

LICHENS — ЛИШАЙНИКИ

Rinodina megistospora (Physciaceae) in the Russian Far East

I. A. Galanina¹, A. K. Ezhkin², L. S. Yakovchenko¹

¹ Federal Scientific Center of East Asian Terrestrial Biodiversity FEB RAS, Vladivostok, Russia

² Institute of Marine Geology and Geophysics FEB RAS, Yuzhno-Sakhalinsk, Russia

Corresponding author: I. A. Galanina, gairka@yandex.ru

Abstract. The paper presents new data on distribution of the lichen *Rinodina megistospora* in the Russian Far East and its revealed range in eastern Asia. *R. megistospora* is recorded for the first time for the Sakhalin Region (Sakhalin and Iturup islands). It has been found on the territory of Russia in eight localities in the boreal and nemoral zones of Northeast Asia. The species grows in old-growth intact coniferous and oak forests on bark of *Betula* sp., *Kalopanax septemlobus*, *Picea* sp., *Quercus crispula* and *Sorbus* sp. Current data suggest that *R. megistospora* is one of the species belonging to the Eastern Asiatic — Western North American group of species, characterized by disjunctive range. The paper presents the anatomical and morphological description of *Rinodina megistospora*, based on the examined specimens.

Keywords: Asia, biogeography, disjunction, lichens.

Rinodina megistospora (Physciaceae) на Дальнем Востоке России

И. А. Галанина¹, А. К. Ёжкин², Л. С. Яковченко¹

¹ Федеральный научный центр биоразнообразия наземной биоты Восточной Азии ДВО РАН, Владивосток, Россия

² Институт морской геологии и геофизики ДВО РАН, г. Южно-Сахалинск, Россия

Автор для переписки: И. А. Галанина, gairka@yandex.ru

Резюме. Приводятся новые данные о распространении *Rinodina megistospora* на российском Дальнем Востоке и его выявленный ареал в восточной Азии. *R. megistospora* впервые приводится для Сахалинской области (о-ва Сахалин и Итуруп). Вид найден на территории России в восьми местонахождениях, расположенных в бореальной и неморальной зонах северо-восточной Азии. *R. megistospora* встречается в старовозрастных малонарушенных хвойных и дубовых лесах на коре *Betula* sp., *Kalopanax septemlobus*, *Picea* sp., *Quercus crispula* и *Sorbus* sp. Полученные данные показывают, что *R. megistospora* является одним из видов, которые характеризуются восточноазиатско-западно-североамериканским дизъюнктивным ареалом. В статье представлено анатомо-морфологическое описание вида, выполненное на основе изученных образцов.

Ключевые слова: Азия, биогеография, дизъюнкция, лишайники.

The ranges of many lichen species are still inadequately studied. The genus *Rinodina* (Ach.) Gray until recently remained insufficiently studied in East Asia (Sheard *et al.*, 2017). Up to 2010, the keys to *Rinodina* species in Russia were prepared on the base of European specimens (Tomin, 1956; Mayrhofer, Poelt, 1979; Foucard, 2001; Mayrhofer,

Moberg, 2002; Kotlov, 2008). In 2010 the treatment of the genus *Rinodina* in the North America was published (Sheard, 2010) and shed new light on the material from the Russian Far East. The corticolous species of *Rinodina* are the most problematic and poorly known group. At present, the information about the *Rinodina* species of the Russian Far East could be found in the checklist published by Tchabanenko (2002); it contains 15 species and 2 forms. The synopsis of lichens from the Russian Arctic includes 14 *Rinodina* species from the Chukotka Region (Andreev *et al.*, 1996). The most recent key to the Russian species of *Rinodina* was published in the Handbook of the lichens of Russia (Kotlov, 2008). It contains 16 species from the Russian Far East. Recently, the first author began the revision of the genus *Rinodina* in Russia. The specimens from different regions of the Russian Far East were studied, 34 species of this genus were reported (Sheard *et al.*, 2017).

Rinodina megistospora was recently described from North America (Sheard *et al.*, 2011); it was found in the oak forest, perhaps on the oak tree, in the southern Oregon, not far from the coast where the large amount of annual precipitation is observed. Sheard and Mayrhofer (Sheard *et al.*, 2011) point out that the locality of the species is a well-known refuge where many relic species and a great diversity of conifers have been preserved since «Tertiary» period (Raven, Axelrod, 1978; Coleman, Kruckberg, 1999; Stein *et al.*, 2000). In Russia, *R. megistospora* was found for the first time in the Russian Far East and known from two localities in the Primorye and Khabarovsk territories (Sheard *et al.*, 2017). This is one of the species belonging to the Eastern Asiatic — Western North American group and having disjunctive range. The species is characterized by light, grayish-white thallus consisting of coalescing areoles and having lobules at the margin that are often overlapping, large apothecia with strongly convex blackish disc, almost half globose, very large spores of *Pachysporaria*-type I. The goal of this paper is to represent new data on the distribution of *R. megistospora* and show its range as well as to give anatomical and morphological description of the studied Russian specimens for comparison with North American specimens.

Material and methods

The material was collected by the authors in 2012–2016 at the territory of the Russian Far East. The only specimen of *R. megistospora* collected by L. A. Knyazheva in 1971 is kept in VLA — herbarium of Federal Research Center of Biodiversity of Far East Branch of Russian Academy of Science (FRCB FEB RAS). Another 12 specimens were newly studied, all of them are placed in the same herbarium. Doublets are stored in SAK — herbarium of Institute of Marine Geology and Geophysics FEB RAS (IMGG FEB RAS). The investigation of the specimens was carried out by the first author in the Laboratory of cryptogamic plants of the FRCB FEB RAS.

The study of anatomical and morphological features of the specimens was made using the microscopes Carl Zeiss Axioplan 2 and Stemi 2000-C. The investigation of spore structure and their measurements were made using the immersion oil under the magnifi-

cation 1000 \times . For the majority of characters minimal and maximal sizes are given. For the sizes of apothecia and spores mean is also indicated. The number of measurements (N) is indicated in parentheses after the size of spores and apothecia. All the localities of the studied specimens are shown at the map (Fig.).

Results

The detailed description of *Rinodina megistospora* is given by Sheard and Mayrhofer (Sheard *et al.*, 2011) on the basis of specimens from North America. The anatomical and morphological description based on 12 Russian specimens is given below and fully corresponds to the protologue.

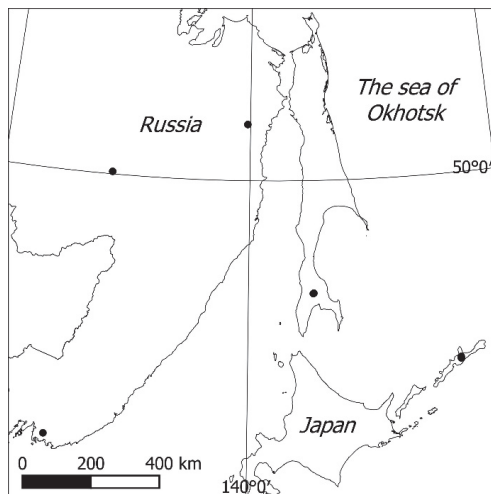


Fig. Known localities of *Rinodina megistospora* in Russia.
Рис. Местонахождения *Rinodina megistospora* в России.

Rinodina megistospora Sheard et H. Mayrhofer, 2011, *Bryologist*, 114(3): 460–461.

Description. Thallus thin, whitish-gray, first composed of dispersed areoles, then confluent into a continuous crust with determinate margin (Table, 1). Areoles to 0.5–0.8 mm wide, overlapped, margins finely dissected with radiating lobules to 0.1–0.15 mm wide, surface flat, matt. Prothallus and vegetative propagules are absent.

Apothecia broadly attached, scattered, numerous, sometimes contiguous, 0.5–0.7(1) mm diam. (N = 55); disc dark brown to black, naked, first flat, then becoming convex, usually half globose; thalline margin concolorous with thallus, entire, to 0.1 mm wide, often dissected into very small lobules densely appressed to the convex disk, persistent, sometimes almost disappearing (when apothecia with strongly convex disc); 70–90 μ m wide laterally, cortex to 10 μ m wide, epinecral layer absent, cortical cells 5–6 μ m diam., not pigmented, algal cells 8–13 μ m long, crystals present in cortex and absent in medulla; proper exciple hyaline, 5–10 μ m wide, expanding to 10–40 μ m at surface and slightly brownish, concolorous with epihymenium; hypothecium hyaline or yellowish, 60–100 μ m high; hymenium 110–160 μ m high, paraphyses 1.5–2.5 μ m wide, branched, often confluent, apices to 3.5–4.5 μ m wide, slightly pigmented, forming a dark brown epihymenium. Ascospores 8 per ascus, type A development, *Pachysporaria*-type I (Table, 2), 32–36.8–42.5 \times 15–17–22 μ m (N = 110), torus narrow, walls lightly ornamented.

Type. USA, Oregon, Curry Co., Siskiyou Nat. Forest, Oak Flat off road along Rogue River, near Agness (probably on *Quercus*), 20 X 1996, Bratt 9969 (SBBG — holotype, SASK — isotype).

Chemistry. Spot tests: K+ yellow, C-, P+ faint yellow. Sheard and coauthors reported atranorin in the cortex (Sheard *et al.*, 2011) or atranorin and two unknown compounds (Sheard *et al.*, 2017).

Ecology. *Rinodina megistospora* occurs in old-growth undisturbed coniferous and oak forests; in the northern Russian part (Khabarovsk Territory) of the range it is found on spruce (*Picea* sp.) and oak (*Quercus* sp.), in the southern Russian part (Primorye Territory, Sakhalin and Iturup islands) — on spruce (*Picea* sp.) and mountain ash (*Sorbus* sp.). It should be noted that in Asia, like in North America, the localities of this species occur near the sea coast, and several localities were found in the region under the influence of monsoon climate. The climate of the South Kuril Islands is typically maritime, it is characterized by large amount of annual precipitation (up to 1100–1400 mm per year), high humidity (average relative humidity 80%) and the monsoon wind regime. Typical are mild winter and cool summer, abrupt changes in the weather during the day. The average annual temperature is 4–5° C (South..., 1992). The climate of the southern part of Sakhalin is milder compared to northern and middle part of the Island. The area is characterized by mild winter and warm summer, positive average annual temperatures (from + 1.8° C to + 3° C), significant rainfall (an average of 800 mm per year), high relative humidity throughout the year (annual average 78–83%), frequent fogs (up to 73 days per year) (Zemtsova, 1968).

Distribution. *Rinodina megistospora* has been found in eight localities in Russia, in boreal and nemoral zones of its south-eastern Asian part (Fig.). It is known from the Primorye Territory, Sakhalin and Iturup islands, as well as from the Khabarovsk Territory (spurs of the Sikhote-Alin). The species was also recently found in the coastal area at low altitudes in Hokkaido, Japan (unknown substrate) and at 1610–1630 m above sea level in Kochi province, on the island of Shikoku (Sheard *et al.*, 2017). *R. megistospora* is reported here for the Sakhalin Region (Sakhalin and Iturup islands) for the first time.

Specimens examined: **Russia**, Khabarovsk Territory, Ulcha District, south of village Sofiysk, north-eastern spurs of the Sikhote-Alin, the northern slope of Mountain Tiul-Shaman, upper part of Kamenka River in Amur River basin, 51°28'56"N, 139°52'45"E, 500 m a. s. l., oak forest with birch and maple, with yew and cedar elfin wood and petrophytic-motley grass, on bark of *Quercus* sp., 09 VIII 2012, *Yakovchenko* (Яковченко) *Kh-12-51-1*, *Kh-12-51-2*, *Kh-12-51-3*, VLA; south-eastern slope of Kukansky Ridge, 50°04'N, 134°23'E, 1146 m a. s. l., subalpine fir forest with herbs and green mosses, on twig of *Picea* sp., 06 VII 2012, *Galanina* (Галанина), VLA; Primorye Territory, Shkotovsky District, Mountain Hualaza, spruce-fir forest, on bark of *Picea* sp., 09 VIII 1971, *Knyazheva* (Княжева), VLA; Iturup Island, Kurilka Valley, 45°07'49.8"N, 147°47'21.4"E, 225 m a. s. l., old-growth oak forest of *Quercus crispula* Blume and *Kalopanax septemlobus* (Thunb.) Koidz., on bark of *Q. crispula*, 25 VIII 2012, *Ezhkin* (Ёжкин) 17R, VLA; *ibid.*, 45°10'16.3"N, 147°57'24.7"E, 218 m a. s. l., old-growth oak forest of *Q. crispula* and *K. septemlobus*, on bark of *Q. crispula*, 26 VIII 2012, *Ezhkin* (Ёжкин) 23R, VLA; Sakhalin Island, near the Yuzhno-Sakhalinsk, mountain Mitsul, western slope, at the top, 47°02'13.4"N, 142°31'04.9"E, 712 m a. s. l., spruce-fir forest with *Betula* sp., on bark of *Sorbus* sp., 26 VIII 2016, *Ezhkin* (Ёжкин) 13R, 14R, VLA; *ibid.*, 47°02'12.0"N, 142°30'55.5"E, 638 m a. s. l., spruce-fir forest with *Betula* sp., on bark of *Picea* sp., 26 VIII 2016, *Ezhkin* (Ёжкин) 17R, 18R, VLA; *ibid.*, 47°01'36.5"N, 142°29'24.5"E, 594 m a. s. l., spruce-fir forest with *Betula* sp., on bark of *Picea* sp., 7 VIII 2016, *Ezhkin* (Ёжкин) 19R, VLA.

Discussion

Current data suggest that *Rinodina megistospora* is one of the species belonging to the Eastern Asiatic — Western North American group of species characterized by disjunctive range. Analyzing the known distribution of *R. megistospora*, one can suppose that this species had a wider range in the northern Asia and North America during the late Paleogene. At that time, this territory was covered by broad-leaved forests with small addition of evergreen, small-leaved and pine forests (Biske, Baranova, 1976). As Sheard with coauthors wrote (Sheard *et al.*, 2011), the origin of *R. megistospora* in north-western North America remains mysterious and, perhaps, the species originated in the south. It seems probable that the species survived the glacial epochs in refuges at the Pacific coasts of North America and Eastern Asia. However, there are data indicating that lichen species having a disjunctive distribution, similar to that of *R. megistospora*, could not be isolated for so long (Spribille, 2011; Resl *et al.*, 2016; Sheard *et al.*, 2017). This opinion is based on the molecular study of *Mycoblastus saguinarius* and *Rinodina subparieta* from the eastern Asia and the eastern North America. Further studies of the *Rinodina* genus in the eastern Asia are necessary in order to get better understanding of the origin of species with similar disjunctive range.

Acknowledgments

The authors are grateful to John Sheard and Toby Spribille for joint work on the genus *Rinodina*. This work was partially supported by RFBR grant № 15-29-02382 ofi_m and Global Greengrants Fund.

References

- Andreev M., Kotlov Yu., Makarova I. 1996. Checklist of lichens and lichenicolous fungi of the Russian Arctic. *Bryologist*. 99: 137–169.
- Biske S. F., Baranova Yu. P. 1973. The main features of Beringia paleogeography in the pre-Quaternary Cenozoic. *Beringiyskaya susha i ee znachenie dlya razvitiya golarkticheskikh flor i faun v kaynozoe* [Beringian land and its importance for the development of Holarctic flora and fauna in Cenozoic]. Khabarovsk: 19–20. (In Russ.).
- Coleman R. G., Kruckberg A. R. 1999. Geology and plant life of the Klamath-Siskiyou Mountain Region. *Nat. Areas J.* 19: 320–340.
- Foucard T. 2001. *Svensk skorplavs flora*. Stockholm: 306 p.
- Kotlov Yu. V. 2008. *Rinodina* (Ach.) Gray. *Opredelitel lishaynikov Rossii T. 10* [Handbook of the lichens of Russia. Vol. 10]. St. Petersburg: 309–359. (In Russ.).
- Mayrhofer H., Moberg R. 2002. *Rinodina*. *Nordic lichen flora*. Vol. 2. Uddevalla: 41–69.
- Mayrhofer H., Poelt J. 1979. Die saxicolen Arten der Flechtengattung *Rinodina* in Europa. *Bibl. Lichenol.* 12: 1–186.
- Raven P. H., Axelrod D. I. 1978. Origin and relationships of the California flora. *Univ. Calif. Publ. Bot.* 72: 1–134.
- 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* 48(5): 469–488.
- Sheard J. 2010. *The lichen genus Rinodina* (Ach.) Gray (*Lecanoromycetidae*, *Physciaceae*) in North America, North of Mexico. Ottawa: 246 p.
- Sheard J. W., Knudsen K., Mayrhofer H., Morse C. A. 2011. Three new species of *Rinodina* (Physciaceae) and a new record from North America. *Bryologist* 114(3): 453–465.

- Sheard J. W., Ezhkin A. K., Galanina I. A., Himelbrant D. E., Kuznetsova E. S., Shimizu A., Stepanchikova I., Thor G., Tønsberg T., Yakovchenko L. S., Spribille T. 2017. The lichen genus *Rinodina* (Physciaceae, Caliciales) in north-eastern Asia. *Lichenologist* 49(6): 617–672.
- Spribille T. 2011. Circumboreal lichen diversification: phylogenetic and phylogeographic studies in the genus *Mycoblastus*. *Ph. D. thesis*. Graz: 131 p.
- Stein B. A., Kutner L. S., Adams J. S. 2000. *Precious Heritage: The status of biodiversity in the United States*. New York: 416 p.
- Tchabanenko S. I. 2002. *Konspekt flory лишайников юга российского Дальнего Востока* [Synopsis of the lichen flora of the south of the Russian Far East]. Vladivostok: 232 p. (In Russ.).
- Tomin M. P. 1956. *Opredelitel korkovykh лишайников Европейской части СССР (кроме крайнего севера и Крыма)* [Handbook of crustose lichens of the European part of the USSR (except the Far North and the Crimea)]. Minsk: 532 p. (In Russ.).
- Yuzhnye Kurilskie ostrova (prirodno-ekonomicheskii ocherk)* [South Kuril Islands (natural-economic survey)]. 1992. Yuzhno-Sakhalinsk: 158 p. (In Russ.).
- Zemtsova A. I. 1968. *Klimat Sakhalina* [The climate of Sakhalin]. Leningrad: 197 p. (In Russ.).

Литература

- Andreev M., Kotlov Yu., Makarova I. 1996. Checklist of lichens and lichenicolous fungi of the Russian Arctic. *Bryologist* 99: 137–169.
- [Biske, Baranova] Бискэ С. Ф., Баранова Ю. П. 1973. Основные особенности палеогеографии Берингии в дочетвертичном кайнозое. *Берингийская суша и ее значение для развития голарктических флор и фаун в кайнозое*. Хабаровск: 19–20.
- Coleman R. G., Kruckberg A. R. 1999. Geology and plant life of the Klamath-Siskiyou Mountain Region. *Nat. Areas J.* 19: 320–340.
- Foucard T. 2001. *Svensk skorplavs flora*. Stockholm: 306 p.
- [Kotlov] Котлов Ю. В. 2008. *Rinodina* (Ach.) Gray. *Opredelitel лишайников России. Вып. 10*. СПб.: 309–359.
- Mayrhofer H., Poelt J. 1979. Die saxicolen Arten der Flechtengattung *Rinodina* in Europa. *Bibl. Lichenol.* 12: 1–186.
- Mayrhofer H., Moberg R. 2002. *Rinodina. Nordic lichen flora. Vol. 2*. Uddevalla: 41–69.
- Raven P. H., Axelrod D. I. 1978. Origin and relationships of the California flora. *Univ. Calif. Publ. Bot.* 72: 1–134.
- 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* 48(5): 469–488.
- Sheard J. 2010. *The lichen genus Rinodina (Ach.) Gray (Lecanoromycetidae, Physciaceae) in North America, North of Mexico*. Ottawa: 246 p.
- Sheard J. W., Knudsen K., Mayrhofer H., Morse C. A. 2011. Three new species of *Rinodina* (Physciaceae) and a new record from North America. *Bryologist* 114(3): 453–465.
- Sheard J. W., Ezhkin A. K., Galanina I. A., Himelbrant D. E., Kuznetsova E. S., Shimizu A., Stepanchikova I., Thor G., Tønsberg T., Yakovchenko L. S., Spribille T. 2017. The lichen genus *Rinodina* (Physciaceae, Caliciales) in north-eastern Asia. *Lichenologist* 49(6): 617–672.
- [South...] *Южные Курильские острова (природно-экономический очерк)*. 1992. Южно-Сахалинск: 158 с.
- Spribille T. 2011. Circumboreal lichen diversification: phylogenetic and phylogeographic studies in the genus *Mycoblastus*. *Ph. D. thesis*. Graz: 131 p.
- Stein B. A., Kutner L. S., Adams J. S. 2000. *Precious Heritage: The status of biodiversity in the United States*. New York: 416 p.
- [Tchabanenko] Чабаненко С. И. 2002. Конспект флоры лишайников юга российского Дальнего Востока. Владивосток: 231 с.
- [Tomin] Томин М. П. 1956. *Opredelitel korkovykh лишайников Европейской части СССР (кроме Крайнего Севера и Крыма)*. Минск: 532 с.
- [Zemtsova] Земцова А. И. 1968. *Климат Сахалина*. Ленинград: 197 с.

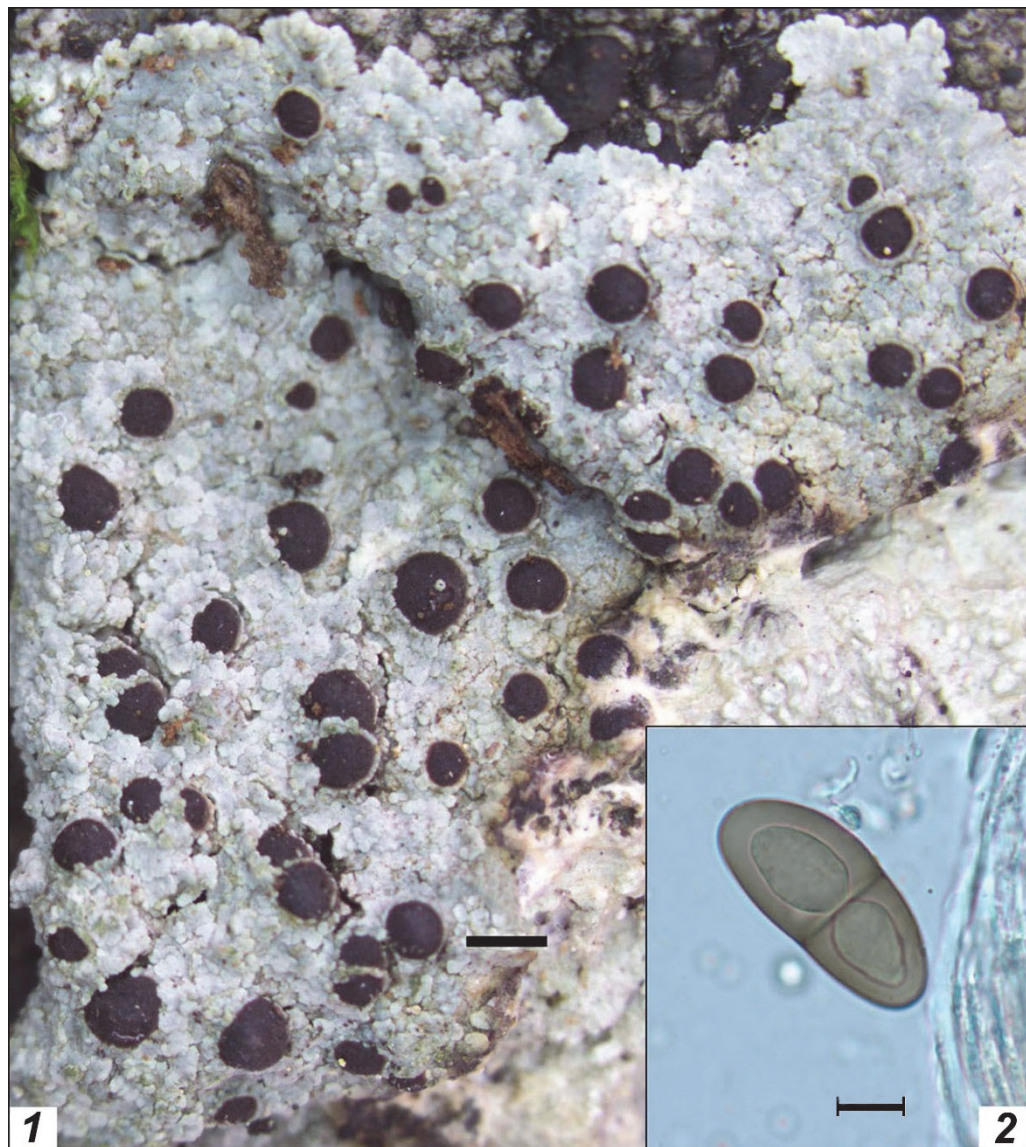


Table. *Rinodina megistospora*. 1 — thallus and apothecia; 2 — mature *Pachysporaria*-type I spore.
Scale bar: 1 — 1 mm; 2 — 10 μ m.

Таблица. *Rinodina megistospora*. 1 — таллом и апотеции; 2 — зрелая спора *Pachysporaria*-типа I.
Масштабная линейка: 1 — 1 мм; 2 — 10 мкм.

