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Rinodina bischoffii (Physciaceae, lichenized Ascomycota), a new species for the Southern Russian Far East from Primorsky Krai and Sakhalin Island

Irina A. Galanina[1]✉ , Lidia S. Yakovchenko[1], Evgeny A. Davydov[2], Fedor V. Skirin[3], Tatyana M. Kharpukhaeva[4], Irina F. Skirina[3]

[1]*Federal Scientific Center of the East Asian Terrestrial Biodiversity, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, 690041, Russian Federation*
[2]*Altai State University, Barnaul, 656049, Russian Federation*
[3]*Pacific Geographical Institute, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, 690041, Russian Federation*
[4]*Institute of General and Experimental Biology, Siberian Branch of the Russian Academy of Sciences, Ulan-Ude, 670047, Russian Federation*
✉ *Corresponding author, e-mail: gairka@yandex.ru*

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Abstract: The calcicolous lichen *Rinodina bischoffii* is reported for the first time in the southern part of the Russian Far East from Primorsky Krai and Sakhalin Island. The species was collected on calcareous rocks in four localities. The paper provides data on morphology, anatomy, ecology, distribution and differences of *Rinodina bischoffii* from the closely related species based on the studied material. In addition, the verified localities of the species from Republic of Buryatia and Republic of Sakha (Yakutia) are given. The species is reported for the first time in the Okinsky District of Buryatia.

Key words: Sikhote-Alin Range, lichenized fungus, calcicolous species, saxicolous species, new records, biodiversity, biogeography, temperate East Asia.

Rinodina bischoffii (Physciaceae, лихенизированные Ascomycota) – новый вид для юга Дальнего Востока России из Приморского края и Сахалина

Ирина Александровна Галанина[1]✉ , Лидия Сергеевна Яковченко[1], Евгений Александрович Давыдов[2], Федор Владимирович Скирин[3], Татьяна Михайловна Харпухаева[4], Ирина Федоровна Скирина[3]

[1]*Федеральный научный центр биоразнообразия наземной биоты Восточной Азии ДВО РАН, Владивосток, 690041, Российская Федерация*
[2]*Алтайский государственный университет, Барнаул, 656049, Российская Федерация*
[3]*Тихоокеанский институт географии ДВО РАН, Владивосток, 690041, Российская Федерация*
[4]*Институт общей и экспериментальной биологии СО РАН, Улан-Удэ, 670047, Российская Федерация*
✉ *Автор-корреспондент, e-mail: gairka@yandex.ru*

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Аннотация. Кальцефильный лишайник *Rinodina bischoffii* приводится впервые для юга Дальнего Востока России из Приморского края и Сахалина. Вид собран на кальцийсодержащих породах в четырех местонахождениях. В статье размещены данные о морфологии, анатомии, экологии, распространении и отличиях *Rinodina bischoffii* от близких видов на основе изученных образцов. Кроме этого, приведены подтвержденные местонахождения вида в республике Бурятия и республике Саха (Якутия). *Rinodina bischoffii* впервые описываются для Окинского района Бурятии.

Ключевые слова: хр. Сихотэ-Алинь, лихенизированные грибы, кальцефильные виды, эпилитные виды, флористические находки, биоразнообразие, биогеография, умеренная Восточная Азия.

Introduction

Rinodina (Ach.) Gray is the largest genus of Physciaceae comprising ca. 300 species worldwide (Sheard 2010; Wijayawardene et al. 2022). The representatives of the genus are characterized by crustose to squamulose thalli, lecanorine apothecia, one-septate brown ascospores mostly with thickenings of inner wall, and *Lecanora*-type asci. The genus has cosmopolitan distribution occurring on various substrates: wood, tree bark, soil, mosses, plant debris and rocks (Sheard 2010).

The group of saxicolous *Rinodina* is of particular interest. Saxicolous *Rinodina* species are well studied in Europe (Mayrhofer, Poelt 1979; Mayrhofer 1984; Mayrhofer, Moberg 2002). A monograph of the genus in North America published by J. W. Sheard (2010) includes 42 saxicolous species of the 111 species recorded to date (Sheard 2018). In Russia, 21 saxicolous *Rinodina* species are reported from Kaliningrad Oblast to Chukotka Autonomous Okrug and Kamchatka Krai (Mayrhofer 1984; Bredkina et al. 1992; Tchabanenko 1999, 2002; Kotlov 2008; Sedel'nikova 2007; Sheard et al. 2017; Davydov et al. 2021; Galanina et al. 2021, 2022). The most important diagnostic character of the genus *Rinodina* is the spore type. The common spore types among the saxicolous *Rinodina* species are the *Bicincta*-, *Bischoffii*-, *Dirinaria*-, *Mischoblastia*-, *Pachysporaria*-, *Physcia*-, *Physconia*-type. In Russia, only a group with the *Bischoffii*-type of spores is present among saxicolous *Rinodina* species. Determining the spore type in *Rinodina* is a difficult task due to the numerous kinds of wall thickenings which often get confused during identification. Therefore, revision of saxicolous *Rinodina* is needed in order to clarify the actual species distribution in Russia.

Rinodina bischoffii (Hepp) A. Massal. is a common and widespread calcicolous species occurring predominantly on calcareous rocks, rarely on basic siliceous rocks, on walls, roofing tiles etc. both in sun-exposed and shaded conditions. It is widely distributed in the temperate zone from low elevations to mountains and the Arctic, recorded from 20 to 3075 m. a. s.l. (Kaschik 2006; Kotlov 2008; Sheard 2010; Nimis et al. 2018). In Russia the species is widely distributed from the European part to Siberia, including the Arctic (e. g., Andreev et al. 1996; Kristinsson et al. 2010; Kotlov 2008).

In the Russian Far East the species is only known from Wrangel Is. (Andreev et al. 1996). The species was reported from the Republic of Buryatia (Buryatia) including Kurumkansky and Bauntovsky Districts and from the Barguzinsky Ridge (Budaeva 2000; Kharpukhaeva 2013; Kharpukhaeva, Lishtva 2020). In the Republic of Sakha (Yakutia) *Rinodina bischoffii* was found on Zemlya Bunge Island (New Siberian Islands) and in Anabarsky District (Makarova 1985; Makarova et al. 1988).

As a result of the herbarium material revision the first author revealed the first localities of *Rinodina bischoffii* in the southern part of the Russian Far East (A checklist… 2010) in Primorsky Krai and Sakhalin Oblast. In addition, the verified localities of the species from Buryatia and Yakutia are given. The species is reported here for the first time in the Okinsky District of Buryatia. The purpose of this paper is to report, illustrate and discuss this new record. The study is a part of a revision of the *Rinodina* genus in Russia and Northeast Asia in general.

Materials and Methods

Sampling and phenotypic studies

The herbarium material was collected from limestone outcrops in the lowlands of the central and southern Sikhote-Alin Range in Primorsky Krai near Dalnegorsk, Partizansk (Lozovy Ridge (Chandalaz)), Novitskoe (Novitskoe rock outcrop) in 2008, 2011, 2017

as well as Vaida Mt. on Sakhalin Island in 2019. The localities are marked in Figure 1. The review of the distribution, natural conditions and lichenological studies of limestone outcrops in the southern part of the Russian Far East is given in Yakovchenko et al. (2020, 2023) and Davydov et al. (2023). In addition, the materials from three administrative districts of Buryatia and one district of Yakutia collected in 1981, 2004, 2005, 2009, 2017 were studied. The specimens examined were deposited in the herbariums of Russia: ALTB, SASY, VGEO, VLA, and UUH. Materials were identified by the first author in the Laboratory of Botany of the Federal Scientific Center of Biodiversity FEB RAS. Cross-sections of apothecia and thalli were made by hand with a razor blade and observed after mounting in water using a stereomicroscope (Zeiss Stemi 2000-C) and a compound microscope (Zeiss Axioplan 2). Photos were taken by Axiocam ERc5s. Measurements of ascospores are presented as percentiles (5–)25–75(–95) μm length × breadth, thus excluding outliers. Lichen substances of some species were studied by spot-tests using potassium hydroxide solution (K), sodium hypochlorite solution (C), 1,4-Phenylenediamine (P), and iodine (I), and by thin-layer chromatography (TLC) in solvent systems A, B, and C (Orange et al. 2001). The protocol of Meyer & Printzen (2000) was used to characterize the epihymenium pigments. The distance from localities was measured by air using Google Earth (www.earth.google.com).

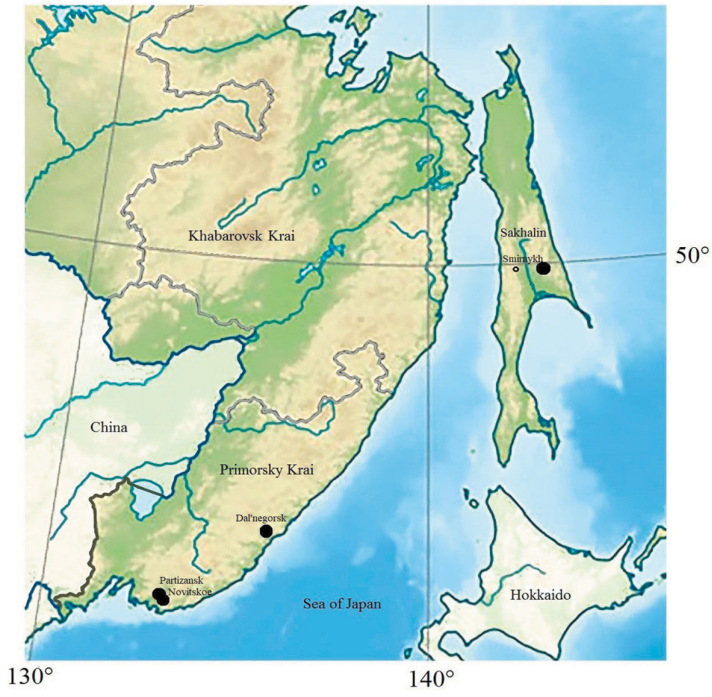

Fig. 1. The revealed localities of the *Rinodina bischoffii* in Primorsky Krai and Sakhalin Island.
Рис. 1. Выявленные местонахождения *Rinodina bischoffii* в Приморском крае и на Сахалине.

Results and Discussion

***Rinodina bischoffii* (Hepp) A. Massal.**

The studied Far Eastern specimens of *Rinodina bischoffii* possess an inconspicuous, often endolithic thallus consisting of small gray areoles up to 0.1 mm in diameter, apothecia

up to 0.5 mm in diameter with the brown-black, flattened to slightly convex disc, permanent thalline margin (Fig. 2.), hymenium inspersed by oil droplets, *Bischoffii*-type ascospores of Type *A* development, (14.5–)16.5–18.0(–20.0) × (8.0–)10.0–11.5(–13.0) μm, with a broad pigmented band around the septum and without torus, (Fig. 3.). No conidia were seen in the studied specimens. The epihymenial pigment belongs to *arnoldiana*-brown. All spot tests were negative and no substances were detected by the thin-layer chromatography which was consistent with the available descriptions (Mayrhofer, Moberg 2002; Sheard 2010).

The Far Eastern material of *Rinodina bischoffii* fit into the descriptions well, however, apothecial discs were slightly convex and did not develop into hemispheres as reported by Sheard (2010) who considered *Rinodina bischoffii* a highly polymorphic species. We also noted the variability in the degree of thallus development from endolithic to epilithic. In addition, we observed dark pigmented thalline margins almost concolorous with the disc in the material from Buryatia. In addition, it was noted that the hymenium may contain a small amount of oil, and sometimes oil droplets were absent. This agrees with the opinion of J. Sheard (2010) that the species is very polymorphic in this trait.

The closest species, *Rinodina immersa* (Körb.) J. Steiner is considered a synonym of *R. bischoffii* (Sheard 2010) based on the inspersed hymenium and similar morphology.

Fig. 2. *Rinodina bischoffii*: endolithic thallus consisting of small gray areoles, apothecia with the brown-black, flattened to slightly convex disc, and permanent thalline margin. Scale bar: 0.5 mm.
Рис. 2. *Rinodina bischoffii*: слоевище эндолитное, состоящее из мелких серых ареол, апотеции с коричнево-черным, плоским до слегка выпуклого диском, с постоянным слоевищным краем. Масштабная линейка – 0.5 мм.

Fig. 3. *Bischoffii*-type spores of *Rinodina bischoffii*: immature spores within the ascus, note the *Physconia*-like lumina of Type A development, and the lack of a torus; in the mature spores note the broad pigmented band around the septum, and the absence of torus; the dark brown epihymenium is composed of expanded apical cells of paraphyses with the dark brown pigment (arnoldiana-brown); oil drops are located along the paraphyses in the hymenium. Scale bar: 10 μm.
Рис. 3. Споры *Bischoffii*-типа: незрелые споры светло-коричневые, расположенные внутри сумки, имеют *Physconia*-подобную люмину типа развития А и отсутствие торуса; в структуре зрелых темно-коричневых спор хорошо видна широкая пигментированная полоса вокруг перегородки, отсутствует торус; темно-коричневый эпигимений, сложенный расширенными апикальными клетками парафиз с темно-коричневым пигментом (арнольдиана-коричневый); капли масла расположены вдоль парафиз в гимении. Масштабная линейка – 10 мкм.

R. bischoffii is similar to *R. guzzinii* Jatta but the latter species has a more developed thallus and larger ascospores (21–22 μm long) broadly rounded at the ends while the ascospores of *R. bischoffii* (16–18 μm long) and ellipsoidal et the ends. Morphologically similar species, *R. castanomelodes* H. Mayrhofer & Poelt differs by its well-developed thallus which is almost lobed at the edges, larger apothecia (up to 0.9 mm) and the ascospores broadly rounded at the ends. M. Giralt (2010) considered *R. castanomelodes* a variety of *R. bischoffii*. Finally, the Arctic species, *R. calcigena* (Th. Fr.) Lynge has larger broadly ellipsoid ascospores (19–20 μm long) and a rapidly disappearing thin canal (immature colorless spores look bipolar). A pigmented belt around the septum is visible only in mature ascospores (Sheard 2010).

In the southern part of the Russian Far East *Rinodina bishoffii* occurs on sun-exposed surfaces of calcareous rocks at the elevations 387–1935 m. The species was found in four localities in Primorsky Krai and Sakhalin Island at latitude between 43° to 49° and at a maximum distance of about 1100 km from each other. The nearest locality in Bauntovsky District of Buryatia is about 2000 km and 2200 km NW from newly reported localities in the Primorsky Krai and Sakhalin Island respectively. The species is also reported from Ningxia, Chine (Joshi et al. 2014) with the distance ca. 2500 km SW from the nearest locality in Primorsky Krai. The Yakutian locality of *Rinodina bishoffii* is situated ca. 3400 km NNW from the most remote Far Eastern locality in Primorsky Krai. The species might be found in suitable conditions within East Asia.

Specimens examined: Russia, Primorsky Krai, Partizansky District, at 15 km SW of the Partizansk, Lozovyi Ridge (Chandalaz) on the top, S exposure, Chertov Utyes cliff, limestone outcrops in a sparse broad-leaved forest with a predominance of *Quercus mongolica*, 43°01′44″ N, 133°01′39″ E, elev. 750 m, on calcareous rocks, 07 VII 2008, leg. L. S. Yakovchenko 1264 (ALTB), (VLA 3227, 3228, 3229); near Novitskoe, Pad Pryamaya River valley, Novitskoye rock outcrop, at the top, meadow with carbonate rocks, 43°03′26.84″ N, 133°13′25.2″ E, elev. 387 m, on calcareous rock, 14 III 2017, leg. F. V. Skirin (VGEO 35018); Dalnegorsk District, 2.5 km N from Dalnegorsk, Partizanskaya Mt., limestone outcrop, lower part of the slope, 44°35’17″ N, 135°33’17″ E, elev. 380 m, on calcareous rocks, 15 IX 2011, leg. L. S. Yakovchenko 1260 (ALTB); Sakhalin Oblast, Smirnykhovsky District, 47 km E of Smirnykh, Vaida Mountain, NW slope at the headwaters of Vitnitsa River, left bank, limestone rock outcrops, 49°52′49″ N, 143°28′02″ E, elev. 700 m, on calcareous rocks, 11 VIII 2019, leg. E. A. Davydov 18115, 18071 (ALTB).

Additional specimen examined: Russia, Buryatia, Okinsky District, at the border with the Tukinsky District, Lake Okinskoe, shrub-sedge tundra, 51°55′02.9″ N, 100°39′53.1″ E, elev. 1935 m, on rock, 15 VI 2005, leg. T. M. Kharpukhaeva (UUH); Kurumkansky District, Ikatsky Ridge, Ikat River valley, S slope, carbonate rock outcrops, 54°25′15.3″ N, 111°22′17.9″ E, elev. 1000 m, on calcareous rock, 17 VIII 2017, leg. T. M. Kharpukhaeva (UUH); *ibid*., Dzherginsky Reserve, Dzhirga River valley, left bank opposite the confluence of the Valukochen River, carbonate rocks, on calcareous rock, 09 VII 2004, leg. T. M. Kharpukhaeva (UUH L-174-00730, was determined as *Rinodina calcigena*); Bauntovsky District, Ikatsky Ridge, Verkhnyaya Tzypa River basin, S slope in the Bugarikta Riner valley, carbonate rock outcrops in the steppe, 54°57′ N, 112°04′ E, elev. 1292 m, on calcareous rock, 11 VIII 2009, leg. T. M. Kharpukhaeva (UUH L-01284, L-00879, was determined as *Rinodina calcigena*); Yakutia, Anabarsky District, 800 m SW of Saskylakh, herbaceous-willow larch sparse forest in the burnt area, on the S slope, 71º57′12.4″ N, 114º04′33.8″ E, elev. 507 m, on calcareous rock, 11 VIII 1981, leg. Perfiljeva (SASY L-1981-08-11/42-5).

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