

Caloplaca anularis and *Caloplaca scrobiculata* are distinct

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Abstract: VONDRÁK, J. & MAYRHOFER, H. 2013. *Caloplaca anularis* and *Caloplaca scrobiculata* are distinct. – Herzogia 26: 21–29.

Caloplaca anularis, described from the Western Alps, and *Caloplaca scrobiculata*, described from Central Asia, are distinct species. The main differences are the shape of the thallus margin, the anatomy of the thalline cortex, characters of the algal layer and the ascospores. *Caloplaca anularis* is a widespread lichen known from mountain ranges in Europe (Alps, Carpathians, Balkan Peninsula), Near Asia (continental Turkey and Caucasus) and Central Asia (Altay, Karakorum, Hengduan Shan). The specimens from Central Asia differ slightly from the European specimens in thallus and medulla thickness, but we consider this difference environmentally induced and taxonomically insignificant. *Caloplaca scrobiculata* is restricted to arid mountain ranges of Central Asia. The Central Asian *Caloplaca bohlinii* does not differ significantly from *C. anularis*. The new combination *Caloplaca anularis* f. *ignea* is made for specimens of *C. anularis* with a red thallus.

Zusammenfassung: VONDRÁK, J. & MAYRHOFER, H. 2013. *Caloplaca anularis* und *Caloplaca scrobiculata* sind verschieden. – Herzogia 26: 21–29.

Caloplaca anularis, beschrieben aus den Westalpen, und *Caloplaca scrobiculata*, beschrieben aus Zentralasien, sind verschiedene Arten. Die wichtigsten Unterschiede sind die Form des Lagerrandes, die Anatomie der Lagerrinde, die Merkmale der Algenschicht und der Ascosporen. *Caloplaca anularis* ist eine weit verbreitete Flechte, die aus Gebirgen in Europa (Alpen, Karpaten, Gebirge der Balkanhalbinsel), Vorderasien (kontinentale Türkei und Kaukasus) und Zentralasien (Altai, Karakorum, südosttibetisches Randgebirge) bekannt ist. Die Proben aus Zentralasien unterscheiden sich gering von denen aus Europa hinsichtlich der Dicke von Lager und Mark, aber diese Merkmale werden als umweltbedingt induziert und taxonomisch unbedeutend betrachtet. *Caloplaca scrobiculata* ist beschränkt auf aride Gebirge in Zentralasien. Die zentralasiatische *Caloplaca bohlinii* unterscheidet sich nicht deutlich von *C. anularis*. Die neue Kombination *Caloplaca anularis* f. *ignea* wird eingeführt für Proben mit rotem Lager.

Key words: Algal stacks, alpine lichens, desert lichens, fungal stacks, lichenized Ascomycota, taxonomy, Teloschistaceae.

Introduction

Field experience from Central Asia and study of herbarium specimens indicate that the lichen names *Caloplaca anularis* Clauzade & Poelt, *C. bohlinii* H.Magn. and *C. scrobiculata* H.Magn. have not always been applied correctly. *Caloplaca scrobiculata* and *C. bohlinii* were described from high mountain ranges in Kansu, an arid region in the Central Asian part of China (MAGNUSSON 1940). *Caloplaca anularis* was described from the Western Alps by CLAUZADE & POELT (1972) and POELT & HAFELLNER (1980) illustrated its morphological and anatomical characters and provided a distribution map. POELT & HINTEREGGER (1993) treated *C. anularis* as a synonym of *C. scrobiculata*, a view which was accepted by a number of authors and which presently appears in the checklists of Austria (HAFELLNER & TÜRK 2001),

Bulgaria (MAYRHOFER et al. 2005), France (ROUX 2012), Italy (NIMIS & MARTELOS 2008), Montenegro (KNEŽEVIĆ & MAYRHOFER 2009), Slovakia (PIŠÚT et al. 1996) and Slovenia (SUPPAN et al. 2000). KHODOSOVTSSEV et al. (2004) did not follow POELT & HINTEREGGER (1993) and treated *C. anularis* and *C. scrobiculata* as distinct, a view which is supported here. *Caloplaca bohlinii* is a little known name, which KHODOSOVTSSEV et al. (2004) referred as an independent species distinct from *C. anularis* and *C. scrobiculata*. However, we cannot find any significant difference between *C. bohlinii* and *C. anularis*.

Material and Methods

To test the hypotheses that (1) *Caloplaca anularis* is morphologically separated from *C. scrobiculata* and (2) *Caloplaca bohlinii* does not differ morphologically from *C. anularis*, we investigated European and Asian populations of *C. anularis*, *C. scrobiculata* and *C. bohlinii* including their type material. We have evaluated phenotypic characters separately for the following four groups: (i) nine specimens of European *C. anularis*; (ii) five specimens morphologically recalling the former group, but from mountain ranges of Central Asia; (iii) the type specimen of *C. bohlinii* (which is the only specimen available); (iv) three Central Asian specimens of *C. scrobiculata*.

Thirteen phenotypic characters were evaluated (Table 1). The microscopic examinations were made on hand-cut sections mounted in water without KOH pretreatment. The ascospore characters (size and septum width) were measured only in samples with well developed ascospores (always 10 measurements per sample). Ascospores were measured in their stabilized state (\pm dead spores) with thin cytoplasmic channel within the septum (important when evaluating fresh material containing young spores with indistinct channel in the septum). The measurements of the ascospores are presented as “(minimum value observed–) lowest specimen arithmetic mean observed – arithmetic mean of all observations – highest specimen arithmetic mean observed (–maximum value observed) [n; s]”, where “n” is the number of all measurements and “s” the standard deviation. The observations of thallus characters (width of thallus, thickness of cortex, algal layer and medulla) were carried out in each sample. The conidia were examined in at least one specimen in each of the four groups. The maximum and minimum values were employed for measurements of conidia and cortex and algal layer thicknesses. Only the maxima were noticed for thallus and medulla thicknesses. The measurements are summarized in Table 1.

Specimens examined

Caloplaca anularis. **Austria**. Ennstaler Alpen, Admonter Kalbling, alt. 1900–2000 m, 1990, H. Mayrhofer & G. Kantvilas (GZU); *ibid.*, 1996, H. Mayrhofer (GZU); Hochschwab, Schiestlhaus, alt. 2050 m, 1989, J. Hafellner (GZU); Hochschwab, Fölzstein, alt. 1900 m, 2003, J. Hafellner (GZU). **France**. Hautes Alpes, Grand Aréa NNW of Briançon, alt. 2300 m, 1970, J. Poelt (GZU, holotype). **Macedonia**. Galičica, alt. 1800–1900 m, H. Mayrhofer (GZU); Šar Planina, Rudoka, Popova šapka, alt. 2100 m, 1977, J. Hafellner, H. Mayrhofer & J. Poelt (GZU). **Montenegro**. Komovi Mts, Mt. Vasojevicki, alt. 1800–2050 m, 1974, J. Poelt (GZU); Durmitor National Park, pass Sedlo, steep slopes of Sedlena Greda above the pass, 2060–2100 m, 2011, H. Mayrhofer 19012 & J. Müllneritsch (GZU). **Pakistan**. Baltistan, Haramosh range, pass Ganto-La, alt. about 3500 m, 1991, J. Poelt (GZU); *ibid.*, SE of Ganto-La, alt. 3500 m, 1991, J. Poelt (GZU, 2 samples). **Russia**. Republic of Altay, Kosh-Agach district, SE part of Kuray Ridge, NE of village Chagan-Uzun, alt. 3000 m, 2012, I. Frolov & J. Vondrák (CBFS JV9927). **Tibet**. 120 km SSW of Quamdo (= Changtu), 10 km S of Bamda, alt. 4500–4700 m, 1994, W. Obermayer (GZU).

Caloplaca bohlinii. **China**. Kansu, Gun-tsan, alt. 3800 m, 1932, B. Bohlin (S, holotype).

Caloplaca scrobiculata. **China**. Kansu, Yeh-ma-ta-ch'üan, alt. 3000 m, 1931, B. Bohlin (S, holotype). **Uzbekistan**. Aman Kutan (between Samarkand and Shakhrisabe), alt. 1500 m, 1975, I. Pišút (BRA 11106, 11107).

Caloplaca scrobiculata var. *ignea* (= *C. anularis* f. *ignea*). **Russia**. Republic of Altay, Kosh-Agach district, SE part of Kuray Ridge, NE of village Chagan-Uzun, alt. 3000 m, 2012, I. Frolov & J. Vondrák (CBFS JV9928).

Images of the holotypes of *Caloplaca bohlinii* and *C. scrobiculata* are available on the web of the http://andor.nrm.se/fmi/xsl/kryptos/kbo/publFindspecies.xsl?-view&db=kbo_svampregister&-token.languagecode=en-GB.

Images of the holotype of *Caloplaca anularis* and holotype of *C. scrobiculata* var. *ignea* on the lichenological web at the University of South Bohemia (GZU type gallery) <http://botanika.bf.jcu.cz/lichenology/index.php?pg=5&func=cat&idx=35#photos>.

Images of selected studied samples on the lichenological web at the University of South Bohemia (lichen gallery) <http://botanika.bf.jcu.cz/lichenology/index.php?pg=5&func=cat&idx=29#photos>.

Results

Diagnostic characters of *Caloplaca anularis*

Important characters are the yellow to slightly orange-yellow thallus with well-developed, long and narrow marginal lobes without pruina (Figs 1A, B), the presence of a real prosoplectenchymatous cortex (Fig. 1C) and lengthened subrhomboid ascospores with a wall that is mostly thin but distinctly broadened around the septum (Fig. 1E). The thalli of *C. anularis* have a distinctive manner of development: when the thallus grows (radially), its central areoles die and fall off and only the marginal areas partly remain, forming ring-shaped fragments on rocks. The algal layer is more or less continuous (Fig. 1D), usually thinner than in *C. scrobiculata* and “fungal stacks” are not formed, or present but less pronounced than in *C. scrobiculata*. Asian populations have a somewhat thicker thallus than the European ones (up to 700 µm vs. up to 400 µm) and the specimens from the Karakorum have smaller ascospores (Table 1).

Diagnostic characters of *Caloplaca scrobiculata*

This peculiar lichen is easily recognized by the following characters. It forms very thick yellow to orange-yellow crusts with a rough upper surface with wrinkles and grooves (Figs 2A, B); the grooves are a kind of pseudocyphellae (Fig. 2C). The surface of the ridges between the pseudocyphellae is regularly covered with a white pruina. The vertical section through the thallus shows the absence of a real cortex, but the presence of vertically arranged prosoplectenchymatous hyphal bundles, which divide the thick algal layer (Fig. 2C). The terms “fungal stacks” and “algal stacks” are proposed by VONDRÁK & KUBÁSEK (2013) for these vertically arranged tissues. *Caloplaca scrobiculata* may have a squamulose margin of the basically areolate thallus, but does not form any marginal lobes. Its two-celled ascospores have a thin walled septum (Fig. 2D) and are similar to those in *Fulgensia desertorum* (Tomim) Poelt or *Caloplaca australis* (Arnold) Zahlbr. The phenotype characters are summarized in Table 1.

Observations of the type of *Caloplaca bohlinii*

Morphologically the specimen fits well with *C. anularis* (Table 1). Its anatomy fits the populations of *C. anularis* from the Karakorum: thallus thicker and ascospores smaller than in European material. It has also a thinner cortex (usually up to 40 µm thick), but a thin layer of a “false” alveolate cortex (sensu VONDRÁK et al. 2009) has been observed below the true cortex. The ring-shaped fragments, typical for *C. anularis*, are not well developed in the specimen.

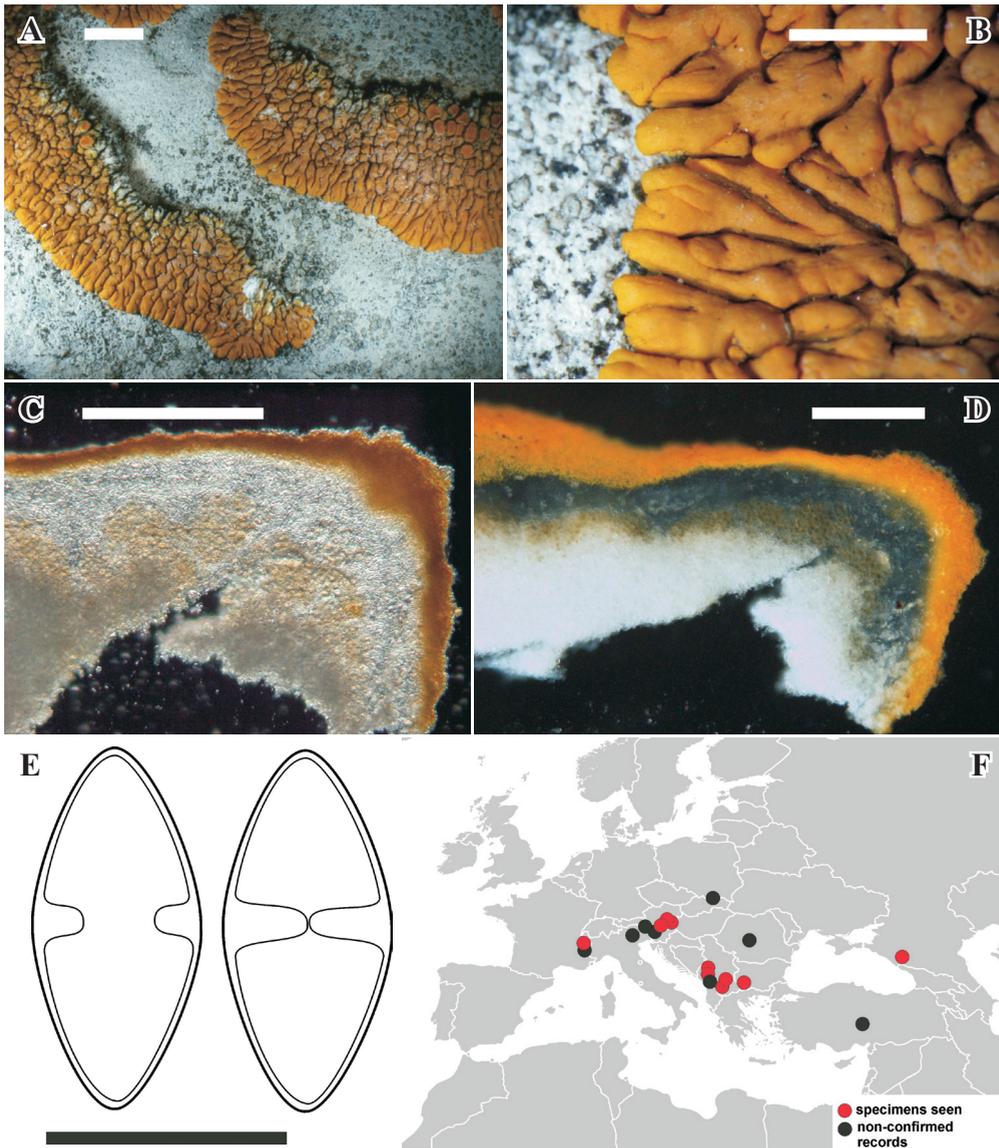


Fig. 1: *Caloplaca anularis* (Alps, 2003, leg. Hafellner, GZU). **A**–thalli; **B**–surface and shape of thallus lobes; **C**–vertical section of thallus showing prosoplectenchyma in cortex; **D**–vertical section of thallus showing the difference between the translucent cortex and the “milky” medulla with numerous extracellular crystals; **E**–ascospores; **F**–distribution in Europe and the Near East (non-confirmed records are adopted from NIMIS & MARTELOS 2008, PIŠŮT 2002, POELT & HAFELLNER 1980, SUPPAN et al. 2000, SVOBODA et al. 2012, URBANOVICHUS & URBANOVICHENE 2012, YAZICI et al. 2008); Scales: A=5 mm, B=1 mm, C, D=100 µm, E=10 µm.

Other observations in thallus anatomy and ascospores

In all investigated specimens the medulla forms a distinct layer clearly recognized by the bleary or “milky” appearance (Figs 1D, 2C). It is formed by loose hyphae hardly recognizable in water, as they are constantly enclosed in a dense coat of \pm isodiametric translucent crystals

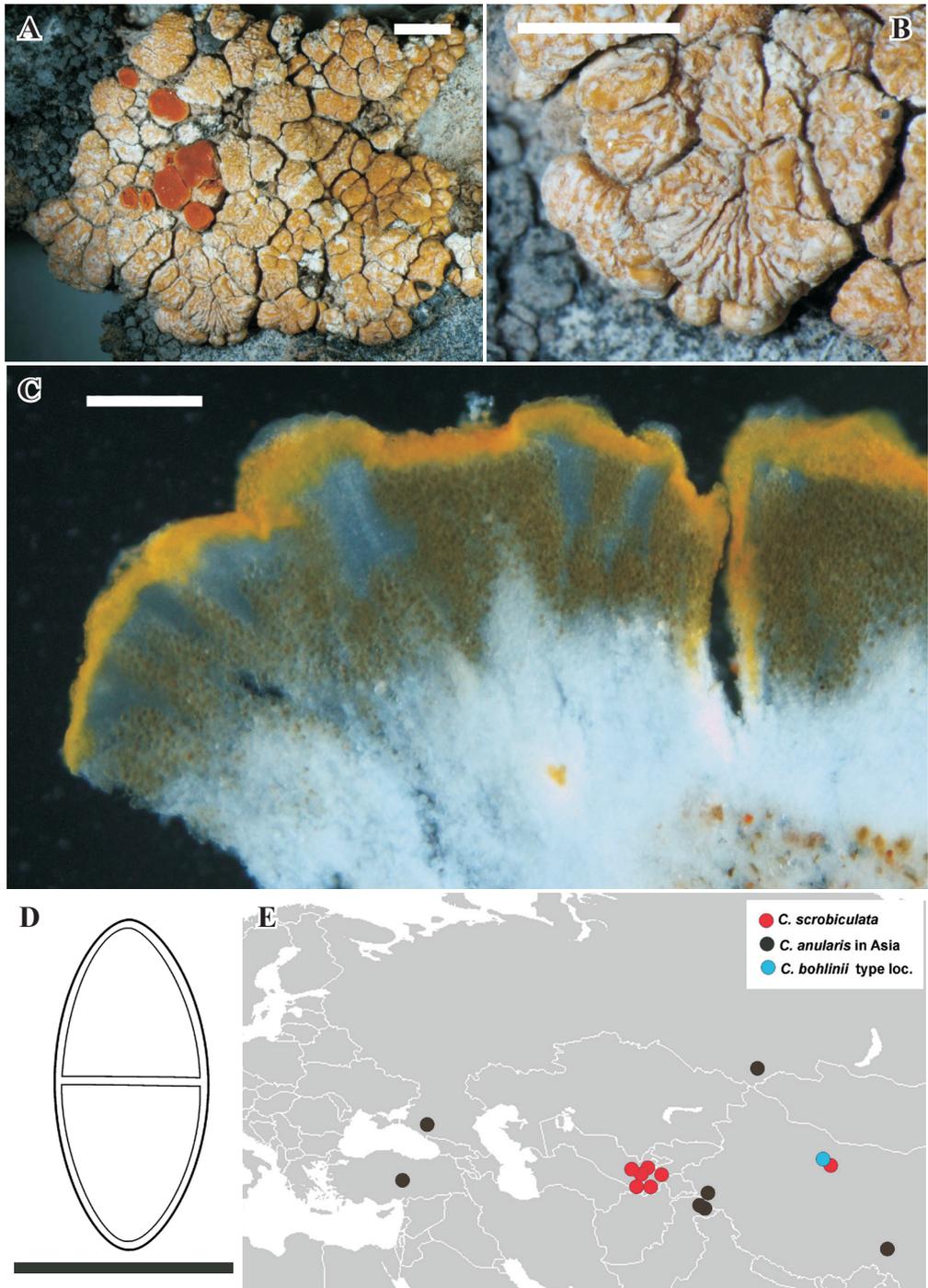


Fig. 2: *Caloplaca scrobiculata* (Uzbekistan, BRA 11106). **A**–thallus; **B**–surface and shape of the thallus margin; **C**–vertical section of thallus showing translucent fungal stacks and the “milky” medulla with numerous extracellular crystals; **D**–ascospore; **E**–distributions of studied lichens in Asia; data from Tajikistan adopted from KUDRATOV & MAYRHOFER (2002). Scales: A, B=1 mm, C=100 µm, D=10 µm.

Table 1: Selected characters of the studied lichens.

| | <i>C. anularis</i> (Europe) | <i>C. anularis</i> (Asia) | <i>C. bohlinii</i> (holotype) | <i>C. scrobiculata</i> |
|----------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------------------|---------------------------------------------------------|
| Ascospore length | (14.0–)15.5–16.5–17.3(–20.5) μm [20; 1.9] | (10.5–)13.2–15.0–17.7(–21.5) μm [40; 2.5] | (13.0–)14.0(–16.0) μm [10; 1.2] | (13.0–)15.3–16.8–18.3(–21.5) μm [20; 2.1] |
| Ascospore width | (5.0–)5.7–6.1–6.4(–8.0) μm [20; 0.7] | (4.5–)5.7–6.5–6.7(–8.0) μm [40; 0.8] | (5.5–)6.5(–7.5) μm [10; 0.7] | (6.0–)6.5–7.0–7.5(–8.5) μm [20; 0.8] |
| Ascospore shape | narrowly ellipsoid - narrowly rhomboid | ellipsoid - rhomboid | ellipsoid - rhomboid | ellipsoid |
| Ascospore septum | (1.25–)1.6–1.8–1.9(–2.25) μm [20; 0.3] | (0.5–)1.5–1.6–1.7(–2.5) μm [40; 0.5] | (1.0–)1.6(–2.0) μm [10; 0.4] | septum wall not thickened |
| Thallus shape | at first radial, later of ring-shaped fragments | at first radial, later of ring-shaped fragments | at first radial, later of ring-shaped fragments | \pm radial; central part of thallus not falling off |
| Thallus surface | smooth; pruina on inner areols only | smooth; pruina on inner areols only | smooth; pruina on inner areols only | wrinkled; pruina on ridges |
| Marginal lobes | well-developed | well-developed | well-developed | absent (\pm isodiametric marginal squamules present) |
| Thallus thickness | up to 400 μm | up to 700 μm | up to 600 μm | up to 700 μm |
| Cortex thickness / cortex tissue | 60–140 μm / prosoplectenchymatous; without crystals | 30–150 μm / prosoplectenchymatous; without crystals | 0–40 μm / prosoplectenchymatous; without crystals | horizontal cortex layer absent; without crystals |
| Algal layer thickness | 70–150 μm | 80–170 μm | 100–250 μm | 100–200 μm |
| Algal stacks / fungal stacks | usually absent (but \pm developed in material from Balkan) | usually distinct, thin, up to 20 μm wide | \pm distinct, thin, up to 20 μm wide | distinct, up to 50 μm wide |
| Medulla characters | up to 200 μm thick; filled by crystals | up to 550 μm thick; filled by crystals | up to 500 μm thick; filled by crystals | up to 500 μm thick; filled by crystals |
| Conidia size | 3.0–4.5 \times 1–1.5 μm | 3.0–4.5 \times 1–1.5 μm (in one sample up to 6 μm long) | 3.0–4.5 \times 1–1.5 μm | 3–5 \times 1.25–1.75 μm |
| Substrate, ecology | limestone, alpine belt | limestone, dry alpine sites | limestone, 3800 m (arid region) | lime-rich rocks, dry alpine sites |

(about 0.5–5.0 μm in diameter). Sulphuric acid rapidly dissolves these extracellular crystals (perhaps calcium carbonate / oxalate) and forms rosettes of needle-shaped crystals of calcium sulphate (as described e.g. in TIMDAL 1992). The thickness of the medulla differs greatly between European and Asian specimens of *C. anularis*, and this is mainly responsible for differences in the thickness of the whole thalli (Table 1). It may represent an environmentally-induced character, because thalli of various lichens (e.g. *Acarospora* spp., *Aspicilia* spp., *Caloplaca* spp. and *Lecanora* spp.) with unusually thick areoles are very common in arid habitats of Central Asia, but they are rare or absent in regions with mesic or humid conditions (our observations).

Fungal stacks (sensu VONDRÁK & KUBÁSEK 2013) are always well-developed in *C. scrobiculata* (Fig. 2C), but rather variable in *C. anularis*. In *C. anularis* from the Alps, they are absent (Fig. 1D) or inconspicuous - forming cortex cones (“Kegelrinden” sensu POELT 1958) extending downwards into the algal layer (Fig. 1C). However, in populations from arid regions the fungal stacks are better pronounced; sometimes they are connected with the medulla, but they are never so distinct as in *C. scrobiculata*. We suggest that this variability in *C. anularis* is also induced by the environment; the stack anatomy is preferred by lichens in dry and well-lit habitats (VONDRÁK & KUBÁSEK 2013).

Ascospore lengths in *C. anularis* are distinctly shorter in the specimens from the Karakorum (spore length specimen means: 13.2, 14.3, 14.3 μm) than in European specimens (15.5, 17.3 μm) and the specimen from Altay (17.7 μm). We do not consider these differences taxonomically relevant because of the low number of fertile specimens and also the low production of ascospores within fertile specimens; furthermore, ascospore sizes are very variable within and among specimens.

Discussion

The misunderstanding of the names *C. anularis* and *C. scrobiculata* started with POELT & HINTEREGGER (1993), who reported lichens from the Karakorum with the appearance of *Caloplaca anularis*, but used the name *C. scrobiculata* for them. They stressed that *C. anularis* is the younger synonym of *C. scrobiculata*, but unfortunately they did not provide any reason for their synonymization. Although POELT & HINTEREGGER (1993) cited the type of *C. scrobiculata*, they did not explicitly state that they had seen it. Their synonymization was perhaps based on similarity between European *C. anularis* and some Central Asian samples of *C. anularis* incorrectly named “*C. scrobiculata*” by earlier authors. Since that date, the name *C. scrobiculata* has been fully accepted by lichenologists for both European and Near East populations of *C. anularis* (e.g. PIŠŮT 2002, YAZICI et al. 2008, more citations under introduction).

The samples cited as *C. scrobiculata* from Pakistan (POELT & HINTEREGGER 1993) and Tibet (OBERMAYER 2004) are similar to *C. anularis*. We consider them conspecific with the European specimens of *C. anularis*, but they have a somewhat thicker thallus, a slightly different thallus anatomy and smaller ascospores. The generally thicker medulla and thallus of Asian specimens may be merely an adaptation to the conditions in dry mountains. According to our observations from continental Eurasia, unusually thick crusts of various lichens often dominate on rocks in dry conditions.

The concept proposed by POELT & HINTEREGGER (1993) was not accepted in the Lichen Flora of Russia (KHODOSOVTVSEV et al. 2004), which distinguishes *C. anularis* and *C. scrobiculata*. The disagreement with the European concept is mentioned by the authors e.g. in the note after *C. anularis*: “The name *C. scrobiculata* is incorrectly used by some authors for this taxon, which clearly differs from the real *C. scrobiculata* by radial thalli with distinct marginal lobes, with a pruina restricted to the central parts of thallus, with a smooth surface without pseudocyphellae, ...” (orig. in Russian, p. 77). The descriptions of both taxa in the Russian Flora fit our observations approximately. Unfortunately, the correct concept is then confused by the drawings below *C. scrobiculata* (Fig. 68, p. 196), which are adopted from the original description of *C. anularis*. KHODOSOVTVSEV et al. (2004) also consider *C. bohlinii* as a separate taxon, similar to *C. anularis*, but not forming ring-shaped thallus fragments on rocks.

KUDRATOV (1978) provided descriptions of *Caloplaca bohlinii* and *C. scrobiculata* from Tajikistan and also introduced the new combinations *Gasparrinia bohlinii* and *G. scrobicu-*

lata. His description of ascospores and the thallus surface of *C. scrobiculata* corresponds with our observations, but unfortunately the thallus anatomy is not described precisely, and there is no mention of algal stacks or fungal stacks. Kudratov's description of *C. bohlinii* corresponds approximately with our observations on Asian specimens of *C. anularis*, e.g. thallus anatomy and morphology, ascospore size and width of ascospore septa. However, he described the ascospore shape as ellipsoid, but we have mostly observed subrhomboid ascospores. He also did not stress the disappearance of central areoles, an important character in older thalli; he only writes: "thalli firstly radial, small, up to 3 cm diam., later with irregular shape". Further investigation is required to determine the real status of specimens from Tajikistan.

GAYA et al. (2008) included *Caloplaca anularis* (named as *C. scrobiculata*) from Karakorum in her ITS phylogeny of Teloschistaceae; its ITS sequence is placed separately in the phylogeny, without close relatives. The position of the real *C. scrobiculata* is not known yet.

We conclude that *Caloplaca scrobiculata* is a Central Asian taxon (Fig. 2E) well separated from *C. anularis* by its peculiar stacking anatomy, the wrinkled upper surface and the absence of marginal lobes. The name *C. anularis* covers well-characterized alpine lichens in European and the Near Asian mountain ranges (Fig. 1F), which have been incorrectly named *C. scrobiculata* since 1993. Asian samples with the appearance of *C. anularis*, including the type of *C. bohlinii*, we consider conspecific with the European *C. anularis*, although we have observed slight differences. The name *C. bohlinii* should be borne in mind in future studies, in case the widely distributed *C. anularis* proves to be a complex of distinct taxa within its highly disjunct regions of occurrence.

New combination

Caloplaca anularis f. *ignea* (Poelt & Hinteregger) Vondrák & H.Mayrhofer **comb. nov.** [Mycobank 803188]

Basionym: *Caloplaca scrobiculata* H.Magn. var. *ignea* Poelt & Hinteregger, Bibliotheca Lichenologica 50: 200 (1993).

Type: Pakistan, Karakorum, Haramosh Range, 1991, J. Poelt (GZU).

The taxon was established for the morphotype of *Caloplaca anularis* (= *C. scrobiculata* auct., non Poelt & Hinteregger) with a red thallus. The red colour is the only character distinguishing this taxon from typical *C. anularis*. This taxon was known only from its type locality, until we found it also in Altay. As in the type locality, red thalli of the forma *ignea* are intermixed with yellow thalli in the Altay locality.

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