LICHENS – ЛИШАЙНИКИ

The first record of the lichen genus *Tayloriellina* (Teloschistoideae) and the North American species *T. microphyllina* in Eurasia (Russian Far East)

I. V. Frolov[1], I. A. Prokopiev[2], P. D. Tumanina[3]

[1]Institute Botanic Garden, Ural Branch of the Russian Academy of Sciences, Yekaterinburg, Russia
[2]Komarov Botanical Institute of the Russian Academy of Sciences, St. Petersburg, Russia
[3]St. Petersburg State University, St. Petersburg, Russia
Corresponding author: I. V. Frolov, ivfrolov@gmail.com

Abstract. The subfamily Teloschistoideae (Teloschistaceae) is mainly distributed in the Southern Hemisphere. Just a few its species were recorded in eastern Asia, and only *Teloschistes flavicans* has been known in the Russian Far East. Here, we report the discovery of *Tayloriellina microphyllina* in the Primorye Territory on the eastern shore of Lake Khanka where it is abundant in xerothermic conditions of *Quercus mongolica–Pinus* × *funebris* forest. This corticolous Teloschistoideae species has been previously known in the temperate regions from the southern Canada to central Mexico in North America. Our finding is confirmed by molecular data (nrITS). Morphology and chemistry as well as long distance dispersal vs. relict origin of the Far Eastern population of *T. microphyllina* are shortly discussed.

Keywords: *Caloplaca* s. l., Teloschistaceae, ITS, new record, Primorye, Russia.

Первая находка рода *Tayloriellina* (Teloschistoideae) и североамериканского вида *T. microphyllina* в Евразии (Дальний Восток России)

И. В. Фролов[1], И. А. Прокопьев[2], П. Д. Туманина[3]

[1]Ботанический сад УрО РАН, Екатеринбург, Россия
[2]Ботанический институт им. В. Л. Комарова РАН, Санкт-Петербург, Россия
[3]Санкт-Петербургский государственный университет, Санкт-Петербург, Россия
Автор для переписки: И. В. Фролов, ivfrolov@gmail.com

Резюме. Подсемейство Teloschistoideae (Teloschistaceae) распространено, главным образом, в Южном полушарии. Только несколько видов этого подсемейства найдены в Восточной Азии, и только *Teloschistes flavicans* известен на Дальнем Востоке России. Настоящая статья посвящена находке *Tayloriellina microphyllina* в Приморском крае, на восточном побережье озера Ханка, в ксеротермных условиях смешанного леса с доминированием *Quercus mongolica* и *Pinus* × *funebris*. Этот эпифитный вид подсемейства Teloschistoideae ранее был известен только в Северной Америке, где он распространен в умеренных регионах от южной Канады до центральной Мексики. Наша находка подтверждена молекулярными данными (nrITS). Приводится описание анатомии, морфологии и состава вторичных метаболитов российского материала,

https://doi.org/10.31111/nsnr/2024.58.2.L1
Received: 7 June 2024 Accepted: 3 October 2024 Published: 8 October 2024

а также кратко обсуждается возможное происхождение дальневосточной популяции *T. microphyllina* (дальний занос или реликт).

Ключевые слова: *Caloplaca* s. l., Teloschistaceae, ITS, лишайники, новая находка, Приморье, Россия.

Teloschistoideae Arup et al., one of the three Teloschistaceae Zahlbr. subfamilies, has a mainly Southern Hemisphere distribution (Arup *et al.*, 2013; Wilk *et al.*, 2021). About a quarter of its about 80 currently accepted species and six genera (*Brownliella* S. Y. Kondr. et al., *Haloplaca* Arup et al., *Neobrownliella* S. Y. Kondr. et al., *Tassiloa* S. Y. Kondr. et al., *Tayloriellina* S. Y. Kondr. et al., and *Teloschistes* Norman) are known in the Northern Hemisphere. Just a few species were recorded in eastern Asia [*Teloschistes flavicans* (Sw.) Norman, *Wetmoreana decipioides* (Arup) Arup et al., and some taxa of *Brownliella* and *Neobrownliella*] and only *T. flavicans* was found in the Russian Far East (Tchabanenko, 2002). Here we report the discovery of *Tayloriellina microphyllina* (Tuck.) Søchting et Arup, a species of Teloschistoideae previously known only in North America, in the Primorye Territory (southern part of the Russian Far East).

The genus *Tayloriellina* was originally described in the subfamily Brownlielloideae S. Y. Kondr. et al. (Kondratyuk *et al.*, 2015, 2016). The latter, however, was recognized as an artifactual taxon based on a "chimeric" data set and *Tayloriellina* fixedly ended up in Teloschistoideae (Wilk *et al.*, 2021). Currently the genus *Tayloriellina* consists of three crustose corticolous species, namely Australian *T. erythrosticta* (Taylor) S. Y. Kondr. et al., South American *T. malmeana* Wilk, and previously known as North American *T. microphyllina*. Two further South American species [*"Caloplaca" byrsonimae* (Malme) Zahlbr. and *"C." trabicola* H. Magn.] probably also belong to *Tayloriellina* (Wilk, 2023). *Tayloriellina* is closely related to *Villophora* Søchting et al., a genus found exclusively in the Southern Hemisphere, and their taxonomic distinctiveness was discussed by Søchting *et al.* (2021).

Materials and Methods

The specimens were collected by the first author in the Primorye Territory of Russia in 2020 and deposited in LE and the personal herbarium of I. Frolov. Geographical coordinates are given in the coordinate system WGS 84.

All microscopic observations were based on hand-cut sections mounted in water, without chemical treatments. Measurements of morphological characters follow Vondrák *et al.* (2013); morphological terminology follows Smith *et al.* (2009) and Vondrák *et al.* (2013).

The secondary metabolite patterns were identified using HPLC-UV-MS as described by Frolov *et al.* (2021). Calculations of the relative composition of the secondary compounds are based on absorbance at 270 nm according to Søchting (1997).

DNA was extracted with a CTAB-based protocol (Aras, Cansaran, 2006). Amplifications were made of the internal transcribed spacer regions (ITS) of the nuclear ribosomal RNA gene. Primers for PCR amplification were ITS1F (Gardes, Bruns, 1993)

and ITS4 (White *et al*., 1990). The PCR settings followed Ekman (2001). Three newly generated sequences from the Primorye Territory were submitted to the NCBI (GenBank, 2024): PP838317, PP838318, and PP838319. We also submitted to GenBank four sequences from the USA that were newly generated and kindly provided by Steve Leavitt (Provo, Utah): PP838323, PP838324, PP838325, and PP838326.

The ITS alignment was compiled with all the species of the genus *Tayloriellina* and closely related genera, and *Wetmoreana decipioides* (Arup) Arup et al. was used as an outgroup, according to Arup *et al*. (2013), Søchting *et al*. (2021), Wilk *et al*. (2021), and Wilk (2023). The dataset was aligned online by MAFFT v.7 (Katoh, Standley, 2013; MAFFT version 7, 2019), with the L-INS-i method (Katoh *et al*., 2005) selected automatically by the program. The final alignment consists of 38 sequences belonging to 18 species and six genera, with a total of 576 positions. Phylogenetic reconstruction was carried out using Bayesian inference in MrBayes 3.2.6 (Ronquist, Huelsenbeck, 2003) and the analysis was run on the CIPRES Web Portal. SYM + G model was proposed by the program jModelTest (Guindon, Gascuel, 2003; Posada, 2008) as the best DNA substitution model. MrBayes analysis was performed using two independent runs with four MCMC chains (three cold and one heated) in each run. Trees were sampled every 500th generation. The analysis was stopped when the average standard deviation of split frequencies between the simultaneous runs dropped below 0.01 (355 000 generations). The first 25% of trees were discarded as burn-in, and the remaining trees were used for construction of a 50% majority-rule consensus tree.

Pairwise genetic distances between ITS sequences were calculated in PAUP under the JC model of evolution. The mean and standard deviation of the pairwise distances were calculated in Excel.

Results

Tayloriellina microphyllina (Tuck.) Søchting et Arup, 2021, The Lichenologist 53(3): 248. ≡ *Placodium microphyllinum* Tuck., 1882, Syn. N. Amer. Lich. (Boston) 1: 174. ≡ *Caloplaca microphyllina* (Tuck.) Hasse, 1913, Contr. U. S. Natl. Herb. 17(1): 114. ≡ *Villophora microphyllina* (Tuck.) S. Y. Kondr., 2015, Ukrain. Bot. J. 72(6): 582. — Type: [USA], Pennsylvania, 1879, *J. W. Eckfeldt*, FH, lectotype selected by Wetmore (2004): 511; UC, isolectotype.

Observation of the specimens from Russia (Fig. 1). Thallus greenish orange, subsquamulose to areolate, 100–185 μm thick, irregular in outline, without prothallus, areoles ca. 0.3–1.0 mm diam.; cortex alveolate, 25–45 μm thick, without pruina, usually with epinecral layer 5–13 μm thick; algal layer 60–110 μm thick; medulla poorly developed. Soralia on surface and margins of areoles and sometimes on thalline exciple, punctiform, then bursting into larger discrete or confluent formations, brighter than the areoles surface, yellow-orange; soredia granular, 25–50 μm diam. Apothecia common, scattered, sessile to adnate, round, 0.25–0.65 mm diam.; disk flat,

dark orange; true exciple concolorous with disk, slightly raised above disk, 10–50 μm thick; thalline exciple usually well-developed, 12–50 μm thick, concolorous with thallus. Hymenium 60–90 μm high, hypothecium 85–115 μm high, both colorless, without extracellular oil drops and crystals, hypothecium delimited by algal layer from below; epihymenium with golden-brown epipsamma. Paraphyses ca. 2 μm wide in lower part, usually upper 2–3 cells increased, with the widest upper cell 3–5 μm wide; cells of the upper part of true exciple 5.0–7.0 × 4.0–5.5 μm. Ascospores 8 per ascus, colorless, polarilocular, 10.0–11.5 × 5.0–6.0 μm with rounded ends, septa 2.5–4.5 μm. Pycnidia numerous, flush with or slightly raised above thallus surface, and the same color as apothecial disks, ca. 150 μm wide, conidia narrowly ellipsoid to bacilliform 2.5–4.0 × 1.0–1.5 μm.

Epihymenium, upper true exciple, cortex of thalline exciple, and areoles with anthraquinones, K+ purple. Apothecia and thallus (specimen *Frolov* 2828) contain parietin as a major compound, and traces of citreorosein, emodin, emodinal, emodic acid, fallacinal, parietinic acid, and teloschistin, which corresponds to chemosyndrome A of Søchting (1997).

Phylogeny. The nine available ITS sequences of *Tayloriellina microphyllina* are quite diverse. They have almost 30 variable positions (ignoring gaps; Fig. 2), and mean pairwise genetic distance is 0.0203 ± 0.0132. Such genetic variability is comparable with this of, for example, *Athallia holocarpa* (Hoffm.) Arup et al. in its wide sense (Vondrák *et al*., 2016). Nevertheless, all of the nine ITS sequences of *Tayloriellina microphyllina* form a monophyletic highly supported clade (PP = 0.99) in the Bayesian phylogeny of the genus *Tayloriellina* (Fig. 3). The specimen MW397536 from California is more closely related to our three specimens from Primorye than to the other North American specimens of *T. microphyllina* (Figs 2, 3), and they only differ in three positions (ignoring gaps). Our three ITS sequences obtained from the three individuals from a single population in Primorye are identical and have an indel 22 bases long, which is absent in the North American sequences (Fig. 2).

Specimens examined. **Russia, Primorye Territory:** Khankaysky District, 6 km N of Novokachalinsk, shore of Lake Khanka, 45°09′20.9″N, 132°00′12.8″E, 100 m a. s. l., forest with *Pinus* × *funebris* Kom. and *Quercus mongolica* Fisch. ex Turcz., 1 VII 2020, *Frolov*, LE L-25807, hb. *Frolov* 2688, 2828, 2928, 2934.

Discussion

Phenotypic characters of our material agree well with the description of *Tayloriellina microphyllina* by Wetmore (2004). The species is characterized by orange to greenish orange usually distinctly subsquamulose sorediate thallus without prothallus. In the Russian Far East, the species could be confused with other yellow to orange lichen crusts with vegetative propagules such as *Caloplaca taranii* S. Y. Kondr. et al., *Flavoplaca flavocitrina* (Nyl.) Arup et al., *Gyalolechia oxneri* (S. Y. Kondr. et Søchting) Søchting et al., *G. ussuriensis* (Oxner et al.) Vondrák, and *Polycauliona phlogina* (Ach.) Arup et al. Of these, *Gyalolechia ussuriensis* is most similar to *Tayloriellina*

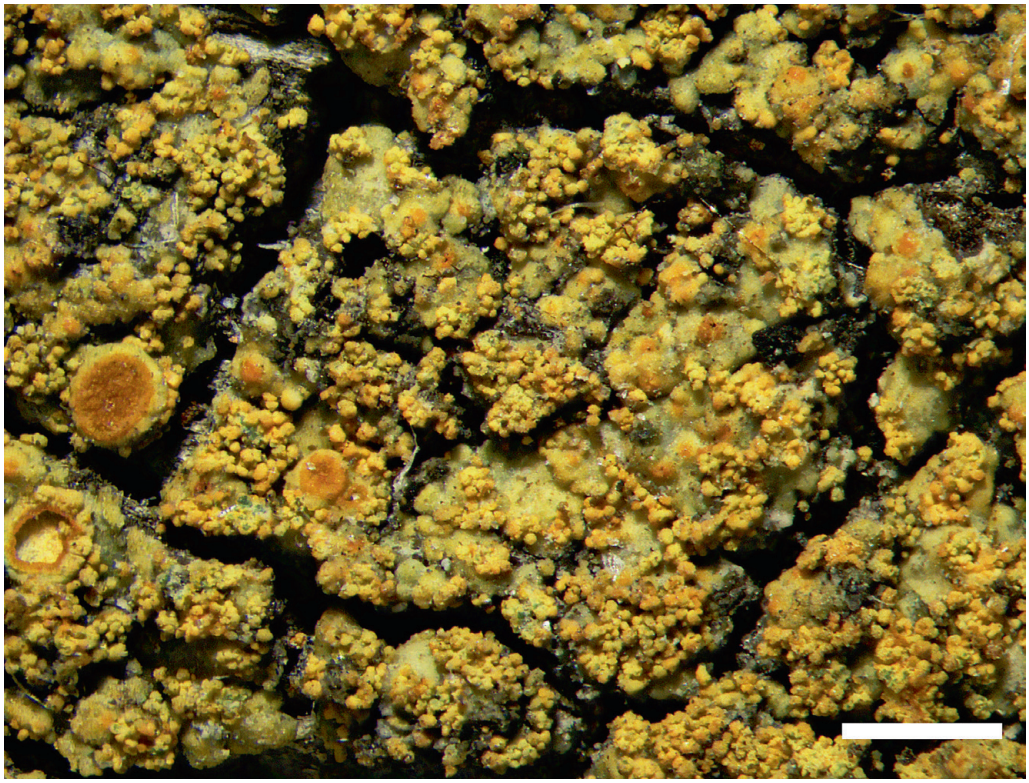

Fig. 1. *Tayloriellina microphyllina* (LE L-25807). Scale bar: 0.5 mm.

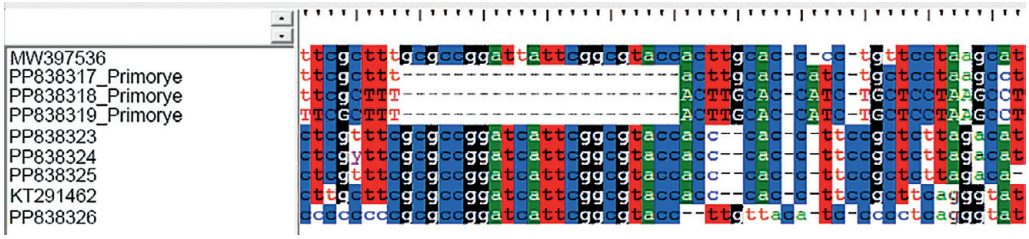

Fig. 2. Shortened nrITS alignment, including only variable positions, of the nine sequences of *Tayloriellina microphyllina*. These positions are numbered as follows in our alignment: 1, 15, 29, 34, 47, 68, 84, 85, 98–119, 141, 142, 145–147, 158, 169, 170, 172, 174, 177, 359, 375, 382, 383, 387, 423, 467, 470, 473, 474, 476, 483, 490, 497, 499, 502.

microphyllina and differs from the latter by the never subsquamulose, but smooth to rimose or areolate thallus, usually well-delimited roundish to elongated laminate soralia, and by the presence of fragilin in thallus and 7-chloroemodin in apothecia (chemosyndrome B2; Søchting, 2001; Kondratyuk *et al.*, 2011). *Gyalolechia oxneri* differs in having phyllidia and schistidia rather than soralia and by a strong dominance of fragilin in both thallus and apothecia (chemosyndrome B4; Kondratyuk *et*

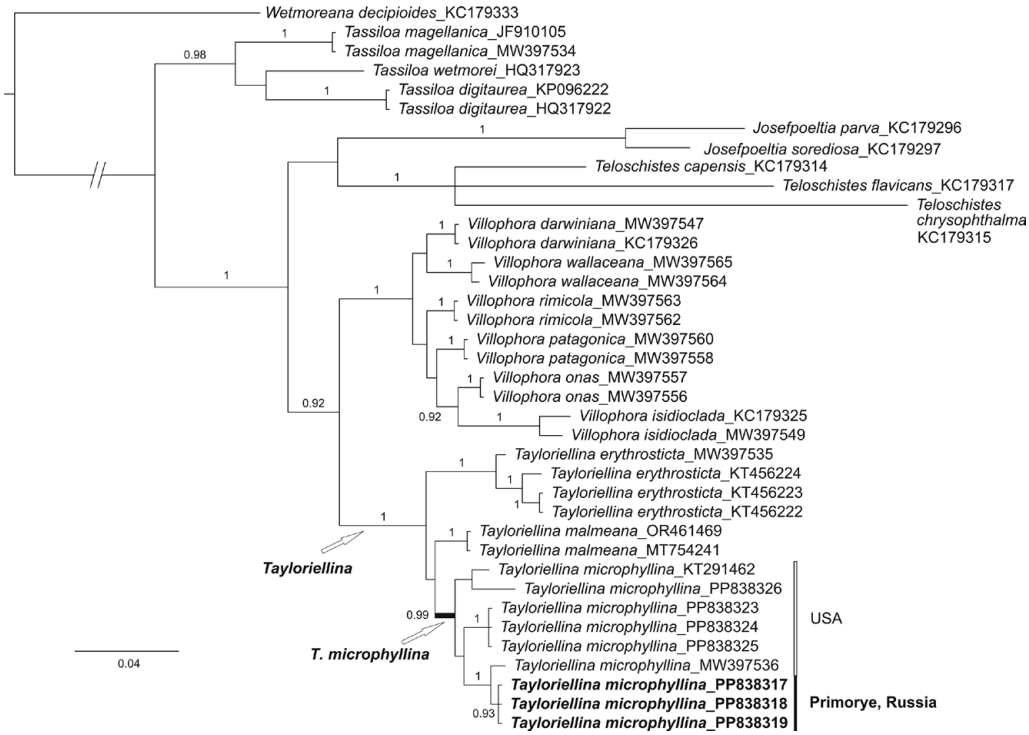

Fig. 3. Phylogeny of the genus *Tayloriellina* and closely related Teloschistoideae genera based on the Bayesian analysis of nrITS. GenBank accession numbers are given; sequences from the Primorye Territory are in bold. Numbers at branches represent posterior probability values ⩾ 0.90. The branch of the *T. microphyllina* clade is thickened.

al., 1996; Søchting, 2001). *Caloplaca taranii* differs by the greenish-yellow areolate thallus with isidia-like or protuberance-like outgrowths often disintegrating into confluent granular-sorediate mass in the thallus center (Kondratyuk *et al*., 2013). In the Far East, *Flavoplaca flavocitrina* is an exclusively saxicolous lichen (Davydov *et al*., 2021; Frolov in prep.) and differs from *Tayloriellina microphyllina* in having thallus consisting of scattered to contiguous areoles with mainly marginal soralia then covering the entire surface of the areoles (Arup, 2006). *Polycauliona phlogina* has pale yellow to yellow thallus consisting of small areoles, which are more or less completely dissolved into soredia (Arup, 2006).

Tayloriellina microphyllina has a temperate distribution in North America from the southern Canada to central Mexico and is especially common in the central United States; it grows on wood or bark, usually in open sun (Wetmore, 2004). Records of this species from Europe were not validated and attributed to *Flavoplaca flavocitrina* by Arup (2006). In Russia, a single population of *Tayloriellina microphyllina* was found in the south of the Primorye Territory on the eastern shore of Lake Khanka where it is abundant in xerothermic condition of *Quercus mongolica*–*Pinus* × *funebris* forest on

the well-lit bark of *Juniperus rigida* Siebold et Zucc., *Pinus* × *funebris*, and especially *Q. mongolica*. Surroundings of Lake Khanka (Prikhankaiskaya Plain) are characterized by a unique within Primorye forest steppe vegetation and relatively xerothermic climate with precipitation–evaporation ratio *ca*. 0.8 (Kurencova, 1962, 1968).

Such a remarkable eastern Asian–North American disjunction is known for several lichens species of *Gyalolechia* A. Massal., *Megalospora* Meyen, Pannariaceae Tuck., Parmeliaceae F. Berchtold et J. Presl, Physciaceae Zahlbr., etc. (Kurokawa, 2006; Galanina *et al*., 2011, 2018; Lendemer *et al*., 2012; Sheard *et al*., 2017; Ezhkin, 2018; Ezhkin, Jørgensen, 2018; Spribille *et al*., 2020). There is some debate regarding whether this disjunction originated through long distance dispersal or represent fragmented relicts of a once continuous geographical range. Some researchers support the latter hypothesis assuming that this is a result of Tertiary range sunderings (Kurokawa, 2006; Lendemer *et al*., 2012). However, Sheard *et al*. (2017) emphasized that emerging molecular data do not appear to support such an ancient disjunction for lichens, but suggest active gene flow between eastern Asian and North American populations. Also Garrido-Benavent *et al*. (2018) demonstrated that a direct long distance dispersal without stepping stones is the most plausible mechanism for the emergence of the *Mastodia tessellata* s. l. bipolar populations.

In the case of *Tayloriellina microphyllina* we can assume that the 22 bases long indel detected in the ITS sequences of the Far Eastern population of this species may be a sign of the long isolated existence of this population and hence its relict origin. The last time, when East Asian and North American parts of the *T. microphyllina* range could be connected was in the late Pliocene, *ca*. 3.6–2.5 million years ago, when the forest steppe landscapes with deciduous trees existed in the Bering land bridge area (Kozhevnikov, Zheleznov-Chukotskii, 1995). According to some estimates of the age of divergence of lichen species and populations (e. g., Garrido-Benavent *et al*., 2016, 2018), the Far Eastern population of *T. microphyllina* may have existed in isolation since the late Pliocene without splitting to separate species.

Nevertheless, we cannot exclude long distance dispersal either, since the Far Eastern population of *Tayloriellina microphyllina* could be an example of the founder effect, when a few propagules of a still undetected North American population having this indel directly reached the eastern Asia. However, since this population in Primorye is quite large and has numerous thalli of *T. microphyllina*, we can assume that this dispersal was not very recent.

Acknowledgments

Steve Leavitt (Provo, Utah) kindly provided his nrITS sequences of *Tayloriellina microphyllina* and Vladimir Kukarskikh (Yekaterinburg) provided access to photographic equipment. The first author would also like to thank Kirill Korznikov (Vladivostok) for his hospitality during the first author's fieldwork in the Primorye Territory. The study was supported by the Russian Science Foundation (RSF grant no. 23-24-00207: https://rscf.ru/en/project/23-24-00207/).

References / Литература

Aras S., Cansaran D. 2006. Isolation of DNA for sequence analysis from herbarium material of some lichen specimens. *Turkish Journal of Botany* 30(6): 449–453.

Arup U. 2006. A new taxonomy of the *Caloplaca citrina* group in the Nordic countries, except Iceland. *The Lichenologist* 38(1): 1–20. https://doi.org/10.1017/S0024282905005402

Arup U., Søchting U., Frödén P. 2013. A new taxonomy of the family Teloschistaceae. *Nordic Journal of Botany* 31(1): 16–83. https://doi.org/10.1111/j.1756-1051.2013.00062.x

Davydov E., Yakovchenko L., Galanina I., Paukov A., Frolov I., Ahti T. 2021. New records of lichens from the Russian Far East. III. Lichens of coastal habitats. *Turczaninowia* 24(1): 25–36. https://doi.org/10.14258/turczaninowia.24.1.4

Ekman S. 2001. Molecular phylogeny of the Bacidiaceae (Lecanorales, lichenized Ascomycota). *Mycological Research* 105(7): 783–797. https://doi.org/10.1017/S0953756201004269

Ezhkin A. K. 2018. *Megalospora porphyritis* (Tuck.) R. C. Harris, a new record for Russia. *Botanica Pacifica* 7(2): 143–145. https://doi.org/10.17581/bp.2018.07208

Ezhkin A. K., Jørgensen P. M. 2018. New records of Pannariaceae (lichenized Ascomycota) from Sakhalin and the Kuril Islands, Russian Far East. *Evansia* 35(2): 43–52. https://doi.org/10.1639/0747-9859-35.2.043

Frolov I. V., Himelbrant D. E., Stepanchikova I. S., Prokopiev I. A. 2021. *Polycauliona comandorica*, a new fruticulose species in the family Teloschistaceae from the Commander Islands, Russia. *The Lichenologist* 53(4): 299–306. https://doi.org/10.1017/S0024282921000268

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(1): 1–6. https://doi.org/10.13158/heia.24.1.2011.59

Galanina I. A., Ezhkin A. K., Yakovchenko L. S. 2018. *Rinodina megistospora* (Physciaceae) in the Russian Far East. *Novosti sistematiki nizshikh rastenii* 52(1): 133–139. https://doi.org/10.31111/nsnr/2018.52.1.133

Gardes M., Bruns T. D. 1993. ITS primers with enhanced specificity for basidiomycetes — application to the identification of mycorrhizae and rusts. *Molecular Ecology* 2(2): 113–118. https://doi.org/10.1111/j.1365-294X.1993.tb00005.x

Garrido-Benavent I., Søchting, U., de los Ríos Murillo A., Pérez-Ortega S. 2016. *Shackletonia cryodesertorum* (Teloschistaceae, Ascomycota), a new species from the McMurdo Dry Valleys (Antarctica) with notes on the biogeography of the genus *Shackletonia*. *Mycological Progress* 15(7): 743–754. https://doi.org/10.1007/s11557-016-1204-x

Garrido-Benavent I., de los Ríos A., Fernández-Mendoza F., Pérez-Ortega S. 2018. No need for stepping stones: direct, joint dispersal of the lichen-forming fungus *Mastodia tessellata* (Ascomycota) and its photobiont explains their bipolar distribution. *Journal of Biogeography* 45(1): 213–224. https://doi.org/10.1111/jbi.13105

GenBank Overview. 2024. https://www.ncbi.nlm.nih.gov/genbank/ (Date of access: 3 III 2024).

Guindon S., Gascuel O. 2003. A simple, fast and accurate method to estimate large phylogenies by maximum-likelihood. *Systematic Biology* 52(5): 696–704. https://doi.org/10.1080/10635150390235520

Katoh K., Standley D. M. 2013. MAFFT multiple sequence alignment software version 7: improvements in performance and usability. *Molecular Biology and Evolution* 30(4): 772–780. https://doi.org/10.1093/molbev/mst010

Katoh K., Kuma K., Toh H., Miyata T. 2005. MAFFT version 5: improvement in accuracy of multiple sequence alignment. *Nucleic Acids Research* 33(2): 511–518. https://doi.org/10.1093/nar/gki198

Kondratyuk S., Søchting U., Kärnefelt I. 1996. *Caloplaca oxneri* (Teloschistaceae), a new lichen species from east Asia. *Natural History Research* 4: 17–20.

Kondratyuk S. Y., Elix J. A., Galanina I. A., Yakovchenko L. S., Kärnefelt I., Thell A. 2011. Four new *Caloplaca* species (Teloschistaceae, Ascomycotina). *Folia Cryptogamica Estonica* 48: 17–23.

Kondratyuk S. Y., Lökös L., Zarei-Darki B., Haji Moniri M., Tchabanenko S., Galanina I., Yakovchenko L., Hooshmand F., Ezhkin A., Hur J. 2013. Five new *Caloplaca* species (Teloschistaceae, Ascomycota) from Asia. *Acta Botanica Hungarica* 55(1–2): 41–60. https://doi.org/10.1556/ABot.55.2013.1-2.4

Kondratyuk S. Y., Kärnefelt I., Thell A., Elix J. A., Kim J.-A., Kondratiuk A. S., Hur J.-S. 2015. Brownlielloideae, a new subfamily in the Teloschistaceae (Lecanoromycetes, Ascomycota). *Acta Botanica Hungarica* 57(3–4): 321–343. https://doi.org/10.1556/034.57.2015.3-4.6

Kondratyuk S. Y., Lökös L., Kim J. A., Kondratiuk A. S., Jeong M.-H., Jang S. H., Oh S.-O., Wang X. Y., Hur, J.-S. 2016. *Fauriea*, a new genus of the lecanoroid caloplacoid lichens (Teloschistaceae, lichen-forming ascomycetes). *Acta Botanica Hungarica* 58(3–4): 303–318. https://doi.org/10.1556/ABot.58.2016.3-4.6

Kozhevnikov Yu. P., Zheleznov-Chukotskii N. K. 1995. *Beringiya: istoriya i evolyutsiya* [Beringia: history and evolution]. Moscow: 383 p. [Кожевников Ю. П., Железнов-Чукотский Н. К. 1995. *Берингия: история и эволюция*. М.: 383 с.]

Kurencova G. E. 1962. *Rastitel'nost' Prikhankaiskoi ravniny i okruzhajushchikh predgorii* [Vegetation of Prikhankaiskaya Plain and surrounding foothills]. Moscow, Leningrad: 140 p. [Куренцова Г. Э. 1962. *Растительность Приханкайской равнины и окружающих территорий*. М., Л.: 140 с.].

Kurencova G. E. 1968. *Rastitel'nost' Primorskogo kraya* [Vegetation of the Primorye Territory]. Vladivostok: 192 p. [Куренцова Г. Э. 1968. *Растительность Приморского края*. Владивосток: 192 с.].

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

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. *The Lichenologist* 44(2): 179–187. https://doi.org/10.1017/S0024282911000764

MAFFT version 7. 2019. http://mafft.cbrc.jp/alignment/server/

Posada D. 2008. jModelTest: phylogenetic model averaging. *Molecular Biology and Evolution* 25(7): 1253–1256. https://doi.org/10.1093/molbev/msn083

Ronquist F., Huelsenbeck J. P. 2003. MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics* 19(12): 1572–1574. https://doi.org/10.1093/bioinformatics/btg180

Sheard J. W., Ezhkin A. K., Galanina I. A., Himelbrant D., Kuznetsova E., Shimizu A., Stepanchikova I., Göran T., Tønsberg T., Yakovchenko L. S., Spribille T. 2017. The lichen genus *Rinodina* (Physciaceae, Caliciales) in northeastern Asia. *The Lichenologist* 49(6): 617–672. https://doi.org/10.1017/S0024282917000536

Smith C. W., Aptroot A., Coppins B. J., Fletcher A., Gilbert O. L., James P. W., Wolseley P. A. 2009. *The lichens of Great Britain and Ireland*. London: 1046 p.

Søchting U. 1997. Two major anthraquinone chemosyndromes in Teloschistaceae. *Bibliotheca Lichenologica* 68: 135–144.

Søchting U. 2001. Chemosyndromes with chlorinated anthraquinones in the lichen genus *Caloplaca*. *Bibliotheca Lichenologica* 78: 395–404.

Søchting U., Søgaard M. Z., Sancho L. G., Arup U. 2021. The lichen genus *Villophora* (Teloschistaceae, Ascomycota). *The Lichenologist* 53(3): 245–255. https://doi.org/10.1017/S0024282921000141

Spribille T., Fryday A. M., Pérez-Ortega S., Svensson M., Tønsberg T., Ekman S., Holien H., Resl P., Schneider K., Stabentheiner E. *et al.* 2020. Lichens and associated fungi from Glacier Bay National Park, Alaska. *The Lichenologist* 52(2): 61–181. https://doi.org/10.1017/S0024282920000079

Tchabanenko S. I. 2002. *Konspekt flory lishainikov yuga rossiiskogo Dal'nego Vostoka* [Checklist of the lichen flora of the south of the Russian Far East]. Vladivostok: 232 p. [Чабаненко С. И. 2002. *Конспект флоры лишайников юга российского Дальнего Востока*. Владивосток: 232 с.].

Vondrák J., Frolov I., Arup U., Khodosovtsev A. 2013. Methods for phenotypic evaluation of crustose lichens with emphasis on Teloschistaceae. *Chornomorskiy Botanichniy Zhurnal* 9(3): 382–405. https://doi.org/10.14255/2308-9628/13.93/6

Vondrák J., Halıcı M. G., Güllü M., Demirel M. 2016. Taxonomy of the genus *Athallia* and its diversity in Turkey. *Turkish Journal of Botany* 40(3): 319–318. https://doi.org/10.3906/bot-1502-12

Wetmore C. M. 2004. The sorediate corticolous species of *Caloplaca* in North and Central America. *The Bryologist* 107(4): 505–520. https://doi.org/10.1639/0007-2745(2004)107[505:TSCSOC]2.0.CO;2

White T. J., Bruns T., Lee S., Taylor J. W. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. *PCR protocols: a guide to methods and applications*. New York: 315–322. https://doi.org/10.1016/B978-0-12-372180-8.50042-1

Wilk K. 2023. New species of *Tayloriellina* (lichenized Ascomycota, Teloschistaceae) from Bolivia. *Phytotaxa* 616(2): 183–188. https://doi.org/10.11646/phytotaxa.616.2.8

Wilk K., Pabijan M., Saługa M., Gaya E., Lücking R. 2021. Phylogenetic revision of South American Teloschistaceae (lichenized Ascomycota, Teloschistales) reveals three new genera and species. *Mycologia* 113(2): 278–299. https://doi.org/10.1080/00275514.2020.1830672