent when young but quickly become narrowly attached, sometimes almost stipitate, and the discs of older apothecia may become convex (even half globose) and/or pruinose due to the surface accumulation of hymenial gelatin (Sheard 2010). The ascospores are intermediate between the *Physcia*- and *Physconia*-types, possessing rather narrow lumen canals in immature spores and becoming darkly pigmented with a prominent torus. The spore type and structure suggest that *R. sibirica* might be related to the *R. archaea* species aggregate, although it was not included in the study of that group by Mayrhofer & Sheard (2007). It is perhaps most closely related to *R. orculata* Poelt & M. Steiner which has smaller but otherwise very similar spores. In the present collections it was noted that spore development may be asynchronous and this may lead to the full development of only four spores per ascus. *Rinodina sibirica* may be similar in its external morphology to *R. cinereovirens* but it lacks sphaerophorin and, therefore, crystals in the medulla are absent. The spores of *R. sibirica* are also smaller, averaging 20·5–21·5 × 10·0–10·5 µm (Sheard 2010), than those of *R. cinereovirens* which average 23·0–25·5 × 11·5–13·5 µm, as quoted above.

Previously known from subarctic North America (Sheard 2010) and Siberia (Magnusson 1947), and previously reported from the central Russian Far East (Urbanavichus & Andreev 2010). The distribution of *R. sibirica* is similar to that of *R. freyi* and *R. septentrionalis*, occupying a band across the northern half of our study area (Fig. 7A).

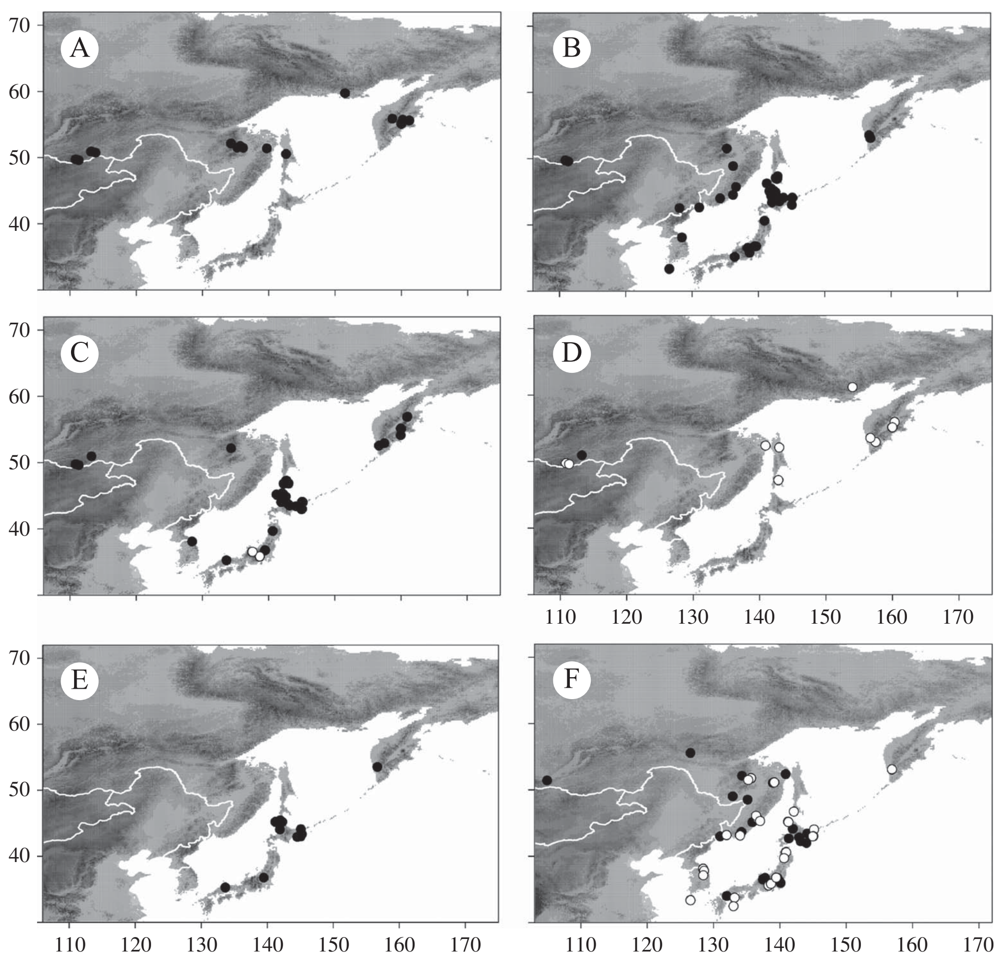


FIG. 7. Distribution of *Rinodina* species in north-eastern Asia (cont.) A, *R. sibirica*; B, *R. subminuta*; C, *R. subparieta* (solid circles: sorediate thalli; open circles: fertile non-sorediate thalli); D, *R. turfacea* (solid circle = record from soil; open circles = lichenicolous records on *Lobarina scrobiculata*); E, *R. willeyi*; F, *R. xanthophaea* (solid circles = previous records; open circles = new records).

https://doi.org/10.1017/S0024282917000536 Published online by Cambridge University Press

*Selected specimens examined.* **Russia:** *Kamchatka Krai*: Bystrinsky District, Bystrinsky Nat. Park, Gorgochan Pass, 55°51'48"N, 158°38'40"E, alt. 686 m, on *Betula platyphylla*, 18 viii 2003, *D. Himelbrant* & *E. Kuznetsova* (LECB 12-042); Mil'kovo District, Kamchatka River basin, SW slope of Tobalchik Volcano, *c.* 40–43 km SE of Kozyrevsk, near the Bubochka hill, 55°43'54"N, 160°11'27"E, alt. 680 m, on *Alnus fruticosa*, 10 viii 2006, *D. Himelbrant* (LECB 12-016 with *R. septentrionalis*); Mil'kovo District, Kronotsky Nature Reserve, Levaya Schapina River basin, right bank of Ipuin River, 55°06'05"N, 159°59'22"E, alt. 280 m, 10 viii 2009, *D. Himelbrant* & *I. Stepanchikova* (LECB 12-020, 12-025, with *R. subparieta*); Kronotsky Nature Reserve, Levaya Schapina River basin, mouth of Ipuin River, 55°06'55"N, 159°57'45"E, alt. 280 m, on old *Crataegus chlorosarca*, 8 viii 2009, *D. Himelbrant* & *I. Stepanchikova* (LECB 12-058 with *R. subparieta*, *R. septentrionalis*); Ust'-Kamchatsk District, Kamchatka River basin, WSW slope of Shiveluch Volcano, *c.* 31 km NE of Kluchi, 56°33'60"N, 161°12'19"E, alt. 721 m, on *Betula ermanii*, 24 viii 2002, *D. Himelbrant* & *E. Kuznetsova* (LECB 12-033). *Khabarovskiy Krai*: Komsomolsk-De Kastri route, Khomi Mountains, 14 km ESE of Reshayushchiy, 51°23·030'N, 139°41·948'E, on *Abies nephrolepis*, 132 m elev., 2009, *T. Spribille* 30597 (GZU); Moni station on BAM railroad, along main route between Komsomolsk and Berezovyy, 34 km (air line) SE of crossing of Amgun', 51°28·322'N, 136°07·591'E, on *Betula*, 349 m elev., 2009, *T. Spribille* 31277 (GZU); foothills of Etkil'-Yankanskiy Mountains, Amgun' River region, 9·7 km (air line) due N of Berozovyy, 51° 46·193'N, 135°41·045'E, on *Picea* twigs, 550 m, 2009, *T. Spribille* 31285 (GZU), *C. Printzen* 11795, 11813 (FR); Sonakh River, Amgun' River region, *c.* 7·6 km NW of main Berezovyy-Badzhal route, 51°30·411'N, 135° 14·111'E, on *Alnus* twigs, 342 m elev., 2009, *T. Spribille* 31389 (GZU); Sonakh River, Amgun' River region, *c.* 7·6 km NW main Berezovyy-Badzhal route, on *Rhododendron*, elev. 330 m, 51°30·363'N, 135°14·221'E, 2009, *C. Printzen* 11880 (FR); Bureinskiy Zapovednik, upper reach of Pravaya Bureya River, Tsarskaya Doroga, *c.* 650 m N of patrol cabin 'Staraya Medvezhka', 52°09·002'N, 134°19·035'E, on ?*Alnus*, 872 m, 2009, *T. Spribille* 31737 (with *R. subparieta*), 31761 (both GZU). *Magadanskaya Oblast'*: vicinity of Klepka, 59°44'N, 151°29'E, on dry *Larix* twig, 2002, *A. Iamborko* M-02-1 (VLA). [*Sakhalinskaya Oblast'*:] Sakhalin Island, Tymovsky District, 441 km federal highway, 50°32'N, 142°36'E, *Betula*, 2008, *N. A. Tsarenko* S-W08-19-03W-7 (VLA). *Zabaykalskiy Krai*: Nat. Park Alkhanay, Ara-Ilya forest station, steppe, on *Betula* and *Populus*, 50°54'06·4"N, 113°09'10·8"E, 8 vii 2006, *L. S. Yakovchenko*; on *Betula,* 50°56'35·1"N, 113° 14'32·14"E, alt. 883 m, 6 vii 2006, *L. S. Yakovchenko*; Duldurginskiy District, south-east of Toptanay, 50° 44'30"N, 113°51'51"E, 14 vii 2006, *L. S. Yakovchenko* (all VLA); Sokhondinskiy Biosphere Zapovednik, 2 km N of Agutsakan forest station, Agutsakan River flood plain, on *Betula*, 49°36·611'N, 111°19·477'E, alt. 1125 m, 23 vii 2006, *L. S. Yakovchenko* (VLA); Aginskiy Buryatskiy Autonomous Okrug, Alkhanay Nat. Park, 3·5 km E of ranger station 'Ara-Ilya', fold 'Niznyaya Tangaya', on *Pinus*, 50°56'35"N, 113°14'32"E, alt. 883 m, 6 vii 2006, *L. S. Yakovchenko* (VLA).

## Rinodina sicula H. Mayrhofer & Poelt

*Biblioth. Lichenol.* **12:** 143 (1979); type: Italy, Sicilia, Messina, Monti Nebrodi, 1978, *Hertel* & *Hertel* 19609 (M—holotype).

A rare saxicolous species in Europe (Mayrhofer & Moberg 2002; Mayrhofer & Sheard 2007) characterized by its *Physconia*-type ascospores and the presence of gyrophoric acid in the apothecium margin (C+ faint red under the compound microscope, and PL+). The material studied from our area is very poorly developed, lacking a thallus, and only possessing apothecia sitting in the centre of black, radiating and fimbriate prothalli. The spores are larger and more narrowly ellipsoid than the size quoted in the above references (21·0–24·0 × 9·0–10·0 µm, $n = 8$) but their structure is characteristic of the species. The specimens are too small to be examined for gyrophoric acid using TLC.

*Rinodina sicula* was previously known from southern Sweden and Denmark, and other scattered localities across Europe (Mayrhofer & Sheard 2007). This is a new record for Russia (Fig. 3D).

*Specimens examined.* **Russia:** *Kamchatka Krai*: Tigil' District, vicinity of Palana, 59°05'N, 159°56'E, vii 2003, *Bakalin* (LECB 12-038). *Magadan Region*: Omsukchanskiy District, 500 km NE from Magadan, foothills of Kilganskie Range, vicinity of mining camp Dzuletta, 61°11'43·3"N, 153°58'34·9"E, 1321 m alt., 2012, *L. S. Yakovchenko* M-12-27-1 (VLA). *Zabaikal'skiy Krai*: Sokhondinskiy Biosphere Zapovednik, 4 km NE of Agutsakan forest station, 49°43·47'N, 111°66·12'E, 27 vii 2006, *L. S. Yakovchenko* (VLA).

## Rinodina subalbida (Nyl.) Vain.

*Bot. Mag., Tokyo* **35:** 62 (1921).—*Lecanora subalbida* Nyl., *Lich. Japon.*: 40 (1890); type: Japan, Vega Expedition (1879) *Almquist* s. n. (H-Nyl. p.m. 2998—lectotype, designated here).

*Thallus* light grey, often darker grey to grey-brown, at first comprised of isolated, thin areoles scattered on a dark prothallus, areoles becoming contiguous, usually thick, sometimes merging to form a continuous or typically rimose-areolate thallus; areoles to (0·80–)1·20–1·40 mm diam.; surface sometimes plane, typically becoming rugose or verrucose, matt; margin determinate, delimited by a blackish, continuous to fimbriate prothallus, narrower and entire adjacent to other species; vegetative propagules absent.

*Apothecia* often erumpent, remaining broadly attached, frequent, contiguous or not, to 0·60–1·20 mm diam.; *disc* black, concave or plane, sometimes becoming convex, even half spherical, frequently pruinose; thalline margin concolorous with thallus, *c.* 0·10 mm wide, typically persistent but sometimes becoming excluded when disc half spherical; excipular ring absent, or confluent or raised, rarely forming proper margin when thalline margin incomplete. *Thalline exciple* (40–)55–80 µm wide laterally; cortex poorly organized, epinecral layer 5–15 µm wide; crystals present in medulla and cortex (pannarin); cortical cells mostly obscured by crystals, to 3·5–4·5 µm wide, not pigmented; algal cells 8·0–14·5 µm long; *proper exciple* hyaline or light brown, 10–15 µm wide (unless thalline margin absent and then *c.* 55 µm wide and carbonized), expanding to 20–45 µm wide above. *Hymenium* hyaline or lightly pigmented, 90–120 µm high, not inspersed; *paraphyses* 2·0–2·5 µm wide, strongly conglutinate, apices 3·0–4·0 µm wide, hardly pigmented, immersed in dispersed pigment, forming a red-brown epihymenium, crystals (pannarin) typically present. *Asci* 70–90 × 23–28 µm; *ascospores* (4–)8 per ascus, type A development, *Teichophila*-type, (19·0–)22·0–26·5(–29·0) × (10·5–)12·0–14·0(–15·0) µm ($n = 189$), l/w ratio (1·6–)1·7–2·0(–2·2); lumina *Physcia*-like at first although with relatively thick lateral walls, finally *Pachysporaria*-like, not inflated at septum in KOH, often slightly constricted at the septum when mature; torus well developed at maturity (Fig. 9), walls not ornamented. *Hypothecium* hyaline or light reddish brown, 50–80 µm deep.

*Pycnidia* not seen.

*Chemistry.* Spot tests K−, C−, P+ cinnabar. Secondary metabolites: pannarin in cortex and medulla, ± zeorin (in medulla only?), unknown A7, B7 (deep blue in LW), C7 or often B7 only, usually present in absence of zeorin; pannarin also in epihymenium (red needles in alcoholic P), causing pruinosity of discs in older apothecia.

A full description of this corticolous species is given above for the first time. *Rinodina subalbida* is a rather variable species in its external morphology. The thallus, at maturity, is typically rugose to verrucose and the apothecia, although most commonly plane, may become convex or rarely half-spherical with the exclusion of the thalline margin. The apothecial variation is added to by the presence of disc pruinosity in many mature specimens, reflecting the accumulation of pannarin in the epihymenium. The developmental variablity of the *Teichophila*-type ascospores is typical (Sheard 2010), the lumina being *Physcia*-like when immature and later becoming more rounded and *Pachysporaria*-like.

The habit (but not the colour) of young thalli of *Rinodina subalbida* (Fig. 9) and the structure of its spores are reminiscent of the recently described *R. campestris* Sheard & C. A. Morse from the central plains of North America (Sheard *et al.* 2011). However, *R. subalbida* is well distinguished by the presence of pannarin in both the thallus and epihymenium. Very rarely (*Tønsberg* 22750) verrucate thalli approach the bullate morphology of *R. excrescens* and it is then best distinguished by the presence of zeorin, which is normally absent in *R. excrescens*, and by the smaller, *Physcia*-type spores of the latter species. *Rinodina subalbida* is also similar to *R. bolanderi* H. Magn., from coastal California and the Georgia Straits area of British Columbia, in its *Teichophila*-type spores and general habit but differs in its smaller apothecia and thallus containing pannarin rather than atranorin.

The spores of *R. subalbida* are similar in size and shape to the *Teichophila*-type spores of *R. buckii*, but they are more *Physcia*- and less *Pachysporaria*-like than the latter species. Another apothecial similarity of the two species is their lightly pigmented hypothecium. Although the thalli of both species are also somewhat similar in being verrucose, *R. subalbida* is never sorediate. Unlike *R. subalbida*, pannarin is not present in the epihymenium of *R. buckii*.

Nylander's description of the species refers to both corticolous and saxicolous material, causing an obvious challenge for lectotypification. A specimen in S (Nagasaki, 1879, *Almquist*), mentioned in the type description, is saxicolous but is not conspecific with the corticolous material deposited in H-Nyl. Mayrhofer (1984) referred the saxicolous specimen to *Rinodina compensata*. Two other corticolous specimens in H-Nyl. represent young thalli in which the thallus itself is thinner than typical, and also some apothecia are eroded, perhaps eaten away by invertebrates. Both have crystals in their medulla and epihymenium. The spores of both belong to the *Teichophila*-type and fall within the range of the more luxuriant material measured above. One of these specimens (H-Nyl. 2884) is from a locality (Simonosaki) not listed among the paratypes. The other, H-Nyl. 2998, has no locality reference other than "Japonia, Vega exp." but is cited as "Jap. p. 40" in the type description. This specimen is accordingly selected here as the lectotype of *R. subalbida*.

*Rinodina subalbida* was described from Japan and is new to South Korea and the southern part of far eastern Russia (Fig. 8A).

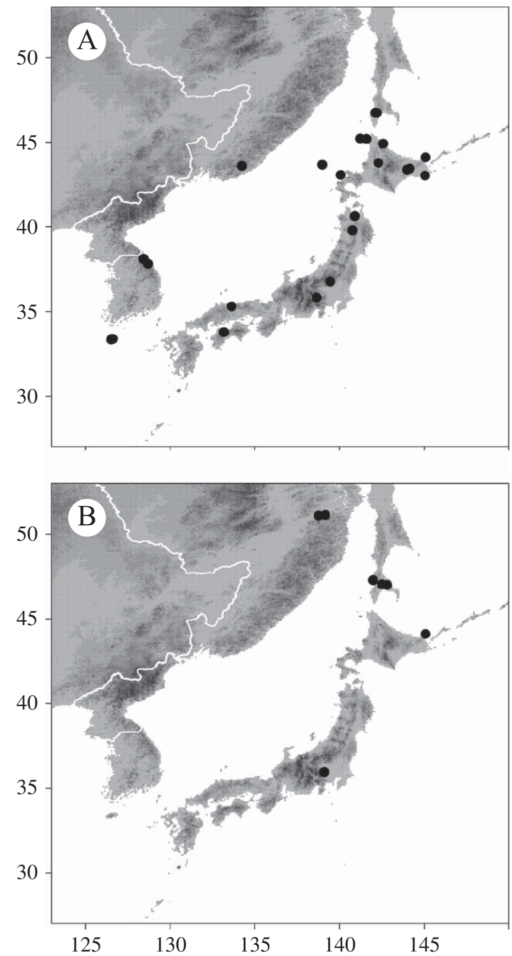


FIG. 8. Distribution of *Rinodina* species in north-eastern Asia (cont.) A, *R. subalbida*; B, *R. tenuis*.

*Selected specimens examined.* **Japan:** *Hokkaido*: Ishikari Prov., nr. Mt. Arashiyama, Asahikana City, 43°47'N, 142°18'E, *A. Shimizu* 1541, 1551 (TNS with *R. ascociscana*); Kitami Prov., Esashi-gun, Esashi-cho, 2 km S of town of Honcho, just SW of road 238, 44°55'N, 142° 35'E, alt. 10–20 m, on *Abies sachalinensis*, 1995, *T. Tønsberg* 22750 (BG); Rishiri-gun, Rishiro-to Island, Oshidomari area, 45°13'N, 141°13'E, on *Picea*, *G. Thor* 13749 (TNS); Shiretoko Nat. Park, 9 km NE of Utoro Village, along trail around Shiretoko-goko Lakes, 44° 07'N, 145°05'E, alt. 260 m, on *Prunus*, 1995, *T. Tønsberg* 22804 (BG with *R. subparieta*), 22905 (BG with *R. buckii*); Kushiro Prov., Akan-gun, Taro-ko to Mt. O-akan trail, 43°27'N, 144°09'E, on *Sorbus*, *Y. Ohmura* 1488 (TNS); Akkeshi-gun, Hamanaka-cho, 55 km E of Kushiro City, 3 km E of Hichirripputo Lake, 43°02'N, 145°03'E, alt. 60 m, on *Sorbus*, 1995, *T. Tønsberg* 22931, 22932, 22933 with *R. willeyi* (all BG); Teshio Prov., Teshio-gun, Toyotomi-cho, 35 km NNW of the small town of Teshio along small road 2·5 km from coast, 45° 12'N, 141°36'E, alt. 10–20 m, on *Quercus serrata* var. *grosseserrata*, 1995, *T. Tønsberg* 22224 (BG); Tokachi Prov., Ashoro-gun, Lake Onneto, 43°23'N, 143°59'E, on *Picea, Y. Ohmura* 1794 (TNS). *Honshu*: Kozuke Prov., Minakami, Takaguwa Hotspring, 34°40'N, 138° 59'E, *K. Tsunoda* 744 (TNS); Bizen Prov. (Okayama Pref.), Maniwa-gun, Kawakami-mura, 1–2·3 km N of Hiruzen Research Institute, on exposed tree at roadside, alt. 500–550 m, 35°18'N, 133°38'E, 1994, *G. Thor* 12220 (TNS & UPS); Mutsu Prov. (Aomori Pref.), Mt. Hakkoda, *c.* 3 km E of Kasamatsu Pass along route 103, on *Fagus crenata*, alt. 850 m, 40°38'N, 140°54'E, 1994, *G. Thor* 11895 (TNS & UPS with *R. xanthophaea* and *R. subminuta*); Kai Prov. (Yamanashi Pref.), Makioka-cho, Yamanashi-City, road to Odarumi Pass, on *Salix* sp., alt. 1726 m, 35°49·172'N, 138°38·963'E, 2012, *G. Thor* 28176 (UPS); Prov. Tohoku (Prefecture Akita), Nikko City, 14 km WNW of Nikko and 4 km SE of Yumoto Village, field station Nikko Shizen Fureai House on *Malus toringo*, elev. 1400 m, 36°46'11·2"N, 139° 27'21·8"E, 2015, *G. Thor* 32322 (UPS); 11 km NE Lake

Tazawa, 2 km SSW of Tsuru-no-yu Onsen, on old *Quercus*, alt. 616 m, 39°47·303'N, 140°46·405'E, 2013, *G. Thor* 29787 (UPS). *Shikoku*: Kochi Pref., Ino-cho Town, along path from road to small and steep hill Mt. Komochi-gon'gen, on *Hydranga paniculata*, alt. 1610–1630 m, 33°46'49–54"N, 133°11'16–19"E, 2006, *G. Thor* 21364 (UPS).—**Russia:** *Primorskiy Krai*: Sikhote-Alin' Mountains, 25 km (air line) ESE of Yasnoye, hunting/fishing base camp near river, 43°36·058'N, 134° 14·315'E, on *Picea jezoensis*, 2007, *T. Spribille* 23492 (GZU). [*Sakhalinskaya Oblast'*:] Sakhalin Island, Nevelskiy Pass, mixed forest, 46°44'35·92"N, 142° 6'21·02"E, 425 m alt., on *Sorbus*, 6 xi 2013, *A. K. Ezhkin* (VLA).—**South Korea:** *Cheju Island*: along the Young-shil trail on west slope of Mt. Halla, on dead *Abies koreana*, alt. 1650–1700 m, 33°21'N, 126°32'E, 2001, *G. Thor* 17001 (AK & UPS); rim surrounding crater of Mt. Halla, on dead *Berberis amurensis*, alt. 1850–1950 m, 33° 22'N, 126°33'E, 2001, *G. Thor* 17057 (AK & UPS); Namcheju-gun, Namwon-up, along Songpanak trail on east slope of Mt. Halla, from Songpanak Nat. Park office to Azalea field shelter, on dead deciduous tree, alt. 750–1500 m, 33°23'N, 126°37'E, 2001, *G. Thor* 17398 (AK & UPS); Cheju-shi, Odung-dong, Kwanumsa Temple, on deciduous tree, alt. 580 m, 33°25'N, 126°34'E, 2001, *G. Thor* 17634 (UPS). *Gangwon Prov.*: Gangrun City, Mt. Odae, Odaesan Nat. Park, on *Juglans*, alt. 240 m, 37° 49'N, 128°42'E, 2014, *A. Aptroot* 72636; Inje-gun, Mt. Seorak, Seoraksan Nat. Park, on *Abies*, alt. 1400–1600 m, 38°07'N, 128°27'E, 2014, *A. Aptroot* 73199 (both ABL); Yangyang-gun, Ser-myun, Osaeck-ri, southern part of the massif Sorak Mts, Sorak-san Nat. Park, south slope of Mt. Dachong, on exposed, dead *Abies* sp., alt. 1400–1350 m, 38°06·45–28'N, 128°26·00–25·10'E, 2006, *G. Thor* 20621 (AK with *R. chrysidiata*).

## Rinodina subminuta H. Magn.

*Bot. Not.* 44 1947; type: USA, New Hampshire, White Mountains, on *Acer saccharinum*, s. d., *E. Tuckerman* s. n. (S—lectotype; BG, DUKE, FH, L, UPS, US—isolectotypes, Sheard 2010).

*Rinodina erumpens* H. Magn., *Acta Horti Gotob.* **17:** 231 (21 Nov., 1947); type: Siberia, Yeniseisk, Gorinskij Volok, on *Sorbus aucuparia*?, 59.20N, 3 October 1876, *M. Brenner* 466j (S—lectotype, Sheard 2010).

The morphology and anatomy of the collections reported here are entirely consistent with records from eastern North America (Sheard 2010) including the erumpent apothecia, frequent presence of zeorin, and *Physcia*-type spores measuring (16·5–)18·0–21·0(–23·0) × (8·5–)9·0–10·0(–11·0) µm ($n = 144$), l/w ratio (1·8–)1·9–2·2(–2·4). *Rinodina subminuta* should not be confused with the newly described species *R. orientalis* which possesses a similar but mostly darker grey-brown thallus, erumpent apothecia and smaller *Physcia*-type spores. A more detailed comparison between the two species is made under that species. *Rinodina oleae* can also possess erumpent apothecia but has smaller *Dirinaria*-type spores (with *Physcia*-like lumina) that tend to inflate at the septum on application of KOH.

FIG. 9. *Teichophila*-type ascospores of *R. subalbida*, Japan, Honshu, Tohoku Prov., 11 km NE Lake Tazawa, *Thor* 29787, UPS. Note the variable shape of the lumina from *Physcia*- to *Pachysporaria*-like and the prominent tori. Scale = 10 µm.

Two specimens from Klondike Gold Rush National Historical Park (*Tønsberg* 39042, 39046) were identified as *Rinodina subminuta* by JWS in Spribille *et al.* (2010). On further examination, they have been shown to belong to *R. pallidescens* Sheard & Tønsberg. The latter has also been reported by Sheard *et al.* (2014) from Glacier Bay National Park (*Fryday* 10242, MSC), another locality in the northern part of the Alaskan Panhandle.

*Rinodina subminuta* is a new record for far eastern Asia, with a distribution spanning Russia, Japan and the Korean Peninsula (Fig. 7B) that is similar to that of *R. ascociscana* (Fig. 1A), *R. excrescens* (Galanina *et al.* 2011; see also Fig. 1F) and *R. subparieta* (Fig. 7C). It has a wide altitudinal range: in Japan it occurs from sea level to 1200 m in Hokkaido, and 855–1980 m in Honshu, whereas in South Korea its elevational range is 1650–1950 m on the southerly Cheju Island, and 1350–1400 m in the Sorak Mountains of Gangwon Province. It is one of six species in this study that have an exclusively eastern North American–East Asian distribution.

https://doi.org/10.1017/S0024282917000536 Published online by Cambridge University Press

*Selected specimens examined*. **Japan:** *Hokkaido*: Ishikari Prov., nr. Mt. Arashiyama, Asahikana City, 43°47'N, 142°18'E, *A. Shimizu* 1541, 1551 (TNS with *R. ascociscana*); Kitami Prov., Esashi-gun, Esashi-cho, 2 km S of town of Honcho, just SW of road 238, 44°55'N, 142° 35'E., alt. 10–20 m, on *Abies sachalinensis*, 1995, *T. Tønsberg* 22750 (BG); Rishiri-gun, Rishiro-to Island, Oshidomari area, 45°13'N, 141°13'E, on *Picea, G. Thor* 13749 (TNS); Shari-gun, Shiretoko Nat. Park, 44°07'N, 145°05'E, on *Alnus, G. Thor* 14342 (TNS); Kushiro Prov., Akan-gun, Taro-ko to Mt. O-akan trail, 43°27'N, 144°09'E, on *Sorbus, Y. Ohmura* 1488 (TNS); Akkeshi-gun, nr. Sanbanswana, 43°04'N, 140°04'E, *S. Arakawa* 1548 (TNS); Akkeshi-gun, Hamanaka-cho, 55 km E of Kushiro City, 3 km E of Hichiripputo Lake, 43°02'N, 145°03'E, alt. 60 m, on *Sorbus*, 1995, *T. Tønsberg* 22931, 22932, 22933 with *R. willeyi* (all BG); Teshio Prov., Teshio-gun, Toyotomi-cho, 35 km NNW of the small town of Teshio along small road 2·5 km from coast, 45° 12'N, 141°36'E, alt. 10–20 m, on *Quercus serrata* var. *grosseserrata*, 1995, *T. Tønsberg* 22224 (BG); Tokachi Prov., Ashoro-gun, Lake Onneto, 43°23'N, 143°59'E, on *Picea*, *Y. Ohmura* 1794 (TNS). *Honshu*: Kozuke Prov., Minakami, Takaguwa Hotspring, 34°40'N, 138° 59'E, *K. Tsunoda* 744 (TNS); Bizen Prov. (Okayama Pref.), Maniwa-gun, Kawakami-mura, 1–2·3 km N of Hiruzen Research Institute, on exposed tree at roadside, alt. 500–550 m, 35°18'N, 133°38'E, 1994, *G. Thor* 12220 (TNS & UPS); Mutsu Prov. (Aomori Pref.), Mt. Hakkoda, *c.* 3 km E of Kasamatsu Pass along route 103, on *Fagus crenata*, alt. 850 m, 40°38'N, 140°54'E, 1994, *G. Thor* 11895 (TNS & UPS with *R. xanthophaea* and *R. subminuta*); Kai Prov. (Yamanashi Pref.), Makioka-cho, Yamanashi-City, road to Odarumi Pass, on *Salix* sp., alt. 1726 m, 35°49·172'N, 138°38·963'E, 2012, *G. Thor* 28176 (UPS); Prov. Tohoku (Prefecture Akita), Nikko City, 14 km WNW of Nikko and 4 km SE of Yumoto Village, field station Nikko Shizen Fureai House on *Malus toringo*, elev. 1400 m, 36°46'11·2"N, 139° 27'21·8"E, 2015, *G. Thor* 32322 (UPS); 11 km NE of Lake Tazawa, 2 km SSW of Tsuru-no-yu Onsen, on old *Quercus*, alt. 616 m, 39°47·303'N, 140°46·405'E, 2013, *G. Thor* 29787 (UPS). *Shikoku*: Kochi Pref., Ino-cho Town, along path from road to small and steep hill Mt. Komochi-gon'gen, on *Hydranga paniculata*, alt. 1610–1630 m, 33°46'49–54"N, 133°11'16–19"E, 2006, *G. Thor* 21364 (UPS).—**Russia:** *Primorskiy Krai*: Sikhote-Alin' Mountains, 25 km (air line) ESE of Yasnoye, hunting/fishing base camp near river, 43°36·058'N, 134° 14·315'E, on *Picea jezoensis*, 2007, *T. Spribille* 23492 (GZU). [*Sakhalinskaya Oblast'*:] Sakhalin Island, Nevelskiy Pass, mixed forest, 46°44'35·92"N, 142° 6'21·02"E, 425 m alt., on *Sorbus*, 6 xi 2013, *A. K. Ezhkin* (VLA).—**South Korea:** *Cheju Island*: along the Youngshil trail on west slope of Mt. Halla, on dead *Abies koreana*, alt. 1650–1700 m, 33º21'N, 126º32'E, 2001, *G. Thor* 17001 (AK & UPS); rim surrounding crater of Mt. Halla, on dead *Berberis amurensis*, alt. 1850–1950 m, 33º22'N, 126º33'E, 2001, *G. Thor* 17057 (AK & UPS); Namcheju-gun, Namwon-up, along Songpanak trail on east slope of Mt. Halla, from Songpanak Nat. Park office to Azalea field shelter, on dead deciduous tree, alt. 750–1500 m, 33°23'N, 126°37'E, 2001, *G. Thor* 17398 (AK & UPS); Cheju-shi, Odung-dong, Kwanumsa Temple, on deciduous tree, alt. 580 m, 33°25'N, 126° 34'E, 2001, *G. Thor* 17634 (UPS). *Gangwon Prov.*: Gangrun City, Mt. Odae, Odaesan Nat. Park, on *Juglans*, alt. 240 m, 37°49'N, 128°42'E, 2014, *A. Aptroot* 72636; Inje-gun, Mt. Seorak, Seoraksan Nat. Park, on *Abies*, alt. 1400–1600 m, 38°07'N, 128°27'E, 2014, *A. Aptroot* 73199 (both ABL); Yangyang-gun, Ser-myun, Osaeck-ri, southern part of the massif Sorak Mts, Sorak-san Nat. Park, south slope of Mt. Dachong, on exposed, dead *Abies* sp., alt. 1400–1350 m, 38°06·45–28'N, 128°26·00–25·10'E, 2006, *G. Thor* 20621 (AK with *R. chrysidiata*).

## Rinodina subparieta (Nyl.) Zahlbr.

*Cat. Lich. Univers.* **7:** 554 (1931).—*Lecanora subparieta* Nyl., *Acta Soc. Sci. Fenn.* **26:** 30 (1900); type: Japan, Itchigômé, 1879, *Almquist* (H-Nyl. 28856—holotype!).

*Rinodina degeliana* Coppins, *Lichenologist* **15:** 147 (1983); type: Sweden, Lule Lappmark, Kvikkjokk parish, south-east slope of Nammatj, 66°56'N, 17°42'E, alt 520 m, on *Salix* bark in *Picea* woodlands, 28 July 1977, *B. J. Coppins* 6238 & *L. Tibell* (E—holotype!; UPS—isotype!).

*Rinodina subparieta* is distinguished by its thallus structure which is composed of light grey, scattered areoles, with abundant atranorin, mostly with whitish soredia first forming along the areole margins in a labriform or sublabriform manner. The areoles may occasionally merge in later development to form a more continuous thallus and the soredia frequently spread to cover the areole surfaces. Molecular studies (Resl *et al.* 2016) have shown that the sorediate *R. degeliana* must be regarded as a synonym of the non-sorediate *R. subparieta*, which was previously known only from high elevations in Honshu and thought to be endemic to Japan.

A characteristic of *Rinodina* species possessing vegetative diaspores is that, when fertile, spore size and structure are variable. *Rinodina degeliana* was originally described as possessing *Dirinaria*-type spores (Coppins 1983) but was reported to have *Physcia*-type spores by both Mayrhofer & Moberg (2002) and Sheard (2010). However, Sheard (2010) questioned the distinction between the *Physcia*- and *Physconia*- spore types, suggesting that specimens exhibiting the *Physcia*-spore type merely exhibit an arrested stage of spore development, a very common feature of the species in Europe and North America. It is important to note that the type specimens of both *R. subparieta* and *R. degeliana* have fully developed *Physconia*-type spores at maturity and this seems to be a constant feature of the non-sorediate Japanese collections. All spores are also characterized by the possession of an obvious torus and dark, strongly ornamented walls. The molecular phylogeny of Resl *et al.* (2016) showed that the eastern North American and the Japanese collections are more closely related to each other than to samples from elsewhere in the Northern Hemisphere, although this relationship was not statistically significant.

*Rinodina subparieta* is relatively frequent in Hokkaido where it is found from close to sea level to 1100 m elevation. It is less frequent in Honshu and found from 500–2550 m, and the single record from South Korea, from where it is reported for the first time, is at 1350–1400 m. It was previously reported as *R. degeliana* from Kamchatka (Himelbrant & Stepanchikova 2011), from the central Russian Far East by Urbanavichus & Andreev (2010) and from the Khentey region of Mongolia by Hauck & Javkhlan (2006). Its distribution in our study area (Fig. 7C) is comparable to *R. ascociscana*, *R. excrescens* and *R. subminuta*. As *R. degeliana*, the species has been reported as widely distributed in the Northern Hemisphere but is rather infrequently collected. It is found in Scotland (Giavarini *et al.* 2009), Scandinavia and Austria (Tønsberg 1992*a*; Mayrhofer & Moberg 2002), and eastern and western North America (Sheard 2010; Spribille *et al.* 2010).

*Selected sorediate specimens examined.* **Japan:** *Hokkaido*: Ishikari Prov., Kamikawa-gun, Kamikawa-cho, 0·5–1·5 km E of Obako Gorge Tourist Centre, on *Abies sachalinensis*, alt 720 m, 43°42'N, 143°01'E, 1995, *G. Thor* 14624 (UPS with *R. buckii*); Kitami Prov., Esashi-gun, Esashi-cho, 2 km S of Honcho, on *Larix*, alt. 10–20 m, 44°55'N, 142°35'E, 1995, *G. Thor* 14251 (UPS with *R. buckii*); Shiretoko Nat. Park, NW slope of Shiretoko Peninsula *c.* 10 km NE of Utoro Town, along the trail from Iwaobetsu hot-spring hotel (Onsen) to Mt. Rausu-dake, on *Taxus cuspidata*, alt. 388 m, 44·10611° N, 145·09242°E, 2010, *G. Thor* 23978 (UPS); Kushiro Prov., Akkeshi-gun, Akkeshi-cho, 44 km E of Kushiro City, S Akkeshiko Lake, on *Quercus mongolica* var. *grosseserrata*, alt. 120 m, 42°60'N, 144°57'E, 1995, *G. Thor* 14486 (UPS); Nemuro Prov., Shiretoko Peninsula, Menashi-gun, Rausu-cho, just S of road 334 crossing Shiretoko Peninsula, 4 km WNW of Sakae City, Rausu hot spring, on *Alnus* sp., alt. 130 m, 44°02'N, 145°09'E, 1995, *G. Thor* 14406 (UPS with *R. xanthophaea*); Teshio Prov., Rumoi-gun, Obira-cho, 21 km ENE of small town of Obira at the coast, along the trail from parking area to Tengunotaki Waterfall, 44°04'N, 141°55'E, alt. 50–100 m, on *Betula*, 1995, *T. Tønsberg* 21995 (BG with *R. hypobadia*); alt. 130–150 m, on *Abies sachalinensis*, 1995, *T. Tønsberg* 21994, 22010 (BG); alt. 160 m, *T. Tønsberg* 22018 (BG); Teshio-gun, Toyotomi-cho, Rishiri-Rebun-Sarobetsu Nat. Park, 23 km NNW of the small town of Teshio at coast, Wakasakanai area, S of road from coast to the town of Toyotomi, on dead *Salix* sp., alt. 20 m, 45°05'N, 141°39'E, 1995, *G. Thor* 13614 (UPS); Tokachi Prov., Kato-gun, Kamishihoro-cho, 6 km S of Mikuni tunnel through Mt. Mikuni-yama, just W of road 273, on dead deciduous tree, alt. 680 m, 43° 32'N, 143°09'E, 1995, *G. Thor* 14581 (UPS). *Honshu*: Bizen Prov. (Okayama Pref.), Maniwa-gun, Kawakami-mura, 1–2·3 km N of Hiruzen Research Institute, on exposed tree at roadside, alt. 500–550 m, 35°18'N, 133° 38'E, 1994, *G. Thor* 12212 (UPS with *R. willeyi*); Etchu Prov. (Toyama Pref.), Nakashinkawa-gun (Nakanii-kawa-gun), Tateyama-cho, 25 km ESE of Toyama, Bijodaira, path S of Bijodaira bus stop, on old deciduous tree, alt. 960–980 m, 36°35'N, 137°28'E, 1994, *G. Thor* 12664 (UPS); Kai Prov. (Yamanashi Pref.), Makioka-cho, Yamanashi-City, at road to Odarumi Pass, on *Prunus* sp., alt. 1726 m, 35°49·172'N, 138°38·963'E, 2012, *G. Thor* 28169 (UPS); Shimotsuke Prov. (Tochigi Pref.), 20 km WNW of Nikko, 1 km S of Yumoto Village, 36° 48'N, 139°26'E, Yudaki Falls, on deciduous tree, alt. 1440–1480 m, 1994, *G. Thor* 12771 (UPS with *R. xanthophaea*); 13 km NW of Nikko and 5 km ESE of Yumoto Village, on *Alnus* sp., elev. 1640 m, 36° 47'59·0"N, 139°28'59·2"E, 2015, *G. Thor* 32481; Prov. Tohoku (Prefecture Akita), W shore of Lake Tazawa, outlook at Katamaeyama Woods Park, on old *Castanea japonica*, alt. 336 m, 39°42·995'N, 140°37·759'E, 2013, *G. Thor* 29757 (all UPS).—**Russia:** *Kamchatka Krai*: Elizovo District, Kronotsky Nature Reserve, Pikhtovaya Growe, 54°08'N, 159°56'E, alt. 25–50 m, *Abies gracilis*, 2009, *L. I. Rassokhina* (LECB 12-055); xii 2010, *L. I. Rassokhina* (LECB); Mil'kovo District, Kronotsky Nature Reserve, Levaya Schapina River basin, right bank of Ipuin River, 55°06'05"N, 159°59'22"E, alt. 280 m, on *Alnus hirsuta* and *Picea ajanensis*, 10 viii 2009, *D. Himelbrant* & *I. Stepanchikova* (LECB 12-020 with *R. sibirica* and *R. efflorescens*, LECB 12-025 with *R. sibirica*); Ust'-Bol'sheretsk District, Bannaya River basin, right bank of the Bannaya River, 52°54'40"N, 157°28'28"E, alt. 270 m, on *Betula ermanii*, 8 viii 2002, *D. Himelbrant* & *E. Kuznetsova* (LECB k-445); Ust'-Kamchatsk District, Yelovka River basin, right bank of Yelovka River near estuary of Levaya River, 56°53'00"N, 160°55'06"E, alt. 160 m, on *Picea ajanensis* branch, 25 viii 2003, *D. Himelbrant* & *E. Kuznetsova* (LECB 12-044). *Khabarovskiy Krai*: Bureinskiy Zapovednik, upper reach of Pravaya Bureya River, Tsarskaya Doroga, *c.* 650 m N of patrol cabin 'Staraya Medvezhka', 25 km SE of Sofiysk and 2·6 km N (upstream) of patrol cabin 'Novaya Medvezhka', 52°09·002'N, 134°19·035'E, on *Alnus*, 872 m, 2 viii 2009, *T. Spribille* 31737 (GZU). *Sakhalinskaya Oblast'*: Sakhalin Island, 48th km of route Yuzhno-Sakhalinsk - Kholmsk, 46°50'N, 142°16'E, on *Abies*, *I. A. Galanina* S-C2-06; Sakhalin Island, 2 km north-east from Kluchi, 47°11'N, 142°35', on *Abies*, *I. A. Galanina* (VLA); Sakhalin Island, Dolinsky District, 106 km of federal highway, 47°17'N, 142°42'E, on *Alnus*, *A. V. Bogacheva*, *N. A. Tsarenko* S-T19-3 (VLA); Sakhalin Island, Yuzhno-Sakhahlinsk District, Yuzhno-Sakhalinsk, Mt. Tshekhov, on *Picea jezoensis*, elev. *c.* 390 m, 46°58'43·0"N, 142°49'24·5"E, 2004, *C. Printzen* 9179, 9188 (FR). *Zabaikal'skiy Krai*: Sokhondinskiy Biosphere Zapovednik, 2 km N of Agutsakan forest station, on *Betula*, 49°36·611'N, 111°19·477'E, alt. 1125 m, 23 vii 2006, *L. S. Yakovchenko* (VLA); Aginskiy Buryatskiy Autonomous Okrug, Alkhanay Nat. Park, 3·5 km E of ranger station 'Ara-Ilya', fold 'Niznyaya Tangaya', on *Pinus*, 50°56'35"N, 113°14'32"E, alt. 883 m, 6 vii 2006, *L. S. Yakovchenko* (VLA).—**South Korea:** *Gangwon Prov.*: Yangyang-gun, Ser-myun, Osaeck-ri, southern part of the Sorak Mts. massif, Sorak-san Nat. Park, the south slope of Mt. Dachong, on dead *Abies* sp., alt. 1400–1350 m, 38°06·45–28'N, 128°26·00–25·10'E, 2006, *G. Thor* 20620 (AK & UPS with *R. buckii*).

*Non-sorediate specimens examined.* **Japan:** *Honshu*: Etchu Prov., Nakasinkawa-gun, 33 km ESE of Toyama, Midagahara along path to Tateyama crater, lat. 36°34'N, long. 137°34'E, alt. 1960–2000 m., on dead, standing, *Abies mariesii*, 1994, *G. Thor* 12708 (UPS – duplicate in TNS, not seen); Kai Prov. (Yamanashi Pref.), Kofu-City, along trail between Odarumi Pass and Mt. Kinpu (Kimpō), old-growth, subalpine forest, on *Abies mariesii*, alt. 2552 m, 35°52·163'N, 138°37·930'E, 2012, *G. Thor* 27994 (UPS); Makioka-cho, Yamanashi-City, Odarumi Pass, near mountain hut, on *Abies mariesii*, alt. 2368 m, 35°52·171'N, 138°40·001'E, 2012, *G. Thor* 28096 (UPS); on *Sorbus* sp., *G. Thor* 28120 (UPS).

## Rinodina teichophila (Nyl.) Arnold

*Flora* **46:** 329 (1863).—*Lecanora teichophila* Nyl., *Flora* **46:** 78 (1863); type: [United Kingdom: England:] Cleveland, Ayton, Mudd, *Lich. Brit. Exs.* 108 as *R. exigua* var. *metabolica* Mudd (BM—lectotype, Mayrhofer & Moberg 2002).

This saxicolous species is characterized by its large *Teichophila*-type spores (20·0–32·0 × 11·0–19·0 µm) which are often swollen at the septum and more so in KOH (Mayrhofer & Moberg 2002; Sheard & Mayrhofer 2002) and lack of secondary substances in the thallus. It is widespread in the British Isles, scattered in Scandinavia, central and southern Europe, North Africa and Asia Minor (Mayrhofer & Moberg 2002) but absent from North America (Sheard 2010). It has also been recorded from Japan (Mayrhofer 1984; Kurokawa & Kashiwadani 2006), from Korea by Kondratyuk *et al.* (2013) and recently from four islands in Peter the Great Bay (Russia) in the Sea of Japan (Skirina 2010). The record of *Rinodina teichophila* reported by Aptroot & Moon (2014) represents the first record of *R. moziana* from Korea.

## Rinodina tenuis Müll. Arg.

*Nuov. Giorn. Bot. Ital.* **24:** 195 (1892); type: Japan, Honshu, Musashi Prov. [= Saitama Pref.], Mt. Buko, Chichibu, 3 April 1891, *Yatabe* 246 (G—holotype!; TNS—isotype!).

New synonym. *Rinodina adirondackii* H. Magn., *Bot. Not.* 48 1947; type: USA, New York, Essex Co., Adirondack Mountains, Chapel Pond, near St. Huberts, 1600 ft., on cedar in gully, 1933, *J. L. Lowe* 3751 (UPS—holotype!; NY—isotype!).

*Thallus* thin, light grey, quickly becoming continuous; surface plane, matt; margin indeterminate; prothallus lacking; vegetative propagules absent.

*Apothecia* erumpent, remaining broadly attached, frequent, rarely contiguous, 0·50–0·60 mm diam.; *disc* black, persistently plane, often eroded (eaten by invertebrates?); thalline margin concolorous with thallus, *c.* 0·10 mm wide, entire and persistent; excipular ring sometimes present, slightly raised. *Thalline exciple* (50–)80–100 µm wide laterally, cortex poorly developed, structure occluded by crystals, 5–15 µm wide; epinecral layer absent; crystals in cortex and medulla (pannarin); cortical cells 3·5–4·5 µm wide, not pigmented; algal cells 9·5–11·5 µm long; *proper exciple* hyaline to yellowish, 10–20 µm wide, expanding to 15–30 µm wide above. *Hymenium* 100–130 µm high, not inspersed; *paraphyses* 2·0–3·0 µm wide, conglutinate, apices expanded to 3·0–4·5 µm wide, not or slightly pigmented and immersed in dispersed pigment forming a light, red-brown epihymenium. *Asci* 80–100 × 24–35 µm; *ascospores* (4–) 8 per ascus, type A development, *Pachysporaria*-type I, (27·0–)32·0–35·5(–39·0) × (12·5–) 14·5–17·0(–18·5) µm ($n = 63$), l/w ratio (1·7–) 2·1–2·3(–2·6); lumina irregularly rounded to subpolygonal in immature spores, becoming

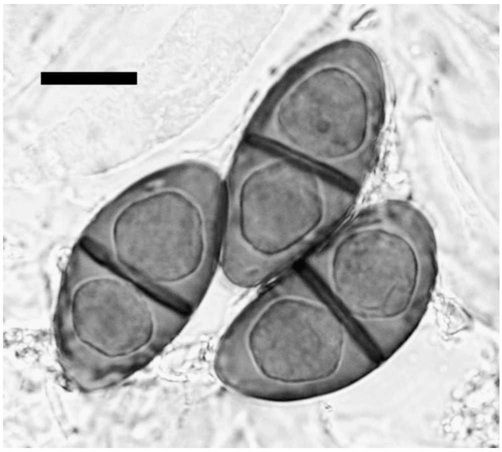

FIG. 10. *Pachysporaria*-type ascospores of *R. tenuis*, Japan, Honshu, Musashi Prov., Mt. Buko, 3 April 1891, *Yatabe* 246 (TNS—isotype). Note the well-developed tori and the close to spherical lumina. Scale = 10 µm.

*Mischoblastia*-like, then rounded in mature spores, sometimes with apical satellite lumina when over-mature; torus well developed in mature spores; walls not ornamented (Fig. 10). *Hypothecium* hyaline, 20–60 µm deep.

*Pycnidia* not observed.

*Chemistry.* Spot tests K−, C−, KC−, P+ cinnabar. Secondary metabolites: pannarin in medulla and cortex, observed as crystals under PL and formation of red needles in alcoholic P.

The above description results from a detailed study of the isotype of *R. tenuis* and the specimens listed below. It is entirely typical of *R. adirondackii* as known from eastern North America (Sheard 2010, spores not illustrated) with the possible exception of the somewhat larger, but widely overlapping, spore size. The larger size may be due to the spores from 4-spored asci, which have not been reported from North America. *Rinodina tenuis* was named for its thin thallus but it is not atypically thin in comparison with many other *Rinodina* species. The spores are larger than typical for *R. willeyi*, a species with which it could possibly be confused due to its similar chemistry, but that possesses soredia spreading from the areole margins. The type description of *R. membranifera* (Hue) Zahlbr. from Korea notes its thin, continuous thallus and very large spores, suggesting that this name might be a later homonym of *R. tenuis* but the type specimen of this species is not readily available for examination.

*Rinodina tenuis* has a Great Lakes-Appalachian distribution in North America. Although widespread in eastern North America, it is relatively infrequent (Lendemer *et al.* 2014, as *R. adirondackii*). We have seen very few collections from eastern Asia, and the species seems to have a narrow distribution in the boreal zone of Khabarovskiy Krai, Sakhalin Island, a single record from Hokkaido, and another from Honshu (Fig. 8B). The records from Russia are the first reports from the country.

*Specimens examined.* **Japan:** *Hokkaido*: Kitami Prov., Shari-gun, Shari-cho, Shiretoko Nat. Park, around path along small stream NE of Iwaobetsu hot-spring hotel (Onsen), 44°07'N, 145°05'E, alt. 240–280 m, on ± mossy, horizontal log, 1995, *T. Tønsberg* 22845b (BG, with *R. excrescens*). *Honshu*: Musashi Prov., Mt. Buko, *Yatabe* 246 (TNS).—**Russia:** *Khabarovskiy Krai*: Komsomolsk-De Kastri route, Khomi Mountains, *c.* 20 air km E of Chernyy Mys, hills on north bank of the Salasu River, 51°05·896'N, 138°46·303'E, on *Picea* branch, 316 m elev., 2009, *T. Spribille* 30494 (GZU); Gorelaya Mountain, 51°08·565'N, 139°09·775'E, bases of branches on snag (bark remnants), 460 m elev., 2009, *T. Spribille* 31214, 31227 (on base of *Abies nephrolepis*) (both GZU). [*Sakhalinskaya Oblast'*:] Sakhalin Island, Cholmskiy District, Slepikovskiy promontory, 47°17'28·00"N, 141°59'10·79"E, alt. 10 m, on *Picea*, 2013, *A. K. Ezhkin* R5/5, R8/5 (VLA); Sakhalin Island, vicinity of Yuzhno-Sakhalinsk, Mitsulsky Ridge, Mitul Mountain, 47°02'59·5"N, 142°30'39·1"E, 480 m alt., on *Abies*, 2012, *A. K. Ezhkin* R8\13 (VLA); Sakhalin Island, Susunayskiy Ridge, vicinity of Yuzhno-Sakhalinsk, Turgenev Mountain, 47°00'42·3"N, 142°48'13·2"E, 602 m alt., on *Picea*, *A. K. Ezhkin* R5\13 (VLA).

## Rinodina turfacea (Wahlenb.) Körb.

*Syst. lich. Germ.*: 123 (1855).—*Lichen turfaceus* Wahlenb., *Flora Lappon.*: 408 (1812); type: Norway, Finnmark, Insel Kvalja, Hammerfest, 1802, *G. Wahlenberg* s. n. (UPS—lectotype, Mayrhofer & Moberg 2002).

This species typically grows on moss and decaying plants, less often on wood, in oro-arctic environments. It is characterized by its densely contiguous apothecia which are sometimes angular by compression, have narrow, dark brown margins and slightly concave to persistently plane discs, and by a thallus containing sphaerophorin in the medulla. The spores of the single specimen seen growing directly on soil are the same shape and size (pointed apices, 25·5–32·5 × 11·0–13·0 µm, $n = 10$) as those from North America (Sheard 2010) and Europe (Mayrhofer & Moberg 2002), including the presence of lightly pigmented bands around the cells of some mature spores.

*Rinodina turfacea* has been previously reported to grow on cyanolichens by Magnusson (1947, 1952), who found it on *Lobarina scrobiculata* (Scop.) Nyl. thalli from Gällivare, Sweden and *Peltigera* thalli in the Swiss canton of Wallis. Nowhere does this substratum affinity appear to be as pronounced as in the Russian Far East and Alaska, so much so that we have suspected a cryptic, cyanolichen-specific species may be in play. Specimens from Russia growing on *L. scrobiculata* were previously identified as *R. olivaceobrunnea* C. W. Dodge & G. E. Baker but this species does not possess sphaerophorin, and hence lacks crystals in the medulla. *Rinodina olivaceobrunnea* also has smaller spores, which may become *Physconia*-like, and it has not been found among the present collections, probably because it is another oro-arctic, rather than boreal, species (Mayrhofer & Moberg 2002; Sheard 2010). These lichenicolous specimens have frequent and typically widely spaced, small apothecia with spores measuring (20·0–)21·0–24·0(–25·0) × (9·0–)10·0–10·5(–11·0) µm, l/w ratio (1·9–)2·1–2·4 (–2·6) ($n = 50$). They are smaller than the mean range for *R. turfacea* quoted by Sheard (2010) but have a similar pointed, elongate-ellipsoid shape and angular lumina with wall thickening at the apices and septum. Two well-developed specimens from Alaska (*Spribille* 27701, 28055b, GZU) have slightly larger spores and when combined with the above collections the range increases slightly to (20·0–)22·0–24·5 (–25·5) × (9·5–)10·0–10·5(–11·0) µm, but retains the same l/w ratio. These Alaskan specimens also possess sphaerophorin (confirmed by TLC). In the absence of molecular evidence (DNA isolation has not been successful to date), we suggest that these specimens growing on *L. scrobiculata* be provisionally referred to the type variety of *R. turfacea*, their smaller size perhaps being the result of a suboptimal habitat and possibly a substratum on which they might never reach full maturity. Specimens from Alaska have also been observed on *Erioderma pedicellatum* (Hue) P. M. Jørg. and *Nephroma helveticum* Ach. (*Spribille* 28115 and 27575, respectively, GZU).

*Rinodina turfacea* is a common species of acidic ground in arctic and oro-arctic North America, northern Scandinavia and Siberia, and has previously been reported for the Russian Far East from Yakutia (Afonina *et al.* 1980), Chukotka (Makarova & Katenin 1983), Kamchatka (Himelbrant *et al.* 2009), the Sikhote-Alin' Mountains (Chabanenko 2002) and Khabarovskiy Krai (Skirina 2012, as '*turphacea*'). Its distribution in far eastern Asia (Fig. 7D) is similar to that of *R. cinereovirens*, *R. septentrionalis* and *R. sibirica*.

*Specimens examined on* Lobarina scrobiculata. **Russia:** *Kamchatka Krai*: Mil'kovo District, Kronotsky Nature Reserve, Levaya Schapina River basin, W slope, 55°08'38"N, 159°59'24"E, alt. 370 m, on *Picea ajanensis*, 13 viii 2009, *D. Himelbrant* & *I. Stepanchikova* (LECB 12-061); Kronotsky Nature Reserve, Levaya Schapina River basin, SW part of Askhachny Ridge, SSE slope, 55°08'07"N, 159°57'23"E, alt. 300 m, on *Picea ajanensis*, 11 viii 2009, *D. Himelbrant* & *I. Stepanchikova* (LECB 12-001 with *R. subparieta*); Kronotsky Nature Reserve, Levaya Schapina River basin, SW part of Askhachny Ridge, 55°08'54"N, 159°59'38"E, alt. 410 m, on *Picea ajanensis*, 13 viii 2009, *D. Himelbrant* & *I. Stepanchikova* (LECB 12-026 with *R. subparieta*; LECB 12-023); Ust'-Bol'sheretsk District, Bannaya River basin, right bank of the Bannaya River, 52°54'40"N, 157°28'28"E, alt. 270 m, on *Betula ermanii*, 8 viii 2002, *D. Himelbrant* & *E. Kuznetsova* (LECB k-443); Ust'-Bol'sheretsk District, Pravyy Kikhchik River basin, right bank of Mokushka River, near bridge, 53°32'58"N, 156°41'09"E, alt. 251 m, on *Alnus hirsuta*, 22 vii 2004, *D. Himelbrant* (LECB k-442, k-482). *Khabarovskiy Krai*: Sredniy Khrebet Mountains, Polosataya Mountain, 45·5 km (air line) NW of Lazarev, between Pravaya Tumi River and Krutoberezniy stream, 52°22·779'N, 140°53·503'E, alt. 212 m, on *Abies nephrolepis*, 2009, *T. Spribille* 31025 (GZU). *Magadanskaya Oblast'*: Omsukchanskiy District, 500 km north-eastward from Magadan, foothills of Kilganskie Range, vicinity of mining camp Dzuletta, 61°11'43·3"N, 153°58'34·9"E, 1321 m alt., 2012, *L. Yakovchenko* M-12-27-2, M-12-27-3 (VLA). [*Sakhalinskaya Oblast'*:] Sakhalin Island, Dolinsky District, 108 km of the federal highway, 47°12'N, 142°49'E, on dry twig, 2008, *A. V. Bogacheva & N. A. Tsarenko* S-T12-3 (VLA); Sakhalin Island, Noglikskiy District, Dagi River, floodplain forest, 52°06'33·5"N, 142°57'26·2"E, 10 m alt., 2012, *A. K. Ezhkin* R19\13 (VLA). *Zabaikal'skiy Krai*: Sokhondinskiy Biosphere Zapovednik, 2 km N of Agutsakan forest station, on *Betula*, 49°36·611'N, 111°19·477'E, alt. 1125 m, 23 vii 2006, *L. S. Yakovchenko* (VLA); Sokhondinskiy Biosphere Zapovednik, road between forest stations Shergen-Daban and Ust'-Bablashniy, right bank Burecha River valley, on *Picea*, 49°44·945'N, 110°50·822'E, alt. 1464 m, 2 vii 2007, *L. S. Yakovchenko* (VLA).

*Specimen examined on ground.* **Russia:** *Zabaikal'skiy Krai*: Aginskiy Buryatskiy Autonomous Okrug, Alkhanay Nat. Park, 3·5 km E of ranger station 'Ara-Ilya', fold 'Nizhnyaya Tangaya', on soil, 50°56'35"N, 113°14'32"E, alt. 883 m, 6 vii 2006, *L. S. Yakovchenko* (VLA).

## Rinodina willeyi Sheard & Giralt

*Herzogia* **11:** 124 (1995); type: [USA], Massachusetts, Bristol Co., New Bedford, 1874, *H. Willey* s. n. (US—holotype).

The collections reported here are fully comparable with North American specimens. The margins of young areoles are often minutely lobate, becoming raised (subsquamulose, Sheard (2010)) before producing marginal soredia (sublabriform soralia). Soredia may then develop over the surface of the areoles and ultimately completely cover them. *Rinodina willeyi* might be mistaken for *R. buckii* owing to its sorediate thallus, presence of pannarin and similar-sized spores but, as previously noted, the spores of *R. buckii* belong to the *Teichophila*-type rather than the *Pachysporaria*-type I of *R. willeyi*. In addition, *R. willeyi* usually possesses lighter coloured and smaller soredia, (<40 µm in diam.) than *R. buckii* and, most importantly, these soredia initially develop on the areole margins rather than on verrucae in the centre of the areoles, as in *R. buckii* (Sheard *et al.* 2012).

A new finding is that pannarin is not always accompanied by zeorin (*Tønsberg* 21985, 22104, 22791, 22911, 22918, BG) but care must be taken to ascertain that such specimens do not represent the lobate form of *R. excrescens*, a species that mostly lacks zeorin. The blastidia and soredia of *R. excrescens* are associated with raised verrucae (bullate areoles) and are usually either concolorous with the thallus or greenish, rather than being lighter than the thallus which is the typical case for *R. willeyi*.

*Rinodina willeyi* is also related to *R. tenuis* by its *Pachysporaria*-type I spores (see Fig. 2C & D, Sheard *et al.* (2012), not illustrated in Sheard (2010)). It differs from *R. tenuis* in the discontinuous thallus, much less erumpent apothecia and the presence of soredia. Also *R. willeyi* might possibly be mistaken for *R. subparieta* due to its light-coloured thallus and soredia originating around the areole margins. However, it is well separated from that species by the presence of pannarin rather than atranorin.

*Rinodina willeyi* is reported here for the first time from Japan and Russia (Fig. 7E); it is found at elevations of up to 300 m in Hokkaido and Kamchatka, and at 500–550 m in Honshu. Similarly to *R. tenuis*, these records are another addition to the list of eastern Asiatic–eastern North American disjunct species.

*Selected specimens examined.* **Japan.** *Hokkaido*: Kitami Prov., Wakkanai City administrative area, 7 km S of Soyamisaki Cape and 2·5 km from coast, on *Alnus* sp., alt. 20 m, 45°28'N, 141°57'E, 1995, *G. Thor* 14013 (UPS); Shari-gun, Shari-cho, Shiretoko Nat. Park, 7 km NE of Utoro Village, N and S of small road to Iwaobetsu hot-spring hotel (Onsen), 2 km (road distance) from jct road to Shiretoko-goko Lakes, 44°06'N, 145°05'E, alt. 130 m, on *Prunus*, 1995, *T. Tønsberg* 22789, 22790 (BG); Kushiro Prov., Akkeshi-gun, Hamanaka-cho, 55 km E of Kushiro City, 3 km E of Hichirripputo Lake, just S of road following coast, 43°02'N, 145°03'E, alt. 60 m, on *Sorbus*, 1995, *T. Tønsberg* 22933 (with *R. subalbida*), 22934, 22935b, 22936a (with *R. subminuta* and *R. buckii*; BG); Kushiro-gun, Kushiro-cho, 13 km E of Kushiro City, 3 km (road distance) E of Konbumori Village, just S of road following the coast, 42°57'N, 144°33'E, alt. 130 m, on *Sorbus*, 1995, *T. Tønsberg* 23018, 23122 (with *R. excrescens*; BG); *ibid.*, on *Acer* sp., *G. Thor* 14531 (UPS); Nemuro Prov., Notsuke-gun, Btsukai-cho, 100 km ENE of Kushiro City, N shore of Furenko Lake, just NW of road 244, 43°22'N, 145°15'E, alt. 5–10 m, on *Betula*, 1995, *T. Tønsberg* 22911; *ibid.*, on *Quercus*, 1995, *T. Tønsberg* 22918 (both BG); *ibid.*, *G. Thor* 14425 (UPS, with *R. excrescens*); Teshio Prov., Rumoi-gun, Obira-cho, 21 km ENE of the small town of Obira at coast, along E and upper trail from Tengunotaki Waterfall to parking area, 44°04'N, 141°55'E, alt. 130–150 m, on *Abies sachalinensis*, 1995, *T. Tønsberg* 21985 (BG, with *R. buckii*). *Honshu*: Bizen Prov. (Okayama Pref.), Maniwa-gun, Kawakami-mura, 1–2·3 km N of Hiruzen Research Institute, on exposed tree at roadside, alt. 500–550 m, 35°18'N, 133°38'E, 1994, *G. Thor* 12212 (UPS with *R. subparieta*); Shimotsuke Prov. (Tochigi Pref.), Nikko City, 15 km WNW of Nikko, along the trail E of Yukawa stream above the Ryuzu Waterfalls N of Lake Chuzenji, elev. 1390 m, 36°45'57·3"N, 139°26'49·4"E, 2015, *G. Thor* 32094 (UPS).—**Russia:** *Kamchatka Krai*: Ust'-Bol'sheretsk District, Pravyy Kikhchik River basin, vicinity of Mokushka River, 53°32'56"N, 156°41'07"E, alt. 235 m, on *Chosenia arbutifolia*, 22 vii 2004, *D. Himelbrant* (LECB k-449, with *R. subparieta*, *R. subminuta*).

## Rinodina xanthophaea (Nyl.) Zahlbr.

*Cat. Lich. Univers.* **7:** 559 (1931).—*Lecanora xanthophaea* Nyl., *Lich. Jap.*: 41 (1890); type: Japan, Magayesi,1879, *E. Almquist* (H–NYL 29084—lectotype; H–NYL 29085—isolectotype *pro parte*).

New synonym. *Rinodina xanthophaea* f. *sorediosa* Pczelkin, *Novosti sistematiki nizshikh rastenii* **24:** 167 (1987); type: [Russia:] USSR Far East, Sikhote-Alin' Nature Reserve, along the sea, 2 km from the River Belimbe [approximately 45·320937°N, 137·012290°E], on oak bark, 1982, *A. V. Pczelkin* (LE—holotype!).

This golden yellow, xanthone-containing corticolous species has been discussed in detail by Urbanavichene & Skirina (2011) and Lendemer *et al.* (2012; Fig. 2 photomicrographs of thallus). The holotype of the forma *sorediosa* is fertile, possessing large *Physcia*-type spores, and the thallus is relatively densely covered with the coarse soredia, both typical characters of *R. xanthophaea*. Other forms may be fertile and lack soredia or, alternatively, may be sorediate and lack apothecia. The species has a similar distribution in far eastern Asia to another xanthone-containing species, *R. chrysidiata* (Fig. 1C), but has been collected more frequently, particularly in Japan, and unlike *R. chrysidiata* the species has not been recorded outside eastern Asia. A further xanthone-containing species, *R. citrinisidiata*, has been described from Thailand and is discussed under *R. chrysidiata*. Pycnidia have been observed for the first time (*Printzen* 11853, FR). They are *c.* 1 mm diam., with an orange-brown ostiole, and contain bacilliform conidia *c.* 4·0 × 1·0 µm.

*Rinodina xanthophaea* was described from Japan (Nylander 1890) and has been previously recorded from Russia (Oxner 1948; Pczelkin 1987; Chabanenko 2002; Skirina 2010, 2012; Urbanavichene & Skirina 2011; Rodnikova 2012, 2013; Yakovchenko *et al.* 2013). The species is found at relatively high elevations in the south of the region: 850–2460 m into the subalpine zone of Honshu, Japan, 1000–1700 m on Cheju Island, 1400–1600 m in Gangwon Prov., South Korea, and further north at 60–300 m on Hokkaido, Japan and 500 m in Primorskiy Krai, Russia (Urbanavichene & Skirina (2011) report 1200–1600 m). It is widespread in the region (Fig. 7F) and has been reported as far west as the Khamar-Daban Mountains in the Baikal region (51°25'34"N, 104°54'26"E; Urbanavichene 2010), from Gora Olocha in the Stanovoye Nagor'e Mountains in Amurskaya Oblast' (Urbanavichene & Skirina 2011, interpreted here as 55·57851°N, 126·53028°E) and from the Jewish Autonomous Region (Urbanavichene & Skirina 2011; also Zhurbenko 2014, as the host of *Ovicuculispora parmeliae* (Berk. & Curt.) Etayo). It was recently reported as new to Korea by Kondratyuk *et al.* (2016).

*Additional selected specimens examined* (previously unpublished records only; more records are reported in Urbanachivene & Skirina (2011) and Lendemer *et al.* (2012)). **Japan:** *Hokkaido*: Kitami Prov., Rishiri-to Island, Rishiri-gun, Rishirifuji-cho, Oshidomari area, along path from Rishiri-hokuroku campsite, 2·5 km S of the town of Sakae to Mt. Pon, on *A. sachalinensis*, alt. 300 m, 45°13'N, 141°13'E, 1995, *G. Thor* 13773 (UPS); Kushiro Prov., Akkeshi-gun, Hamanaka-cho, 55 km E of Kushiro City, 3 km E of Hichiripputo Lake, just S of road following coast, on *Alnus* sp., alt. 60 m, 43°02'N, 145°03'E, 1995, *G. Thor* 14450 (UPS with *R. excrescens* and *R. buckii*), 14452 (UPS); Nemuro Prov., Shiretoko Peninsula, Menashi-gun, Rausu-cho, just S of road 334 crossing Shiretoko Peninsula, 4 km WNW of Sakae City, Rausu hot spring, on *Alnus* sp., alt. 130 m, 44°02'N, 145°09'E, 1995, *G. Thor* 14405, 14406 (UPS both with *R. subparieta*). *Honshu*: Kai Prov. (Yamanashi Pref.), Makioka-cho, Yamanashi-City, at road to Odarumi Pass, on *Salix* sp., alt. 1726 m, 35°49·172'N, 138°38·963'E, 2012, *G. Thor* 28180 (UPS); Kochi Pref., Ino-cho Town, NE slope of Mt. Iwaguro-yama, along path from the road, on deciduous tree, alt. 1300 m, 33°45'10"N, 133°09'54"E (WGS84), 2006, *G. Thor* 21344 (UPS); Mutsu Prov. (Aomori Pref.), Mt. Hakkoda, *c.* 3 km E of Kasamatsu Pass along route 103, on *Fagus crenata*, alt. 850 m, 40°38'N, 140°54'E, 1994, *G. Thor* 11895 (TNS & UPS with *R. subalbida* and *R. subminuta*); Shimotsuke Prov. (Tochigi Pref.), 20 km WNW of Nikko, 1 km S of the village of Yumoto, 36°48'N, 139°26'E, Yudaki Falls, on deciduous tree, alt. 1440–1480 m, 1994, *G. Thor* 12771 (UPS with *R. subparieta*); Shinano Prov. (Nagano Pref.), Minamisaku-gun, along SW trail from Kinpuzan Hut to top of Mt. Kinpu (Kimpō), on *Salix* sp., alt. 2460 m, 35°52·100'N, 138°37·451'E, 2012, *G. Thor* 27861 (UPS); Prov. Tohoku (Prefecture Akita), 100 m W of the W shore of Lake Tazawa, outlook at Katamaeyama Woods Park, on old *Castanea japonica*, alt. 336 m, 39°42·995'N, 140°37·759'E, 2013, *G. Thor* 29754, 29755 (UPS).—**Russia:** *Kamchatka Krai*: Ust'-Bol'sheretsk District, Bannaya River basin, right bank of Bannaya River, 53°05'37"N, 156°53'29"E, alt. 150 m, on old *Betula ermanii*, 16 viii 2002, *D. Himelbrant* & *E. Kuznetsova* (LECB k-240, LECB k-422). *Khabarovskiy Krai*: Khomi Mountains, De Kastri-Komsomolsk route, between Tsimmermannovka and Chernyy Mys, Gorelaya Mountain, logging road S into mountains, on *Betula*, elev. 390 m, 51°08·256'N, 139°09·538'E, 2009, *C. Printzen* 11771, 11778 (FR); base of the Etkil'-Yankanskiy Mountains, Amgun' River region, 12·3 km N of Berozovyy, headwaters of the stream Lesosechnaya, on *Betula*, elev. 613 m, 51°47·289'N, 135°39·161'E, 2009, *C. Printzen* 11836, 11853 (FR); Sonakh River, Amgun' River region, *c.* 7·6 km NW of Berezovyy-Badzhal route, logging road, on log of *Betula*, elev. 330 m, 51°30·363'N, 135°14·221'E, 2009, *C. Printzen* 11877 (FR). *Primorsky Krai*: Sikhote Alin, valley of Taratay River, on upper part of mountain ridge, 45°44'42"N, 136°36'11"E, on *Pinus koraiensis*, 14 viii 2010, *E. Kuznetsova* (LECB); Sikhote Alin', vicinity of Kush mountain, valley of Berezovaya River, 46°06'40"N, 136°24'47"E, on *Abies nephrolepis*, 14 viii 2010, *E. Kuznetsova* (LECB); Lazo Nature Reserve, Tretylog, along Rv. Perekatnaya, 43:11N, 13:58E, 500 m, on *Quercus*, *R. Moberg* 9746 (with *R. chrysidiata*, UPS); Lazo Nature Reserve, Nogeevskaya Gorge, 43:08N, 134:01E, 500 m, on *Picea yuanensis, R. Moberg* 9837; on rocks, *R. Moberg* 9804 (UPS). [*Sakhalinskaya Oblast'*:] Sakhalin Island, Nevelskiy Pass, on *Sorbus*, 46° 44'35·92"N, 142°06'21·02"E, 425 m alt., 2013, *A. K. Ezhkin* gps11 (VLA).—**South Korea:** *Cheju Island*: along the Eorimok trail on the NW slope of Mt. Halla, on *Carpinus*, alt. 1000–1600 m, 33°23'N, 126°31'E, 2001, *G. Thor* 16970 (AK & UPS); on *Quercus dentata*, *G. Thor* 16988 (AK & UPS); Amcheju-gun, Namwon-up, along Songpanak trail on east slope of Mt. Halla above Azalea field shelter, on *Sorbus commixta*, alt. 1500–1700 m, 33° 21'N, 126°32'E, 2001, *G. Thor* 17551, 17559 (AK & UPS). *Gangwon Prov.*: Inje-gun, Mt. Seorak, Seoraksan Nat. Park, alt. 1400–1600 m, on *Abies*, 38°07'N, 128° 27'E, 2014, *A. Aptroot* 73207; alt. 1600–1700 m, on *Abies*, *A. Aptroot* 73086 (both ABL); Pyeonchang-gun, Mt. Odae, Odaesan Nat. Park, alt. 1300–1560 m, on *Quercus*, 37°48'N, 128°34'E, 2014, *A. Aptroot* 72768 (ABL); Yangyang-gun, Ser-myun, Osaeck-ri, southern part of the massif Sorak Mts, Sorak-san Nat. Park, south slope of Mt. Dachong, alt. 1350–1600 m, 38°07·10–06·45'N, 128°27·25–26·00'E, 2006, *G. Thor* 20470, 20495, 20512, 20515, 20602 (UPS).

## Rinodina sp. A

*Thallus* dark grey to grey-brown, continuous to areolate, areoles to 0·50–0·80 mm wide, verrucose; vegetative propagules absent; prothallus not seen.

*Apothecia* to 0·60–0·80 mm diam., margins 0·10–0·15 mm wide. *Thalline exciple* to *c.* 90 µm wide, crystals in medulla, no detectable cortex. *Proper exciple c.* 15 µm laterally, expanding to *c.* 25 µm above. *Hymenium* to *c.* 110 µm high; *paraphyses c.* 3·0 µm wide, apices to *c.* 4·5 µm wide immersed in a diffuse pigment forming a conglutinate, dark, red-brown epihymenium. *Asci c.* 75 × 23 µm, only a few possessing mature ascospores; *ascospores* 4–8 per ascus, *Pachysporaria*-type I, (22·0–)23·5–27·(–28·5) × (10·5–)11·5–14·5(–15·5) µm ($n = 29$), l/w ratio (1·6–)1·9–2·1(–2·2); lumina with very obvious apical canals. *Hypothecium* pigmented light brown, to *c.* 40 µm deep.

*Pycnidia* not seen.

*Chemistry*. Spot tests K−, C−, P+ cinnabar (red needles under the microscope). Secondary metabolites: pannarin and possible trace of zeorin by TLC.

Due to the scarcity of the collections, the apothecial measurements were taken from hand-cut sections only. Other species with *Pachysporaria*-type I ascospores have subtropical distributions in North America, with the exception of sorediate species found in the Pacific Northwest region (Sheard 2010). This taxon is of particular interest because ascospores with persistent apical canals are known only in one other species in the genus, *Rinodina luteonigra*, detailed above. *Rinodina flavosoralifera* Tønsberg and *R. verruciformis* Sheard (Sheard 2010) are probably related because, at maturity, their spores possess apical satellite lumina formed at the terminus of transient canals. *Rinodina sheardii* Tønsberg also has a pigmented hypothecium but is sorediate, the soralia are sometimes distinctly yellow and C+ orange due to the presence of an unknown pigment (xanthone?) and lacks pannarin (Tønsberg 1992*b*). The newly described *R. hypobadia* also has a pigmented hypothecium and pannarin but its spores are much smaller and belong to the *Dirinaria*-type.

The species is known only from two collections from the subtropical Cheju Island and one from Gangwon Province, South Korea.

*Specimens examined.* **South Korea:** *Cheju Island*: rim surrounding the crater of Mt. Halla, rocky slope with small trees and shrubs, on dead *Betula ermanii*, alt. 1850–1950 m, 33°22'N, 126°33'E, 2001, *G. Thor* 17045 (AK & UPS); Namcheju-gun, Namwon-up, along Songpanak trail on east slope of Mt. Halla above Azalea field shelter, *Abies koreana* forest with scattered deciduous trees, on *Sorbus commixta*, alt. 1500–1700 m, 33°21'N, 126°32'E, 2001, *G. Thor* 17544 (UPS). *Gangwon Prov.*: Yangyang-gun, Ser-myun, Osaeck-ri, southern part of the massif Sorak Mts, Sorak-san National Park, south slope of Mt. Dachong, along trail from the village of Osaeck towards top of Mt. Dachong, from where trail crosses a small stream *c.* 1·5 km NNE of the village of Osaeck to *c.* 2·5 km NNE of the village, on *Quercus* sp., alt. 1400–1600 m, 38°06·45–07·00'N, 128°27·30–28·00'E, 2006, *G. Thor* 20302 (AK & UPS).

## Species not seen in the present study but reported in the literature

A number of additional species have been reported in the literature from north-eastern Asia that we have not seen and, therefore, have been unable to confirm. Some corticolous taxa in the list are old names that have been widely misinterpreted in the past and may not occur in our area. The species that in our opinion are the most likely to occur in north-eastern Asia are included in the key and are marked by an asterisk (*) below.

**Rinodina archaea* (Ach.) Arnold. A widely distributed, primarily lignicolous species in the Northern Hemisphere (Mayrhofer & Moberg 2002; Mayrhofer & Sheard 2007; Sheard 2010). Previously reported from Russia (Andreev *et al.* 1996; Chabanenko 2002; Skirina 2010, 2012; Urbanavichus & Andreev 2010; Rodnikova 2013) in many localities but possibly a misapplied name for *R. sibirica*.

**Rinodina bischoffii* (Hepp) A. Massal. This species from calcareous rock is accepted for the Russian Far East Arctic by Urbanavichus & Andreev (2010).

*Rinodina calcarea* (Arnold) Arnold. Another species from calcareous rocks, listed as a rare species occurring on Wrangel Island by Belikovich *et al.* (2006), and accepted for the Russian Far East Arctic by Urbanavichus & Andreev (2010). However, this species has a Mediterranean-Turanian distribution and is unlikely to be present in the Arctic. It is possibly a misidentification of *R. calcigena* (Th. Fr.) Lynge (H. Mayrhofer 2017, pers. comm.).

*Rinodina colobinoides* (Nyl.) Zahlbr. An epiphytic species accepted for the Russian Far East by Urbanavichus & Andreev (2010), perhaps based on an earlier report of *R. sorediata* H. Magn. (a synonym) from *Quercus mongolica* in the Sikhote-Alin' Mountains by Insarov and Pchelkin (reported by Chabanenko 2002).

**Rinodina confragosa* (Ach.) Körb. A saxicolous species reported from the lower reaches of the Amur (Yakovchenko *et al.* 2013), from an island in the Sea of Japan (Rodnikova 2012) and previously on Bol'shoi Pelis Island, another island in Peter the Great Bay (Skirina 1996). The species is known from Europe, South Africa, Australia (Kaschik 2006) and western North America (Sheard 2010). It distinguished by its *Physcia*-type spores, columnar apothecial lower cortex and the presence of atranorin.

*Rinodina exigua* (Ach.) S. Gray. This is a corticolous species with *Physcia*-type spores and a thallus containing atranorin. It is widespread in Europe and adjacent regions (Mayrhofer & Moberg 2002) and infrequent in the Coastal Range and Sierra Nevada of California (Sheard 2010). Many primary and secondary literature reports are taken up by Andreev *et al.* (1996), Chabanenko (2002), Skirina (2010), Rodnikova (2013) and Urbanavichus & Andreev (2010) from the Russian Far East but the name might have been misapplied.

*Rinodina exigua* f. *laeviuscula* (Nyl.) Zahlbr. This taxon was described from Japan but was not studied by Magnusson (1947) or by ourselves.

*Rinodina fimbriata* Körb. Reported from Korea by Kondratyuk *et al.* (2013) but we have not seen the material. A saxicolous species with large *Mischoblastia*-type spores found in mesic habitats in Europe and the Great Lakes region of North America (Sheard 2010). It is related to *R. moziana* and *R. oxydata*.

*Rinodina laevigata* (Ach.) Malme. This corticolous species is characterized by its deep, lower apothecial cortex, *Physcia*-type spores and the lack of secondary substances. It was reported from South Korea by Aptroot & Moon (2014) but the specimens do not belong to *R. laevigata* and appear to represent at least two species unknown to us.

*Rinodina melanconia* Vain. A saxicolous species described from Yinretlen, near Kolyushinskaya Bay on the Arctic Ocean coast of Chukotka. The type was studied by Mayrhofer (1984) and treated as a *species excludenda* because it was in poor condition. Listed for the Russian Far East by Urbanavichus & Andreev (2010).

*Rinodina membranifera* (Hue) Zahlbr. This corticolous species was described by Hue (1909) from Korea and explicitly compared to *R. ascociscana* and *R. tenuis*. We have not seen type material because it was not available for loan but the type description, which notes the thin thallus and very large spores, suggests that it might be a synonym of *R. tenuis*. It was the only *Rinodina* species (except *Dimelaena oreina*, which was included in *Rinodina*) in the two Korean checklists (Hur *et al*. 2005; Moon 2013).

**Rinodina milvina* (Wahlenb.) Th. Fr. A saxicolous species with a dark brown thallus and large, *Milvina*-type spores reported from Scandinavia, Scotland, the mountains of Central and Southern Europe, North Africa and central Asia (Mayrhofer & Moberg 2002), and western North America (Sheard 2010). The report from Japan (Kurokawa & Kashiwadani 2006) needs to be confirmed. Also reported from the central Russian Far East by Urbanavichus & Andreev (2010), but it is not known on what this record is originally based.

**Rinodina olivaceobrunnea* Dodge & Baker. Primarily an oro-arctic, muscicolous species with large, *Physcia*- to *Physconia*-type spores. The spores are not as large as those of *R. turfacea* and it also lacks sphaerophorin. Reported from the Arctic Russian Far East (Andreev *et al*. 1996; Urbanavichus & Andreev 2010) and likely to be correct.

**Rinodina pyrina* (Ach.) Arnold. This corticolous species possesses *Buellia*-like, *Dirinaria*-type spores (Sheard *et al*. 2011) and occurs in the Northern Hemisphere (Mayrhofer & Moberg 2002; Sheard 2010), often in dryish habitats, and is probably introduced into Australia (Mayrhofer *et al*. 1999). The species was reported from several islands in the southern Russian Far East by Chabanenko (2002) and Skirina (2010) and, probably on this basis, included for the southern Russian Far East by Urbanavichus & Andreev (2010). It was also recently reported from the Stanovoye Nagor'e highlands in the west of our study area (Chesnokov & Konoreva 2015) and from Korea by Joshi *et al*. (2013). It is included on the most recent checklist of Japanese lichens (Kurokawa & Kashiwadani 2006).

*Rinodina sophodes* (Ach.) A Massal. This is a distinctive corticolous species characterized mainly by its brown thallus and *Milvina*-type spores. It is widely distributed in the British Isles, Central and Southern Europe and Macaronesia, and it is also reported from northern Africa and Asia Minor (Mayrhofer & Moberg 2002). It is absent from North America (Sheard 2010). *Rinodina sophodes* is another old name that has also been reported for Korea (Joshi *et al*. 2013), Japan (Kurokawa & Kashiwadani 2006) and the Russian Far East (Chabanenko 2002; Kotlov 2008; Urbanavichus & Andreev 2010; Rodnikova 2012). Chabanenko (2002, citing Skirina (1996) and using the name *R. cacuminum* [Th. Fr.] Malme) and Skirina (2010) have reported the species from islands in Peter the Great Bay in the Sea of Japan and Skirina (2012) reported it from Khabarovskiy Krai.

**Rinodina trevisanii* (Hepp) Körb. This species is broadly distributed across Scandinavia and Siberia and is scattered in montane localities in the Southern Alps, Asia Minor and western North America (Mayrhofer & Sheard 2007). It has been widely reported from the Russian Far East (Chabanenko 2002) and from western Mongolia by Hauck *et al.* (2013).

*Rinodina xanthomelana* Müll. Arg. Specimens reported by Aptroot & Moon (2014) belong to a *Buellia* species, probably closely related to *B. ocellata* (Flot.) Körb. but with smaller spores.

## Discussion

Biogeographers have long been fascinated by the disjunctive distribution of flowering plants between eastern Asia and eastern North America (Gray 1846; Boufford & Spongberg 1983; Wen 1999; Xiang *et al.* 2000; Qian 2002). This "East–East disjunction" has also been noted for bryophytes (Schofield 1969) and lichens (Yoshimura 1968; Culberson 1972; Sheard *et al.* 2008, 2012; Galanina *et al.* 2011; Lendemer *et al.* 2012). The present paper adds four additional disjunct species (for a total of six) known for the genus *Rinodina* alone, and suggests that such disjunctions might prove to be more common than previously anticipated when other crustose genera are studied in detail. In flowering plants, East Asian–western North American disjunctions are less common than East–East disjunctions (Xiang *et al.* 1998; Kurokawa 2006) due to the late Tertiary and Quaternary orogenies in western North America (Wen 1999). We were therefore intrigued to discover three recently described western North American species, *Rinodina endospora*, *R. macrospora* and *R. megistospora*, in far eastern Asia. *Rinodina macrospora* is a species limited to coastal foreshores in the Pacific Northwest (Sheard & Mayrhofer 2002; Sheard 2010) and is now recorded from a similar locality in Khabarovskiy Krai, Russia.

Explanations for such disjunctions in lichens have largely mirrored those provided for flowering plants. Nearly all papers that have discussed this topic start from the assumption that they are results of Tertiary range sunderings (Jørgensen 1983; Kärnefelt 1990; Galanina *et al.* 2011; Lendemer *et al.* 2012). However, the emerging molecular evidence does not appear to support an ancient disjunction for the lichen mycobiont, at least at the species level. Instead, genetic data from East–East disjunctions in lichen mycobionts suggest active gene flow. Spribille (2011) found a strong East–East clade structuring in *Mycoblastus sanguinarius*, but haplotypes were nearly identical between the Russian Far East and eastern North America, a result inconsistent with long isolation. More recently, Resl *et al.* (2016) found sequences of *Rinodina subparieta* from eastern Asia and eastern North America formed a single clade, with interdigitation of Asian and American samples. Such a result seems hard to reconcile with >12 million years of isolation, regardless of how a lichen reproduces (asexually or sexually) or whether the mycobiont is homo- or heterothallic. Furthermore, genetic evidence supporting reciprocally monophyletic sister species (vicariants) in lichen mycobionts occurring in eastern Asia and eastern North America has been mixed. Of the ten putative East–East vicariants cited by Culberson (1972), molecular data have subsequently supported only one pair to truly be sister species (*Umbilicaria esculenta*/*mammulata*: Davydov *et al.* (2010)). By contrast, five East–East vicariants mentioned by Culberson that have been studied using molecular methods have been shown not to be each other's closest relatives (*Anzia colpodes*/*colpota*: Wang *et al.* (2015); *Cladonia caroliniana*/*nipponica* and *C. uncialis*/*pseudostellata*: Stenroos *et al.* (2015); *Cladonia evansii*/*pseudevansii*: Athukorala *et al.* (2016); *Punctelia rudecta*/*ruderata*: Alors *et al.* (2016)); a further four chemical species pairs in *Cladonia* cited by Culberson have yet to be sampled with molecular methods. Though not included in previous biogeographical overviews, it should be noted that at least one pair of East–East sister genera is also known (*Cetradonia*/*Gymnoderma*: Zhou *et al.* (2006)).

It cannot be ruled out that East–East disjunctions at the species level in fungi might in fact be the outcomes of different biogeographical processes than would be expected in vicariants. Spribille (2011) noted that climate, especially the coincidence of the annual precipitation peak with the warmest quarter of the year, is shared between East Asia and eastern North America, closely tracking the geographical provenance of the corresponding mycobiont sequence data. Climate is also implicated for western North American–European disjuncts in lichen fungi: in both regions, peak precipitation tends to coincide with the coolest time of the year. This raises the possibility that, at least in these cases, current climate may be a more parsimonious explanation for species' distribution than historical range sundering. It would appear to be consistent with the "everything is everywhere, but the environment selects" hypothesis to explain the distribution of fungi and other microbes; the sexual dispersal propagules of many lichen mycobionts easily fall within the diaspore size range for which this view has been advanced (Baas Becking 1934). Genetic studies hold considerably more promise in shedding light on the cause of such distributions than do classical specimen-based studies. The latter bump up against two perennial limitations: morphological studies of lichens can both over- and underestimate genetic divergence of its lecanoromycete symbiont (Crespo & Pérez-Ortega 2009), affecting hypotheses of geographical patterns of relatedness; and the raw geographical data themselves are still constantly being augmented by newly discovered range extensions, as evidenced by the present paper. Even well-known, comparatively large lichens continue to be discovered in new parts of the world, upending long-standing biogeographical paradigms (e.g. Cornejo *et al.* 2016) and rendering speculation about endemism, especially in crustose lichens, tentative at best.

Although the results of the present study are a substantial advance on previous concepts of *Rinodina* in north-eastern Asia, much work remains to be done. Within our mapping area we did not have access to *Rinodina* collections from vast areas, including Amurskaya Oblast', Magadanskaya Oblast', the entire Sakha Republic, much of the central Sikhote-Alin' Mountains, most of the Korean Peninsula and the easternmost provinces of China. Biogeographical hypotheses rely not only on knowledge of species' occurrence but also on reasonable certainty concerning species' absence. It is our hope that the present study will make it easier to interpret *Rinodina* in north-eastern Asia in the future and lay the groundwork for a deeper understanding of the biogeography of this fascinating genus.

The curators of the following herbaria are thanked for loans of specimens: ABL, AK, B, COLO, DUKE, E, FR, G, GZU, H, LE, M, NBM, NY, S, TNS, US and W. GT wishes to thank Akiri Mori, Yokohoma National University, for arranging collecting permits in Shiretoko, Japan (2010) and Tatsuhiro Ohkubo, Utsunomiya University, for arranging collecting permits in Japan (2015). The field trip in South Korea by GT (2006) was financially supported by a grant to K. H. Moon (no. 052-052040) from the Core Environmental Technology Development Project for the Next Generation, funded by the Ministry of Environment of the Korean Government. IS and DH gratefully acknowledge research grant 1.37.151.2014 from St Petersburg State University and grant 14–04–01411 from the Russian Foundation for Basic Research. LSY and IAG were supported by grant 15-29-02382 "Mycobiota Russian Far East: revision of biological diversity as a unique component of the nature of Northeast Asia". TS gratefully acknowledges the support of Pavel Krestov for his first field trip to Primorskiy Krai in 2007 and Austrian Science Fund grant FWF P21052-B16 for the 2009 field trip, and help from Viktoria Wagner with some of the Russian literature and labels. Work by TS on the current manuscript was supported by Austrian Science Fund grant FWF P25237. TT acknowledges financial support for fieldwork in Japan (Hokkaido) in 1995 from The Scandinavia-Japan Sasakawa Foundation. JWS thanks Teuvo Ahti and Helmut Mayrhofer for helpful discussions on a number of taxonomic and nomenclatural issues connected with this paper. We are grateful to two anonymous reviewers and the editors who contributed substantially to the final manuscript.

## References

Afonina, O. M., Bredkina, L. I. & Makarova, I. I. (1980) Distribution of lichens and mosses in forest-steppe landscapes in the middle reaches of the River Indigurka. *Botanicheskii Zhurnal* **65:** 66–82. [in Russian]

Almquist, E. (1879) Lichenologiska iakttagelser på Sibiriens nordkust. *Öfversigt af Kongliga Vetenskaps-Akademiens Förhandlingar, Stockholm* **1879** (9)**:** 29–59.

Alors, D., Lumbsch, H. T., Divakar, P., Leavitt, S. D. & Crespo, A. (2016) An integrative approach for understanding diversity in the *Punctelia rudecta* species complex (*Parmeliaceae*, Ascomycota). *PLoS ONE* **11:** e0146537.

Andreev, M., Kotlov, Y. & Makarova, I. (1996) Checklist of lichens and lichenicolous fungi of the Russian Arctic. *Bryologist* **99:** 137–169.

Aptroot, A. & Moon, K. H. (2014) 114 new reports of microlichens from Korea, including the description of five new species, show that the microlichen flora is predominantly Eurasian. *Herzogia* **27:** 347–365.

Aptroot, A. & Sparrius, L. B. (2003) New microlichens from Taiwan. *Fungal Diversity* **14:** 1–50.

Aptroot, A., Saipunkaew, W., Sipman, H. J. M., Sparrius, L. B. & Wolseley, P. (2007) New lichens from Thailand, mainly microlichens from Chiang Mai. *Fungal Diversity* **24:** 75–134.

Athukorala, S. N. P., Pino-Bodas, R., Stenroos, S., Ahti, T. & Piercey-Normore, M. D. (2016) Phylogenetic relationships among reindeer lichens of North America. *Lichenologist* **48:** 209–227.

Baas Becking, L. G. M. (1934) *Geobiologie of Inleiding tot de Milieukunde*. The Hague: W. P. Van Stockum & Zoon. [in Dutch]

Belikovich, A. V., Galanin, A. V., Afonina, O. M. & Makarova, I. I. (2006) Redkie vidy lishaynikov okhranyaemykh territoriy Chukotki. In *Rastitel'niy mir Osobo Okhranyaemyx Territoriy Chukotki* (A. V. Belikovich, A. V. Galanin, O. M. Afonina & I. I. Makarova, eds): 1–260. Vladivostok: BSI DBO. [in Russian]

Boufford, D. E. & Spongberg, S. A. (1983) Eastern Asian–eastern North American phytogeographical relationships: a history from the time of Linnaeus to the twentieth century. *Annals of the Missouri Botanical Garden* **70:** 423–439.

Bredkina, L. I., Dobrysh, A. A., Makarova, I. I. & Titov, A. N. (1992) The lichen flora of Kunashir Island (Kuril Islands). *Novosti Sistematiki Nizshikh Rastenii* **28:** 90–94. [in Russian]

Chabanenko, S. I. (2002) *Konspekt Flory Lishaynikov Yuga Rossiyskogo dal'nego Vostoka [Conspectus of the Lichen Flora of the Southern Russian Far East]*. Vladivostok: Dalnauka. [in Russian]

Chesnokov, S. & Konoreva, L. (2015) Additions to the lichen biota of SE Siberia: records from the Stanovoye Nagor'e highlands (Trans-Baikal region, Russia). *Polish Botanical Journal* **60:** 203–216.

Coleman, R. G. & Kruckeberg, A. R. (1999) Geology and plant life of the Klamath-Siskiyou Mountain Region. *Natural Areas Journal* **19:** 320–340.

Coppins, B. J. (1983) A new corticolous sorediate *Rinodina* from Swedish Lappland. *Lichenologist* **15:** 146–150.

Cornejo, C., Nelson, P. R., Stepanchikova, I., Himelbrant, D., Jørgensen, P. M. & Scheidegger, C. (2016) Contrasting pattern of photobiont diversity in the Atlantic and Pacific populations of *Erioderma pedicellatum* (*Pannariaceae*). *Lichenologist* **48:** 275–291.

Crespo, A. & Pérez-Ortega, S. (2009) Cryptic species and species pairs in lichens: a discussion on the relationship between molecular phylogenetics and morphological characters. *Anales del Jardín Botánico de Madrid* **66S1:** 71–81.

Culberson, C. F. (1972) Improved conditions and new data for identification of lichen products by a standardized thin-layer chromatographic method. *Journal of Chromatography* **72:** 113–125.

Culberson, C. F. & Kristinsson, H. (1970) A standardized method for the identification of lichen products. *Journal of Chromatography* **46:** 85–93.

Culberson, W. L. (1972) Disjunctive distributions in the lichen-forming fungi. *Annals of the Missouri Botanical Garden* **59:** 165–173.

Davydov, E. A., Peršoh, D. & Rambold, G. (2010) The systematic position of *Lasallia caroliniana* (Tuck.) Davydov, Peršoh & Rambold comb. nova and considerations on the generic concept of *Lasallia* (*Umbilicariaceae*, Ascomycota). *Mycological Progress* **9:** 261–266.

Elix, J. A. & Tønsberg, T. (1999) Notes on the chemistry of some lichens from Norway. *Graphis Scripta* **10:** 4–6.

Galanina, I. A., Yakovchenko, L. S., Tsarenko, N. A. & Spribille, T. (2011) Notes on *Rinodina excrescens* in the Russian Far East (*Physciaceae*, lichenized Ascomycota). *Herzogia* **24:** 59–64.

Giavarini, V., James, P. W. & Purvis, O. W. (2009) *Rinodina* (Ach.) Gray. In *The Lichens of Great Britain and Ireland*, 2nd edition (C. W. Smith, A. Aptroot, B. J. Coppins, A. Fletcher, O. L. Gilbert, P. W. James & P. A. Wolseley, eds): 812–826. London: British Lichen Society.

Giralt, M. (2001) The lichen genera *Rinodina* and *Rinodinella* (lichenized Ascomycetes, *Physciaceae*) in the Iberian Peninsula. *Bibliotheca Lichenologica* **79:** 1–160.

Giralt, M. (2010) *Flora Liquenológica Ibérica, Vol. 5:* Physciaceae *I.* Endohyalina, Rinodina *y* Rinodinella. Barcelona: Sociedad Española de Liquenología (SEL).

Giralt, M. & Mayrhofer, H. (1994) Four corticolous species of the genus *Rinodina* (lichenized Ascomycetes, *Physciaceae*) with polyspored asci. *Herzogia* **10:** 29–37.

Giralt, M. & Mayrhofer, H. (1995) Some corticolous and lignicolous species of the genus *Rinodina* (lichenized Ascomycetes, *Physciaceae*) lacking secondary lichen compounds and vegetative propagules in Southern Europe and adjacent regions. *Bibliotheca Lichenologica* **57:** 127–160.

Giralt, M., Kalb, K. & Mayrhofer, H. (2009) *Rinodina brasiliensis*, a new corticolous isidiate species, and closely related taxa. *Lichenologist* **41:** 179–187.

Gray, A. (1846) Analogy between the flora of Japan and that of the States. *American Journal of Science and Arts* **2:** 135–136.

Harada, H., Okomoto, T. & Yoshimura, I. (2004) A checklist of lichens and lichen-allies of Japan. *Lichenology* **2:** 47–174.

Hauck, M. & Javkhlan, S. (2006) Additions to the lichen flora of Mongolia: records from Khentey and Khangay. *Willdenowia* **36:** 895–912.

Hauck, M., Tønsberg, T., Mayrhofer, H., de Bruyn, U., Enkhtuya, O. & Javkhlan, S. (2013) New records of lichen species from western Mongolia. *Folia Cryptogamica Estonica* **50:** 13–22.

Helms, G., Friedl, T. & Rambold, G. (2003) Phylogenetic relationships of the *Physciaceae* inferred from rDNA sequence data and selected phenotypic characters. *Mycologia* **95:** 1078–1099.

Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G. & Jarvis, A. (2005) Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology* **25:** 1965–1978.

Himelbrant, D. E. & Stepanchikova, I. S. (2011) The lichen flora of Kamchatka fir groves (Kronotsky Reserve). *Novosti Sistematiki Nizshikh Rastenii* **45:** 150–158. [in Russian]

Himelbrant, D. E., Stepanchikova, I. S. & Kuznetsova, E. S. (2009) Lichens of some shrubs and dwarf shrubs of Kamchatka Peninsula. *Novosti Sistematiki Nizshikh Rastenii* **43:** 150–171. [in Russian]

Hinteregger, E. (1994) Krustenflechten auf den *Rhododendron*-Arten (*Rh. ferrugineum* und *Rh. hirsutum*) der Ostalpen unter besonderer Berücksichtigung einiger Arten der Gattung Biatora. *Bibliotheca Lichenologica* **55:** 1–346.

Hue, A. (1909) Le *Lecanora oreina* Ach. et quelques lichens Coréens. *Journal de Botanique, sér. 2* **2:** 77–85.

Hur, J.-S., Koh, Y. J. & Harada, H. (2005) A checklist of Korean lichens. *Lichenology* **4:** 65–95.

Jørgensen, P. M. (1983) Distribution patterns of lichens in the Pacific region. *Australian Journal of Botany, Supplementary Series* **10:** 43–66.

Joshi, S., Kondratyuk, S. Y., Crişan, F., Jayalal, U., Oh, S.-O. & Hur, J.-S. (2013) New additions to lichen mycota of the Republic of Korea. *Mycobiology* **41:** 177–182.

Kärnefelt, I. (1990) Evidence of a slow evolutionary change in the evolution of lichens. *Bibliotheca Lichenologica* **38:** 291–306.

Kaschik, M. (2006) Taxonomic studies on saxicolous species of the genus *Rinodina* (lichenized Ascomycetes, *Physciaceae*) in the Southern Hemisphere with emphasis in Australia and New Zealand. *Bibliotheca Lichenologica* **93:** 1–162.

Kondratyuk, S., Lökös, L., Tschabanenko, S., Haji Moniri, M., Farkas, K., Wang, X. Y., Oh, S.-O. & Hur, J.-S. (2013) New and noteworthy lichen-forming fungi. *Acta Botanica Hungarica* **55** (3–4)**:** 275–349.

Kondratyuk, S. Y., Lökös, L., Halda, J. P., Haji Moniri, M., Farkas, E., Park, J.-S., Lee, B. G., Oh, S.-O. & Hur, J.-S. (2016) New and noteworthy lichen-forming and lichenicolous fungi. 4. *Acta Botanica Hungarica* **58** (1–2)**:** 75–136.

Kotlov, Y. V. (2008) *Rinodina* (Ach.) Gray. In *Handbook of the Lichens of Russia, Volume 10* (N. S. Golubkova, ed): 309–360. St. Petersburg: Nauka. [in Russian]

Kurokawa, S. (2003) *Checklist of Japanese Lichens*. Tokyo: National Science Museum.

Kurokawa, S. (2006) Phytogeographical elements in the lichen flora of Japan. *Journal of the Hattori Botanical Laboratory* **100:** 721–738.

Kurokawa, S. & Kashiwadani, H. (2006) Checklist of Japanese lichens and allied fungi. *National Science Museum Monograph* **33:** 1–89.

Lamb, I. M. (1963) *Index Nominum Lichenum Inter Annos 1932 et 1960 Divulgatorum*. New York: Ronald Press.

Lendemer, J. C., Sheard, J. W., Thor, G. & Tønsberg, T. (2012) *Rinodina chrysidiata*, a new species from far eastern Asia and the Appalachian Mountains of North America. *Lichenologist* **44:** 179–187.

Lendemer, J. C., Harris, R. C. & Tripp, E. A. (2013) The lichens and allied fungi of Great Smoky Mountains National Park. *Memoirs of the New York Botanical Garden* **104:** 1–152.

Lendemer, J. C., Tripp, E. A. & Sheard, J. (2014) A review of *Rinodina* (*Physciaceae*) in Great Smoky Mountains National Park highlights the growing significance of this "island of biodiversity" in eastern North America. *Bryologist* **117:** 259–281.

Magnusson, A. H. (1944) Lichens from central Asia. Part II. *Sino-Swedish Expedition Publication 22, XI Botany* **2:** 1–68.

Magnusson, A. H. (1947) Studies in non-saxicolous species of *Rinodina*, mainly from Europe and Siberia. *Acta Horti Gothoburgensis* **17:** 191–338.

Magnusson, A. H. (1952) Lichens from Torne Lappmark. *Arkiv för Botanik, Ser. 2*, **2**(2)**:** 45–249.

Makarova, I. I. & Katenin, A. E. (1983) Lichens in the mountains south-east of the Chukotka Peninsula. *Botanicheskii Zhurnal* **68:** 1477–1487.

Makryy, T. V. (2008) Likhenoflora yugo-zapadnogo Pribaykaliya. In *Fundamental'nye i Prikladnye Problemy Botaniki v Nachale XXI Veka: Materialy vserossiyskoy konferenstii (Petrozadovsk, 22–27 Sentabrya 2008 g.). Chast' 2: Al'gologiya, Mikologiya, Likhenologiya, Briologiya* (K. L. Vinogradova, L. V. Gagarina, A. E. Kovalenko, L. E. Kurbatova, A. F. Luknitskaya, Yu. K. Novozhilov, A. D. Potemkin, O. O. Predtechenskaya & I. N. Urbanavichene, eds): 201–203. Petrozadovsk: Karel'skiy Nauchnyy Tsentr RAN. [In Russian]

Mayrhofer, H. (1984) Die saxicolen Arten der Flechtengattungen *Rinodina* und *Rinodinella* in der Alten Welt. *Journal of the Hattori Botanical Laboratory* **55:** 327–493.

Mayrhofer, H. & Moberg, R. (2002) *Rinodina*. In *Nordic Lichen Flora, Volume 2: Physciaceae* (T. Ahti, P. M. Jørgensen, H. Kristinsson, R. Moberg, U. Søchting & G. Thor, eds): 41–69. Uddevalla: Nordic Lichen Society.

Mayrhofer, H. & Sheard, J. W. (2007) *Rinodina archaea* (*Physciaceae*, lichenized Ascomycetes) and related species. *Bibliotheca Lichenologica* **96:** 229–246.

Mayrhofer, H., Kantvilas, G. & Ropin, K. (1999) The corticolous species of the lichen genus *Rinodina*

(*Physciaceae*) in temperate Australia. *Muelleria* **12:** 169–194.
Mayrhofer, H., Sheard, J. W., Grassler, M. C. & Elix, J. A. (2001) *Rinodina intermedia* (*Physciaceae*, lichenized Ascomycetes): a well-characterized species with submuriform ascospores. *Bryologist* **104:** 456–463.
Menlove, J. E. (1974) Thin-layer chromatography for the identification of lichen substances. *British Lichen Society Bulletin* **34:** 3–5.
Moon, K. H. (2013) *Lichen-forming and Lichenicolous Fungi of Korea*. Incheon Metropolitan City, South Korea: National Institute of Biological Resources.
Nadyeina, O., Grube, M. & Mayrhofer, H. (2010) A contribution to the taxonomy of the genus *Rinodina* (*Physciaceae*, lichenized Ascomycotina) using combined ITS and mtSSU rDNA data. *Lichenologist* **42:** 521–531.
Nylander, W. (1890) *Lichenes Japoniae. Accedunt Observationibus Lichenes Insulae Labuan*. Paris: P. Schmidt.
Oxner ["Oksner"], A. M. (1948) Malovidomi i novi dlya SRSR lishayniki. *Botanicheskiy Zhurnal AN URSR* **5:** 92–98. [in Ukrainian]
Pczelkin, A. V. (1987) Novy i interesnye taksony lishainikovepifitov dal'nego vostoka (Lichenum epiphytorum taxa nonnulla ex oriente extremo nova et curiosa). *Novosti Sistematiki Nizshikh Rastenii* **24:** 166–168. [in Russian]
Pebesma, E. J. & Bivand, R. S. (2005) Classes and methods for spatial data in R. *R News* **5** (2)**:** 9–13. http://cran.r-project.org/doc/Rnews/.
Qian, H. (2002) Floristic relationships between eastern Asia and North America: test of Gray's hypothesis. *American Naturalist* **160:** 317–332.
Resl, P., Mayrhofer, H., Clayden, S. R., Spribille, T., Thor, G., Tønsberg, T. & Sheard, J. W. (2016) Morphological, chemical and species delimitation analyses provide new taxonomic insights into two groups of *Rinodina*. *Lichenologist* **45:** 469–488.
Rodnikova, I. M. (2012) The present state of lichen cover of Putjatin Island (Peter the Great Bay, Sea of Japan). *Turczaninowia* **15:** 63–69. [in Russian]
Rodnikova, I. M. (2013) On the lichen flora of islands and mainland coast of Peter the Great Bay (Sea of Japan). *Novosti Sistematiki Nizshikh Rastenii* **47:** 253–261. [in Russian]
Schofield, W. B. (1969) Phytogeography of northwestern North America. *Madroño* **20:** 155–207.
Sheard, J. W. (2010) *The Lichen Genus* Rinodina *(Ach.) Gray (Lecanoromycetidae,* Physciaceae*) in North America, North of Mexico*. Ottawa: NRC Research Press.
Sheard, J. W. & Mayrhofer, H. (2002) New species of *Rinodina* (*Physciaceae*, lichenized Ascomycetes) from western North America. *Bryologist* **105:** 645–672.
Sheard, J. W., Lendemer, J. C. & Tripp, E. A. (2008) *Buellia japonica* (*Physciaceae*), a new lichen record for North America. *Bryologist* **111:** 124–127.
Sheard, J. W., Knudsen, K., Mayrhofer, H. & Morse, C. A. (2011) Three new species of *Rinodina* and a new record from North America. *Bryologist* **114:** 453–465.
Sheard, J. W., Lendemer, J., Spribille, T. & Tønsberg, T. (2012) Further contributions to the genus *Rinodina* (*Physciaceae*, Lecanoromycetidae): two new species to science and a new record for North America. *Herzogia* **25:** 125–143.
Sheard, J. W., McCune, B. & Tønsberg, T. (2014) A new corticolous species of *Rinodina* (*Physciaceae*) and two interesting range extensions for species collected in Katmai National Park, Alaska. *Bryologist* **117:** 253–258.
Skirina, I. F. (1996) Lishayniki ostrovov zaliva Petra Velikogo (Yaponskoe more). *Botanicheskii Zhurnal* **81** (11)**:** 41–45. [in Russian]
Skirina, I. F. (2010) Addition to lichen flora of islands and coast of Peter the Great Bay (the Sea of Japan, Primori Territory). *Novosti Sistematiki Nizshikh Rastenii* **44:** 221–236. [in Russian]
Skirina, I. F. (2012) An annotated list of lichens of Bolshekhekhtsirsky Nature Reserve (Khabarovsk Territory). *Novosti Sistematiki Nizshikh Rastenii* **46:** 202–216. [in Russian]
Spribille, T. (2011) *Circumboreal lichen diversification: phylogenetic and phylogeographic studies in the genus* Mycoblastus. Ph.D. thesis, Karl-Franzens-University of Graz.
Spribille, T., Pérez-Ortega, S., Tønsberg, T. & Schirokauer, D. (2010) Lichens and lichenicolous fungi of the Klondike Gold Rush National Historic Park, Alaska, in a global biodiversity context. *Bryologist* **113:** 439–515.
Stenroos, S., Pino-Bodas, R., Weckman, D. & Ahti, T. (2015) Phylogeny of *Cladonia uncialis* (*Cladoniaceae*, Lecanoromycetes) and its allies. *Lichenologist* **47:** 215–231.
Tønsberg, T. (1992*a*) The sorediate and isidiate, corticolous, crustose lichens in Norway. *Sommerfeltia* **14:** 1–331.
Tønsberg, T. (1992*b*) *Rinodina sheardii*, a new lichen species from northwest Europe and northwest North America. *Bryologist* **95:** 216–217.
Trinkaus, U., Mayrhofer, H. & Matzer, M. (1999) *Rinodina gennarii* (*Physciaceae*), a widespread species in the temperate regions of the Southern Hemisphere. *Australasian Lichenology* **45:** 15–21.
Urbanavichene, I. N. (2010) New and rare species for lichen flora of Siberia. *Novosti Sistematiki Nizshikh Rastenii* **44:** 245–249. [in Russian]
Urbanavichene, I. N. & Palice, Z. (2016) Rarely recorded lichens and lichen-allied fungi from the territory of the Baikal Reserve – additions for [the] lichen flora of Russia. *Turczaninowia* **19:** 42–46.
Urbanavichene, I. N. & Skirina, I. F. (2011) *Rinodina xanthophaea* (*Physciaceae*) in Russia. *Novosti Sistematiki Nizshikh Rastenii* **45:** 237–241. [in Russian]
Urbanavichene, I. N. & Urbanavichus, G. P. (1998) Lishayniki baykal'skogo zapovednika. *Flora i Fauna Zapovednikov* **68:** 1–55. [in Russian]
Urbanavichene, I. N. & Urbanavichus, G. P. (2008) Pervye rezul'taty izucheniya likhenoflory okinskogo

ploskogor'ya (vostochnyy Sayan, respublika Buryatiya). In *Fundamental'nye i Prikladnye Problemy Botaniki v Nachale XXI Veka: Materialy vserossiyskoy konferenstii (Petrozadovsk, 22–27 Sentabrya 2008 g.). Chast' 2: Al'gologiya, Mikologiya, Likhenologiya, Briologiya* (K. L. Vinogradova, L. V. Gagarina, A. E. Kovalenko, L. E. Kurbatova, A. F. Luknitskaya, Yu. K. Novozhilov, A. D. Potemkin, O. O. Predtechenskaya & I. N. Urbanavichene, eds): 249–252. Petrozadovsk: Karel'skiy Nauchnyy Tsentr RAN. [In Russian]

Urbanavichus, G. P. & Andreev, M. P. (eds) (2010) *Spisok Likhenoflory Rossii. A Checklist of the Lichen Flora of Russia*. St. Petersburg: Nauka.

Vainio, E. (1909) Lichenes in viciniis hibernae expeditionis Vegae prope pagum Pitlekai septentrionalis a Dr. E. Almquist collecti. *Arkiv för Botanik* **8** (4): 1–175.

Wang, X. Y., Goffinet, B., Liu, D., Liang, M. M., Shi, H. X., Zhang, Y. Y., Zhang, J. & Wang, L. S. (2015) Taxonomic study of the genus *Anzia* (*Lecanorales*, lichenized Ascomycota) from Hengduan Mountains, China. *Lichenologist* **47:** 99–115.

Wen, J. (1999) Evolution of eastern Asian and eastern North American disjunct distributions of flowering plants. *Annual Review of Ecology, Evolution and Systematics* **30:** 421–455.

Xiang, Q.-Y., Soltis, D. E. & Soltis, P. S. (1998) The eastern Asian and eastern and western North American disjunction: congruent phylogenetic patterns in seven diverse genera. *Molecular Phylogenetics and Evolution* **10:** 178–190.

Xiang, Q.-Y., Soltis, D. E., Soltis, P. S., Steven, R. M. & Crawford, D. J. (2000) Timing the eastern Asian–eastern North American disjunction: molecular clock corroborates paleontological estimates. *Molecular Phylogenetics and Evolution* **15:** 462–472.

Yakovchenko, L. S., Galanina, I. A., Malashkina, E. V. & Bakalin, V. A. (2013) Mokhoobraznye i lishayniki malonarushennykh lesnykh soobshchestv v nizhnem Priamur'e (Rossiyskiy Dal'niy Vostok). Mosses and lichens in the minimally disturbed forest communities of the Lower Amur River areas (Russian Far East). *Komarovskie Chteniya* [Komarov Lectures] **60:** 9–66. [in Russian; http://www.biosoil.ru/kr/Downloads/60_9.pdf]

Yoshimura, I. (1968) The phytogeographical relationships between the Japanese and North American species of *Cladonia*. *Journal of the Hattori Botanical Laboratory* **31:** 227–246.

Zhou, Q.-M., Wei, J.-C., Ahti, T., Stenroos, S. & Högnabba, F. (2006) The systematic position of *Gymnoderma* and *Cetradonia* based on SSU rDNA sequences. *Journal of the Hattori Botanical Laboratory* **100:** 871–880.

Zhurbenko, M. P. (2014) Lichenicolous fungi from Far East of Russia. *Folia Cryptogamica Estonica* **51:** 113–119.