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New records of Megasporaceae (lichenized Ascomycota) from Azerbaijan and new nomenclatural combinations in genera *Circinaria* and *Oxneriaria*

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Summary. A study of lichen collections in BAK and LE revealed three new to Azerbaijan species of Megasporaceae, *Aspicilia coronata* (A. Massal.) B. de Lesdain, *A. rosacea* Hue, and *Sagedia zonata* Ach. Morphological characters, secondary chemistry and distribution of the species are discussed. A combination *Circinaria coronata* (A. Massal.) Wirth, Hauck et M. Schultz ex Paukov et Alverdiyeva is validated and a new combination, *Oxneriaria rosacea* (Hue) Paukov et Alverdiyeva is proposed.

Новые находки лишайников сем. Megasporaceae из Азербайджана и новые номенклатурные комбинации в родах *Circinaria* и *Oxneriaria*

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Ключевые слова: аспилиция, Большой Кавказ, вторичная химия, лишенобиота, Малый Кавказ, морфология.

Аннотация. На основании изучения коллекций в гербариях ВАК и ЛЕ приводятся данные о находках трёх новых для Азербайджана видов лишайников из семейства Megasporaceae: *Aspicilia coronata* (A. Massal.) B. de Lesdain, *A. rosacea* Hue и *Sagedia zonata* Ach. Обсуждаются особенности морфологии, состава вторичных метаболитов и географического распространения видов. Валидизирована комбинация *Circinaria coronata* (A. Massal.) Wirth, Hauck et M. Schultz ex Paukov et Alverdiyeva. Предложена новая номенклатурная комбинация *Oxneriaria rosacea* (Hue) Paukov et Alverdiyeva.

Introduction

Valuable historical collections of lichens from Azerbaijan containing among others representatives

of Megasporaceae Lumbsch were made in 1830 by C. Meyer, in 1898 by V. Lipsky, in 1912 by A. Shelkovnikov, in 1935 by A. Oxner, and in 1930–1980-s by Sh. Barkhalov and V. S. Novruzov. The

material of Meyer and Lipsky was studied by A. Elenkin (1901), Megasporaceae in the collections of Shelkovnikov was determined by J. Steiner. Oxner (1940) described a new species, *Aspicilia grossheimii* Oxn., from Absheron peninsula. The extensive *Aspicilia* collection of Barkhalov was partly determined and published in his work on lichens of Caucasus (Barkhalov, 1983). All these collections contain material that needs to be evaluated, and our study resulted in the revelation of three species of Megasporaceae new to Azerbaijan that kept undetermined.

Materials and methods

Specimens and phenotypic studies

Collections of Shelkovnikov and Barkhalov made in the Astara, Balaken, Goygol, and Masally districts of Azerbaijan, kept in BAK and LE, were used as the core material for this study. Type specimens of Megasporaceae were studied by the first author during his visits to the herbaria of the University of Helsinki (H), the University of Oslo (O), the city of Geneva (G), Uppsala university (UPS), and Bavarian Natural History Collections (B). Morphological observations were made using a dissecting microscope. Cross-sections of apothecia and thalli were cut by hand with a razor blade and observed after mounting in water, K, N and iodine solutions. Measurements of spores and conidia are presented as follows: (smallest value recorded) (X-SE) – [X] – (X+SE) (largest value recorded), where [X] is the (arithmetic) sample mean, and SE the sample error of mean. The measurements were made with the precision of 0.5 µm. Secondary products were analyzed by applying standard thin-layer chromatography techniques (TLC, Orange et al., 2001). Solvents A and C were used for the TLC analysis.

Results

Three species of Megasporaceae new to Azerbaijan were determined in the studied collections. The description of the specimens is presented below.

Aspicilia coronata (A. Massal.) B. de Lesd.

The species has an unusual morphology in Megasporaceae with a thallus immersed into the calcareous substrate and visible mainly as whitish-gray rings around apothecia which are immersed

into pits of a rock, 0.1–0.5 mm diam., with a black concave disc covered by a white pruina. Hymenium in studied specimens 100–120 µm, epihymenium brownish-green, paraphyses submoniliform. Spores 1–4 in ascus, (26.0)30.1–[31.0]–31.9(35.0) × (20.0)22.5–[23.1]–23.7(25.0) µm ($n = 15$). Conidia not observed.

Aspicilia coronata grows on dry or moderately wet, well-lit to shady horizontal and inclined limestone surfaces and is known from Spain (Llimona, Hladun, 2001), France (Roux, 2020 and references therein), Germany (Wirth et al., 2013), Austria, Italy, Switzerland (Nimis et al., 2018), Sweden (Fröberg, 1989), Ukraine (Kondratyuk et al., 2021), Turkey (Aslan, 2000) and Iran (Seaward et al., 2004).

Records from Azerbaijan: **Masally district**: “vicinity of Istisu mineral spring on Vilyashchai river, on limestone. 17 VI 1946. Sh. O. Barkhalov” (BAK 653); **Astara district**: “Levain settlement, Ozhakeran, on limestone. 06 VII 1947. Sh. O. Barkhalov” (BAK 626).

New combination

Although it resembles a *Gyalecta* Ach. rather than a Megasporaceae species (Massalongo, 1853), *Aspicilia coronata* is obviously a representative of *Circinaria* Link with its sphaeric spores arranged in a single row in ascus, green epihymenium and submoniliform paraphyses. The position of the species in the Group 1 that corresponds to *Circinaria* was demonstrated by Nordin et al. (2007), but the new combination has not been made in their following paper on the phylogeny of Megasporaceae where genus *Circinaria* was resurrected (Nordin et al., 2010). The formal combination was made by Wirth et al. (2013), but it is invalid following the Shenzhen code (Art. F.5.1) (Turland et al., 2018). Here we legitimize this act.

Circinaria coronata (A. Massal.) Wirth, Hauck et M. Schultz ex Paukov et Alverdiyeva, **comb. nov.**
MycoBank No 853677

Basionym: *Pachyospora coronata* A. Massal., 1853, Memor. Lichenogr.: 131.

Lecanora coronata (A. Massal.) Jatta, 1900, Syll. Lich. Ital.: 215. – *Aspicilia coronata* (A. Massal.) B. de Lesd., 1906, Bull. Soc. Bot. Fr. 53: 516.

Type: ITALY, **prov. Verona**: “Monte Pastello, S. Ambrogio, Cavalo ecc. Sine datum. Massalongo” (iso – M! [M0190138] (Fig. 1A); iso – G! [G00551357]).

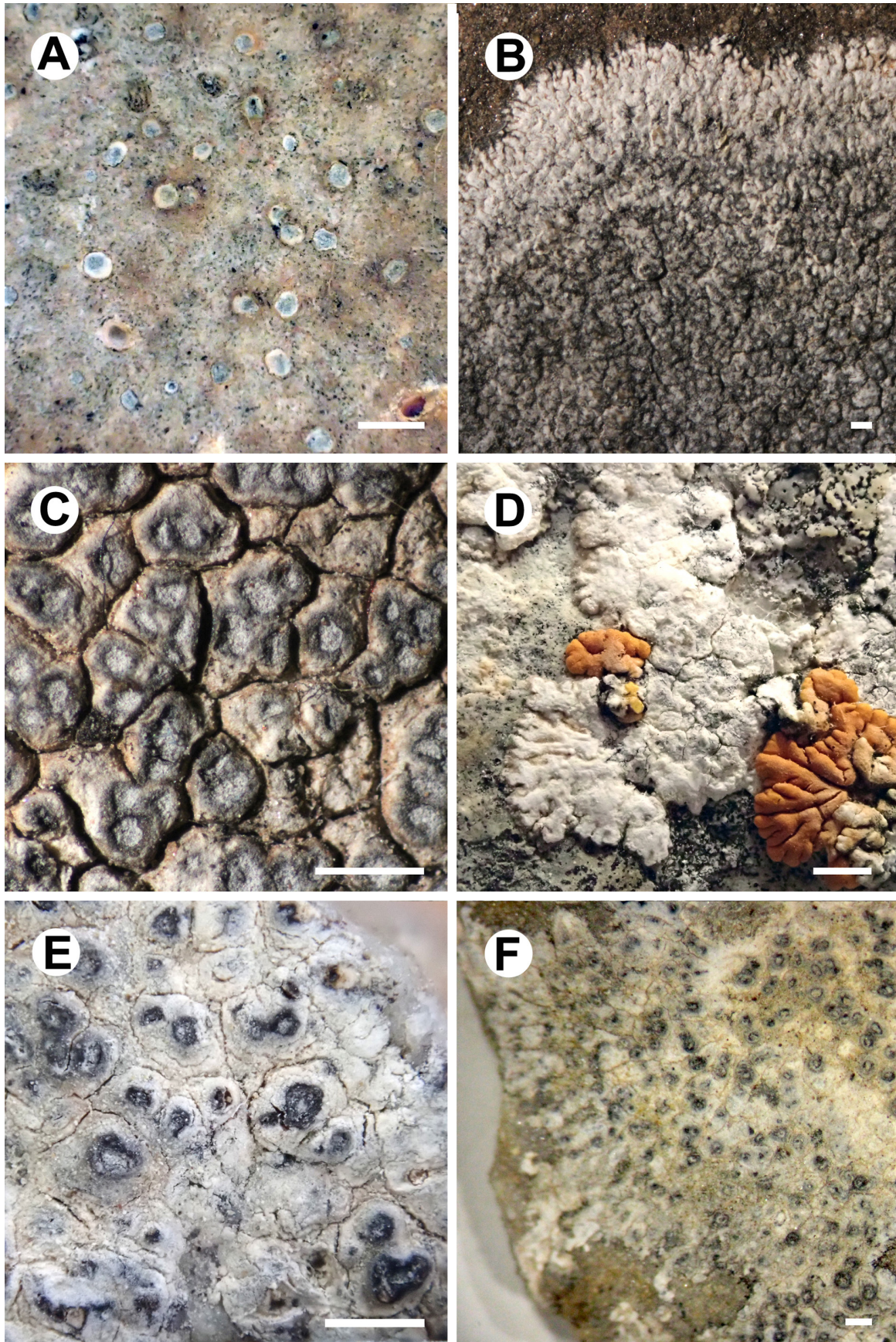


Fig. 1. Type specimens of Megasporaceae and a representative collected in Azerbaijan: A – isotype of *Pachyospora coronata* (M0190138); B – isotype of *Aspicilia rosacea* (H-Nyl 25336), general view; C – isotype of *A. rosacea* (H-Nyl 25336), areoles with apothecia in the central part of the thallus; D – *A. rosacea* (leg. Shelkovnikov), young thalli (LE); E – isotype of *A. nikrapensis* (H), apothecia; F – isotype of *A. nikrapensis* (H), thallus. Scale bar = 1 mm.

***Aspicilia rosacea* Hue**

The species was described by A. Hue (1910) on the basis of Arnold's specimens collected in Pan-veggio (Italy), distributed as exsiccates (Lich. Exsicc., No 999) (Fig. 1B, C) and identified by Arnold as *Aspicilia polychroma* var. *candida* Anzi. Hue, however, differentiated these taxa and, apart from the description of the new species, proposed in the same article a new combination, *Aspicilia candida* (Anzi) Hue based on Anzi's Lich. rarior. Langob. exsiccate No 325, thus separating three taxa, *A. candida*, *A. polychroma* Anzi s. str., and *A. rosacea*. The name *Aspicilia rosacea* has not been in use since the date of its description as far as whitish, indistinctly lobate *Aspicilia* specimens were attributed to *A. candida*, and we did not manage to find a mention of *A. rosacea* as a separate species in papers published since 1910. We agree with the assumption of Hue and suppose that, despite their external similarity, *Aspicilia candida* and *A. rosacea* represent different species.

Aspicilia rosacea has a whitish orbicular thallus, up to 4 cm in diam. and 0.5 mm thick, with a mealy surface, continuous or radially plicate in the external part, with short lobules 1–1.5 × 0.2–0.5 mm on the periphery, and with irregular areoles, 1–2 mm in diameter in the center. Hypothallus black, well-developed. Apothecia 0.2–0.5 mm, often angulate because of mutual pressure, in groups of 1–8 on flat to weakly convex central areoles, immersed to slightly crateriform, with a white-pruinose disc surrounded by a thick black rim. Hymenium 100–120 µm, epihymenium greenish, paraphyses submoniliform. Spores (19.0)21.2–[21.7]–22.2(26.0) × (11.0)14.0–[14.6]–15.2(18.0) µm ($n = 15$). Pycnoconidia rare, as black dots on the surface of thalli. Conidia curved or straight, (14.0)15.5–[15.8]–16.1(18.0) µm ($n = 20$).

Secondary metabolites: stictic acid complex.

Aspicilia candida (Lich. rarior. Langob. exsicc. No 325) has similar whitish, mealy, orbicular thalli. The margin of this species is plicate but lacks definite lobules and surrounded by a grey prothallus. Spores are smaller than in *Aspicilia rosacea* and do not exceed 20 µm, (15.0)17.5–[18.0]–18.5(20.0) × (11.0)12.5–[12.8]–13.2(15.0) µm ($n = 15$). Conidia curved, longer compared to the previous species, (18.0)20.0–[20.5]–20.9(25.0) µm ($n = 20$).

Secondary metabolites: substictic acid.

Specimens examined: ITALY, **prov. Sondrio**: “Bormio, monte Parete, on limestone. Sine datum. Anzi” (iso – H! [H-Nyl 25336]; iso – WU! [WU887]).

Another species that is similar to *Aspicilia rosacea* Hue is *Oxneriaria nikrapensis* (Darb.) S. Y. Kondr. et L. Lőkös that has the same large spores and contains stictic acid. Previously we supposed that *Oxneriaria nikrapensis* is the correct name for specimens with whitish, radiate, mealy thalli and stictic acid (Chesnokov et al., 2018). *Aspicilia nikrapensis* Darb. was described one year earlier (Darbishire, 1909) than *A. rosacea* and, hence, the former name would have a priority over the latter. Nevertheless, despite the fact that the available types of *Aspicilia nikrapensis* are small specimens, a careful examination revealed some differences between these two species. The thalli of *Oxneriaria nikrapensis* also have a lobate pattern, but it is formed by loosely packed radially arranged areoles similar to those of *O. permutedata* (Zahlbr.) S. Y. Kondr. et L. Lőkös. Apothecia of *Oxneriaria nikrapensis* are crater-form, arranged 1 or 2 on thick, convex areoles and never angulate because of the mutual pressure (Table 1; Fig. 1E, F).

Table 1

Morphological characters separating *Oxneriaria nikrapensis* and *O. rosacea*

Character	<i>Oxneriaria nikrapensis</i>	<i>Oxneriaria rosacea</i>
External part of the thallus	Unshapely bordered, true lobes absent, thinning	Sharply bordered, plicate to tiny-lobulate, margin thick
Apothecia	1–2 on areole, rounded, crater-form, separate	1–8 on areole, rounded to angulate, flat, close-standing

Examined specimens of Oxneriaria nikrapensis: CANADA, **Nunavut**: “Ellesmere Island, Innerer Gänsefjord, Westseite, an Steinen. 25 IX 1900. Simons 2676” (iso – H!, [s. n.]; iso – UPS! [L-199558]).

New combination

Genera *Aspicilia* and *Oxneriaria* cannot be easily separated without molecular data by the use of morphological characters and secondary chemistry

only, however species with whitish, mealy, orbicular thalli are not known in *Aspicilia* and may belong to *Oxneriaria* or *Lobothallia*. The latter can be separated by its straight short, 3–8 µm long conidia and a subhymenial algal layer (Nordin et al., 2010). In *Oxneriaria* conidia are longer, curved C- or S-form, and the subhymenial algal layer is absent. *Aspicilia rosacea* is, hence, a representative of this genus. Here we propose a new combination for the species.

Oxneriaria rosacea (Hue) Paukov et Alverdiyeva, **comb. nov.**

Mycobank No 853694

Basionym: *Aspicilia rosacea* Hue, 1912, Nouvelles Archives du Museum d'Histoire Naturelle 2: 66. – *Lecanora rosacea* (Hue) Zahlbr., 1928, Cat. lich. univ. 5: 346.

Type: ITALY, **prov. Trentino**: “Paneveggio in Südtirol. 23 VIII 1883. Arnold” (H-Nyl-3379 isotype! (Fig. 1B, C), UPS L-199555 isotype!).

Records from Azerbaijan: “**Goygol district**: top of Kyapaz mountain, 2900 m a. s. l., on limestone. 20 VII 1912. A. Shelkovnikov” (LE) (Fig. 1D).

Sagedia zonata Ach.

The species is variable in respect to morphology and was described as 14 different taxa which were synonymized by Nordin et al. (2007). *Sagedia zonata* has a grayish areolate thallus occasionally radially zonate on the periphery but the zonation lacks in the thalli growing in dense lichen communities. Apothecia commonly have a blackish rim and look lecideine. Spores (15.0)19.6–[20.1]–20.6(25.0) × (10.0)11.8–[12.1]–12.5(16.0) µm ($n = 30$), conidia (8.0)9.5–[9.7]–9.8(12.0) µm ($n = 50$).

Secondary metabolites: not detected by TLC.

Sagedia zonata is a widespread species in high mountains of the South and North Europe and is known from Austria, France, Germany, Italy

(Nimis et al., 2018; Roux, 2020), Finland, Norway, Poland, Sweden (Magnusson, 1939; Westberg et al., 2021; Szczepańska et al., 2023), Turkey (Kinalioglu, Aptroot, 2017), NW Russia, Urals and South Siberia (Urbanavichus, 2010; Paukov et al., 2014). Here we report it from Azerbaijan.

Record from Azerbaijan: “**Balaken district**: top of Maala-Rassa mountain, 3100 m a. s. l., on rocks. 25 VIII 1974. V. S. Novruzov” (BAK 483).

Discussion

The diversity of Megasporaceae (or *Aspicilia* s. l.) in Azerbaijan prior to this study comprised 32 species of which 20 belong to *Aspicilia*, 8 to *Circinaria*, 3 to *Lobothallia* and 1 to *Megaspora* (Alverdiyeva, Novruzov, 2013). With the addition of three species the total known number of Megasporaceae in Azerbaijan is 35 taxa from 6 genera, of which *Oxneriaria* and *Sagedia* are new to the country. The diversity of the family is higher than in the neighbouring countries where 19 species are known from Armenia (Harutyunyan et al., 2011; Gasparyan, Sipman, 2016; Zakeri et al., 2016), 17 from Turkey (John, 1996; Yazici et al., 2008), 18 from Georgia (Inashvili et al., 2022) and 26 from Iran (Seaward et al., 2004; Moniry et al., 2005; Valadbeigi et al., 2011).

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