

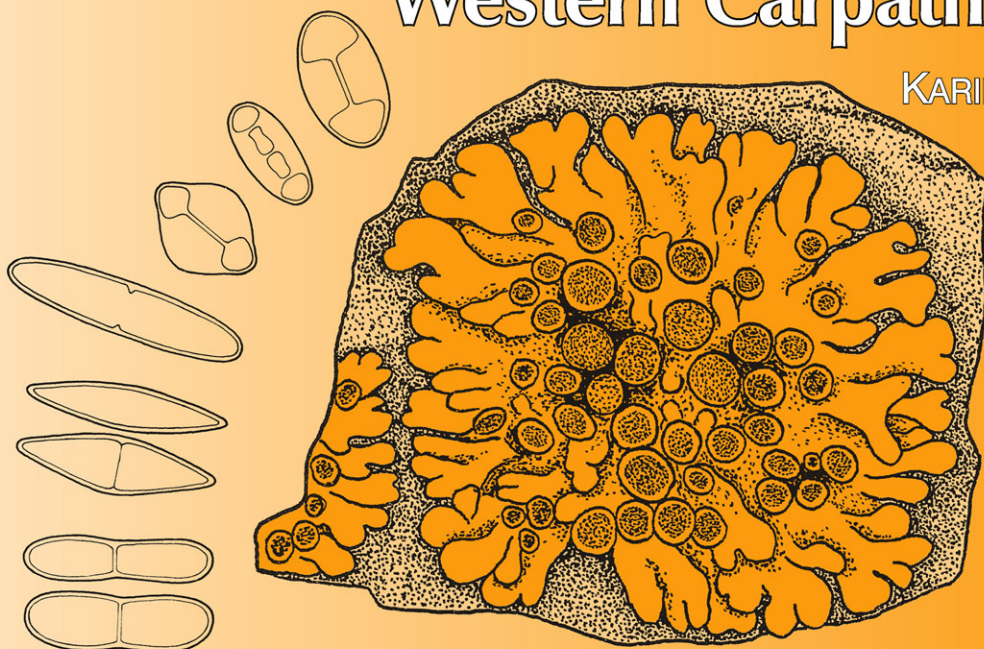
POLISH BOTANICAL STUDIES

29

2012

Calcicolous species of the genus *Caloplaca* in the Polish Western Carpathians

KARINA WILK



P O L I S H B O T A N I C A L S T U D I E S

Vol. 29 2012

Polish Botanical Studies is a companion series of *Polish Botanical Journal* publishing monographs and more comprehensive papers longer than 50 printed pages covering various aspects of vegetation science, plant and fungi biodiversity, biosystematics (including plant anatomy, cytology and embryology), phytogeography, evolution and ecology. The series appears at irregular intervals.

Editors: Zbigniew MIREK & Jan J. WÓJCICKI

Editorial Office: W. Szafer Institute of Botany, Polish Academy of Sciences, Lubicz 46, 31-512 Kraków, Poland
Tel. +48 12 4241711; Fax: +48 12 4219790; e-mail: j.wojcicki@botany.pl
<http://www.botany.pl/ibwyd/pol-b-j/pol-b-j.htm>



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This work was funded by the Ministry of Science and Higher Education (2008–2009, grant no. N N303 294334), National Science Centre (grant no. N N303 821740), and in part through the statutory fund of the W. Szafer Institute of Botany of the Polish Academy of Sciences

Published, sold and distributed by

W. Szafer Institute of Botany, Polish Academy of Sciences, Lubicz 46, 31-512 Kraków, Poland
Tel./Fax: +48 12 4241731; e-mail: wydawnictwa@botany.pl; <http://www.botany.pl>

Typesetting and page layout: Marian WYSOCKI

Cover design: Maciej PIERZCHAŁA

Issued: 28 December 2012

ISBN: 978-83-62975-13-6

Printed in Poland: Drukarnia Kolejowa Kraków sp. z o.o., Forteczna 20A, 32-086 Węgrzce

ISSN: 0867-0730

CALCICOLOUS SPECIES OF THE GENUS *CALOPLACA* IN THE POLISH WESTERN CARPATHIANS

KARINA WILK

Abstract. This monograph is based on a revision of material from national and foreign herbaria and on the author's field study. Thirty-nine taxa of *Caloplaca* Th. Fr. were recognized in the Polish Western Carpathians: *C. albolutescens* (Nyl.) H. Olivier, *C. albopruinosa* (Arnold) H. Olivier, *C. arnoldii* subsp. *obliterata* (Pers.) Gaya, *C. arnoldiiconfusa* Gaya & Nav.-Ros., *C. atroalba* (Tuck.) Zahlbr., *C. aurea* (Schaer.) Zahlbr., *C. biatorina* (A. Massal.) J. Steiner, *C. chalybaea* (Fr.) Müll. Arg., *C. chrysodeta* (Vain. ex Räsänen) Dombr., *C. cirrochroa* (Ach.) Th. Fr., *C. citrina* (Hoffm.) Th. Fr., *C. coccinea* (Müll. Arg.) Poelt, *C. coronata* (Kremp. ex Körb.) J. Steiner, *C. crenulatella* (Nyl.) H. Olivier, *C. decipiens* (Arnold) Blomb. & Forssell, *C. dichroa* Arup, *C. dolomiticola* (Hue) Zahlbr., *C. flavescens* (Huds.) J. R. Laundon, *C. flavocitrina* (Nyl.) H. Olivier, *C. flavovirescens* (Wulfen) Dalla Torre & Sarnth., *C. holocarpa* (Ach.) A. E. Wade, *C. keissleri* (Servít) Poelt, *C. lactea* (A. Massal.) Zahlbr., *C. marmorata* (Bagl.) Jatta, *C. nubigena* (Kremp.) Dalla Torre & Sarnth., *C. oasis* (A. Massal.) Szatala, *C. percrocata* (Arnold) J. Steiner, *C. polycarpa* (A. Massal.) Zahlbr., *C. proteus* Poelt, *C. pseudofulgensia* Gaya & Nav.-Ros., *C. pusilla* (A. Massal.) Zahlbr., *C. saxicola* (Hoffm.) Nordin, *C. soralifera* Vondrák & Hrouzek, *C. teicholyta* (Ach.) J. Steiner, *C. variabilis* (Pers.) Müll. Arg., *C. velana* complex, *C. vitellinaria* Szatala, *C. xantholyta* (Nyl.) Jatta, and *C. xanthostigmoidea* (Räsänen) Zahlbr. Two species are new for Poland: *C. albolutescens* and *C. arnoldiiconfusa*. One is new for the Polish Carpathians: *C. crenulatella*. Many new regional records are given, helping to complete the geographical range of some poorly known taxa, such as *C. chrysodeta*, *C. polycarpa* and *C. xantholyta*. A few species were not confirmed from the study area: *C. alociza* (A. Massal.) Mig., *C. aurantia* (Pers.) Helb., *C. erythrocarpa* (Pers.) Zwackh, and *C. subochracea* (Wedd.) Werner. Detailed descriptions of all recognized species are provided, with illustrations, distribution maps and a key for species identification.

Key words: taxonomy, geographical distribution, Central Europe, new records

Karina Wilk, Laboratory of Lichenology, W. Szafer Institute of Botany, Polish Academy of Sciences, Lubicz 46, 31-512 Kraków, Poland; k.wilk@botany.pl

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INTRODUCTION

According to the current checklist of the Polish lichen biota (Fałtynowicz 2003) and more recent publications (Bielczyk 2003; Ceynowa-Giełdon & Adamska 2005; Wilk & Flakus 2006; Śliwa & Wilk 2008; Wilk 2011; Wilk & Śliwa 2012), 73 species of *Caloplaca* are known from Poland. Among them are 37 saxicolous and calcicolous species occurring in the Polish Western Carpathians.

The first key to the Polish *Caloplaca* species (Tobolewski 1956) gave 26 species, with short descriptions. The number of *Caloplaca* species given as occurring in Poland increased to 48 in Nowak and Tobolewski's (1975) comprehensive treatment of the Polish lichen biota. Other works that have contributed to our knowledge of the *Caloplaca* in Poland were published by Tobolewski (1958), Nowak (1960, 1968) and Alstrup and Olech (1988, 1992). Many new data on these taxa were included in Bielczyk's (2003) list of lichens of the Polish Western Carpathians.

In 2004–2008 I made a study of the taxonomic diversity and distribution of calcicolous species of the genus *Caloplaca* in the Polish Western Carpathians (Wilk 2008). In the course of this survey, several noteworthy species were recognized, including taxa new for Poland (Wilk & Flakus 2006; Śliwa & Wilk 2008; Wilk 2011; Wilk & Śliwa

2012). This monograph summarizes that research, augments the published information on calcicolous Carpathian lichens, and contributes to the taxonomy and general distribution of particular *Caloplaca* species. In total 39 taxa are treated, with detailed descriptions and illustrations of all recognized species, maps of their distribution in the study area, and a key for species identification.

THE GENUS *CALOPLACA*

GENERAL CHARACTERISTICS AND TAXONOMY

The genus *Caloplaca* Th. Fr. belongs to the family Teloschistaceae Zahlbr. (Teloschistales D. Hawksw. & O. E. Erikss., lichenized Ascomycota). The type species is *C. cerina* (Ehrh. ex Hedwig) Th. Fr. It is a group of lichens richly represented worldwide and including 700–800 taxa (Wetmore & Kärnefelt 1998). The majority of the *Caloplaca* species grow on rock substrate, mostly calcareous (e.g., limestone, dolomite, sandstone, shale) rock, and less frequently on siliceous (e.g., sandstone, shale) or silicic (e.g., granite) rock. The remaining *Caloplaca* species grow on bark, wood, bryophytes, plant debris, or the thalli of other lichens. Several saxicolous species inhabit manmade substrates such as mortar, concrete and tile.

The *Caloplaca* species form crustose thalli highly diverse in morphology. Most species have an areolate or lobate thallus. Less frequently the thallus is squamose, uniformly crustose, subfruticose or leprose. Some species have an endolithic or endophloeic thallus. Species also differ in thallus color, which may be yellow, orange, red or less frequently white, grey, brown or blackish. Some species produce vegetative propagules on the thallus surface: isidia, soredia or blastidia. In rare cases the thallus breaks down almost entirely into soredia (e.g., *C. citrina*). *Caloplaca* species produce apothecia of zeorine, lecanorine, pseudolecanorine, cryptolecanorine, lecideine and biatorine types (see also Gaya 2009). The apothecia are mostly yellow, orange or red, rarely brown or black. Pycnidia producing conidial spores also occur often.

Caloplaca species show diverse anatomy. The main spectrum of diagnostic features is connected with apothecium structure: for example, the tissue structure of the proper margin, thalline margin and hypothecium, epihymenium color, hymenium height, and the shape and size of paraphyses and ascospores. Among the most characteristic and important features are those connected with spores. Spores are polarilocular; rarely the spores are 4-celled [in *C. ochracea* (Schaer.) Flagey]. The spore isthmus may be wide to narrow or rarely almost disappearing. The spore wall usually is thin, but in a few species it is distinctly thickened (in *C. calcitrapa* Nav.-Ros., Gaya & Cl. Roux and *C. dichroa*). The spores are produced in asci of Teloschistes type, mostly numbering eight, except 8–16 in *C. cerinella* (Nyl.) Flagey. The non-anthraquinone crystals are often present in the thallus and apothecia, and have various distribution patterns; in some groups of taxa (e.g., *C. aurantia* group, *C. saxicola* group, *C. variabilis* group) the presence and type of their distribution is a diagnostic character (Wetmore 1994; Śliwa & Wilk 2008; Šoun & Vondrák 2008; Gaya 2009).

The *Caloplaca* species contain green algae of the genus *Treuboxia* as photobiont. The type of algal cells does not seem to be a diagnostic character in this group of lichens, but the distribution of algae in the thallus and apothecia does differ

between species and is a useful feature for their determination.

The genus *Caloplaca* is less diverse in its content of lichen substances. Most of the species produce anthraquinones which are responsible for the yellow, orange or red color of the thalli and/or apothecia, and react red with K. Anthraquinones are well enough known and are useful in defining groups of species, but are of minor significance in delimiting particular species. Parietin and related substances such as chloroemodin, emodin, fragilin, teloschistin and xanthorin are the most common anthraquinones (Santesson 1970; Søchting 1997, 2001). They occur in the thalline cortex, apothecial margin and epihymenium. Species that have a whitish, grey, brown or blackish thallus and sometimes also apothecia (subgenus *Pyrenodesmia*, *C. ferruginea* group, *C. siderites* group) produce greyish or aeruginose pigments such as sedifolia-grey (= thalloidima green) and cinereorufa-green (= lecidea green) respectively (Wetmore 1994, 1996; Meyer & Printzen 2000). The chemical structure of the pigments is still unknown. They are located in the thalline cortex, apothecial margins or epihymenium. Sedifolia-grey reacts violet with K and N. This pigment occurs frequently in members of the *Caloplaca* group. It is produced in such species as *C. alociza*, *C. atroalba*, *C. chalybaea*, *C. chlorina* (Flot.) H. Olivier, *C. conversa* (Kremp.) Jatta, *C. variabilis* and *C. xerica* Poelt & Vězda. Cinereorufa-green reacts with N, giving violet color. It occurs less frequently and is known in only a few species, such as *C. concilians* (Nyl.) H. Olivier, *C. conciliascens* (Nyl.) Zahlbr. and *C. exsecuta* (Nyl.) Dalla Torre & Sarnth. (Wetmore 1996). Some *Caloplaca* species contain other lichen substances in the thallus which are depsides or depsidones, such as caloploicin, vicanicin or isofulgidin (Søchting & Figueras 2007). Others produce substances not yet identified or contain no lichen substances at all.

The considerable diversity within *Caloplaca* has led different authors to divide the genus into subgenera, sections or groups, guided by thallus structure, apothecia type, shape and size of spores, and chemistry. The most recent phylogenetic studies indicate that the Teloschistaceae family

is polyphyletic (Arup & Grube 1999; Gaya *et al.* 2003, 2008, 2012; Søchting & Lutzoni 2003) and therefore its new classification most likely will be suggested in the near future.

BACKGROUND AND CURRENT STATE OF RESEARCH

The genus *Caloplaca* is one of the oldest lichen genera, described in 1860 by Theodor Magnus Fries. Particular species or groups of taxa have drawn the interest of specialists around the world. Among the many monographs and contributions to our knowledge of various taxonomic groups, work by Magnusson (1944a), Poelt (1954), Nordin (1972), Wunder (1974), Arup (e.g., 1993a, 2006a), Wetmore (e.g., 1994, 2007a), Navarro-Rosinés & Hladun (1996), Gaya (2009), Vondrák *et al.* (2009) and Šoun *et al.* (2011) deserves special mention. Table 1 gives a more detailed list of important taxonomic publications.

Despite the great number of publications, the taxonomy of the genus is still insufficiently understood. Some taxa and species groups are poorly known, especially the rare species (e.g., *C. albo-pruinosa*, *C. alociza*, *C. coccinea*, *C. keissleri*, *C. nubigena*, *C. percrocata*) but also common ones

belonging to problematic groups, such as *C. citrina* gr., *C. ferruginea* gr. and *C. velana* gr.

The phylogenetic relations within the genus and the family Teloschistaceae are a large unsolved problem (Kärnefelt 1989; Arup & Grube 1999; Gaya *et al.* 2003, 2008, 2012; Søchting & Lutzoni 2003; Fedorenko *et al.* 2009).

The state of research of species diversity depends greatly on the region of the world. The genus is well studied in Europe. There are several keys to the European species (Poelt 1954, 1955, 1969; Clauzade & Roux 1985; Nimis 1992; Wirth 1995). A comprehensive treatment of the genus in Great Britain was published decades ago (Wade 1965) and later supplemented (Laundon 1992a, b; Fletcher & Laundon 2009). *Caloplaca* has been studied intensively by lichenologists from Sweden (e.g., Arup 2006a, 2009; Arup & Åkelius 2009), Denmark (e.g., Søchting & Stordeur 2001; Søchting & Figueras 2007; Søchting *et al.* 2007), Spain, France (Roux & Navarro-Rosinés 1992; Navarro-Rosinés & Roux 1993; Navarro-Rosinés *et al.* 2000a, b, 2001; Gaya *et al.* 2008; Gaya 2009), Italy (Tretiach *et al.* 2003; Tretiach & Muggia 2006; Muggia *et al.* 2008), the Czech Republic (Vondrák & Slavíková-Bayerová 2006;

Table 1. Publications providing data about different taxonomic groups of the genus *Caloplaca*.

Taxonomic group	Papers
Subgenus <i>Pyrenodesmia</i>	Wunder (1974), Poelt & Kalb (1985), Wetmore (1994), Tretiach <i>et al.</i> (2003), Tretiach & Muggia (2006), Muggia <i>et al.</i> (2008), Vondrák <i>et al.</i> (2008a)
Subgenus <i>Gasparrinia</i>	Poelt (1954), Verseghy (1970), Nordin (1972), Wetmore & Kärnefelt (1998), Šoun & Vondrák (2008), Gaya (2009)
Subgenus <i>Xanthocarpia</i>	Hafellner & Poelt (1979)
Subgenus <i>Gyalolechia</i> (<i>C. lactea</i> group)	Navarro-Rosinés & Hladun (1996), Navarro-Rosinés <i>et al.</i> (2001), Vondrák <i>et al.</i> (2011)
Subgenus <i>Caloplaca</i>	
<i>C. cerina</i> group	Wetmore (2007a), Vondrák <i>et al.</i> (2008b), Šoun <i>et al.</i> (2011)
<i>C. citrina</i> group	Wetmore (2001), Arup (2006a), Vondrák <i>et al.</i> (2009), Søchting & Castello (2012)
<i>C. ferruginea</i> / <i>C. sideritis</i> group	Magnusson (1944a), Roux & Navarro-Rosinés (1992), Wetmore (1996), Vondrák & Hrouzek (2006), Arup <i>et al.</i> (2007), Arup & Åkelius (2009)
<i>C. flavorubescens</i> group	Giralt <i>et al.</i> (1992)
<i>C. holocarpa</i> group	Magnusson (1946), Wade (1965), Arup (1994), Søchting & Stordeur (2001), Arup (2009), Vondrák <i>et al.</i> (2012)
<i>C. squamosa</i> group	Arup (1992b), Wetmore (2003)
<i>C. velana</i> complex	Arup (1990)

Šoun & Vondrák 2008; Vondrák & Vitikainen 2008; Vondrák *et al.* 2009; Šoun *et al.* 2011) and Ukraine (Kondratyuk *et al.* 1998; Khodosovtsev 2001, 2002; Khodosovtsev *et al.* 2002, 2003).

Important data for the taxonomy and distribution of *Caloplaca* species are found in papers covering North America (e.g., Magnusson 1944b; Arup 1992a, b, 1993a, b, 1994, 1995a, b; Wetmore 1994, 1996, 2001, 2003, 2004, 2007a, b; Wetmore & Kärnefelt 1998). Also well known are species from polar regions (e.g., Hansen *et al.* 1987; Söchting & Øvstedal 1992; Olech & Söchting 1993; Zhurbenko & Söchting 1993; Söchting & Olech 1995, 2000; Söchting *et al.* 2008; Smykla *et al.* 2011; Söchting & Castello 2012). The Asian species are poorly known. They have been studied by Alon and Galun (1971), Poelt and Kalb (1985), Poelt and Hinteregger (1993), Kondratyuk *et al.* (1996, 2004, 2011), Khodosovtsev *et al.* (2004), and most recently by Joshi and Upreti (2006, 2007), Söchting and Figueras (2007) and Joshi *et al.* (2008, 2010). The taxa of Australia (Kondratyuk *et al.* 2007a, b, 2010) and especially Africa (Wirth & Vězda 1975; Kärnefelt 1987, 1988a, b; Aptroot 2001; Kärnefelt *et al.* 2002; Wirth *et al.* 2005) are insufficiently known. The *Caloplaca* species of South America are the least investigated (Jørgensen 1986; Scutari *et al.* 2002; Larrain & Vargas 2009; Vargas Castillo & Beck 2012).

Apart from taxonomic and geographic studies, work has been done on particular ecological groups of *Caloplaca*, such as species connected with seashore (e.g., Arup 1993a, 1994, 1995a; Vondrák *et al.* 2009). There are no papers devoted exclusively to calcicolous species of the genus, but relevant data are found in many general treatments of calcicolous lichens (e.g., Clauzade & Rondon 1959; Clauzade & Roux 1975; Alonso *et al.* 1989; Casares & Llimona 1989; Alonso & Egea 1995; Renobales 1996; Kossowska 2008). Phytosociological studies on saxicolous and especially calcicolous lichens (including species of the genus *Caloplaca*) by Roux *et al.* (2009) and Nowak (1960) are also worth mentioning here.

Another aspect of research on *Caloplaca* is its chemistry (Santesson 1970; Yosioka *et al.* 1971,

1973; Nakano *et al.* 1972; Söchting 1997, 2001; Elix *et al.* 2000).

There are many papers dealing with or giving data on lichenicolous fungi on *Caloplaca* species (e.g., Navarro-Rosinés & Roux 1987, 1997; Bricaud & Roux 1991; Navarro-Rosinés *et al.* 1998; Navarro-Rosinés & Etayo 2001; Hawksworth & Cole 2004; Vondrák & Kocourková 2008). Little is known, however, about the photobionts in this genus (e.g., Muggia *et al.* 2008; Vargas Castillo & Beck 2012).

THE POLISH CARPATHIANS AND LICHENOLOGICAL RESEARCH IN THE AREA

The Polish Carpathians are divided into the Western and Eastern Carpathians (Kondracki 2002; Fig. 1). There are two geomorphological units within the Western Carpathians: the Central Carpathians (Tatra and Pieniny Mts, and vicinity) and Outer Carpathians (Beskidy Mts and foothills). These two units differ in structure and geological history (Unrug 1969). The orogeny of the Central Carpathians dates to the Upper Cretaceous. They are built of Triassic, Jurassic and Cretaceous rock, with dolomite predominant. The Outer Carpathians formed in the Upper Tertiary. They are built of Upper Jurassic, Cretaceous and Upper Tertiary rock; they mainly consist of sandstone and slate, rarely conglomerate, marl and limestone (Unrug 1969). The Outer Carpathians feature lower mountain ranges: Beskid Śląski (highest peak is Skrzyczne at 1257 m a.s.l.), Beskid Żywiecki (with the highest peaks of the flysch Carpathians: Babia Góra at 1725 m, Pilsko at 1557 m), Beskid Mały (Madohora Mt. at 929 m), Beskid Makowski (Magurka Mt. at 870 m, Kotoń Mt. at 868 m), Beskid Wyspowy (Luboń Wielki Mt. at 1002 m, Śnieżnica Mt. at 1007 m, Mogielica Mt. at 1170 m), Gorce (Turbacz Mt. at 1310 m), Beskid Sądecki (Radziejowa Mt. at 1262 m, Jaworzyna Mt. at 1114 m) and Beskid Niski Mts (Lackowa Mt. at 997 m). Between the mountain ranges are intermountain valleys at elevations between 250 m and 400 m a.s.l. (Kotlina Żywiecka, Kotlina Sądecka and Kotlina Jasielsko-Krośnieńska basins). To the north of the Beskidy range the

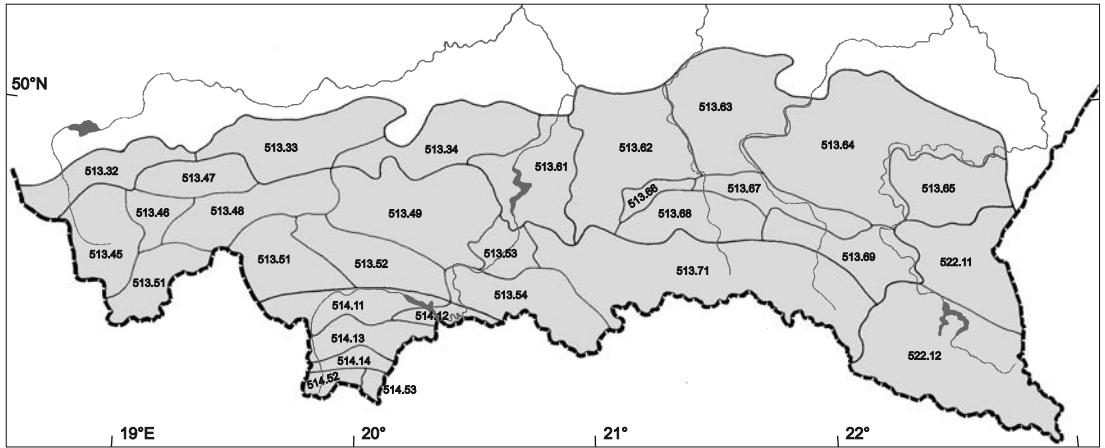


Fig. 1. Physico-geographical regions of the Polish Carpathians (after Kondracki 2002, modified). 513 – OUTER WESTERN CARPATHIANS: 513.3 – Pogórze Zachodniobeskidzkie foothills: 513.32 – Pogórze Śląskie foothills, 513.33 – Pogórze Wielickie foothills, 513.34 – Pogórze Wiśnickie foothills; 513.4/5 – Beskidy Zachodnie Mts: 513.45 – Beskid Śląski Mts, 513.46 – Kotlina Żywiecka basin, 513.47 – Beskid Mały Mts, 513.48 – Beskid Makowski Mts, 513.49 – Beskid Wyspowy Mts, 513.51 – Beskid Żywiecki Mts, 513.52 – Gorce Mts, 513.53 – Kotlina Sądecka basin, 513.54 – Beskid Sądecki Mts; 513.6 – Pogórze Środkowobeskidzkie foothills: 513.61 – Pogórze Rożnowskie foothills, 513.62 – Pogórze Ciężkowickie foothills, 513.63 – Pogórze Strzyżowskie foothills, 513.64 – Pogórze Dynowskie foothills, 513.65 – Pogórze Przemyskie foothills, 513.66 – Obniżenie Gorlickie depression, 513.67 – Kotlina Jasielsko-Krośnieńska basin, 513.68 – Pogórze Jasielskie foothills, 513.69 – Pogórze Bukowskie foothills; 513.7 – Beskidy Środkowe Mts: 513.71 – Beskid Niski Mts. 514 – CENTRAL WESTERN CARPATHIANS: 514.1 – Obniżenie Orawsko-Podhalańskie depression: 514.11 – Kotlina Orawsko-Nowotarska basin, 514.12 – Pieniny Mts, 514.13 – Pogórze Spisko-Gubałowskie foothills, 514.14 – Rów Podtatrzański trough; 514.5 – Tatra Mts: 514.52 – West Tatra Mts, 514.53 – High Tatra Mts; 522 – OUTER EASTERN CARPATHIANS: 522.1 – Beskidy Lesiste Mts: 522.11 – Góry Sanocko-Turczańskie Mts, 522.12 – Bieszczady Zachodnie Mts.

area shelves down to the foothills. The foothills are at elevations between 300 m and 500 m a.s.l. (e.g., Pogórze Ciężkowickie, Pogórze Dynowskie, Pogórze Wielickie and Pogórze Wiśnickie foothills). The Central Carpathians include the Pieniny Mts (Sokolica Mt. at 982 m, Wysokie Skałki Mt. at 1052 m), Tatra Mts (with the highest peak of the Polish Carpathians: Rysy Mt. at 2499 m) and the depressions between them (Kotlina Orawsko-Nowotarska basin and Rów Podtatrzański trough) and Pogórze Spisko-Gubałowskie foothills.

Lichenological studies in the Polish Western Carpathians date to the late 19th century. Bielczyk (2003) summarized that century of work and gave a complete historical bibliography of it.

The biotic and abiotic diversity of the Western Carpathians offers good conditions for the development of many lichen species (Nowak 1972; Bielczyk 1986). The variety of rock substrates promotes diversity of saxicolous lichens, including calcicolous ones. The Tatras and the Pieniny Mts are

considered the most important center of occurrence of calcicolous species in Poland (Bielczyk 2006).

The genus *Caloplaca* is richly represented in the Tatras; 48 species have been reported from the area, 36 of which are calcicolous (Bielczyk 2003; Wilk & Flakus 2006; Śliwa & Wilk 2008; Wilk 2011). Most of the latter grow in the limestone part of the Tatras (e.g., *C. arnoldiiconfusa*, *C. aurea*, *C. polycarpa*, *C. proteus*, *C. variabilis*, *C. xantholyta*); other bryophytic have only a few localities in the High Tatras, in mylonitized areas (*C. ammiospila*, *C. cerina*, *C. tirolensis*) (Flakus 2007). The genus *Caloplaca* shows high species richness in the Pieniny Mts due to the presence of many sites on limestone substrate (Palka 2005). The genus is represented there by 28 species, 19 of them calcicolous (e.g., Tobolewski 1958, 1965; Kiszka 1997b, 2000; Śliwa & Wilk 2008; Wilk 2011).

Calcareous rock is scarce in the rest of the Western Carpathians. It is present in the Beskid

Mały Mts where it forms the Andrychów klippen. In the Kotlina Żywiecka basin, limestone rock occurs in the valley of the Soła River in Żywiec, and in two abandoned limestone quarries near Radziechowy-Wieprz village. There are large limestone outcrops in the Pogórze Cieszyńskie foothills at Jasieniowa Mt. More or less calcareous sandstone and slate are found rarely in the rest of the area. Highly calcareous sandstone occurs in, for example, Przybędza village (Kotlina Żywiecka basin), Pietraszyna village (Beskid Śląski Mts), and Pasma Żurawnicy and Pasma Pewelskie ranges (Beskid Makowski Mts). Many records of calcicolous lichens (including *Caloplaca*) in the Beskidy Mts were provided by Nowak (1965, 1967, 1968, 1998), Kiszka (1967, 1970), Olech (1972, 1973, 1974), Śliwa (1998) and Czarnota (1998, 2000). Bielczyk's (2003) list of lichens of the Western Carpathians should be mentioned here again.

In the Western Carpathians, calcicolous species of the genus *Caloplaca* occur on different types of natural rock containing calcium carbonate: limestone, sandstone, slate and conglomerate. They grow directly on rock or on bryophytes and plant debris covering rock.

MATERIAL AND METHODS

The study is based on material from national and foreign herbaria and on my own collections. The herbarium material originated from the following Polish herbaria: KRA, KRAM, KRAP, KTC, LOD, OLTC, POZ, POZG, TRN, UGDA, WA, WRSL, and the herbaria of Gorce National Park (GPN) and Pieniny National Park (PPN). More than 700 specimens were examined. Reference material, including the type collections, was from CBFS, H, KRAM, LD, MIN, PRM and S.

The field survey and collection of material took place in 2004–2005 in areas of calcareous rock in the Polish Western Carpathians. Lichens were collected in the Central Carpathians (Tatra Mts, Pieniny Mts) and Outer Carpathians (Beskidy Mts: Beskid Mały, Beskid Niski, Beskid Śląski, Beskid Żywiecki, Beskid Makowski incl. Pasma Pewelskie and Pasma Żurawnicy ranges; Kotlina Żywiecka basin) and Pogórze Cieszyńskie foothills (Fig. 2). The material was collected from natural and seminatural habitats, the latter mostly in abandoned quarries.

Additional material examined includes (i) specimens from the Western Carpathians but growing on substrates other than natural calcareous rock, (ii) specimens from localities outside the studied area, and (iii) reference material.

Morphological characters were measured from dry material using a Nikon SMZ 800 stereomicroscope and Nikon Eclipse 50i light microscope. Photographic documentation was made with a DeltaPix-Infinity X digital camera. Anatomical characters were measured from hand-cut sections and squash preparations (for paraphyses) mounted in water. The structure of paraphyses and cortical tissues was observed in 25% KOH (K). Crystals occurring in the cortex and medulla of the thallus, apothecial margin and epihymenium were studied under polarized light (pol+/pol– indicates that the crystals reflect/do not reflect polarized light). The solubility of crystals was tested with K and 65% nitric acid (N). The chemicals used in color reactions and microscopic observations were K and N. Hydrochloric acid (HCL) was used to confirm the presence of calcium carbonate (CaCO_3) in the substrate.

Tissue terminology follows Bungartz (2002), Ryan *et al.* (2002, 2012) and Gaya (2009). The classification of apothecia was modified in some details for the study (compare, e.g., Sheard 1967, Bungartz 2002, and Gaya 2009):

Apothecia zeorine – having both proper and thalline margin (visible or invisible macroscopically). Parathecium thin or thick; amphithecium with \pm abundant algae forming more or less continuous layer below hypothecium, cortex present or absent.

Apothecia biatorine/leceidine – having only proper margin. Parathecium well developed; amphithecium absent.

Apothecia lecanorine – having only thalline margin. Parathecium highly reduced; amphithecium well developed with abundant algae, cortex mostly present (the apothecia were not observed in the studied material).

Apothecia pseudolecanorine – having only proper margin. Parathecium well developed but with single, dispersed algae below hypothecium; amphithecium absent (this type of apothecia is considered synonymous with biatorine apothecia; see Bungartz 2002).

Pigment nomenclature for non-anthraquinones follows Meyer and Printzen (2000).

The physico-geographical division of Poland follows Kondracki (2002).

The following symbols are used in the SPECIES section: !! – species new for Poland, ! – species new for the Polish Carpathians.



Fig. 2. Examples of collecting sites. A – Gęsia Szyja limestone outcrops in the High Tatra Mts, B – limestone outcrops in the valley of the Soła River in Żywiec town, the Kotlina Żywiecka basin, C – calcareous sandstone outcrops in the Beskid Śląski Mts, D – limestone outcrops in Inwałd, the Beskid Mały Mts, E – abandoned calcareous sandstone quarry in Pietraszyna village, the Beskid Śląski Mts, F – abandoned limestone quarry above Radziechowy village, the Kotlina Żywiecka basin.

RESULTS AND DISCUSSION

DETAILED CHARACTERIZATION OF THE GENUS

Thallus morphology

The studied members of the genus *Caloplaca* form crustose thalli, which are highly diverse (Fig. 3) and usually tightly attached to the substrate. In most cases they are epilithic, rarely endolithic (*C. albopruinosa*, *C. lactea*, *C. marmorata*, often *C. crenulatella*). Occasionally the thallus may be endolithic to faintly epilithic and then composed of very small granules immersed in the rock (*C. coccinea*, *C. keissleri* and *C. nubigena*). Among the clearly epilithic thalli the areolate to rimose-areolate growth forms are the most common. Such a thallus type occurs in, for example, *C. albolutescens*, *C. atroalba*, *C. chalybaea*, *C. citrina*, *C. flavocitrina*, *C. flavovirescens*, *C. percroata*, *C. soralifera*, *C. variabilis* and *C. velana*. In this type of thallus the areoles may be crowded or scattered, flat or convex, with margins entire or slightly crenate, and the apothecia usually \pm evenly spread over the thallus surface (except *C. chalybaea* which has apothecia located in its center). The majority of areolate species have an effuse (not definite) thallus. Some species have a sublobate thallus (= effigurate) with marginal areoles lobed, such as *C. dolomiticola*, *C. dichroa*, *C. polycarpa* and *C. teicholyta*. A lobate thallus is the second most common morphological form in *Caloplaca*. Those thalli produce distinctly elongated lobes (lobes are strongly reduced only in *C. arnoldii* subsp. *obliterata* and *C. saxicola*) and are circular (= placodioid) in outline or irregular. Marginal lobes are morphologically very diverse. They may be convex, flat, more or less branched or unbranched, and broadened (or not) toward the tips. Lobate thalli occur in *C. arnoldii* subsp. *obliterata*, *C. arnoldiiconfusa*, *C. aurea*, *C. biatorina*, *C. cirrochroa*, *C. decipiens*, *C. flavescens*, *C. proteus*, *C. pseudofulgensia*, *C. pusilla* and *C. saxicola*. Finally, a leprose thallus occurs in two species: *C. chrysojeta* and *C. xantholyta*. Sometimes the areolate thallus of *C. citrina* breaks down almost entirely into soredia, and then it resembles the leprose type of thallus.

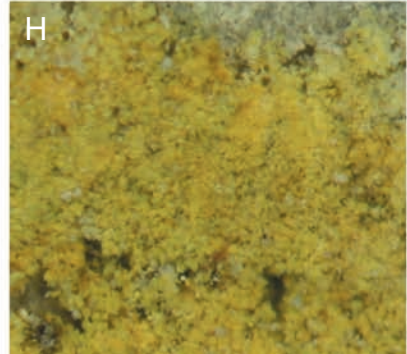
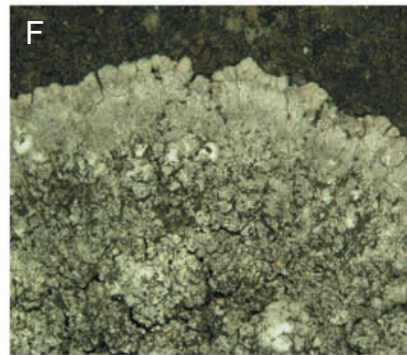
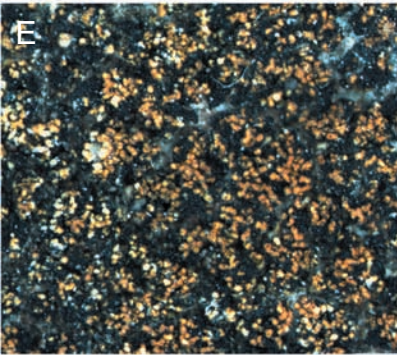
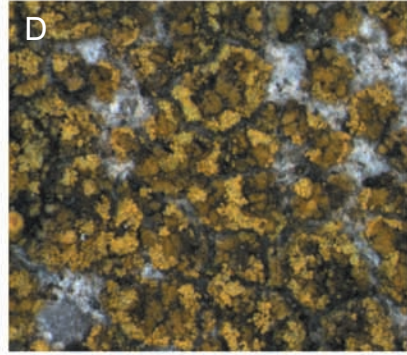
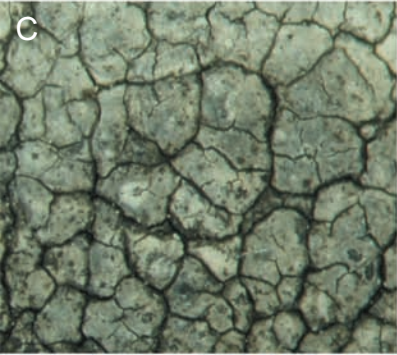
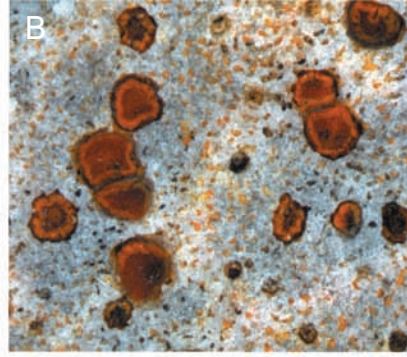
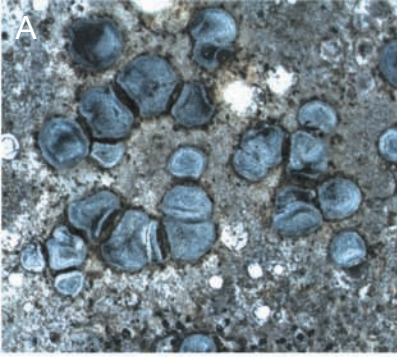
Most of the species have a yellow, orange or red thallus (e.g., *C. arnoldiiconfusa*, *C. aurea*, *C. chrysojeta*, *C. cirrochroa*, *C. coronata*, *C. polycarpa*, *C. pseudofulgensia*). Some species have a grey, brown or almost black thallus (species of the subgenus *Pyrenodesmia* and the *C. ferruginea* group). There are species with a completely or partially white pruinose surface (e.g., *C. arnoldii* subsp. *obliterata*, *C. chalybaea*, *C. cirrochroa*, *C. pusilla*, *C. soralifera*, *C. teicholyta*, *C. variabilis*).

A prothallus is not common in the studied group of lichens. When present it is thin and variously colored: orange (*C. dichroa*, *C. polycarpa*, *C. arnoldii* subsp. *obliterata*), dark grey (*C. albopruinosa*, *C. flavovirescens*, *C. percroata*, *C. variabilis*) or greenish grey (*C. chalybaea*).

Thallus anatomy

Members of the genus *Caloplaca* have heterogeneous thallus with a cortical layer occurring only in the upper part of the thallus. The thalline cortex is paraplectenchymatous or prosoplectenchymatous, with most species having the former type. The cortex is often thin and weakly delimited, especially in species with a poorly developed thallus (e.g., *C. atroalba*, *C. citrina*, *C. flavocitrina*). The thalline cortex of species with a yellow to red thallus is covered and also obscured in the upper part with yellowish orange anthraquinone crystals (pol⁺, soluble in K) which react red with K. The uppermost part of the cortex of species with a grey, brown or blackish thallus is dark grey or brownish. The coloration is from sedifolia-grey pigment which reacts violet with K and N. Several species have an additional layer of colorless crystals in the thalline cortex which are pol⁺, and insoluble in K (e.g., *C. chalybaea*, *C. pusilla*, *C. soralifera*, *C. variabilis*). The thalline cortex in *C. flavescens* is unique. It is thick and has anthraquinone crystals in the uppermost part and a wide layer of large grey crystals below (Fig. 4). *Caloplaca albolutescens* is the only species in which the thalline cortex is not delimited and the surface of the thallus is tartareous.

Usually the algal layer is continuous. Algae occur in groups less frequently (*C. dolomiticola*, *C. flavescens*).



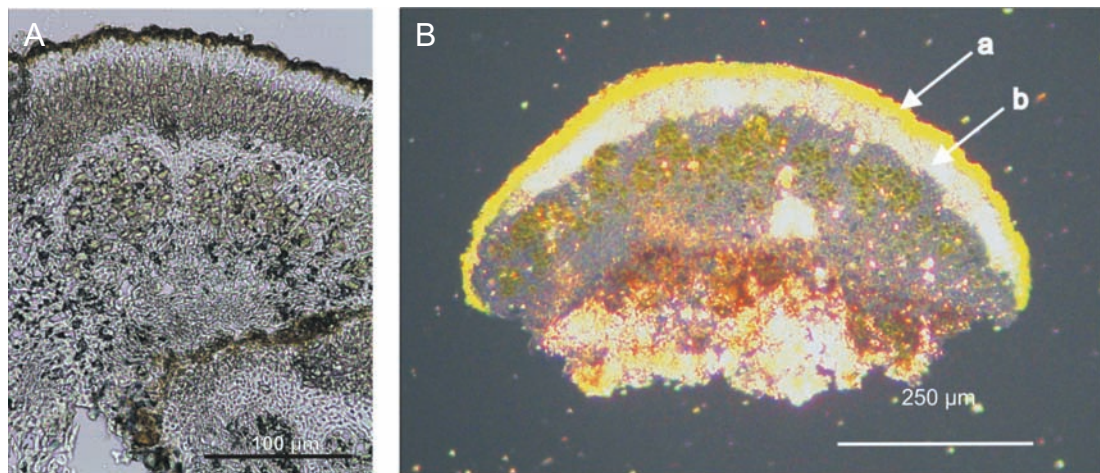


Fig. 4. Thallus section of *C. flavescens* (Huds.) J. R. Laundon (*K. Wilk 2149*, KRAM). A – under normal illumination: layer of anthraquinone crystals at the surface of thalline cortex and layer of grey crystals inside cortex, B – under polarized light: layer of yellow orange anthraquinone crystals at the surface of thalline cortex, pol+ (a), and layer of bright crystals inside cortex, pol+ (b). Scale bars = 100 µm; B = 250 µm.

The medulla of the thallus is dense or loose. Some species (e.g., *C. albolutescens*, *C. chalybaea*, *C. cirrochroa*, *C. flavovirescens*, *C. polycarpa*, *C. pseudofulgensia*) have a medulla with colorless crystals (pol+, insoluble in K).

Apothecial morphology

Most species produce abundant apothecia. In a few taxa apothecia were observed rarely or very rarely (*C. citrina*, *C. coronata*, *C. flavocitrina*, *C. proteus*, *C. teicholyta*), or not at all (*C. cirrochroa*, *C. decipiens*, *C. xanthostigmoidea*). Among the studied species, apothecia are not known in only two – *C. chrysodeta* and *C. xantholyta* (they have been found exclusively in the sterile form).

Usually the apothecia are sessile from the beginning, and rarely at first immersed in the thallus (e.g., *C. arnoldii* subsp. *obliterata*, *C. dichroa*, *C. dolomiticola*, *C. pusilla*, *C. saxiola*, *C. soralifera*) or rock (*C. albopruinosa*). Some species have apothecia permanently immersed in the thallus (*C. chalybaea*) or rock (*C. coccinea*,

C. keissleri). The apothecia are scattered or in groups; rarely they are strongly aggregated and form clusters as in *C. saxicola* and *C. arnoldii* subsp. *obliterata*. They are round, or angular due to compression.

The studied taxa produce zeorine, biatorine and pseudolecanorine apothecia (see MATERIAL AND METHODS) (Fig. 5). Zeorine apothecia occur in the majority of species. In these apothecia the proper margin is usually well developed, raised or level with the disc, and the same color as the disc or slightly paler. The thalline margin is mostly thin and more or less reduced (visible at least at the base of the apothecia) (e.g., *C. albolutescens*, *C. citrina*, *C. dichroa*, *C. flavescens*, *C. flavovirescens*) or excluded (not visible macroscopically at all) (e.g., *C. albopruinosa*, *C. biatorina*). Less frequently the thalline margin is well-developed (*C. crenulatella*, *C. dolomiticola* and *C. variabilis*) and concolorous with the thallus. The other two types of apothecia, biatorine and pseudolecanorine, occur sporadically. They are characterized by



Fig. 3. Various types of thalli in the genus *Caloplaca* Th. Fr. A – endolithic [*C. albopruinosa* (Arnold) H. Olivier], B – granulate, endolithic to slightly epilithic [*C. keissleri* (Servit) Poelt], C – rimose-areolate [*C. chalybaea* (Fr.) Müll. Arg.], D – areolate, dispersed [*C. flavocitrina* (Nyl.) H. Olivier], E – areolate, isidiate [*C. coronata* (Kremp. ex Körb.) J. Steiner], F – sublobate [*C. teicholyta* (Ach.) J. Steiner], G – lobate [*C. pusilla* (A. Massal.) Zahlbr.], H – leprose [*C. xantholyta* (Nyl.) Jatta].

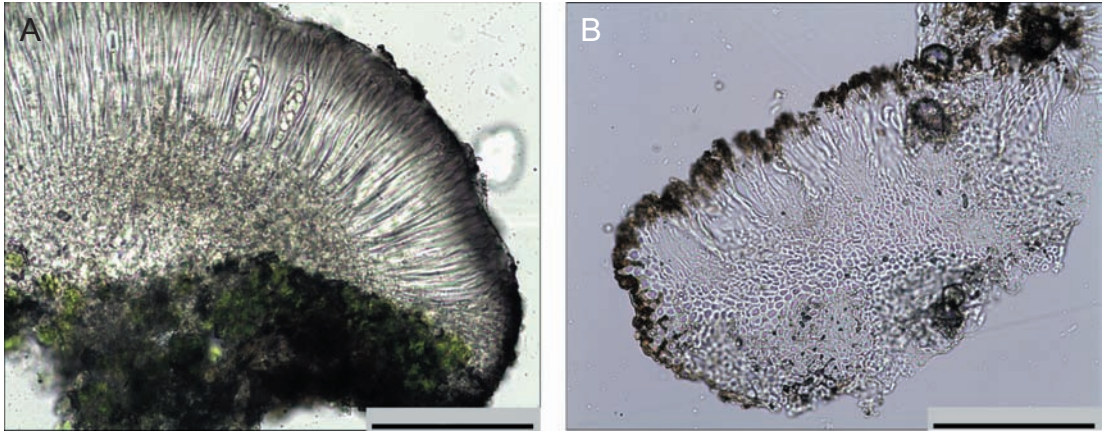


Fig. 5. Apothecia in the genus *Caloplaca* Th. Fr. A – zeorine [*C. atroalba* (Tuck.) Zahlbr.; *K. Wilk 3470b*, KRAM], B – biatorine [*C. keissleri* (Servit) Poelt; *J. Nowak*, KRAM L-18582]. Scale bars = 100 μ m.

having a proper margin that differs in thickness and shape. Biatorine apothecia were observed only in *C. coccinea* and *C. keissleri*, and pseudolecanorine only in *C. marmorata* and *C. nubigena*.

The apothecial discs usually have various tints of yellow, orange or red, rarely grey, brown or black (*C. albopruinosa*, *C. atroalba*, *C. chalybaea*, *C. variabilis*). They may be flat or slightly convex; rarely they are concave initially (*C. albopruinosa*, *C. crenulatella*, *C. flavovirescens*). Sometimes the discs are white pruinose (*C. albopruinosa*, *C. chalybaea*, *C. variabilis*).

Apothecial anatomy

The parathecium (proper margin) is thin or thick, prosoplectenchymatous or rarely paraplectenchymatous (*C. atroalba*, *C. keissleri*, *C. nubigena*) (Fig. 6). The parathecium is colorless inside, and yellow orange (anthraquinones, K+ red) or grey, brown or greenish (sedifolia-grey, K+, N+ violet) toward the surface. The latter pigmentation occurs in species of the subgenus *Pyrenodesmia*.

An amphithecium (thalline margin) usually is present. It is mostly thin, and more or less reduced. Less frequently the amphithecium

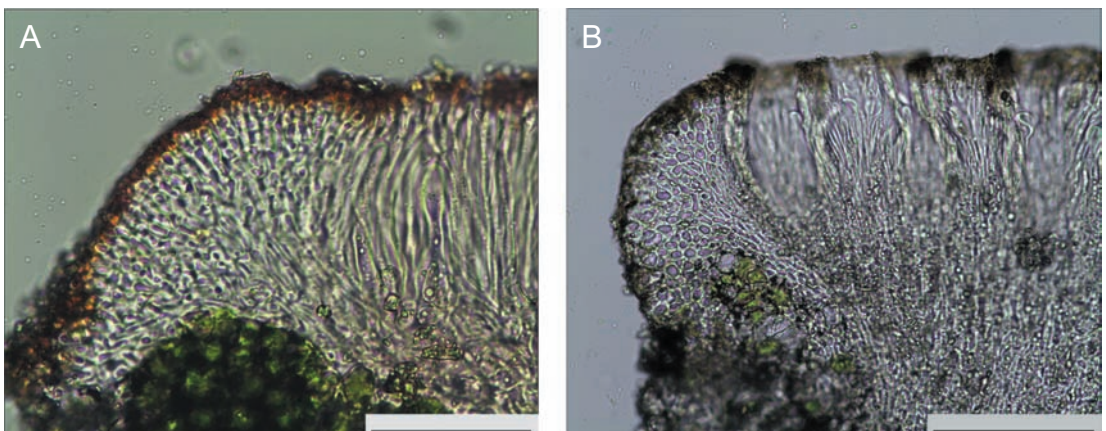


Fig. 6. Parathecium in the genus *Caloplaca* Th. Fr. A – prosoplectenchymatous [*C. albolutescens* (Nyl.) H. Olivier; *K. Wilk 4030*, KRAM], B – paraplectenchymatous [*C. nubigena* (Kremp.) Dalla Torre & Sarnth.; *K. Wilk 2072a*, KRAM]. Scale bars: A = 50 μ m; B = 100 μ m.

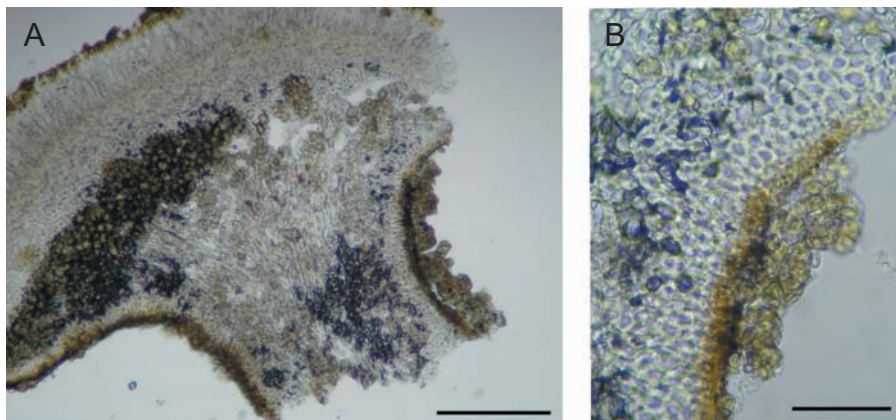


Fig. 7. Microsoredia on the surface of the amphithecial cortex of *Caloplaca saxicola* (Hoffm.) Nordin (*J. Kiszka & J. Piórecki*, KRAM L-29989). Scale bars: A = 150 μm ; B = 30 μm .

is thick and dominant (e.g., *C. crenulatella*, *C. dolomiticola*, *C. polycarpa*, *C. saxicola* and *C. variabilis*). Usually the algae are abundant and form a distinct continuous layer below the hypothecium. Occasionally the amphithecium is highly reduced and algae are visible only at the base of the apothecia (*C. albopruinosa*, *C. flavovirescens*). The amphithecial cortex is mostly thin and inconspicuous, with the exception of *C. albopruinosa*, *C. flavescens*, *C. pusilla* and *C. saxicola*. In red apothecia the amphithecium shows anthraquinone crystals at the surface. In *C. albopruinosa* the amphithecial cortex is almost completely filled by small yellow-brown crystals (pol+, insoluble in K, soluble in N). *Caloplaca saxicola* often has microsoredia on the surface of the amphithecial cortex (Fig. 7).

The outer side of the parathecium as well as the amphithecium may be covered by colorless crystals (pol+, insoluble in K). Their presence or absence is an important diagnostic character in, for example, the *C. variabilis* group.

The epihymenium of yellow to red apothecia is interspersed with yellowish orange to reddish orange crystals of anthraquinones (pol+, K+ red, soluble). The species of the subgenus *Pyrenodesmia* produce an epihymenium that is grey to brownish due to the presence of non-crystallizing sedifolia-grey pigment (K+, N+ violet). The hymenium is hyaline and variable

in height. The paraphyses are simple or slightly branched, septate and slightly constricted at the septa. The apical cells of the paraphyses usually are slightly thickened (up to 5 μm wide); in a few species they are strongly thickened, up to 10 μm wide (*C. arnoldiiconfusa*, *C. lactea*, *C. nubigena*, *C. pusilla*, *C. saxicola*). In fresh material the paraphyses often have oil droplets. The hypothecium is hyaline, usually prosoplectenchymatous, seldom paraplectenchymatous (*C. keissleri*). In the hypothecium, rows of isodiametric cells (*C. chalybaea*) or characteristic intercellular spaces (*C. albolutescens*, *C. variabilis*) may occur (Fig. 8). The structure of hypothecium may be weakly visible due to the presence of many oil droplets.

The ascospores are polarilocular and usually narrow or wide ellipsoid. A few species produce subspherical spores (*C. dolomiticola*, *C. flavovirescens*, *C. velana*). Occasionally the spores are lemon-shaped – narrower at the tips and very broad in the middle (*C. flavescens*), or fusiform with distinctly pointed ends (*C. aurea*). The isthmus is usually distinct, well developed, moderately wide, rarely very wide (*C. flavovirescens*) or thin (*C. atroalba*, *C. aurea*, *C. crenulatella*, *C. lactea*, *C. marmorata*) (Fig. 9). The spore wall usually is thin, up to 1 μm thick; only *C. dichroa* has distinctly thickened spore walls 1–2 μm thick (= sand-glass spores).

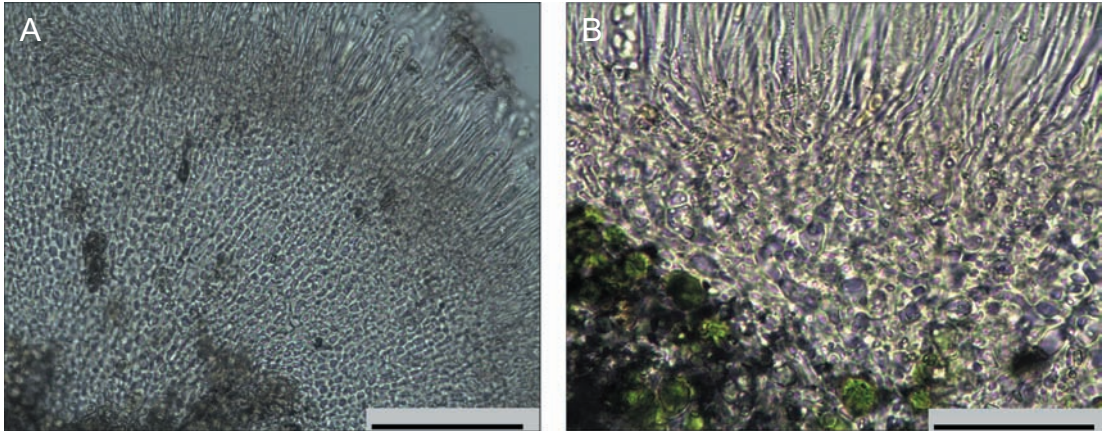


Fig. 8. Structure of hypothecium: A – paraproplectenchymatous hypothecium composed of rows of small isodiametric cells [*Caloplaca chalybaea* (Fr.) Müll. Arg.; *J. Nowak*, KRAM L-4474], B – prosoproplectenchymatous hypothecium with characteristic intercellular spaces [*C. albolutescens* (Nyl.) H. Olivier; *K. Wilk 4030*, KRAM]. Scale bars: A = 100 µm; B = 50 µm.

Vegetative propagules

Vegetative propagules such as soredia, isidia and blastidia do not often appear in the studied taxa. Only some of the species produce them, mostly those occurring in sterile form. Soredia are the most common vegetative propagules. They are present in *C. albolutescens*, *C. cirrochroa*, *C. citrina*, *C. decipiens*, *C. flavocitrina*, *C. proteus*, *C. soralifera* and *C. teicholyta*. Depending on the species, a few types of soralia may be developed, including crater-like and lip-shaped. In some sorediate species delimited soralia are absent and soredia are formed by erosion of the thallus surface – diffuse type of soredia (e.g., *C. albolutescens*, *C. teicholyta*). In *C. chrysodeta* and *C. xantholyta* the whole thallus consists of soredia-like elements (= leprose thalli). In *C. saxicola*, microsoredia were observed on the surface of the amphithecial cortex. Gaya (2009) discussed this type of soredia more extensively. Two species – *C. dichroa* and *C. xanthostigmoidea*, produce blastidia. The blastidia are roundish and surrounded by an indistinct layer of ‘cortical’ hyphae (not true cortex). They often form a series of two or more blastidia growing out of each other. Isidia occur only in *C. coronata*; they are unbranched, longitudinal or roundish.

In species containing anthraquinones the soredia are in shades of yellow, orange or red (K+ red). They are usually concolorous or slightly paler than

the thallus, rarely distinctly contrasting against the thallus (*C. cirrochroa*, *C. flavocitrina*). In species lacking anthraquinones the soredia are violet-grey (K+, N+ violet; sedifolia-grey pigment): *C. albolutescens* and *C. soralifera*. In *C. xanthostigmoidea*, blastidia may be olive green (K–, N+ violet; cinereorufa-green pigment).

Pycnidia and conidia

Pycnidia occur in most of the species. They are partially or completely immersed in the thallus. The ostiola are orange, rarely red (*C. coccinea*) or black (*C. albopruinosa*, *C. variabilis*). In the genus *Caloplaca* the conidia are ± uniform, colorless, bacilliform, ellipsoid or ovoid. The presence of pycnidia is an important diagnostic character, while the shape and size of conidia are not very useful for species identification.

Chemical reactions

Yellow, orange or red thalli and/or apothecia react red with K due to the presence of anthraquinones. Species having grey, brown or black thalli and often apothecia contain another pigment – sedifolia-grey, reacting violet with K and N. Both are located in the thalline cortex, apothecial margin and epihymenium (Fig. 10), and in soredia if present. Another pigment known in the genus is cinereorufa-green. It was found in only one species

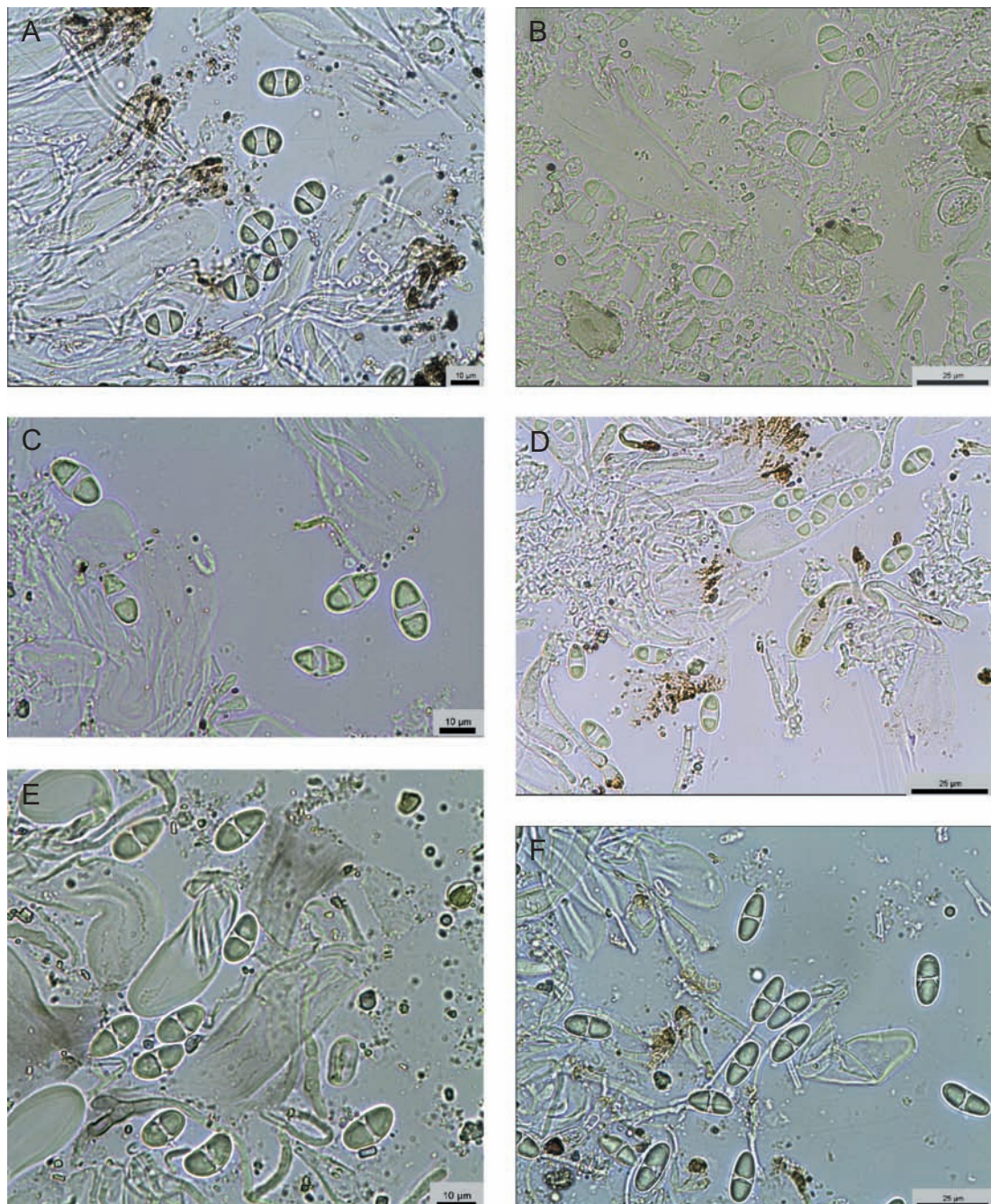


Fig. 9. Examples of spores with different shape and isthmus thicknesses: A – *Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth., B – *C. variabilis* (Pers.) Müll. Arg., C – *C. coccinea* (Müll. Arg.) Poelt, D – *C. marmorata* (Bagl.) Jatta, E – *C. atroalba* (Tuck.) Zahlbr., F – *C. cremulata* (Nyl.) H. Olivier. Scale bars: A, B & F = 25 µm; C, D & E = 10 µm.

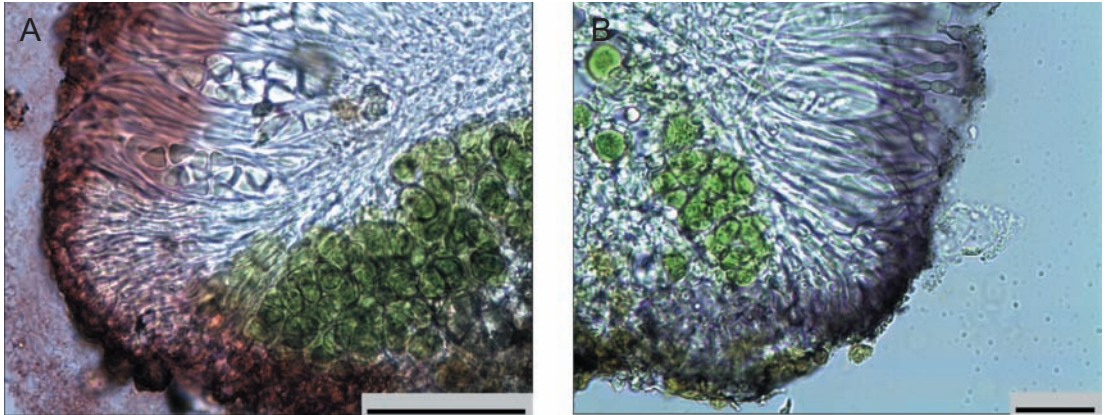


Fig. 10. Color reaction of apothecia with K (cross section): A – red (anthraquinone present) [*C. crenulatella* (Nyl.) H. Olivier; K. Wilk 3885, KRAM], B – violet (sedifolia-grey present) [*C. atroalba* (Tuck.) Zahlbr.; K. Wilk 3470b, KRAM]. Scale bars: A = 50 μ m; B = 25 μ m.

– *C. xanthostigmoidea*. The pigment is olive green color and reacts violet with N. This pigment is located in ‘cortical’ hyphae of blastidia.

Habitat

Most of the examined species prefer dry, sun-exposed places. A few taxa occupy shaded, moist sites (*C. citrina*, *C. chrysodeta*, *C. xantholyta*). Some species occur in rock crevices (*C. aurea*, *C. chrysodeta*, *C. xantholyta*).

In terms of habitat preference the species can be divided into two groups: (i) taxa occurring on calcareous rock, such as limestone and calcareous sandstone (obligate calcicoles), and (ii) taxa occurring on calcareous rock but sometimes also growing on poorly calcareous or noncalcareous rock (non-obligate calcicoles). Most of the studied species belong to the first of these two groups. The second group includes *C. arnoldii* subsp. *obliterata*, *C. chrysodeta*, *C. citrina*, *C. crenulatella* and *C. holocarpa*. Among the obligate calcicoles are those occurring exclusively on limestone (*C. arnoldiiconfusa*, *C. biatorina*, *C. chalybaea*, *C. marmorata*, *C. nubigena*, *C. proteus*, *C. pseudofulgensia*, *C. variabilis*), on limestone and calcareous sandstone or slate (*C. cirrochroa*, *C. decipiens*, *C. dichroa*, *C. flavescens*, *C. flavovirescens*, *C. xantholyta*), and exclusively on calcareous sandstone or slate (*C. albolutescens*, *C. soralifera*). Some saxicolous species may

overgrow bryophytes or plant debris covering rock (*C. aurea*, *C. citrina*, *C. chrysodeta*, *C. xantholyta*, *C. xanthostigmoidea*). Three species – *C. oasis*, *C. polycarpa* and *C. vitellinaria* – grow on thalli of other lichens. Two of those three (*C. oasis*, *C. polycarpa*) are not obligate parasites: they also grow directly on the rock surface.

This treatment deals with natural and seminatural habitats, but it is worth mentioning that some of the species often grow on manmade calcareous substrates such as mortar or concrete (*C. albolutescens*, *C. citrina*, *C. crenulatella*, *C. decipiens*, *C. dolomiticola*, *C. flavocitrina*, *C. oasis*, *C. pusilla*, *C. saxicola*, *C. soralifera*, *C. teicholyta*).

Distribution

The studied taxa vary in their geographical distribution in the Western Carpathians. Among the taxa widely distributed and occurring in many mountain ranges are *C. chrysodeta*, *C. cirrochroa*, *C. citrina*, *C. crenulatella*, *C. decipiens*, *C. dichroa*, *C. dolomiticola*, *C. flavescens*, *C. flavovirescens*, *C. holocarpa*, *C. pusilla* and *C. variabilis*. Some species are limited to one or a few mountain ranges. Many species were found only in the Tatra Mts (*C. albobruinosa*, *C. arnoldiiconfusa*, *C. aurea*, *C. biatorina*, *C. coccinea*, *C. keissleri*, *C. nubigena*, *C. percrocata*, *C. saxicola*, *C. xanthostigmoidea*). Others are known only from the Pieniny Mts (*C. coronata*, *C. marmorata*). The

species occurring in both the Tatras and the Pieniny Mts are *C. atroalba*, *C. chalybaea*, *C. polycarpa*, *C. proteus* and *C. pseudofulgensia*. Three species were recorded only from the Beskidy Mts and other regions outside the Tatra and Pieniny mountain ranges (*C. albolutescens*, *C. flavocitrina*, *C. teicholyta*).

Particular species differ in their frequency in the studied area. The common species (more than 10 localities) are *C. chalybaea*, *C. chrysodeta*, *C. cirrochroa*, *C. citrina*, *C. crenulatella*, *C. decipiens*, *C. flavovirescens*, *C. holocarpa*, *C. proteus*, *C. pseudofulgensia*, *C. variabilis* and *C. xantholyta*. The frequent species (6–10 localities) are *C. albolutescens*, *C. aurea*, *C. dichroa*, *C. dolomiticola*, *C. flavescens*, *C. nubigena* and *C. pusilla*. The infrequent species (3–5 localities) are *C. arnoldii* subsp. *obliterata*, *C. coronata*, *C. flavocitrina*, *C. marmorata*, *C. oasis*, *C. polycarpa*, *C. soralifera* and *C. teicholyta*. The rare species (1–2 localities) are *C. albobruinosa*, *C. arnoldiiconfusa*, *C. atroalba*, *C. biatorina*, *C. coccinea*, *C. keissleri*, *C. percrocata*, *C. saxicola*, *C. vitellinaria* and *C. xanthostigmoidea*.

Caloplaca chrysodeta, *C. polycarpa* and *C. xantholyta*, earlier known from single localities, turned out to be more frequent in the study area. Other taxa such as *C. saxicola*, treated here in a new taxonomic approach, have proved to be

less frequent. Earlier that species was considered very common.

The mountain ranges of the Polish Western Carpathians differ in *Caloplaca* species richness (Table 2). *Caloplaca* species are richly represented in the Tatras and Pieniny Mts. This is related to the availability of suitable habitats there. Both of these ranges have been the subject of intensive lichenological investigations, especially in recent times. More studies in the Beskidy Mts and Carpathian foothills are likely to augment the list of *Caloplaca* species occurring in those places as well.

REVIEW OF SPECIES DIVERSITY

As a result of my revision of *Caloplaca* from the Polish Western Carpathians, 39 species were recognized: *C. albolutescens* (Nyl.) H. Olivier, *C. albobruinosa* (Arnold) H. Olivier, *C. arnoldii* subsp. *obliterata* (Pers.) Gaya, *C. arnoldiiconfusa* Gaya & Nav.-Ros., *C. atroalba* (Tuck.) Zahlbr., *C. aurea* (Schaer.) Zahlbr., *C. biatorina* (A. Massal.) J. Steiner, *C. chalybaea* (Fr.) Müll. Arg., *C. chrysodeta* (Vain. ex Räsänen) Dombr., *C. cirrochroa* (Ach.) Th. Fr., *C. citrina* (Hoffm.) Th. Fr., *C. coccinea* (Müll. Arg.) Poelt, *C. coronata* (Kremp. ex Körb.) J. Steiner, *C. crenulatella* (Nyl.) H. Olivier, *C. decipiens* (Arnold) Blomb. & Forssell, *C. dichroa* Arup, *C. dolomiticola* (Hue) Zahlbr., *C. flavescens* (Huds.)

Table 2. Calcicolous *Caloplaca* species occurring in the Tatra Mts, Pieniny Mts, and the Beskidy Mts and foothills.

Area	Epilithic and calcicolous <i>Caloplaca</i> species	Together
Tatra Mts	<i>C. albobruinosa</i> , <i>C. arnoldiiconfusa</i> , <i>C. atroalba</i> , <i>C. aurea</i> , <i>C. biatorina</i> , <i>C. chalybaea</i> , <i>C. chrysodeta</i> , <i>C. cirrochroa</i> , <i>C. citrina</i> , <i>C. coccinea</i> , <i>C. crenulatella</i> , <i>C. dichroa</i> , <i>C. dolomiticola</i> , <i>C. flavescens</i> , <i>C. flavovirescens</i> , <i>C. holocarpa</i> , <i>C. keissleri</i> , <i>C. lactea</i> , <i>C. nubigena</i> , <i>C. percrocata</i> , <i>C. polycarpa</i> , <i>C. proteus</i> , <i>C. pseudofulgensia</i> , <i>C. saxicola</i> , <i>C. variabilis</i> , <i>C. velana</i> complex, <i>C. vitellinaria</i> , <i>C. xantholyta</i> , <i>C. xanthostigmoidea</i>	29
Pieniny Mts and vicinity	<i>C. albolutescens</i> , <i>C. arnoldii</i> subsp. <i>obliterata</i> , <i>C. atroalba</i> , <i>C. chalybaea</i> , <i>C. chrysodeta</i> , <i>C. cirrochroa</i> , <i>C. citrina</i> , <i>C. coronata</i> , <i>C. crenulatella</i> , <i>C. decipiens</i> , <i>C. dichroa</i> , <i>C. dolomiticola</i> , <i>C. flavescens</i> , <i>C. flavovirescens</i> , <i>C. holocarpa</i> , <i>C. marmorata</i> , <i>C. oasis</i> , <i>C. polycarpa</i> , <i>C. proteus</i> , <i>C. pseudofulgensia</i> , <i>C. pusilla</i> , <i>C. soralifera</i> , <i>C. variabilis</i>	23
Beskidy Mts and foothills	<i>C. albolutescens</i> , <i>C. arnoldii</i> subsp. <i>obliterata</i> , <i>C. chrysodeta</i> , <i>C. cirrochroa</i> , <i>C. citrina</i> , <i>C. crenulatella</i> , <i>C. decipiens</i> , <i>C. dichroa</i> , <i>C. dolomiticola</i> , <i>C. flavescens</i> , <i>C. flavocitrina</i> , <i>C. flavovirescens</i> , <i>C. holocarpa</i> , <i>C. oasis</i> , <i>C. pusilla</i> , <i>C. soralifera</i> , <i>C. teicholyta</i> , <i>C. variabilis</i> , <i>C. vitellinaria</i> , <i>C. xantholyta</i>	20

J. R. Laundon, *C. flavocitrina* (Nyl.) H. Olivier, *C. flavovirescens* (Wulfen) Dalla Torre & Sarnth., *C. holocarpa* (Ach.) A. E. Wade, *C. keissleri* (Servit) Poelt, *C. lactea* (A. Massal.) Zahlbr., *C. marmorata* (Bagl.) Jatta, *C. nubigena* (Kremp.) Dalla Torre & Sarnth., *C. oasis* (A. Massal.) Szatala, *C. perocroata* (Arnold) J. Steiner, *C. polycarpa* (A. Massal.) Zahlbr., *C. proteus* Poelt, *C. pseudofulgensia* Gaya & Nav.-Ros., *C. pusilla* (A. Massal.) Zahlbr., *C. saxicola* (Hoffm.) Nordin, *C. soralifera* Vondrák & Hrouzek, *C. teicholyta* (Ach.) J. Steiner, *C. variabilis* (Pers.) Müll. Arg., *C. velana* complex, *C. vitellinaria* Szatala, *C. xantholyta* (Nyl.) Jatta and *C. xanthostigmoidea* (Räsänen) Zahlbr. Two of them are new for Poland: *C. albolutescens* and *C. arnoldiiconfusa*. One is new for the Polish Carpathians: *C. crenulatella*. The study provided many new regional records, helping to complete the geographical distributions of many poorly known taxa (e.g., *C. chrysodeta*, *C. polycarpa*, *C. xantholyta*). A few species were not confirmed from the area: *C. alociza* (A. Massal.) Mig., *C. aurantia* (Pers.) Helb., *C. erythrocarpa* (Pers.) Zwackh and *C. subochracea* (Wedd.) Werner.

One species now reported as new for Poland, *C. arnoldiiconfusa*, was recently described from other European countries (Gaya 2009). *Caloplaca albolutescens* is an old but problematic species, not always properly understood; it has often been treated as a synonym of *C. teicholyta*. *Caloplaca albolutescens* now seems to be well delimited and should be recognized. *Caloplaca crenulatella* was reported previously from various regions of Poland (e.g., Kossowska 2008) but here it is reported from the Polish Carpathians for the first time.

Among the species reported from the study area are taxa described from other European regions in the past decade, such as *C. dichroa* (Arup 2006a), *C. pseudofulgensia* (Gaya 2009) and *C. soralifera* (Vondrák & Hrouzek 2006). Those three species seem to be common in the studied area, especially in the Tatras and Pieniny Mts. Recently, *C. pusilla* and *C. arnoldii* subsp. *obliterata*, earlier treated by authors as synonyms of *C. saxicola*, were reintroduced by Gaya (2009). Other revised and interesting species include *C. albopruinosa*, *C. atroalba*, *C. flavescens* and *C. flavocitrina*. *Caloplaca albopruinosa*

has often been treated as a synonym of *C. alociza*. The most recent studies indicate that *C. albopruinosa* has diagnostic features distinguishing it from *C. alociza*, and the two taxa should be treated as separate species. *Caloplaca atroalba*, recognized in this study, represents the *C. variabilis* group. It is known mainly from North America. In Europe it was reported from only a few localities in Austria, Sweden, Poland and Ukraine. *Caloplaca atroalba* looks similar to *C. diphyodes*, a species occurring in Europe. *Caloplaca flavescens*, listed here and included in the key to the lichen biota of Poland, seems to have been greatly overlooked. This study indicated that most of the specimens identified as *C. aurantia* are in fact *C. flavescens*. *Caloplaca flavocitrina* represents the difficult *C. citrina* group. For a long time many authors treated *C. flavocitrina* as a synonym of *C. citrina* due to problems in distinguishing the two species. Now there are more data available to separate the two, and *C. flavocitrina* is treated as a distinct but diverse species including cryptic taxa (Vondrák *et al.* 2009).

One of the listed species, *C. velana*, appeared to be especially diverse. The species is not well defined in the literature and the studied material is not uniform. It needs further detailed studies employing modern methods. In the present study, *C. velana* is treated as a complex of species.

All recognized species belong to five subgenera (according to Clauzade and Roux 1985):

I. *Caloplaca* subgenus *Pyrenodesmia* (A. Massal.) Boist.: *C. albopruinosa*, *C. atroalba*, *C. chalybaea*, *C. variabilis* (Fig. 11).

Species of the subgenus *Pyrenodesmia* have white, grey, brownish or black, or endolithic thalli, without marginal lobes. The apothecia are black or brownish, pruinose or epruinose. The thallus and apothecia often react violet with K and N. The spores are polarilocular. Soredia do not occur.

II. *Caloplaca* subgenus *Leproplaca* (Nyl.) Clauzade & Rond.: *C. chrysodeta*, *C. xantholyta* (Fig. 12).

Species of the subgenus *Leproplaca* have yellow or orange yellow leprose thalli, without apothecia. The thallus reacts red with K.

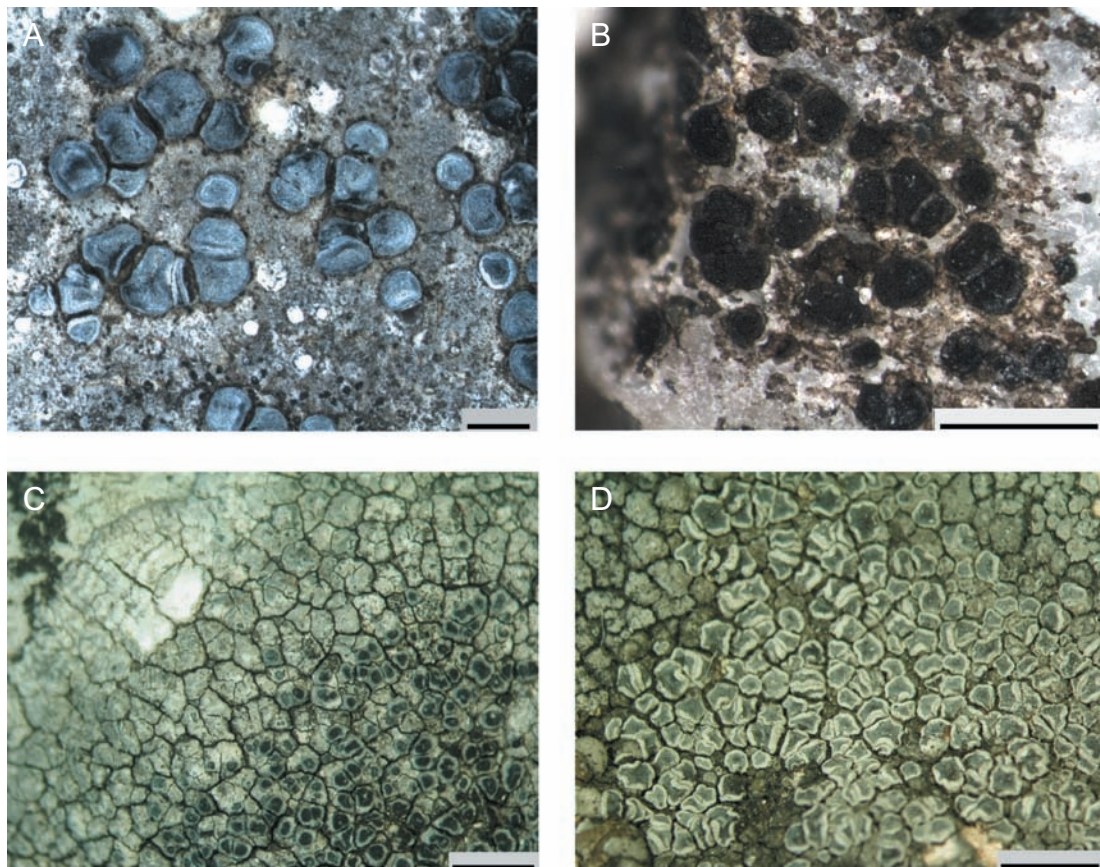


Fig. 11. *Caloplaca* subgenus *Pyrenodesmia* (A. Massal.) Boist. A – *C. albopruinosa* (K. Wilk 2157, KRAM), B – *C. atroalba* (Tuck.) Zahlbr. (*L. Śliwa* 3118, KRAM), C – *C. chalybaea* (Fr.) Müll. Arg. (*J. Nowak*, KRAM L-3814), D – *C. variabilis* (Pers.) Müll. Arg. (*J. Nowak*, KRAM L-3246). Scale bars: A & B = 1 mm; C & D = 2 mm.

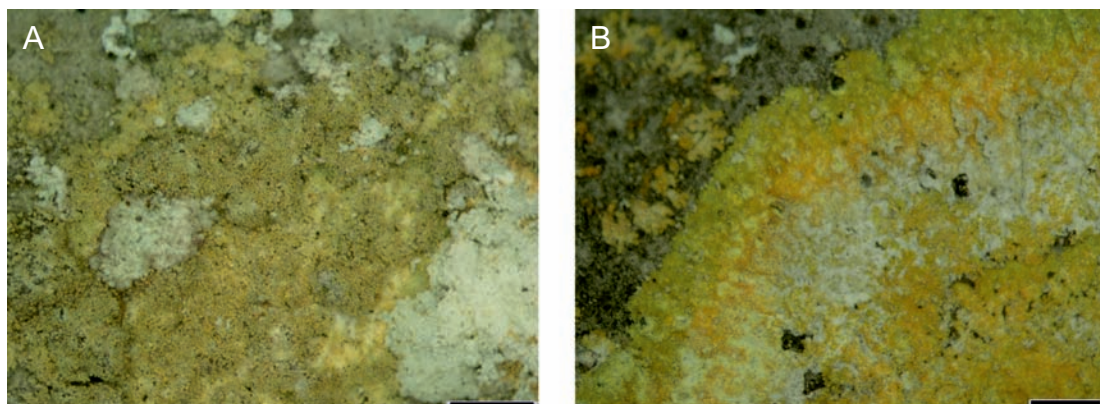


Fig. 12. *Caloplaca* subgenus *Leproplaca* (Nyl.) Clauzade & Rond. A – *C. chrysodeta* (Vain. ex Räsänen) Dombr. (*K. Wilk* 4116, KRAM), B – *C. xantholyta* (Nyl.) Jatta (*K. Wilk* 4091, KRAM). Scale bars = 2 mm.

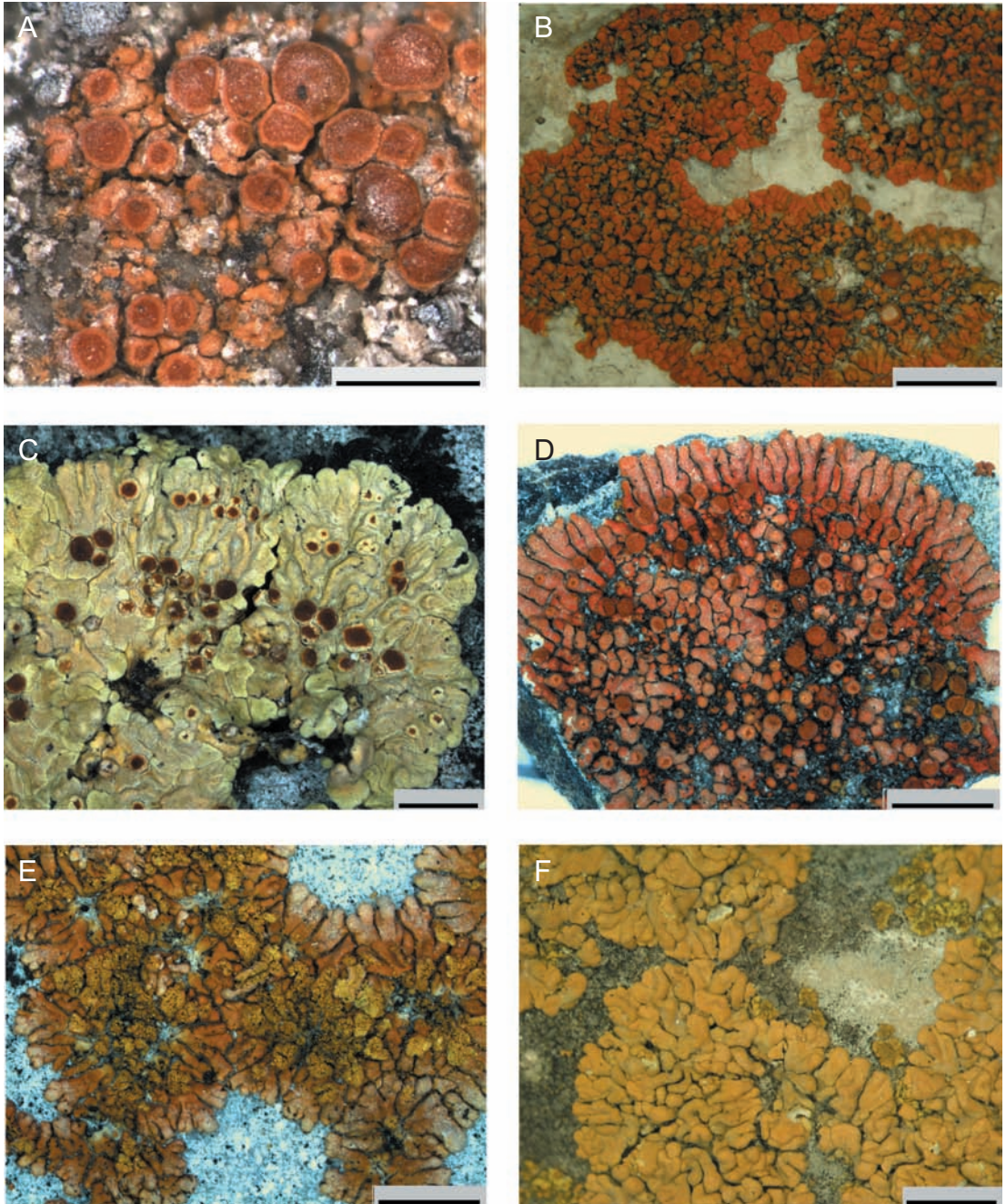


Fig. 13. *Caloplaca* subgenus *Gasparrinia* (Torn.) Th. Fr. A – *C. arnoldii* subsp. *obliterated* (Pers.) Gaya (*K. Glanc*, KRAM L-27470), B – *C. arnoldiiconfusa* Gaya & Nav.-Ros. (*J. Nowak*, KRAM L-19231), C – *C. aurea* (Schaer.) Zahlbr. (*K. Wilk* 2208, KRAM), D – *C. biatorina* (A. Massal.) J. Steiner (*K. Wilk* 11284, KRAM), E – *C. cirrochroa* (Ach.) Th. Fr. (*J. Nowak*, KRAM L-3798), F – *C. decipiens* (Arnold) Blomb. & Forssell (*J. Nowak*, KRAM L-2662). Scale bars: A = 1 mm; B–F = 2 mm.

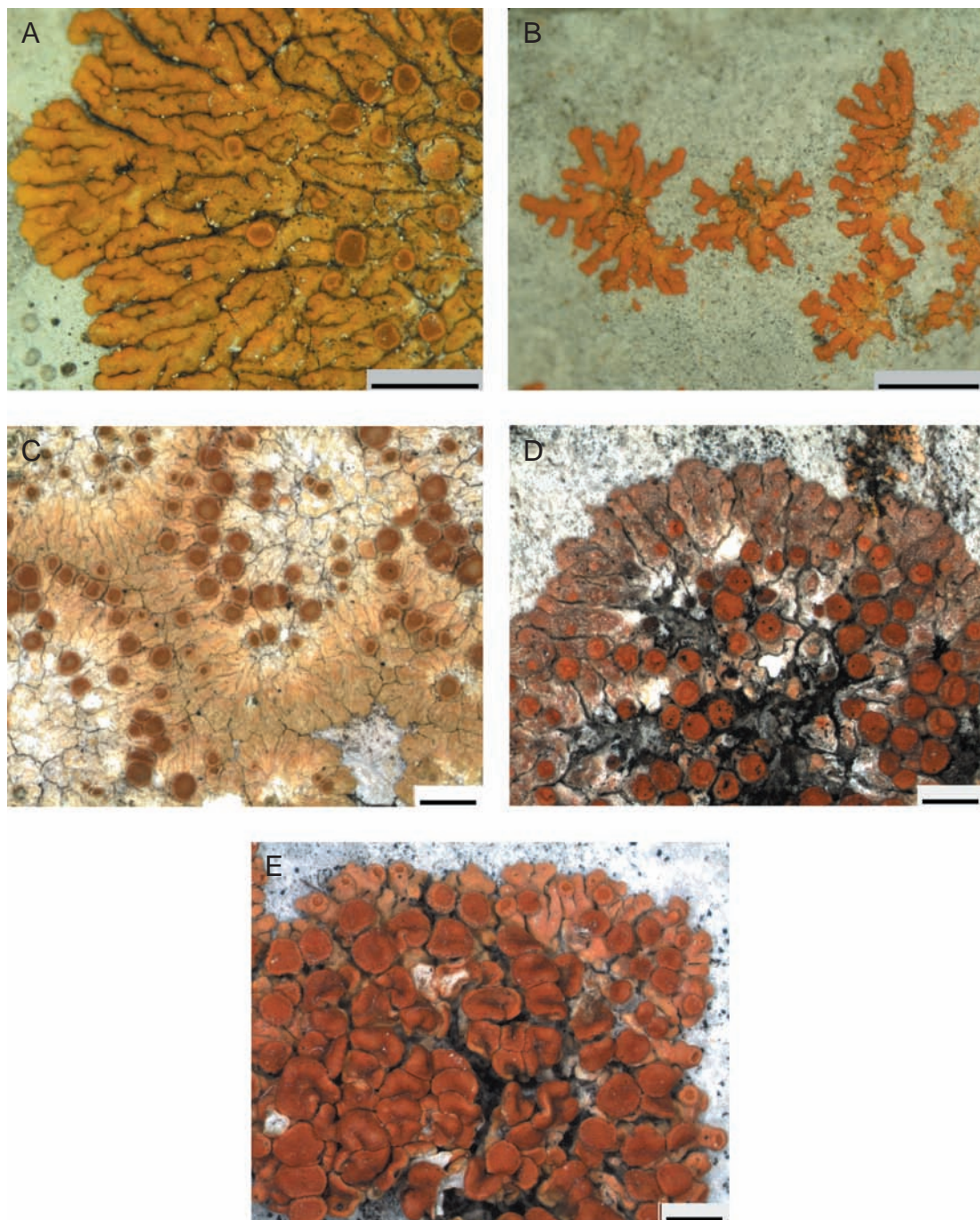


Fig. 14. *Caloplaca* subgenus *Gasparrinia* (Torn.) Th. Fr. A – *C. flavescens* (Huds.) J. R. Laundon (K. Wilk 2147, KRAM), B – *C. proteus* Poelt (U. Bielczyk, KRAM L-44471), C – *C. pseudofulgens* Gaya & Nav.-Ros. (K. Wilk 2277, KRAM), D – *C. pusilla* (A. Massal.) Zahlbr. (K. Toborowicz, July 1980, KTC), E – *C. saxicola* (Hoffm.) Nordin (K. Wilk 2214, KRAM). Scale bars: A & B = 2 mm; C–F = 1 mm.

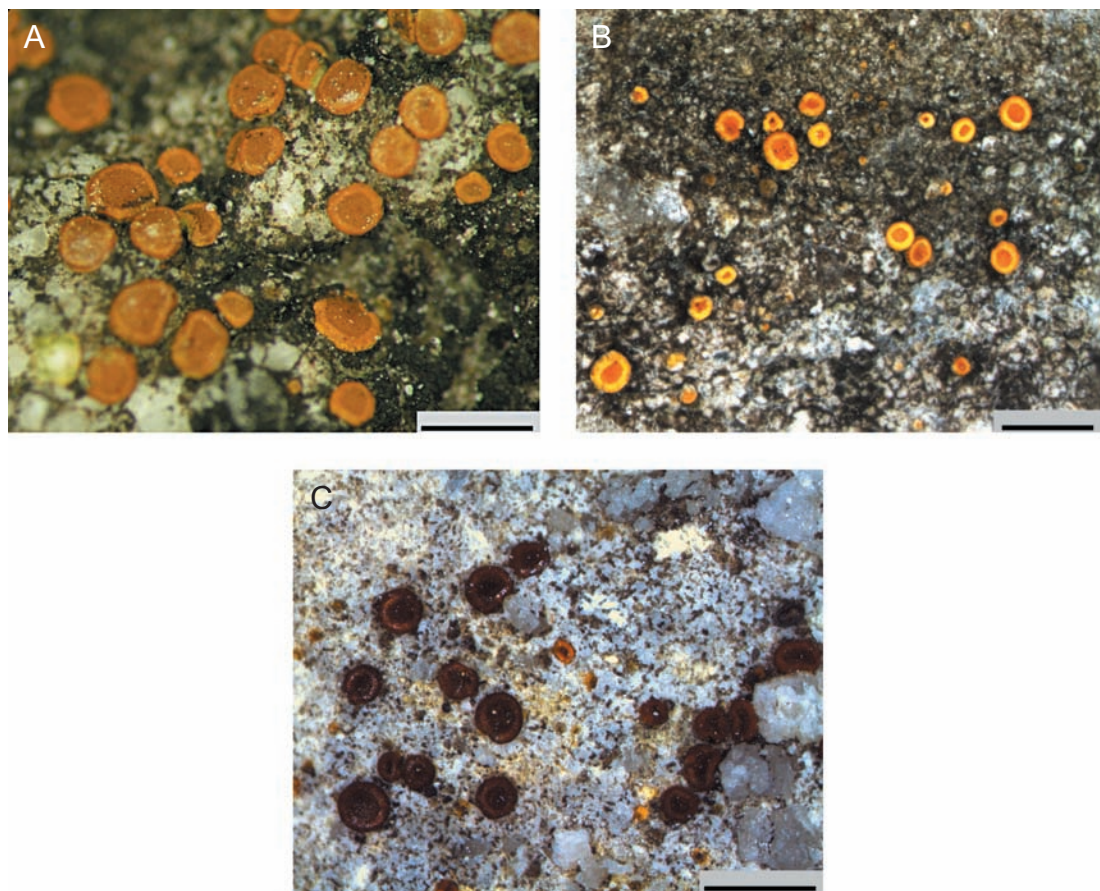


Fig. 15. *Caloplaca* subgenus *Gyalolechia* (A. Massal.) Boist. A – *C. crenulatella* (Nyl.) H. Olivier (*L. Śliwa 3199*, KRAM), B – *C. lactea* (A. Massal.) Zahlbr. (*L. Śliwa 2401*, KRAM), C – *C. marmorata* (Bagl.) Jatta (*J. Nowak*, KRAM L-18696). Scale bars = 1 mm.

III. *Caloplaca* subgenus *Gasparrinia* (Torn.) Th. Fr.: *C. arnoldii* subsp. *obliterata*, *C. arnoldiiconfusa*, *C. aurea*, *C. biatorina*, *C. cirrochroa*, *C. decipiens*, *C. flavescens*, *C. proteus*, *C. pseudofulgensia*, *C. pusilla*, *C. saxicola* (Figs 13, 14).

Species of the subgenus *Gasparrinia* have yellow, orange, salmon or red thalli with usually distinct marginal lobes. The apothecia are yellow to red. Both thallus and apothecia react red with K. The spores are polarilocular. Soredia occur or not.

IV. *Caloplaca* subgenus *Gyalolechia* (A. Massal.) Boist.: *C. crenulatella*, *C. lactea*, *C. marmorata* (Fig. 15).

Species of the subgenus *Gyalolechia* have yellow, white, grey or endolithic thalli (K+ red or K–), without marginal lobes. The apothecia are yellow, orange, red or brownish red (K+ red). The spores are polarilocular with an isthmus not exceeding 3 μm wide (usually 2 μm). Soredia do not occur.

V. *Caloplaca* Th. Fr. subgenus *Caloplaca*: *C. albolutescens*, *C. citrina*, *C. coccinea*, *C. coronata*, *C. dichroa*, *C. dolomiticola*, *C. flavocitrina*, *C. flavovirescens*, *C. keissleri*, *C. holocarpa*, *C. nubigena*, *C. oasis*, *C. percrocata*, *C. polycarpa*, *C. soralifera*, *C. teicholyta*, *C. velana* complex, and *C. xanthostigmoidea* (Figs 16–19).

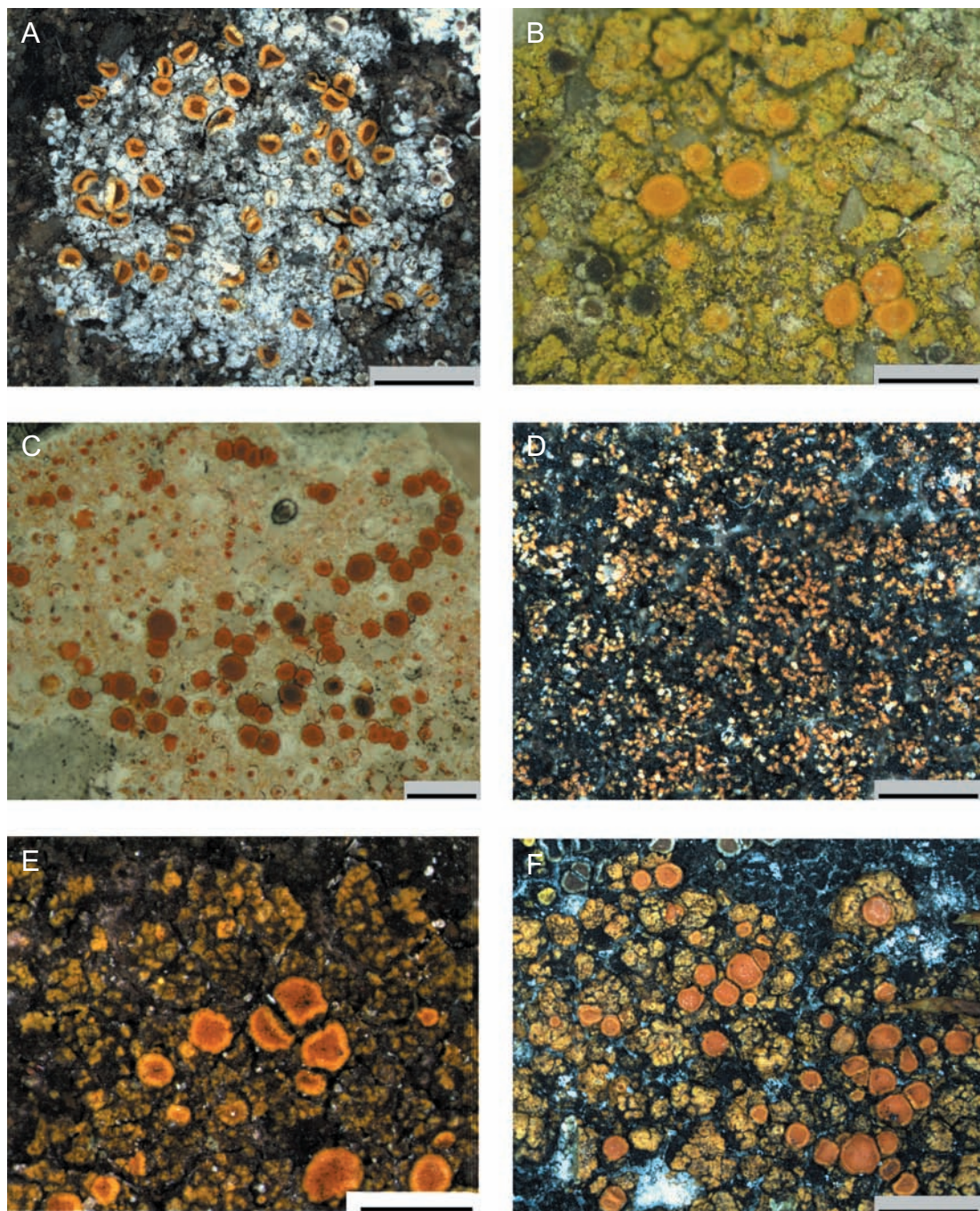


Fig. 16. *Caloplaca* Th. Fr. subgenus *Caloplaca*. A – *C. albullescens* (Nyl.) H. Olivier (*K. Glanc*, KRAM L-27502), B – *C. citrina* (Hoffm.) Th. Fr. (*K. Wilk* 3359, KRAM), C – *C. coccinea* (Müll. Arg.) Poelt (*J. Motyka*, KRAM L-3161), D – *C. coronata* (Kremp. ex Körb.) J. Steiner (*J. Nowak*, KRAM L-1476), E – *C. dichroa* Arup (*K. Wilk* 3485, KRAM), F – *C. dolomiticola* (Hue) Zahlbr. (*J. Nowak*, KRAM L-42353). Scale bars: A & F = 2 mm; B–E = 1 mm.

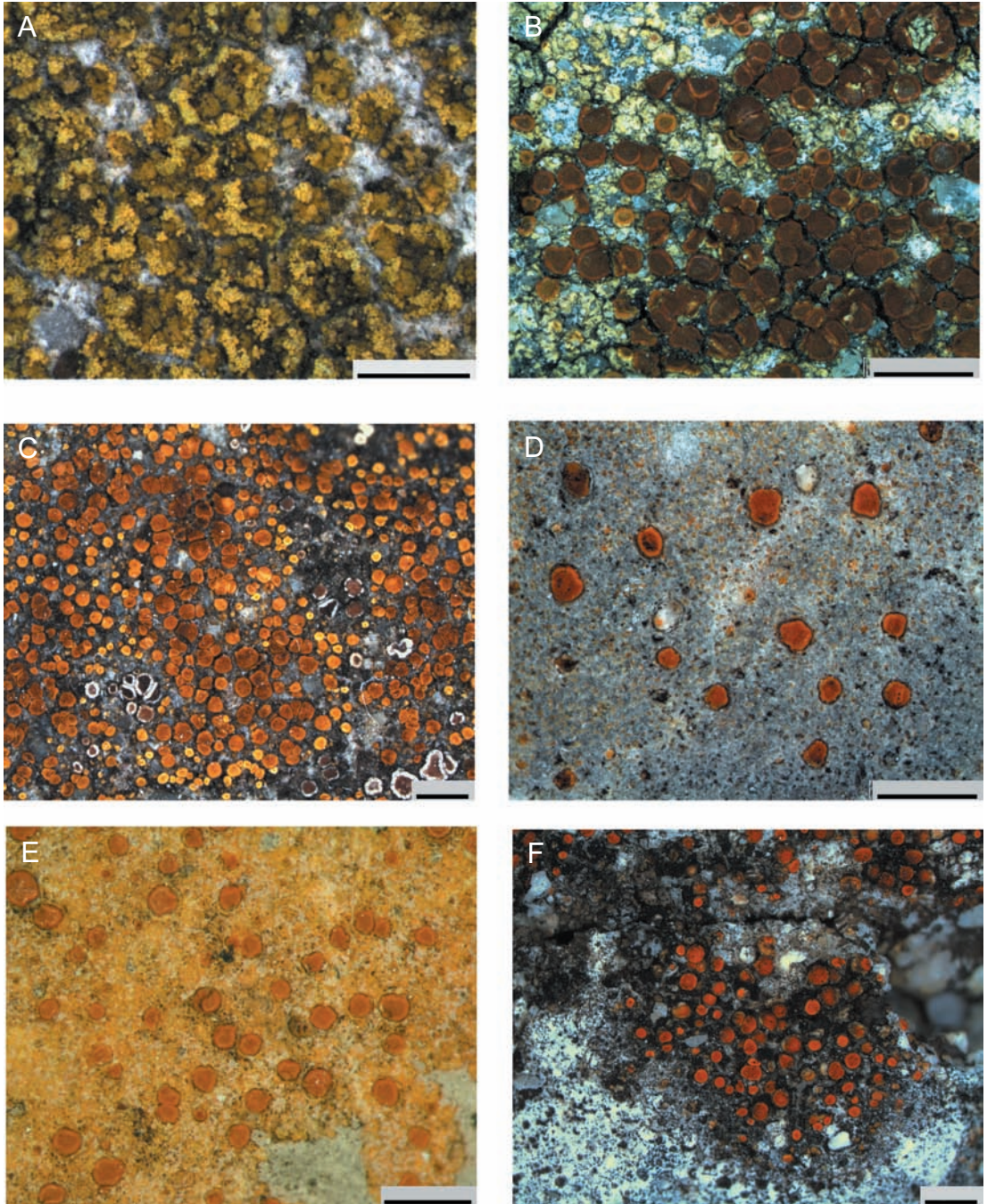


Fig. 17. *Caloplaca* Th. Fr. subgenus *Caloplaca*. A – *C. flavocitrina* (Nyl.) H. Olivier (*K. Wilk 3780*, KRAM), B – *C. flavovire-scens* (Wulfen) Dalla Torre & Sarnth. (*K. Wilk 2164*, KRAM), C – *C. holocarpa* (Ach.) A. E. Wade (*J. Kiszka*, KRAM L-55968), D – *C. keissleri* (Servit) Poelt (*K. Wilk 32199*, KRAM), E – *C. nubigena* (Kremp.) Dalla Torre & Sarnth. (*J. Nowak*, KRAM L-2249), F – *C. oasis* (A. Massal.) Szatala (*J. Kiszka*, KRAM L-55967). Scale bars: A, C–F = 1 mm; B = 2 mm.

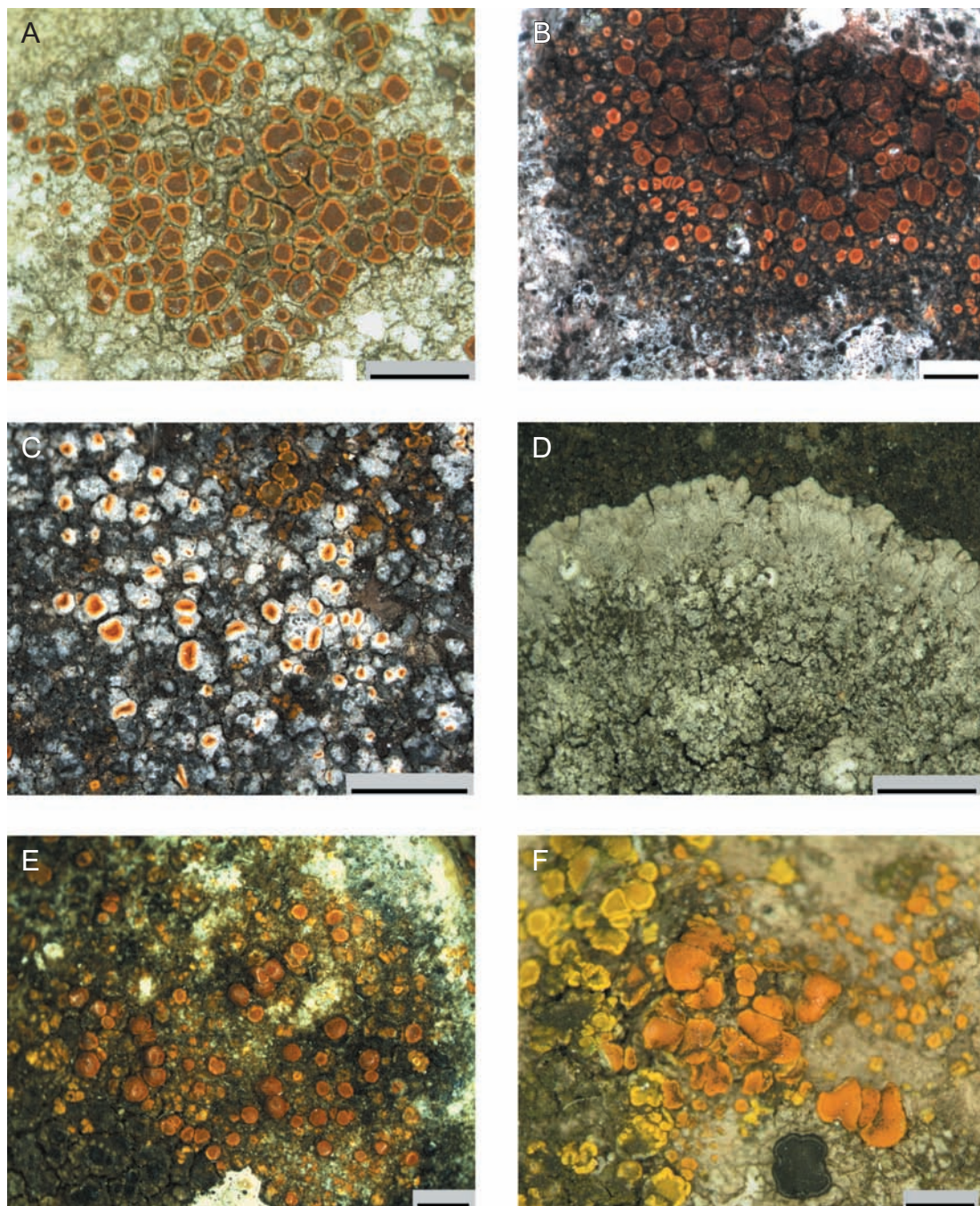


Fig. 18. *Caloplaca* Th. Fr. subgenus *Caloplaca*. A – *C. percrocata* (Arnold) J. Steiner (*A. Flakus* 151, KRAM), B – *C. polycarpa* (A. Massal.) Zahlbr. (*K. Wilk* 4132, KRAM), C – *C. soralifera* Vondrák & Hrouzek (*J. Nowak*, KRAM L-26309), D – *C. teicholyta* (Ach.) J. Steiner (*J. Nowak*, KRAM L-23028), E – *C. velana* complex (Arnold, *Lich. Exsicc.* 1253, KRAM), F – *C. viellinaria* Szatala (*A. Flakus* 5120, KRAM). Scale bars: A, C & D = 2 mm; B, E & F = 2 mm.

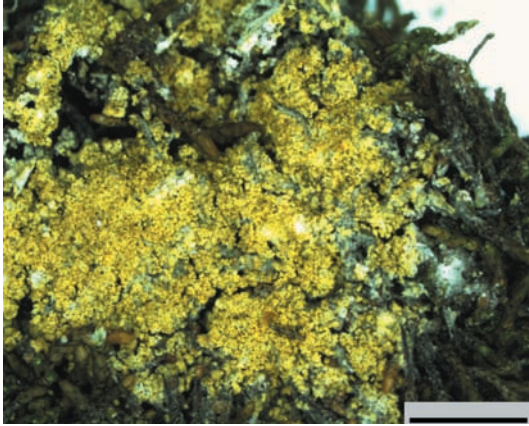


Fig. 19. *Caloplaca* Th. Fr. subgenus *Caloplaca*. *C. xanthostigmoidea* (Räsänen) Zahlbr. (*C. Wetmore* 77363, MIN). Scale bar = 2 mm.

Species of the subgenus *Caloplaca* have yellow, orange (K+ red), white, grey or brownish thalli (often violet reaction with K and/or N), without distinct marginal lobes. The apothecia are yellow, orange, red or brownish red (K+ red). The spores are polarilocular with an isthmus wider than 3 μm . Soredia occur or not.

KEY TO THE SPECIES

The key includes the species recognized in the Polish Western Carpathians as well as taxa previously reported from the area which were not confirmed in the study but which may be found in the future. The latter are not bolded in the key.

1. Thallus and/or apothecia yellow, orange or red, K+ red **2**
- 1* Thallus and/or apothecia white, grey, brown or blackish, K- or K+ violet **35**
 2. Thallus with soredia, isidia or blastidia **3**
 - 2* Thallus lacks soredia, isidia or blastidia **12**
3. Thallus leprose, with no corticated areoles or lobes; always sterile **4**
- 3* Thallus at least partially corticated, with soredia, isidia or blastidia; seldom with apothecia **5**
 4. Thallus bright yellow, often circular; medulla thick *C. xantholyta* (see also *C. citrina*)
 - 4* Thallus creamy orange to brownish orange, irregular in shape; medulla thin or inconspicuous *C. chrysodeta*
5. Thallus with soredia **6**
- 5* Thallus with isidia or blastidia **10**
 6. Thallus areolate **7**
 - 6* Thallus lobate **8**
7. Thallus yellow, areoles convex; soralia on surface and margins of areoles (irregularly arranged), or thallus almost entirely dissolved into soredia; soredia concolorous with thallus; spores 7.5–15.0 \times 4.0–6.5(–8.0) μm , isthmus 2–6 μm *C. citrina*
- 7* Thallus yellow orange or orange, rarely yellow, areoles flat; soralia on margins of areoles, \pm regularly arranged; soredia yellow, contrasting against thallus; spores 9–14 \times 4.5–7.5 μm , isthmus 3–6 μm *C. flavocitrina*
8. Thallus and soredia deep orange or orange red; soralia diffuse towards base of lobes *C. proteus*
- 8* Thallus and soredia with distinct yellow tinge **9**
9. Thallus yellow or yellow orange; soralia lip-shaped on the tips of short lobes in center of thallus; soredia concolorous with thallus *C. decipiens*
- 9* Thallus orange or yellow orange; soralia crater-like, situated towards base of lobes; soredia citrine yellow or dark yellow, contrasting against thallus; central part of thallus often detached *C. cirrochroa*
10. Thallus with abundant isidia; spores thin-walled, 10.0–13.5 \times 6.5–8.5 μm , isthmus 3.5–5.0 μm *C. coronata*
- 10* Thallus with blastidia **11**
11. Thallus areolate, pale yellow; thalline areoles with aggregated isidioid blastidia; blastidia often olive green (cinereorufa-green pigment, K-, N+ violet); apothecia very rare, biatorine; spores thin-walled (wall 0.5–1.0 μm); on bark, wood, bryophytes, calcareous rocks and soil *C. xanthostigmoidea*
- 11* Thallus areolate or sublobate, yellow to orange, often with yellow and orange thalli side by side; thalline areoles with abundant blastidia, soredia and fine granules; apothecia zeorine; spores thick-walled (wall 1–2 μm); on calcareous rock *C. dichroa*
12. Thallus lobate (lobes strongly reduced only in *C. saxicola* and *C. arnoldii* subsp. *obliterata*) **13**
- 12* Thallus areolate, sublobate, or thallus endolithic **21**
13. Spores ellipsoid **14**
- 13* Spores fusiform with distinctly pointed ends or lemon-shaped **19**
14. Thallus yellow, salmon or orange **15**
- 14* Thallus orange red **18**
15. Thalline rosettes with long lobes, closely adjacent to each other; apothecia scattered to crowded **16**
- 15* Thalline rosettes with short or strongly reduced

- lobes; apothecia strongly aggregated, forming clusters **17**
16. Thallus yellow to orange, yellow pruinose; surface of lobes wrinkled and with delicate furrows along lobes; colorless crystals (pol+) present in thalline and apothecial cortex; spores 7–13 × 3.0–6.5 µm, isthmus 2.5–5.0 µm *C. pseudofulgensia*
- 16* Thallus yellow to salmon, white pruinose; surface of lobes not as above; crystals absent in thalline and apothecial cortex; spores 8.5–15.0 × 4.0–8.5 µm, isthmus 1.5–5.0 µm *C. pusilla*
17. Thallus orange or yellow orange, epruinose, slightly ascending from rock; prothallus absent; spores 9–13 × 5.0–6.5 µm, isthmus 3–4 µm *C. saxicola*
- 17* Thallus brownish orange or orange, sometimes white pruinose, tightly adnate to substrate; prothallus concolorous with thallus; spores 8–13 × 3–6 µm, isthmus 2.5–5.0 µm *C. arnoldii* subsp. *obliterata*
18. Marginal lobes long and wide, flat; surface matte, rough *C. biatorina*
- 18* Marginal lobes short and narrow, convex; surface shiny, even *C. arnoldiiconfusa*
19. Spores with pointed ends, 15–20 × 4.5–6.0 µm, isthmus very narrow (*ca* 1 µm) *C. aurea*
- 19* Spores lemon-shaped, up to 15 µm long, isthmus well developed (3–4 µm) **20**
20. Thallus orange, lobes narrow and convex, separated from each other by furrows, slightly broadened at the tips; thalline cortex thick, with wide layer of grey crystals (pol+); spores 8.0–14.5 × 6–11 µm *C. flavescens*
- 20* Thallus lighter and often zonated in color – yellow in thallus center, orange in margin, lobes wide and flat, closely adjacent to each other, distinctly broadened toward the tips; thalline cortex thin, without layer of grey crystals; spores 10.0–11.3(–16.0) × 7–10(–12) µm *C. aurantia*
21. Spores with wide isthmus, more than 3 µm ... **22**
- 21* Spores with narrow isthmus, up to 3 µm **33**
22. Thallus thick, areolate, well visible; apothecia sessile **23**
- 22* Thallus thin, poorly developed or absent; apothecia sessile or immersed **27**
23. Thallus pale yellow; apothecia dark orange, contrasting with thallus; spores large, up to 20 µm long and 12 µm wide, isthmus wide, up to 10 µm *C. flavovirescens*
- 23* Thallus orange or yellow orange; apothecia ± concolorous with thallus; spores smaller, up to 13.5 µm long and 9.5 µm wide, isthmus narrower, up to 7 µm **24**
24. Often parasitic species growing on endolithic species of *Verrucaria* s.l.; spores ellipsoid. **25**
- 24* Free-living species; spores subspherical ... **26**
25. Thallus thick, areolate, often sublobate, yellow orange; distinct orange prothallus usually present; apothecia up to 0.8 mm diam.; proper margin thick, thalline margin ± reduced, visible at base of apothecia *C. polycarpa*
- 25* Thallus thin to disappearing, areolate, yellow; prothallus usually absent; apothecia up to 0.3 mm diam.; proper margin distinctly thin, thalline margin visible only in young apothecia *C. oasis*
26. Thalline areoles flat, lobed on thalline margin; apothecia abundant, covering most of the thallus; spores 8.5–12.5 × 5.0–9.5 µm, isthmus 2.5–5.0 µm *C. dolomiticola*
- 26* Thalline areoles ± convex, not lobed; apothecia less abundant; spores 10.0–13.5 × 6.5–8.5 µm, isthmus 3.5 µm *C. velana* complex
27. Apothecia biatorine or pseudolecanorine **28**
- 27* Apothecia zeorine **31**
28. Thallus endolithic to faintly epilithic, with small granules immersed in rock **29**
- 28* Thallus distinctly epilithic **30**
29. Thallus yellow; apothecia yellow orange, persistently immersed in rock; proper margin thin, distinctly flexuous; hypothecium paraplectenchymatous; spores 11.5–13.5 × 5–8 µm, isthmus 2.5–5.0 µm *C. keissleri*
- 29* Thallus orange; apothecia bright red, first immersed in thallus, then some are sessile; proper margin thick, not flexuous; hypothecium prosoplectenchymatous; spores 8.5–13.5 × 5.5–7.5 µm, isthmus 2–5 µm *C. coccinea*
30. Thallus granular, yellow orange; apothecia first immersed in thallus, then sessile; apothecial disc dark orange; proper margin paler than disc; spores 10–13 × 7 µm, isthmus 2.5–5.0 µm; Central European and montane species *C. nubigena*
- 30* Thallus continuous to rimose-areolate, pale yellow; apothecia sessile; apothecial disc rusty red or red brown; proper margin concolorous with disc; spores 9–13 × 3–10 µm, isthmus 3–5 µm; Mediterranean and littoral species. *C. subochracea*

31. Parasitic species growing on *Candelariella vitellina*; thallus absent *C. vitellinaria*
- 31* Free-living species; thallus granular-areolate, inconspicuous 32
32. Thallus irregular; apothecia yellow orange, of different sizes, up to 0.7–1.0 mm diam., scattered; apothecial margin prominent; spores with wide isthmus (3.5–7.0 μm); on enriched siliceous rock, less frequently on natural calcareous rock and manmade substrates *C. holocarpa*
- 32* Thallus often circular; apothecia orange to brownish orange, of \pm same size, up to 0.4 mm diam., crowded; apothecial margin very thin, inconspicuous; spores with narrower isthmus (3–5 μm); on natural calcareous rocks or concrete and mortar (see also under 25) *C. oasis*
33. Apothecia pseudolecanorine, rusty red; epihymenium reddish orange; spores 12.5–17.0 \times 5.5–8.5 μm , isthmus 1.5–3.5 μm *C. marmorata*
- 33* Apothecia zeorine, yellow or orange; epihymenium yellowish orange 34
34. Thallus usually epilithic, areolate (often weakly developed), yellow, or endolithic; apothecia up to 0.7 mm diam.; thalline margin yellow, crenulate, often disappearing; spores ellipsoid, (13.5–) 15.0–20.0(–22.0) \times (5–)6–9(–10) μm , isthmus 1.0–3.5 μm ; Central European species *C. crenulatella*
- 34* Thallus usually endolithic, if present composed of small granules or areoles, pale grey; apothecia up to 0.3 mm diam.; thalline margin lacking; spores short, broadly ellipsoid, 11.0–13.5 \times 5–7 μm , isthmus 1.5–3.5 μm ; mainly Mediterranean species *C. lactea*
35. Thallus grey, brown to blackish, or endolithic; apothecia brownish or black 36
- 35* Thallus white or grey; apothecia orange to red, or absent 40
36. Thallus epilithic 37
- 36* Thallus endolithic 39
37. Thallus creamy brownish, thin, epruinose; apothecia dark brown, epruinose; epihymenium brown, K+ violet; spores with very narrow isthmus, up to 2 μm *C. atroalba*
- 37* Thallus dark grey, brownish grey or blackish, thick, white-pruinose; apothecia black, white pruinose; epihymenium brownish or grey, K+ pale violet or brown; spores with wider isthmus, more than 2 μm . . . 38
38. Apothecia distinctly immersed in thallus; amphithecium usually reduced; hypothecium with distinct rows of small isodiametric cells; spores 9.0–16.5 \times 5.0–8.5 μm , isthmus 2.5–6.5 μm *C. chalybaea*
- 38* Apothecia sessile; amphithecium well developed; hypothecium not as above; spores 12–18 \times 5–10 μm , isthmus 2.5–5 μm . . . *C. variabilis*
39. Apothecia white pruinose, with thick proper margin; amphithecium strongly reduced, with thick paraplectenchymatous cortex, almost completely filled by small, yellow brown crystals, pol+; epihymenium grey; spores 12.0–16.5 \times 6.5–10.0 μm , isthmus 2–4(–5) μm *C. albopruinosa*
- 39* Apothecia seldom white pruinose, with thin, often disappearing proper margin; lower mountains *C. alociza*
40. Thallus esorediate 41
- 40* Thallus sorediate 42
41. Thallus grey, surface solid; thalline cortex present; apothecia large, sessile; apothecial disc brownish orange; proper margin thick, yellow orange, contrasting with disc *C. percrocata*
- 41* Thallus chalky white, surface crumbling; thalline cortex absent; apothecia small, initially immersed; apothecial disc red; proper margin thin, concolorous with disc *C. erythrocarpa*
42. Thallus sublobate, circular, center of thallus scurfy-granular; thalline cortex present at least at thalline margin; apothecia rare *C. teicholyta*
- 42* Thallus areolate or rimose-areolate, irregular; thalline cortex present or absent; apothecia frequent 43
43. Thallus areolate, grey; thallus surface solid; thalline cortex present; algal layer with distinct isodiametric fungal cells intermixed with algae; soralia usually delimited to areole margins; spore isthmus wide, 3.5–5.5(–7.0) μm *C. soralifera*
- 43* Thallus rimose-areolate, white to pale grey; thallus surface crumbling; thalline cortex absent; algal layer not as above; soredia diffuse; spore isthmus narrow, 2.5–3.5 μm *C. albolutescens*

SPECIES

Caloplaca subgenus *Pyrenodesmia* (A. Massal.) Boist.

Caloplaca albopruinosa (Arnold) H. Olivier
Figs 11A & 20

Mémoir. Soc. Nation. Scienc. Natur. Cherbourg 37: 147. 1909. – *Biatorina albopruinosa* Arnold, Flora 42: 152. 1859 (see Muggia *et al.* 2008).

Thallus endolithic, or somewhere epilithic, continuous to slightly cracked, very thin, *ca* 150 μm , pale grey, rarely delimited by a dark grey prothallus; without vegetative propagules. Thalline cortex very thin, inconspicuous, K⁻; algal layer discontinuous; both layers with many colorless crystals (pol⁺). *Apothecia* zeorine, crowded or less frequently scattered, initially immersed, then becoming sessile, round, or slightly angular or flexuous by compression, 0.2–1.2 mm diam., leaving pits in the rock when detached; disc at first slightly concave, then flat, black, more or less white or bluish due to pruina; proper margin persistent, thick, even (sometimes discontinuous and slightly cracked in young apothecia), distinctly raised above disc, black, white or bluish due to pruina; thalline margin excluded. Parathecium well developed, 65–170 μm , prosoplectenchymatous, cell lumina elongated or slightly oval, blackish toward the surface (K⁺ violet; sedifolia-grey). Amphithecium highly reduced with few algae, cortex sometimes well developed up to 50 μm , paraplectenchymatous, cell lumina round, almost completely filled by small, yellow brown crystals (pol⁺, insoluble in K, soluble in N). Epithemium grey (K⁺ violet, KN⁺ violet-brown; sedifolia-grey), with colorless crystals (insoluble in K). Hymenium hyaline, without crystals, 80–115 μm high. Paraphyses simple, constricted at septa, 1–2(–3) apical cells slightly thickened, up

to 5 μm wide. Hypothecium hyaline, with many oil droplets, paraplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, 12.0–16.5 \times 6.5–10.0 μm , isthmus 2–4(–5) μm wide. *Pycnidia* rather common, immersed in rock or thallus; ostiolum black, distinct; conidia ellipsoid to ovoid, 2.0–3.5 \times 1.0–1.5 μm .

HABITAT AND DISTRIBUTION. It grows on limestone boulders in sun-exposed situations in montane glades at *ca* 1200 m a.s.l.

The species is known only from the Tatra Mts.

DISCUSSION. *Caloplaca albopruinosa* is characterized by an endolithic thallus and black, white pruinose apothecia with a thick proper margin. The thalline margin (amphithecium) is reduced and with few algae. The epithemium is grey and reacts K⁺ violet.

Together with *C. alociza*, *C. badioreagens* Tretiach & Muggia and *C. erodens* Tretiach *et al.*, *C. albopruinosa* forms a group of species characterized by black apothecia and an endolithic thallus. *Caloplaca albopruinosa* (syn. *C. agardhiana* auct., for nomenclature see Muggia *et al.* 2008) is a problematic species, considered a synonym for *C. alociza* by some authors. The presence or absence of crystals in the hymenium was the main character distinguishing the two species (Clauzade & Roux 1985; Nimis 1992). According

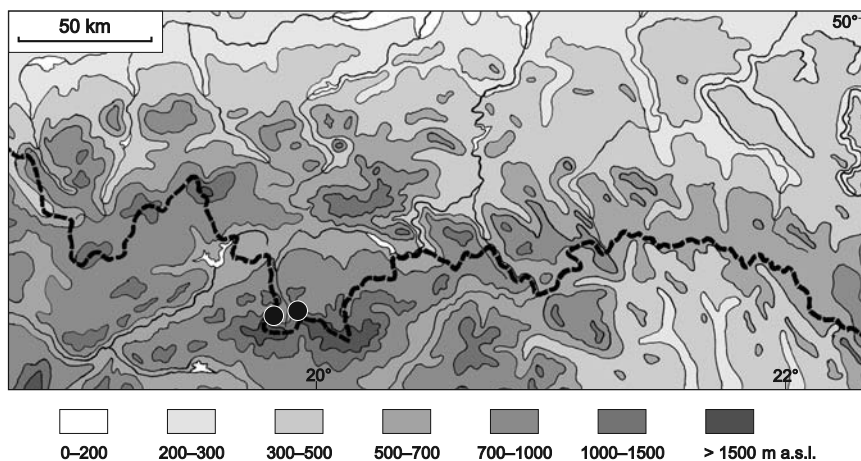


Fig. 20. Distribution of *Caloplaca albopruinosa* (Arnold) H. Olivier in the Polish Western Carpathians.

to the most recent studies, however, crystals may occur in *C. albopruinosa* and in *C. alociza* as well but with different frequency (Muggia *et al.* 2008). According to the current species concept, *C. alociza* is distinguished from *C. albopruinosa* by having a thin apothecial margin disappearing in old apothecia, and by apothecia that are less frequently white pruinose.

For comparison with *C. badioreagens* and *C. erodens* see Muggia *et al.* (2008) and Wilk (2011).

EXSICCATE SEEN. Arnold, *Lich. Exsicc.* 1222 (as *Pyrenodesmia agardhiana*) (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. WEST TATRA MTS, Dolina Chochołowska valley, Polana Dudowa glade, alt. 1185 m, 49°14'58"N, 19°49'37"E, 16 July 2004, *L. Śliwa* 3151, 3169 and *K. Wilk* 2157 (KRAM); Dolina Kościeliska valley, Przysłop Miętusi glade, 49°15'48"N, 19°53'22"E, 15 July 2004, *L. Śliwa* 3026 (KRAM).

***Caloplaca atroalba* (Tuck.) Zahlbr.**

Figs 11B & 21

Cat. Lich. Univ. 7: 68. 1930. – *Placodium atroalbum* Tuck., Proc. Amer. Acad. Arts 12: 172. 1877.

Thallus rimose-areolate, very thin, brownish grey or creamy brownish, epruinose, rarely delimited by a grey prothallus; without vegetative propagules. Areoles irregular, flat, with slightly undulate surface. Thalline cortex paraplectenchymatous,

brownish toward the surface (K+ weakly violet; sedifolia-grey), without crystals; algal layer continuous; medulla prosoplectenchymatous. *Apothecia* zeorine, in groups, sessile from the beginning, round or angular by compression, small, up to 0.5 mm diam.; disc flat, dark brown, epruinose; proper margin persistent, thin, concolorous with disc, epruinose; thalline margin present, thin, ± reduced, visible at least at base of apothecia. Parathecium thin, 50–65 µm, paraplectenchymatous, cell lumina round or oval, brown toward the surface (K+ violet; sedifolia-grey), without crystals. Amphithecium with abundant algae, cortex poorly developed. Epithemium brownish grey or pale brown (K+ violet; sedifolia-grey), with some colorless crystals above (pol±, insoluble in K). Hymenium hyaline, 85–115 µm high. Paraphyses simple to slightly branched, constricted at septa, 1–3 apical cells slightly thickened, up to 5 µm wide, or apical cells not thickened. Hypothecium hyaline, oil droplets present, ca 90 µm high. Asci 8-spored, spores polarilocular or occasionally 1-locular, thin-walled, 11.5–15.0 × 6.0–9.5 µm, isthmus ca 1.7 µm wide, sometimes incomplete or poorly formed. *Pycnidia* inconspicuous, immersed in thallus; conidia not observed.

HABITAT AND DISTRIBUTION. It grows on limestone and calcareous sandstone in sun-exposed situations up to 1100 m a.s.l.

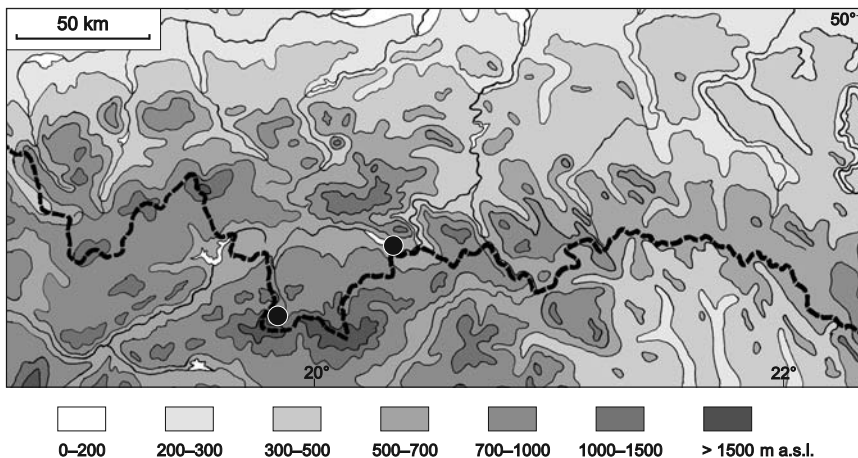


Fig. 21. Distribution of *Caloplaca atroalba* (Tuck.) Zahlbr. in the Polish Western Carpathians.

The species is known from the Pieniny Mts and Tatra Mts.

DISCUSSION. *Caloplaca atroalba* is characterized by its creamy brown, epruinose, areolate thallus. The brown and epruinose apothecia have a usually persistent thalline margin. The spores have a narrow isthmus, *ca* 1.7 μm wide. The epihymenium is brown and reacts K⁺ violet.

Caloplaca atroalba is widely distributed in the temperate zone of North America (Wetmore 1994, 2007b). In Europe it is reported from Austria (Hafellner & Türk 2001), Sweden (Santesson *et al.* 2004) and most recently Poland and Ukraine (Wilk 2011). According to Wetmore (1994), *C. atroalba* is more common in Europe than previously thought, but often has been misidentified as *C. diphyodes* (Nyl.) Jatta. The latter species differs from *C. atroalba* by having spores with a wider isthmus (more than 3 μm wide), and shorter hymenium (usually not exceeding 100 μm). An additional feature distinguishing these two species is the structure of the parathecium, which is prosoplectenchymatous in *C. diphyodes* (Wunder 1974; Oksner 1993; Kondratyuk *et al.* 2004). *Caloplaca atroalba* may be further confused with *C. chalybaea* and *C. variabilis* even though the latter two species show thalli and apothecia covered by conspicuous white pruina (crystals visible in section, pol⁺, insoluble in K) and produce spores with a considerably wider isthmus. Moreover, the apothecia of *C. chalybaea* are \pm immersed in the thallus and have a hypothecium consisting of distinct rows of small isodiametric cells (Wetmore 1994; see Fig. 8A).

For comparison with other similar species see Wilk (2011).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. PIENINY WŁAŚCIWE MTS, limestone outcrops by Czorsztyn Castle, alt. *ca* 600 m, 49°26'11"N, 20°18'48"E, 5 June 2005, *K. Wilk 3470b* (KRAM). WEST TATRA MTS, Dolina Chochołowska valley, Polana Chochołowska glade, alt. 1105 m, 49°14'16"N, 19°47'47"E, 16 July 2004, *L. Śliwa 3118* (KRAM).

ADDITIONAL MATERIAL EXAMINED. POLAND. GÓRY ŚWIĘTOKRZYSKIE MTS. Kielce County, Wesola town above Wierna Rzeka River, the hill

near railway, 31 Aug. 1976, *K. Toborowicz* (KTC 6332). UKRAINE. KHMELNITSKYI REGION. Kamianets Podilskyi district, National Park 'Podilskyi Tovtry', Kitaihorod, 15 km SE of Kamianets Podilskyi, 48°38'25"N, 26°46'58"E, 24 June 2003, *P. Czarnota 3793* (KRAM); Bagota on the Dniester near Stara Ushytsia, 30 km SE Kamianets Podilskyi, alt. 259 m, 48°35'10"N, 26°59'57"E, 25 June 2003, *J. Kiszka* (KRAM L-63304). U.S.A. WASHINGTON. Yakima County. 12 miles ESE of Yakima, along state highway 24, 20 Aug. 1978, *T. D. Trana 5928* (MIN).

Caloplaca chalybaea (Fr.) Müll. Arg.

Figs 11C & 22

Mémoir. Soc. Phys. Hist. Natur. Genève **16**: 388. 1862. – *Parmelia chalybaea* Fr., Lichenogr. Europ. Reform.: 125. 1831.

Thallus rimose-areolate, forming \pm circular patches, *ca* 2–5 cm diam., 150–250 μm thick, grey to brownish grey, often white pruinose especially at margin, sometimes delimited by greenish grey prothallus; without vegetative propagules. Thallus in center with areoles irregular, rarely \pm round, flat or slightly convex, 0.2–1.4 mm diam.; thallus edge thinning, less cracked, radially orientated, sterile. Thalline cortex distinct, thick, 25–53 μm , paraplectenchymatous, brown toward the surface (K⁺ violet; sedifolia-grey), with many colorless crystals (pol⁺, insoluble in K); algal layer continuous; medulla with many colorless crystals (pol⁺, insoluble in K). *Apothecia* zeorine, abundant, in center of thallus, crowded, immersed in thallus, some of them broadly sessile, round or angular by compression, 0.2–0.6 mm diam.; disc flat or rarely slightly concave, black or brown, sometimes slightly white pruinose; proper margin thin, concolorous with disc, often slightly white pruinose; thalline margin thick or thin, \pm reduced, white pruinose. Parathecium thin to thick, 30–115 μm , prosoplectenchymatous, dark brown toward the surface (K⁺ violet; sedifolia-grey), with colorless crystals (pol⁺). Amphithecium with not abundant algae, usually thin and indistinct, cortex with colorless crystals (pol⁺). Epihymenium brown (K⁺ weakly violet; sedifolia-grey), with some crystals above

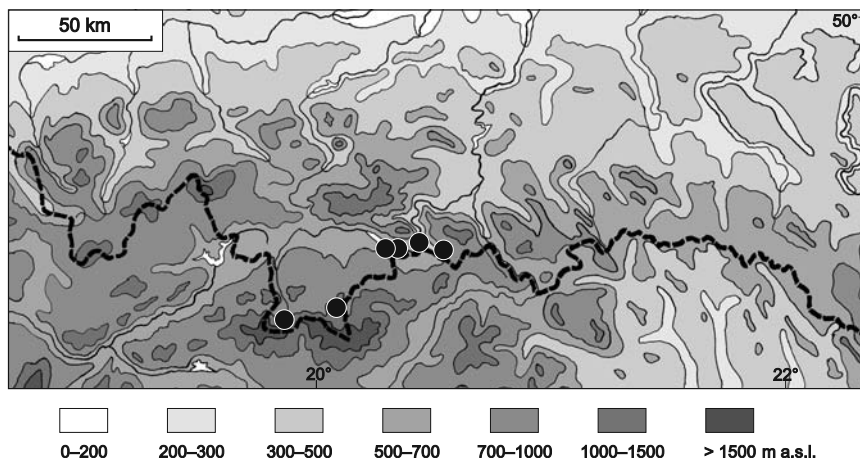


Fig. 22. Distribution of *Caloplaca chalybaea* (Fr.) Müll. Arg. in the Polish Western Carpathians.

(pol±). Hymenium hyaline, 70–110(–135) μm high. Paraphyses simple to slightly branched, 1–3 apical cells slightly thickened, up to 5.0(–6.5) μm wide, or apical cells not thickened. Hypothecium hyaline, paraplectenchymatous, without oil droplets, consisting of distinct rows of small isodiametric cells. Asci 8-spored, spores polarilocular, thin-walled, 9.0–16.5 \times 5.0–8.5 μm , isthmus 2.5–6.5 μm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It grows on limestone rock in sun-exposed and dry places, rarely slightly shaded. It was found at the base or in the upper parts of outcrops facing south, southeast and southwest at 570–1800 m a.s.l.

The species is widely distributed in the Pieniny Mts and Tatra Mts.

DISCUSSION. *Caloplaca chalybaea* is characterized by its grey to brownish grey thallus, and apothecia distinctly immersed in the thallus. The spores are short, up to 17 μm long, with a moderately wide isthmus up to 6.5 μm . The hypothecium in *C. chalybaea* has characteristic rows of small isodiametric cells.

Caloplaca variabilis is the species most similar to *C. chalybaea*. The former is distinguishable by having apothecia that are sessile and by the absence of rows of isodiametric cells in the hypothecium (Wetmore 1994). Another species similar to *C. chalybaea* having apothecia persistently

immersed in the thallus is *C. circumalbata* (Delile) Wunder. The latter differs in having a white thallus, and bigger and wider spores (Wunder 1974; Tretiach *et al.* 2003).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. PIENINY SPISKIE MTS, Zielone Skałki range by the Jezioro Czorsztyńskie lake, alt. 588 m, 49°25'56"N, 20°17'35"E, Nov. 2005, *K. Wilk 4127, 4128* (KRAM), *ibid.*, 6 June 2005, *K. Wilk 3490* (KRAM). PIENINY WŁAŚCIWE MTS, Długa Grapa outcrops, alt. 694 m, 49°24'59"N, 20°20'42"E, 5 June 2005, *K. Wilk 3445* (KRAM); Sokola Perć, 5 May 1955, *J. Nowak* (KRAM L-3814); Trzy Korony massif, Okraglica Mt., alt. ca 960 m, 4 Sep. 1981, *J. Pyrek & K. Toborowicz* (KTC 10568); glade between Kąciki and Łazy, 7 Sep. 1987, *J. Kiszka s.n.* (KRAP); between Kąciki and Łazy, 7 Sep. 1987, *J. Kiszka s.n.* (KRAP); shore of Dunajec by mouth of Pieniński Potok stream, 13 Apr. 2000, *J. Kozik s.n.* (PPN). MAŁE PIENINY MTS, Szafranówka, 24 July 1971, *K. Waydowska* (KRAM L-34446); Sołtysie Skałki outcrops near Jaworki village, alt. 580 m, 49°24'20"N, 20°32'30"E, 3 June 2005, *K. Wilk 3400, 3405, 3420* (KRAM); Jaworki, 1888, *s.coll.* (KRAM L-19924); Jaworki, 1889, *W. Boberski* (KRAM L-20578); Homole canyon near Jaworki, 3 May 1957, *J. Nowak* (KRAM L-4474); Zabaniszczce, Trzy Skałki Mt., alt. 720 m, Aug. 1980, *K. Toborowicz s.n.* (KTC). WEST TATRA MTS, Przelęczka za Saturnem pass, above Dolina Kościeliska valley, alt. ca 1300 m, 25 July 2004, *K. Wilk 2260* (KRAM); Rzędy, S slope of Ciemniak Mt., alt. ca 1800 m, 49°13'75"N, 19°53'80"E, 11 July 2004, *K. Wilk 2112a* (KRAM); Kominiarski Wierch Mt., alt.

1645 m, Aug. 1982, *K. Toborowicz* (KTC 10252). HIGH TATRA MTS, Gęsia Szyja Mt., alt. 1480 m, 49°15'30"N, 20°04'35"E, 14 Aug. 2008, *K. Wilk 4065* (KRAM); Łysa Skałka range, 49°15'30"N, 20°04'35"E, 12 Oct. 2005, *K. Wilk 4116* (KRAM).

Caloplaca variabilis (Pers.) Müll. Arg.

Figs 11D & 23

Mémoir. Soc. Phys. Hist. Natur. Genève **16**: 387. 1862. – *Lichen variabilis* Pers., Ann. Bot. (Usteri) **1**: 26. 1794.

Thallus areolate, thick to almost endolithic, 140–270 µm thick, irregular, grey, dark brown to almost black, more or less pruinose, prothallus black or bluish black; without vegetative propagules. Areoles irregular, 0.2–0.6(–1.0) mm diam., flat or slightly convex, surface slightly undulate, sometimes areoles slightly constricted at base. Thalline cortex distinct, 15–65 µm, paraplectenchymatous, or indistinct, greyish toward the surface (K+ violet, N+ weakly violet; sedifolia-grey), with necral layer and many colorless crystals (pol+, insoluble in K); algal layer continuous or sometimes having algae in groups; medulla dense, paraplectenchymatous with many colorless crystals (pol+). *Apothecia* zeorine, abundant, crowded or seldom scattered, sessile from the beginning, round or angular and flexuous by compression, 0.2–1.2 mm diam.; disc flat, brown or black, ± white or bluish due to pruina, or epruinose; margin without superficial

differentiation between proper and thalline margin, persistent, thick, ± raised above disc, entire or slightly crenate, strongly white pruinose, seldom epruinose. Parathecium thin, 30–75 µm, prosoplectenchymatous, cell lumina round or oval, grey green, grey brown or blackish toward the surface (K+ weakly violet; sedifolia-grey), with colorless crystals (pol+, insoluble in K). Amphithecium well developed, algae abundant, algal layer continuous, cortex with many colorless crystals (pol+, insoluble in K, soluble in N). Epihymenium grey green or grey brown (K+ weakly violet; sedifolia-grey), with crystals above (pol+, insoluble in K, soluble in N). Hymenium hyaline, 65–115 µm high. Paraphyses simple to slightly branched, constricted at septa, apical cells not thickened or 1–2(–3) apical cells slightly thickened, up to 5 µm wide. Hypothecium hyaline, with oil droplets, prosoplectenchymatous, with characteristic intercellular spaces. Asci 8-spored, spores polarilocular, thin-walled, 12–18 × 5–10 µm, isthmus 2.5–5.0 µm wide (swollen in KOH). *Pycnidia* immersed; ostiolum black; conidia 3.0–3.5 × 1.5 µm.

HABITAT AND DISTRIBUTION. The species grows on limestone in sun-exposed situations. It inhabits vertical limestone walls (of various aspect) or their upper parts.

The species is known from the Gorce Mts, Pogórze Spisko-Gubałowskie foothills, Pieniny

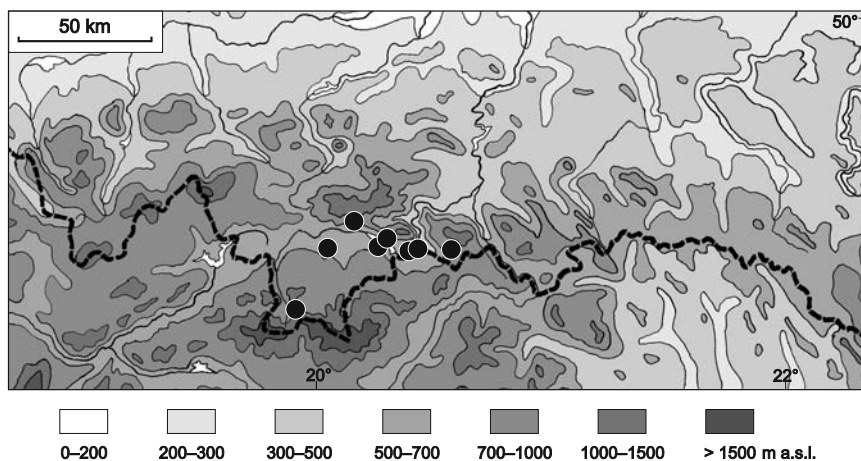


Fig. 23. Distribution of *Caloplaca variabilis* (Pers.) Müll. Arg. in the Polish Western Carpathians.

Mts (Pieniny Spiskie, Pieniny Właściwe, Małe Pieniny) and West Tatras.

DISCUSSION. *Caloplaca variabilis* is characterized by its grey or brownish thallus, and black white pruinose apothecia. The thalline margin (amphithecium) is well developed, with abundant algae. The thalline cortex, parathecium and epihymenium react K⁺ violet.

According to Clauzade and Roux (1985) and Tretiach *et al.* (2003), *C. variabilis* is a highly polymorphic and genetically variable species. Clauzade and Roux (1985) distinguished several forms of it. Additionally, Wunder (1974) differentiated var. *bullata* in addition to var. *variabilis*. The taxon very likely includes several semi-cryptic species.

Caloplaca variabilis could be confused with such species as *C. albobustulata* Khodosovtsev & S. Kondratyuk, *C. albovariegata*, *C. atroalba*, *C. bullata* (Müll. Arg.) Zahlbr., *C. chalybaea* and *C. diphyodes*. *Caloplaca albovariegata* differs in having a bluish grey thallus, areoles strongly constricted at the base, a discontinuous algal layer in the thallus (algae form distinct groups or columns), epruinose apothecia and a narrower spore isthmus (Wetmore 1994). *Caloplaca atroalba* differs from *C. variabilis* by having brownish, epruinose apothecia and thallus, and spores with a very narrow isthmus. Moreover, the apothecia in *C. atroalba* usually have superficial differentiation between the proper and thalline margins. Unlike *C. variabilis*, *C. albobustulata* and *C. bullata* have convex thalline areoles, and additionally *C. albobustulata* has characteristic wart-like structures on the thallus surface. The distribution pattern of *C. bullata* is also quite different; it has been reported exclusively from Asia. For comparison with *C. chalybaea* see comment under this species.

Specimens of *C. variabilis* with a weakly developed, almost endolithic thallus could be confused with *C. alociza*, *C. albopruinosa* and *C. badioreagens*. For comparison between those species see the comments under *C. albopruinosa*. Other similar species are *C. transcaspica* [syn. *C. paulsenii* (Vain.) Zahlbr.] and *C. circumalbata*. Both of the latter have a white thallus (K⁻) and bigger spores (Wunder 1974). Additionally, *C. transcaspica* has

a usually epruinose apothecial disc, a hymenium with abundant fine crystals, and spores usually with a narrow isthmus (Wunder 1974; Clauzade & Roux 1985; Poelt & Hinterreger 1993).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. GORCE MTS, Cymnowa Góra Mt., S slope, above road from Knurów, alt. 650 m, 6 Aug. 1968, *K. Glanc* (KRAM L-27425). PIENINY SPISKIE MTS, Zielone Skalki range by Jezioro Czorsztyńskie lake, alt. 588 m, 49°25'56"N, 20°17'35"E, Nov. 2005, *K. Wilk 4126* (KRAM), *ibid.*, 6 June 2005, *K. Wilk 3489* (KRAM); Biała Skała, 6 May 1955, *J. Nowak* (KRAM L-3246); S of Falsztyn, rocks by road, 4 Sep. 1996, *J. Kiszka s.n.* (KRAP). PIENINY WŁAŚCIWE MTS, limestone outcrops by Czorsztyn Castle, alt. 560 m, 49°26'11"N, 20°18'48"E, 5 June 2005, *K. Wilk 3470a* (KRAM); near Nowa Góra Mt., 5 May 1955, *J. Nowak* (KRAM L-3911); Polana Głębiowa glade, 7 Sep. 1987, *J. Kiszka s.n.* (KRAP); Polana Przyzaczce glade, 11 July 1987, *J. Kiszka s.n.* (KRAP); Podłaźce, 10 Oct. 1999, *J. Kozik s.n.* (PPN); Podskalnica Góra Mt., 26 June 1999, *J. Kozik s.n.* (PPN); Czerwone Skały, 3 June 2000, *J. Kozik* (PPN 152). MAŁE PIENINY MTS, Sołtysie Skalki outcrops near Jaworki village, alt. 580 m, 49°24'20"N, 20°32'30"E, 3 June 2005, *K. Wilk 3406* (KRAM); Jaworki, *s.d.*, *s.coll.* (KRAM L-20903); Bystrzyk Mt., 16 June 1998, *J. Kozik s.n.* (PPN), *ibid.*, 16 June 1999, *J. Kozik s.n.* (PPN); Szafranówka Mt., alt. 740 m, Aug. 1980, *K. Toborowicz s.n.* (KTC). PO-GÓRZE SPISKO-GUBAŁOWSKIE FOOTHILLS, Szaflary, alt. 640 m, 8 Oct. 1968, *J. Kiszka* (KRAP 10611). WEST TATRA MTS, Dolina Kościeliska valley, Przysłop Miętusi glade, 49°15'48"N 19°53'22"E, 15 July 2004, *L. Śliwa 3031* (KRAM).

Caloplaca subgenus *Leproplaca* (Nyl.) Clauzade & Rond.

Caloplaca chrysodeta (Vain. ex Räsänen) Dombr.
Figs 12A & 24

Konsp. Fl. Murm. Sv.–Vost. Finlyandii: 99. 1970. – *Placodium chrysodetum* Vain. ex Räsänen, Ann. Acad. Sci. Fenn., ser. A 34(4): 113. 1931.

Thallus leprose, without corticated areoles and lobes or any corticated parts, irregular in outline, thin, brownish orange or creamy brown, in shade greenish, K⁺ red. Soredia and consoredia 25–110 µm diam. Medulla inconspicuous or absent. *Apothecia* and *pycnidia* not known.

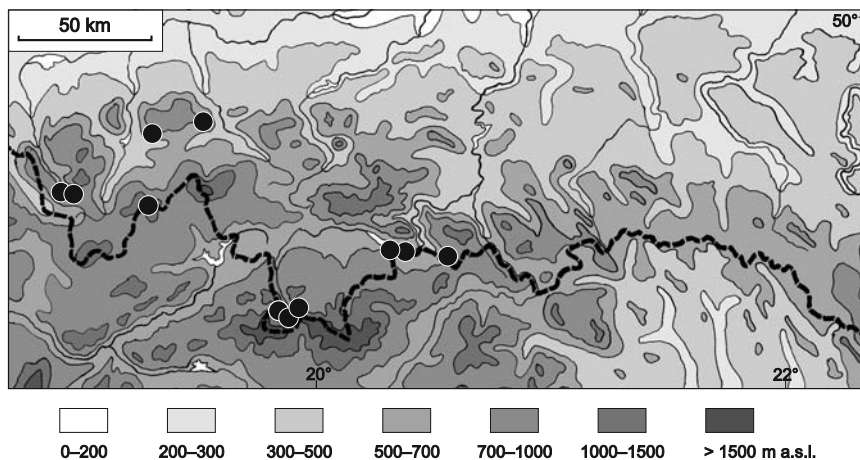


Fig. 24. Distribution of *Caloplaca chrysodeta* (Vain. ex Räsänen) Dombr. in the Polish Western Carpathians.

HABITAT AND DISTRIBUTION. It occurs on limestone rock and calcareous (also poorly calcareous) sandstone and over bryophytes on rock. It prefers shaded and humid places; it grows in rock crevices, on overhangs, or at base of vertical rock walls. It was found at sites of various aspect at 440–1400 m a.s.l.

The species is widely distributed in the Beskidy Mts (Beskid Śląski, Beskid Mały, Beskid Makowski, Beskid Żywiecki), Pieniny Mts (Pieniny Spiskie, Pieniny Właściwe, Małe Pieniny) and West Tatras.

DISCUSSION. *Caloplaca chrysodeta* is characterized by its sterile, leprose, brownish orange or creamy brown thallus with the medulla inconspicuous or absent.

Laundon (1974) transferred *C. chrysodeta* and *C. xantholyta* to the genus *Leproplaca* (Nyl.) Hue, due to the absence of apothecia and its completely sorediate thallus (leprose thallus). Kärnefelt (1989) and others authors preferred to leave both species in the genus *Caloplaca*. Kärnefelt (1989) stated that the genus *Caloplaca* contains many species in which the thallus is often sterile and partially sorediate, often lacking a thalline cortex. Both species are classified as representatives of sect. *Leproplaca* (Nyl.) Wade (Wade 1965) or subgenus *Leproplaca* (Nyl.) Clauzade & Rond. (Clauzade & Roux 1985).

Caloplaca xantholyta differs from *C. chrysodeta* by having a bright yellow thallus, a thicker layer of white medulla and bigger soredia. *Caloplaca xantholyta* also has slightly different habitat preferences; it occurs only on limestone rock (and therefore is much less frequent), whereas *C. chrysodeta* also grows commonly on ± calcareous sandstone. Occasionally, *C. citrina* thalli entirely dissolved into soredia may be confused with *C. chrysodeta*. However, *C. citrina* differs from *C. chrysodeta* by its soredia color (yellow or bright yellow) and the presence of at least small fragments of corticated thalline areoles or granules.

EXSICCATE SEEN. Wetmore, *Telos. Exsicc.* 27 (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. BESKID ŚLĄSKI MTS, Barania Góra range: Dorkowa Skala outcrops above Szarcuła pass, alt. 483 m, 49°36'19"N, 18°55'17"E, 8 Sep. 2005, *K. Wilk* 3836 (KRAM), near the crossroads to Łączyna, Pietraszonka and Stecówka, alt. 440 m, 49°34'48"N, 18°57'04"E, 8 Sep. 2005, *K. Wilk* 3829 (KRAM). BESKID MAŁY MTS, Zamczysko to the N of Łysina village, alt. 756 m, 49°44'52"N, 19°18'17"E, 22 Sep. 2005, *K. Wilk* 3943 (KRAM). BESKID MAKOWSKI MTS, Żurawica Mt., Kozie Skały outcrops, alt. 720 m, 49°45'42"N, 19°30'51"E, 20 Sep. 2005, *K. Wilk* 3925, 3929, 3931, 3932 (KRAM). BESKID ŻYWIECKI MTS, Pilsko Mt., sandstone outcrops between Hala Miziowa and Hala

Jodłowcowa, alt. 1253 m, 49°32'38"N, 19°18'29"E, 27 Sep. 2005, *K. Wilk 4011* (KRAM). PIENINY SPISKIE MTS, Zielone Skalki range by the Jezioro Czorsztyńskie lake, alt. 571 m, 49°25'55"N, 20°17'37"E, 6 June 2005, *K. Wilk 3476* (KRAM). PIENINY WŁAŚCIWE MTS, Wąwóz Sobczański canyon, 22 June 2007, *J. Kozik* (PPN). MAŁE PIENINY MTS, Sołtysie Skalki outcrops near Jaworki village, alt. 580 m, 49°24'20"N, 20°32'30"E, 3 June 2005, *K. Wilk 3403, 3418* (KRAM); Dziobakowe Skały outcrops, SE of Jaworki village, alt. 738 m, 49°23'21"N, 20°34'05"E, 4 June 2005 *K. Wilk, 3426, 3431* (KRAM). WEST TATRA MTS, Stoły above Dolina Kościeliska valley, alt. ca 1400 m, 26 July 2004, *K. Wilk 2275* (KRAM); Wąwóz Kraków canyon: near Smocza Jama, alt. ca 1100 m, 25 July 2004, *K. Wilk 2263* (KRAM), *ibid.*, 15 July 2004, *K. Wilk 2131a* (KRAM), below Ratusz, alt. ca 1100 m, 15 July 2004, *K. Wilk 2135, 2137* (KRAM), alt. ca 1100 m, 15 July 2004, *K. Wilk 2143, 2144, 2146* (KRAM); Dolina Kościeliska valley, by trail to Jaskinia Mylna cave, alt. ca 1140 m, 13 July 2004, *K. Wilk 2125* (KRAM); Dolina za Bramką valley, alt. 1057 m, 49°16'15"N, 19°54'59"E, 22 July 2004, *K. Wilk 2220* (KRAM); Koryciańskie Turnie crags, alt. 947 m, 49°16'08"N, 19°48'52"E, 24 July 2004, *K. Wilk 2239* (KRAM).

Caloplaca xantholyta (Nyl.) Jatta

Figures 12B & 25

Nuovo Giorn. Botan. Ital., nov. ser. **9**: 476. 1902. – *Lecanora xantholyta* Nyl., Flora **62**: 361. 1879.

Thallus leprose, without corticated areoles and lobes or any corticated parts, moderately thick,

ca 300–500 µm, circular or rarely irregular, up to 25 mm diam., usually forming bigger congregations, bright yellow, less frequently yellow or yellow orange, sometimes with a greenish tint, K+ red. Soredia and consoredia 30–180(–200) µm diam. Medulla usually thick and white. *Apothecia* and *pycnidia* not known.

HABITAT AND DISTRIBUTION. *Caloplaca xantholyta* grows on limestone and occasionally on calcareous sandstone in shaded and moist places. It inhabits vertical walls, their bases, overhangs and usually rock crevices. It occupies sites of various aspect. It was recorded at 480–1500 m a.s.l.

The species is widely distributed in the West Tatras, and also is known from the High Tatras and Beskid Śląski Mts.

DISCUSSION. *Caloplaca xantholyta* is characterized by its leprose (no corticated parts of the thallus such as areoles or their fragments are present), bright yellow thallus. The medulla is white and thick. Apothecia and pycnidia are not known in this species.

Caloplaca chrysodeta differs from *C. xantholyta* by having a distinctly thinner, irregular thallus, with an inconspicuous white medulla. The thallus of *C. chrysodeta* is brownish orange or creamy brown. *Caloplaca chrysodeta* is more common than *C. xantholyta* and has a wider ecological spectrum (besides limestone, also inhabits calcareous

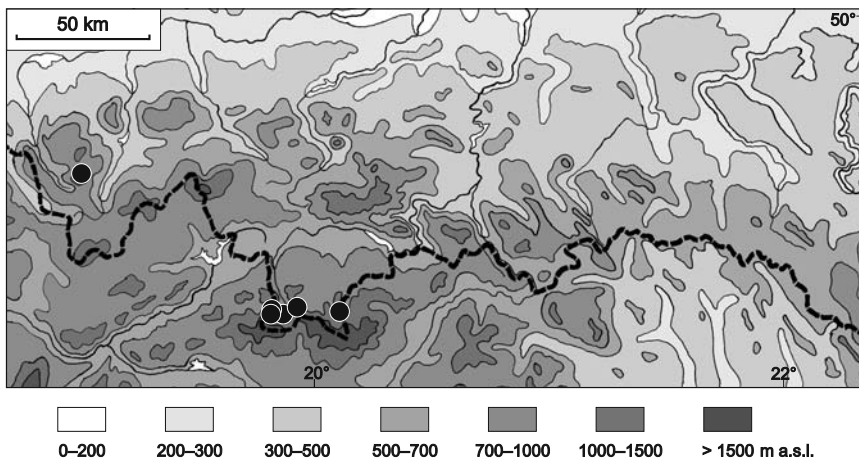


Fig. 25. Distribution of *Caloplaca xantholyta* (Nyl.) Jatta in the Polish Western Carpathians.

or silicic sandstone). *Caloplaca citrina* often is misidentified as *C. xantholyta*, but the former produces a considerably thinner thallus and smaller soredia. *Caloplaca citrina* grows in irregular outline, and corticated parts of the thallus (areoles or their fragments) are usually visible among the soredia.

EXSICCATE SEEN. Arnold, *Lich. Exsicc.* 160 (as *Physcia cirrhochoa*) (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. BESKID ŚLĄSKI MTS, Barania Góra range, Dorkowa Skała outcrops above Szarcuła pass, alt. 483 m, 49°36'19"N, 18°55'17"E, 7 Sep. 2005, *K. Wilk 3821, 3823* (KRAM). WEST TATRA MTS, Koryciańskie Turnie crags, alt. 947 m, 49°16'08"N, 19°48'52"E, 24 July 2004, *K. Wilk 2238* (KRAM), *ibid.*, alt. 1005 m, 49°16'08"N, 19°48'22"E, 24 July 2004, *K. Wilk 2244* (KRAM); Wielkie Koryciska, alt. 1000 m, 19 June 1998, *U. Bielczyk* (KRAM L-44470); Dolina za Bramką valley, alt. 1057 m, 49°16'15"N, 19°54'59"E, 22 July 2004, *K. Wilk 2223* (KRAM); Wąwóz Kraków canyon, alt. ca 1100 m, 15 July 2004, *K. Wilk 2138, 2152, 2153, 2154* (KRAM); Dolina Kościeliska valley: by trail to Jaskinia Mylna cave, alt. ca 1140 m, 13 July 2004, *K. Wilk 2127* (KRAM), near Wyzna Pisana Polana glade, alt. ca 1140 m, 13 July 2004, *K. Wilk 2130* (KRAM); Stoły above Dolina Kościeliska valley, alt. ca 1400 m, 26 July 2004, *K. Wilk 2281* (KRAM); Dolina za Bramką valley, alt. 1057 m, 49°16'15"N, 19°54'59"E, 22 July 2004, *K. Wilk 2222* (KRAM); Dolina Chochołowska valley: naer Skała Kmietowicza, 19 July 2004, *K. Wilk 2188* (KRAM), near Polana pod Jaworki glade, alt. ca 900 m, 19 July 2004, *K. Wilk 2160* (KRAM). HIGH TATRA MTS, Gęsia Szyja Mt., alt. 1480 m, 49°15'30"N, 20°04'35"E, 11 Oct. 2005, *K. Wilk 4060, 4084a* (KRAM); Łysa Skałka range, 49°15'50"N, 20°06'50"E, 12 Oct. 2005, *K. Wilk 4091, 4092* (KRAM).

Caloplaca subgenus *Gasparrinia* (Torn.) Th. Fr.

Caloplaca arnoldii (Wedd.) Zahlbr.

subsp. *obliterata* (Pers.) Gaya Figs 13A & 26

Biblioth. Lichenol. **101**: 39. 2009. – *Lichen obliteratus* Pers., Ann. Bot. (Usteri) **11**: 14. 1794.

Thallus lobate, 3–7(–12) mm diam., 200–450 µm thick, brownish orange, orange, matte, epurine or white pruinose, prothallus usually present, concolorous with thallus, somewhat

dendritic; without vegetative propagules. Marginal lobes short, 0.3–0.7 mm long and 0.3–0.6 mm wide, flat and broadened at the tips, or highly reduced. Internal areoles flat or convex, usually ± entirely covered by apothecia. Thalline cortex thin, 20–50 µm, paraplectenchymatous, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface, without necral layer; algal layer discontinuous, algae in groups; medulla dense. *Apothecia* zeorine, abundant, grouped and aggregated, or less frequently scattered, immersed at first, then sessile and constricted at the base, round or angular by compression, 0.2–1.0(–1.5) mm diam.; disc flat or strongly convex, dark orange, brownish orange, sometimes white pruinose; proper margin thin, concolorous with disc; thalline margin persistent, thick, rarely thin, even, sometimes white or ocher pruinose. Parathecium thin, 25–60 µm, prosoplectenchymatous, anthraquinone crystals present. Amphithecium with many algae, algal layer continuous or algae in distinct groups, amphithecial hyphae loose, cortex inconspicuous, anthraquinone crystals present. Epithymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 60–100 µm high. Paraphyses simple to branched, 1–3 apical cells thickened, up to 6.5(–8) µm wide. Hypothecium hyaline, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, 8–13 × 3.0–5.5 µm, isthmus 2.5–5.0 µm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. The species grows on limestone and calcareous sandstone (also on poorly calcareous rock). It is recorded at 500–700 m a.s.l.

The species is known from the Gorce Mts and Pieniny Mts. It was previously reported from Poland as *C. saxicola* subsp. *obliterata* (Pers.) Clauzade & Cl. Roux and *C. saxicola* subsp. *pulvinata* (A. Massal.) Clauzade & Cl. Roux (for references see Fałtynowicz 2003). All previously published material of *C. saxicola* s.l. needs to be revised so that the Polish distribution of *C. arnoldii* subsp. *obliterata* can be determined. It seems to be common in Poland.

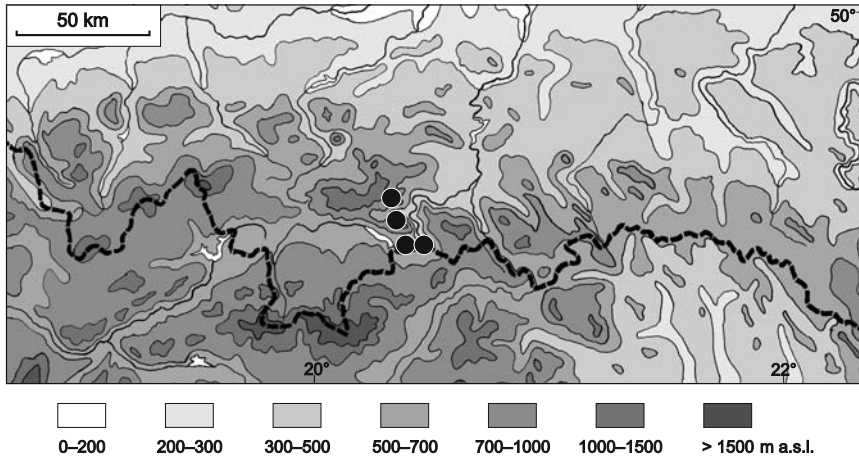


Fig. 26. Distribution of *Caloplaca arnoldii* subsp. *oblitterata* (Pers.) Gaya in the Polish Western Carpathians.

DISCUSSION. *Caloplaca arnoldii* subsp. *oblitterata* is characterized by its brownish orange thallus which sometimes is white pruinose. The marginal lobes are short or highly reduced, usually surrounded by a concolorous prothallus. The apothecia are crowded and aggregated, and produce small spores.

The species belongs to the *C. saxicola* group (Gaya 2009). It is an extremely problematic taxon with complicated nomenclature and numerous morphotypes (Gaya 2009).

The species most similar to *C. arnoldii* subsp. *oblitterata* is *C. saxicola* s.str. The latter has an epruinose thallus, marginal lobes slightly uplifted from the substrate, and does not produce a prothallus. *Caloplaca saxicola* has also bigger apothecia and spores.

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. GORCE MTS, Lubań Mt., NE slope, Biała Skała, alt. 950 m, 4 Aug. 1968, *K. Glanc* (KRAM L-27471); Twarogi Mt., S slope, 'Nad Kucami', alt. 740 m, 5 July 1967, *K. Glanc* (KRAM L-27470); Twarogi Mt., S slope, above Ochotnica Ligasy, alt. 515 m, 22 Aug. 1967, *K. Glanc* (KRAM L-27473). PIENINY WŁAŚCIWE MTS, Sokola Perć, 11 Aug. 1971, *K. Waydowska* (KRAM L-34426). MAŁE PIENINY MTS, Wąwóz Homole canyon, near Jaworki village, 3 May 1957, *J. Nowak* (KRAM L-3792).

ADDITIONAL MATERIAL EXAMINED. POLAND. NIZINY ŚRODKOWOPOLSKIE LOWLANDS. Wzgórza Trzeb-

nickie hills, Osolin, 1874, *s.coll.* (KRAM L-20919). WARMIAN-MASURIAN PROVINCE. Olsztyn County, Smolajny village, Palace of the bishops of Warmia, near Wieża Bramna gate tower, 5 May 2006, *D. Kubiak* & *P. Stepień s.n.* (OLTC, KRAM).

!! *Caloplaca arnoldii*confusa Gaya & Nav.-Ros.
Figs 13B & 27

in Gaya, Biblioth. Lichenol. **101**: 54. 2009.

Thallus lobate, placodioid, 5–10 mm diam., 225–400 µm thick, single or often grouped, deep reddish orange, epruinose; without prothallus and vegetative propagules. Marginal lobes short but distinct, 0.5–1.0 mm long and 0.2–0.3 mm wide, convex, branched, broadened at the tips. Central areoles irregular, convex, often formed from lobe fragmentation, areoles crowded or scattered, with necroses. Thalline cortex thick, 25–50 µm, paraplectenchymatous, with yellowish orange crystals (pol⁺, K⁺ red, soluble; anthraquinones) at the surface; algal layer continuous; medulla dense, prosoplectenchymatous. *Apothecia* zeorine, in center of thallus, grouped or rarely scattered, round or slightly angular and flexuous by compression, up to 0.8(–1.0) mm diam.; disc flat or rarely slightly convex, orange red, ± concolorous with thallus; proper margin persistent, thick, raised, then level with disc, paler than disc; thalline margin usually present, but reduced and visible at base of apothecia, uneven. Parathecium well developed,

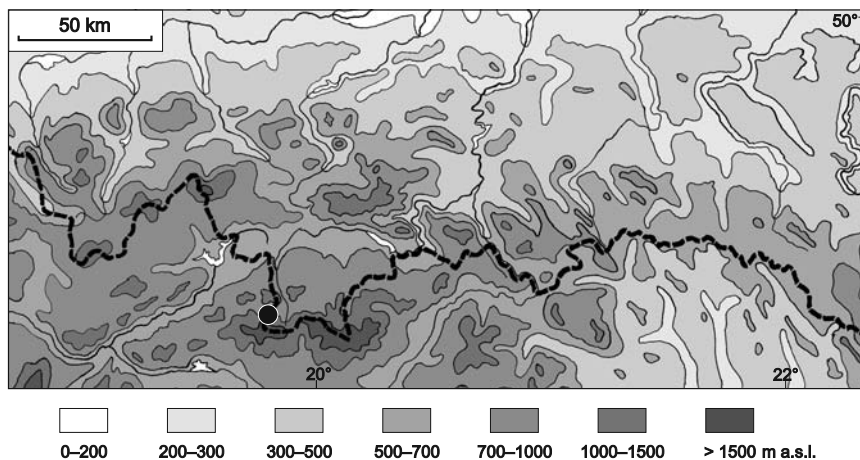


Fig. 27. Distribution of *Caloplaca arnoldiiconfusa* Gaya & Nav.-Ros. in the Polish Western Carpathians.

ca 60 μm , prosoplectenchymatous, anthraquinone crystals present. Amphithecium slightly reduced, algae abundant, cortex *ca* 30 μm with anthraquinone crystals. Epithemium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 75–100 μm high. Paraphyses simple to slightly branched, 1–3 apical cells strongly thickened, up to 8(–9) μm wide. Hypothecium hyaline, prosoplectenchymatous, without oil droplets. Asci 8-spored, spores polarilocular, thin-walled, 10.0–13.5 \times 5.0–6.5 μm , isthmus 2.5–5.0 μm wide. *Pycnidia* inconspicuous, immersed in thallus; ostiolum dark orange, conspicuous; conidia bacilliform, 2.5–3.0 \times 1–2 μm .

HABITAT AND DISTRIBUTION. The species grows on vertical limestone rock. It is known from the West Tatras.

DISCUSSION. *Caloplaca arnoldiiconfusa* is characterized by its placodioid, deep reddish orange, epruinose thallus. The marginal lobes are convex, highly branched. The central part of the thallus has necroses. The spores are broadly ellipsoid.

Caloplaca arnoldiiconfusa belongs to the *C. saxicola* group. Gaya (2009) discussed the species in detail in a monograph of lobate *Caloplaca* species, with special attention to the *C. saxicola* group in Europe.

Caloplaca arnoldii has a smaller thallus than *C. arnoldiiconfusa*, and in *C. arnoldii* it is pruinose, usually without necroses, and with less branched marginal lobes. *Caloplaca arnoldii* also has markedly narrowly ellipsoid spores. For more distinguishing characters see Gaya (2009). *Caloplaca biatorina* differs from *C. arnoldiiconfusa* by having longer and wider marginal lobes and spores with a narrower isthmus. *Caloplaca saxicola* is easily distinguished from *C. arnoldiiconfusa* by its yellow orange thallus and its short and usually highly reduced marginal lobes slightly ascending from rock. The apothecia of *C. saxicola* are bigger, up to 1.2 mm in diam., initially immersed in the thallus, then sessile and aggregated.

EXSICCATES SEEN. Arnold, *Lich. Exsicc.* 748 (as *Physcia pusilla* var. *laceratula*) (KRAM); Pišút, *Lich. Slov. Exsicc.* 226 (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. WEST TATRA MTS, Mnichy Chochołowskie crags above Dolina Chochołowska valley, 10 July 1959, J. Nowak (KRAM L-2963, 2964), *ibid.*, 26 Aug. 1971, J. Nowak (KRAM L-19231); Bobrowiec Mt., alt. 1600 m, Aug. 1982, K. Toborowicz (KTC 10453).

***Caloplaca aurea* (Schaer.) Zahlbr.**

Figs 13C & 28

Annal. Naturhist. Hofmus. Wien 5: 29. 1890. – *Lecidea aurea* Schaer., Naturw. Anzeiger Allgemein. Schweizer. Gesellsch. Naturw. 2: 11. 1818.

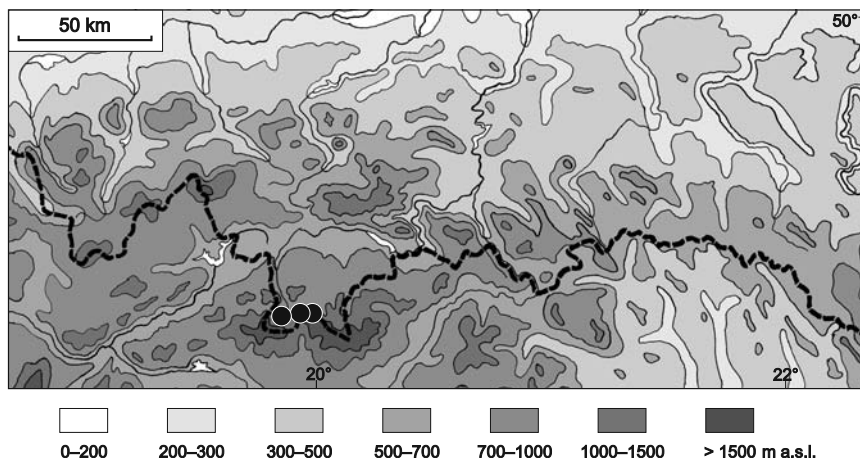


Fig. 28. Distribution of *Caloplaca aurea* (Schaer.) Zahlbr. in the Polish Western Carpathians.

Thallus lobate, irregular in outline, thick, golden yellow to yellow orange, matte, white pruinose, more or less loosely attached to the substrate; without vegetative propagules. Marginal lobes long, closely adjacent to each other, irregularly branched, convex, broadened at the tips and fan-shaped, crenate. Thallus in the center \pm bullate or areolate. Thalline cortex with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface. *Apothecia* zeorine, in center of thallus, at first immersed, then sessile, appressed, scattered, round, 0.4–1.0 mm diam.; disc flat or slightly convex, dark orange to reddish, contrasting against the thallus; proper margin slightly paler than disc, thin, inconspicuous, often level with disc; thalline margin always present, at first thick, becoming thinner. Parathecium thin, prosoplectenchymatous, anthraquinone crystals present. Amphithecium with many algae, anthraquinone crystals present. Epiphytenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, ca 80 μ m high. Paraphyses simple to slightly branched, slightly thickened. Hypothecium hyaline. Asci 8-spored, spores polarilocular or 1-cellular, fusiform with distinctly pointed ends, thin-walled, 15–20 \times 4.5–6.0 μ m, isthmus ca 1 μ m wide, or often incomplete or poorly formed. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. The species

usually grows on soil and bryophytes in fissures of calcareous rock. It occurs less frequently directly on the limestone rock surface. It occupies vertical walls of various aspect and prefers dry and sun-exposed sites. It is a high mountain taxon occurring at 1100–1800 m a.s.l. See more in Palka (2004a).

The species occurs in the West Tatras.

DISCUSSION. *Caloplaca aurea* is characterized by its golden yellow to yellow orange, white pruinose lobate thallus. The spores are 1-cellular or polarilocular, with a narrow or weakly developed isthmus and with characteristic pointed ends.

Together with *C. paulii* Poelt, *C. scrobiculata* H. Magn. (= *C. anularis* Clauzade & Poelt) and *C. cancarixiticola* Nav.-Ros., Egea, Llemona, *C. aurea* forms the *C. aurea* group sensu Clauzade & Roux (1985). The species in this group have spores with a very narrow isthmus not exceeding 2 μ m.

Caloplaca aurea is the species most resembling *C. paulii*, but the latter is distinguished from it by having a distinctly bullate thallus with very short, reduced lobes at the edges (Poelt 1965). In *C. paulii* the thallus surface is almost shiny, not pruinose, and dark orange. *Caloplaca paulii* is a saxicolous taxon only growing directly on calcareous rock, and it is less frequently found than *C. aurea*. Palka (2004b) discussed the distribution

of the two species in detail. *Caloplaca cancarix-iticola* differs from *C. aurea* by having a more deeply lobated thallus, bigger spores, and also in its ecology: it occurs on silicic rock in the Mediterranean region at dry and sun-exposed sites (Navarro-Rosinés *et al.* 2000a).

Caloplaca aurea shows some morphological similarity to members of the genus *Fulgensia* A. Massal. & De Not., but species of *Fulgensia* (*Candelariopsis*) produce non-polarilocular, non- or one-septate ascospores, and the ontogeny of the septum differs completely from that of *Caloplaca* (Poelt 1965; Westberg & Kärnefelt 1998; Gaya *et al.* 2003).

EXSICCATE SEEN. Arnold, *Lich. Exsicc.* 790 (as *Gyalolechia aurea*) (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. WEST TATRA MTS, Mały Giewont Mt., 10 July 1957, *J. Nowak* (KRAM L-2478); Wąwóz Kraków canyon: below Ratusz, alt. ca 1100 m, 15 July 2004, *K. Wilk 2134* (KRAM), alt. ca 1100 m, 15 July 2004, *K. Wilk 2142* (KRAM); Mnichowe Turnie crags above Niżnia Świstówka, alt. ca 1550 m, 49°14'37"N, 19°55'42"E, 20 July 2004, *K. Wilk 2206, 2208* (KRAM); Rzędy, S slope of Ciemniak Mt., alt. ca 1800 m, 49°13'75"N, 19°53'80"E, 11 July 2004, *K. Wilk 2117* (KRAM); Rzędy pod Ciemniakiem, alt. 1760 m, 30 Aug. 1974, *M. Olech s.n.* (KRA); Zadnie Kamienne, alt. 1760 m, 24 June 1971, *M. Olech s.n.* (KRA); Kominiarski Wierch Mt., rocks above Polana Iwanówka glade, alt.

1640 m, 28 Sep. 1976, *M. Olech s.n.* (KRA); Gładkie Jaworzyńskie, precipice of Kasprowy Wierch Mt., 25 July 1961, *J. Nowak* (KRAM L-7367).

ADDITIONAL MATERIAL EXAMINED. BULGARIA. STARA PLANINA MTS. Koloferska Planina range, above mountain shelter Raj, alt. 1800 m, 7 Aug. 1962, *J. Nowak* (KRAM L-9714).

Caloplaca biatorina (A. Massal.) J. Steiner

Figs 13D & 29

Ann. Mycol. 7: 239. 1910. – *Physcia elegans* var. *biatorina* A. Massal., Atti Instit. Veneto, ser. 2, 3(App. 3): 51. 1852.

Thallus lobate, placodioid, up to 20 mm diam., 250–350 µm thick, single or grouped, tightly adnate, orange red, pale orange at tips, matte, rough, epruinose; without prothallus and vegetative propagules. Marginal lobes moderately long, 0.5–1.0 mm long and 0.3–1.0 mm wide, flat, branched, with sublobules, distinctly broadened and sometimes crenate at the tips. Central areoles irregular, convex, often formed from lobe fragmentation. Thalline cortex 20–65 µm thick, paraplectenchymatous, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface; algal layer continuous; medulla loose. *Apothecia* zeorine, in center of thallus, scattered, from the beginning sessile on areoles or lobes, round, constricted at base, young apothecia

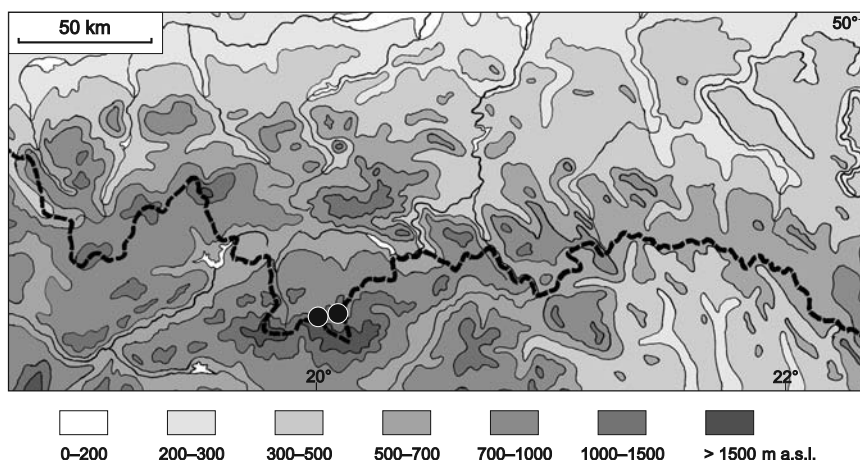


Fig. 29. Distribution of *Caloplaca biatorina* (A. Massal.) J. Steiner in the Polish Western Carpathians.

forming characteristic round wart-like structures, 0.2–0.4 mm diam.; disc flat, dark orange; proper margin thick, then thin, at first raised, then level with disc, concolorous with disc; thalline margin thin, disappearing. Parathecium rather thin, prosoplectenchymatous, anthraquinone crystals present. Amphithecium distinct, with many algae, cortex with anthraquinone crystals. Epithymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 65–75 µm high. Paraphyses simple, 1–2 apical cells thickened, up to 6.5 µm wide. Hypothecium hyaline, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, 10–13 × 6.5 µm, isthmus 3–4(–5) µm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It grows on limestone rock in slightly shaded and moist places.

The species is known from the West Tatras and High Tatras.

DISCUSSION. *Caloplaca biatorina* is characterized by its placodioid, orange red thallus. The thallus surface is rough. The marginal lobes are long and flat. The spores are broadly ellipsoid with a relatively narrow isthmus.

This species belongs to the *C. saxicola* group (Gaya 2009). Macroscopically, *C. biatorina* most resembles *C. rouxii* Gaya, Nav.-Ros. & Llemona, but the latter has a redder thallus, its lobes are less developed, always convex and short, and its apothecia usually are immersed in the thallus. *Caloplaca rouxii* produces longitudinally ellipsoid spores with a wider isthmus, and a prosoplectenchymatous thalline cortex (Gaya 2009). *Caloplaca arnoldiiconfusa* can be confused with *C. biatorina*. The lobes of *C. arnoldiiconfusa* are more convex and its spores differ (see also comment under this species). *Caloplaca saxicola* differs from *C. biatorina* by having a yellow orange thallus with short convex lobes ascending from the substrate, and apothecia initially immersed in the thallus. *Caloplaca saxicola*, similarly to *C. rouxii*, produces longitudinally ellipsoid spores with a slightly wider isthmus.

EXSICCATES SEEN. Nowak, *Lich. Polon. Merid. Exsicc.* 197 (as *C. arnoldii*) (KRAM); Weber, *Lich. Exsicc. Colorado* 693 (as *C. saxicola*) (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. WEST TATRA MTS, Gładkie Jaworzyńskie peak above Kasprowa Valley, alt. ca 1540 m, 26 July 1971, *J. Nowak* (KRAM L-43830). HIGH TATRA MTS, Gęsia Szyja Mt., alt. 1480 m, 49°15'30"N, 20°04'35"E, 14 Aug. 2008, *K. Wilk 11284* (KRAM).

Caloplaca cirrochroa (Ach.) Th. Fr.

Figs 13E & 30

Lich. Scand. 1: 171. 1871. – *Lecanora cirrochroa* Ach., *Syn. Lich.*: 181. 1814.

Thallus lobate, placodioid, up to 1–2 cm diam., 150–280 µm thick, single or grouped, orange or yellow orange, rarely pruinose, sorediate; without prothallus. Marginal lobes distinct, up to 2.5 mm long and 0.5 mm wide, flat or slightly convex, branched, broadened at the tips. Soralia crater-like to level with thallus surface, round, situated towards base of lobes; soredia citrine yellow or dark yellow (K+ red), contrasting against thallus, 15–60 µm diam. Central part of thallus often detached. Thalline cortex distinct, thick, 10–70 µm, paraplectenchymatous, cell lumina large, distinctly oval or round, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface; algal layer continuous or algae in groups; medulla ± dense, prosoplectenchymatous, with many colorless crystals (pol+). *Apothecia* and *pycnidia* not observed.

HABITAT AND DISTRIBUTION. It occurs on limestone rock, less frequently on calcareous sandstone, usually in sun-exposed places. It inhabits vertical rock walls and often occurs at the base or on the upper parts of outcrops. The species sometimes occurs on rocks by streams, rivers or lakes. It grows on south-facing sites at 400–1800 m a.s.l.

The species is widely distributed in the studied area; it is known from the Beskid Makowski Mts, Gorce Mts, Pieniny Mts (Pieniny Spiskie, Pieniny Właściwe, Małe Pieniny) and Tatra Mts.

DISCUSSION. *Caloplaca cirrochroa* is characterized by its placodioid orange thallus with citrine yellow crater-like soralia situated towards base of lobes. The central part of the thallus is often detached and then the thallus forms characteristic rings.

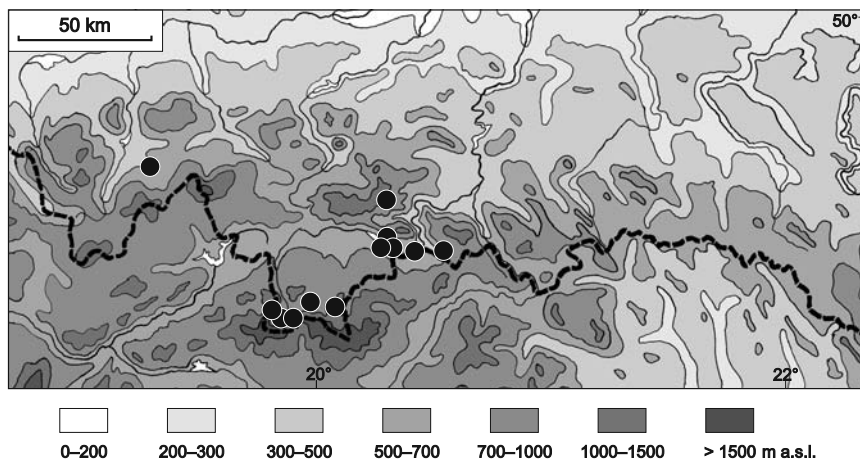


Fig. 30. Distribution of *Caloplaca cirrochroa* (Ach.) Th. Fr. in the Polish Western Carpathians.

Together with *C. proteus* and *C. obliterans* (Nyl.) Blomb. & Forssell, *C. cirrochroa* belongs to the group of sorediate lobed species. Gaya (2009) recently excluded those taxa from the *C. saxicola* group. Navarro-Rosinés and Roux (1994) discussed *C. cirrochroa* in detail and illustrated it.

Caloplaca proteus differs from *C. cirrochroa* by its bright orange red thallus and smaller soredia concolorous with the thallus. *Caloplaca cirrochroa* resembles *C. obliterans* but the latter species occupies a different substrate; it occurs on silicic rock (for detailed discussion see Wilk & Flakus 2006). *Caloplaca decipiens* differs from *C. cirrochroa* by its yellow thallus, lip-shaped soralia located on the end of lobes in the central part of the thallus. In *C. decipiens* the thalline cortex is paraplectenchymatous, with cell lumina smaller and not so distinctly round or oval as in *C. cirrochroa*, and the medulla is looser. *Caloplaca cirrochroa* could be confused with *C. stellata* Wetmore & Kärnefelt but the thallus of the latter is star-shaped in outline and has shorter marginal lobes. *Caloplaca stellata* is a North American species occurring on acidic rock (Wetmore & Kärnefelt 1998).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. BESKID MAKOWSKI MTS, Pasma Pewelskie range, S slope of Janikowa Grapa, sandstone rocks on the shore of Koszarawa River, periodically flooded habitat, alt. 397 m, 49°39'34"N, 19°19'08"E, 28 Sep. 2005, *K. Wilk 4041* (KRAM). GORCE MTS, Ochotnica Dolna

village, above Ochotnica stream, rocks above road, 10 May 1959, *K. Glanc* (KRAM L-27515); Twarogi Mt., S slope, below 'Kuce', alt. 680 m, 14 July 1966, *K. Glanc* (KRAM L-27514). PIENINY SPISKIE MTS, Zielone Skałki range by Jezioro Czorsztyńskie lake, alt. 588 m, 49°25'56"N, 20°17'35"E, Nov. 2005, *K. Wilk 4135* (KRAM); Biała Skała, 6 May 1955, *J. Nowak* (KRAM L-3798). PIENINY WŁAŚCIWE MTS, Długa Grapa outcrops, alt. 694 m, 49°24'59"N, 20°20'42"E, 5 June 2005, *K. Wilk 3444, 3453, 3455a* (KRAM); Pulsztyn Mt., alt. 605 m, Aug. 1981, *K. Toborowicz s.n.* (KTC); Popieska Skałka outcrops by Jezioro Sromowieckie lake, alt. 560 m, 49°24'48"N, 20°19'50"E, 5 June 2005, *K. Wilk 3460* (KRAM), *ibid.* 15 Feb. 2000, *J. Kozik s.n.* (PPN); limestone outcrops by the Czorsztyn Castle, alt. 560 m, 49°26'11"N, 20°18'48"E, 5 June 2005, *K. Wilk 3472* (KRAM); Cyrlowa Skała Mt., 5 May 1955, *J. Nowak* (KRAM L-3799); Trzy Korony massif, *s.d.*, *s.coll.* (KRAM L-20791); Ostry Wierch, 11 Aug. 1971, *K. Waydowska* (KRAM L-34422); Ociemny Wierch Mt., 5 May 1955, *J. Nowak* (KRAM L-3815, KRAM L-21549); Podłaźce, 23 Aug. & 10 Oct. 1999, *J. Kozik s.n.* (PPN); Czerwone Skałki, July 1999, *J. Kozik s.n.* (PPN). MAŁE PIENINY MTS, Jaworki village, Wąwóz Homole canyon, May 1891, *W. Boberski* (KRAM L-21946); Jaworki village, 1889, *W. Boberski* (KRAM L-20795); Sołtysie Skałki outcrops near Jaworki village, alt. 580 m, 49°24'20"N, 20°32'30"E, 3 June 2005, *K. Wilk 3414* (KRAM), *ibid.*, alt. 617 m, 49°24'24"N, 20°32'29"E, 3 June 2005, *K. Wilk 3375, 3376a* (KRAM); Dziobakowe Skały outcrops, SE of Jaworki village, alt. 738 m, 49°23'21"N, 20°34'05"E, 4 June 2005, *K. Wilk 3430, 3432, 3441* (KRAM); Bystrzyk Mt., 12 June

1999, *J. Kozik s.n.* (PPN). WEST TATRA MTS, Dolina Białego valley, alt. 1000 m, 17 June 1998, *U. Bielczyk* (KRAM L-44472, 44473, 44474); Koryciańskie Turmie crags, S slope, alt. 1005 m, 49°16'08"N, 19°48'22"E, 24 July 2004, *K. Wilk 2242* (KRAM); Długi Giewont Mt., S slope, alt. 1773 m, 49°15'11"N, 19°56'32"E, 21 July 2004, *K. Wilk 2212* (KRAM); Stoły above Dolina Kościeliska valley, S slope, alt. ca 1400 m, 26 July 2004, *K. Wilk 2266, 2280* (KRAM); Rzędy, S slope of Ciemniak Mt., alt. ca 1800 m, 49°13'75"N, 19°53'80"E, 11 July 2004, *K. Wilk 2118, 2121* (KRAM); below Mnichy Chochołowskie crags, E of Skorusi Żleb, alt. ca 1300 m, 49°14'29"N, 19°47'43"E, 19 July 2004, *K. Wilk 2175, 2176* (KRAM). HIGH TATRA MTS, Łysa Skalka range, 49°15'50"N, 20°06'50"E, 12 Oct. 2005, *K. Wilk 4107* (KRAM); Gęsia Szyja Mt., alt. 1480 m, 49°15'30"N, 20°04'35"E, 11 Oct. 2005, *K. Wilk 4059* (KRAM).

ADDITIONAL MATERIAL EXAMINED. POLAND. WESTERN CARPATHIANS. GORCE MTS, Twarogi Mt., S slope, 'Nad Kucami', alt. 740 m, 5 July 1967 *K. Glanc* (KRAM L-27516).

Caloplaca decipiens (Arnold) Blomb. & Forssell
Figs 13F & 31

Points-Förteckning: 69. 1880. – *Physcia decipiens* Arnold, Flora 50: 562. 1867.

Thallus lobate, 0.5–2.0 cm diam., placodioid or irregular, single or grouped, thick, 175–500 µm, usually slightly robust, yellow, yellow orange, orange, matte, sometimes white pruinose, ± rough, sorediate; without prothallus. Marginal lobes distinct, 3–4 mm long, 0.5–0.8 mm wide, strongly convex, branched, closely adjacent to each other or imbricate, often folded, broadened at the tips. Central thallus of continuous lobes or formed from lobe fragmentation. Soralia usually abundant, lip-shaped on the tips of short lobes in center of thallus; soredia concolorous with thallus (K+ red), 20–120 µm diam. Thalline cortex 10–75 µm thick, paraplectenchymatous, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface, necral layer seldom present, up to 11 µm thick; algal layer continuous; medulla loose, prosoplectenchymatous, crystals absent. *Apothecia* not observed. *Pycnidia* immersed; ostiolum orange; conidia 2–4 × 1.0–1.5 µm.

HABITAT AND DISTRIBUTION. It grows on limestone and calcareous sandstone in sun-exposed places. It was collected from outcrops in the forest, on single stones by roads or on river banks. It occurs on east-facing sites at 350–660 m a.s.l.

The species is known from the Kotlina Żywiecka basin, Gorce Mts, Beskid Wyspowy Mts, Pieniny Właściwe Mts and Małe Pieniny Mts.

DISCUSSION. *Caloplaca decipiens* is characterized by its lobate, yellow or yellow orange, sorediate thallus. The soralia are lip-shaped produced on the tips of lobes in the central part of the thallus. The soredia are concolorous with the thallus.

The species belongs to the *C. saxicola* group (Gaya 2009). *Caloplaca decipiens* is distinguishable from other lobed and sorediate species (*C. cirrochroa*, *C. proteus*) by the type of soralia, thallus color, and its more convex lobes (see discussion under the species). Another species, *C. stellata*, differs from *C. decipiens* by having a star-shaped thallus, thinner and shorter lobes, different ecology and different distribution – it occurs on acidic rock in North America. Kondratyuk and Kudratov (2003) described two species similar to *C. decipiens* from Tajikistan: *C. mongoltanika* S. Kondratyuk & I. Kudratov and *C. vorukhica* S. Kondratyuk & I. Kudratov. Both of them are characterized by their esorediate, bigger thallus, with longer lobes. *Caloplaca mongoltanika* has also longer and narrower spores than *C. decipiens*.

EXSICCATES SEEN. Wetmore, *Telos. Exsicc.* 5 (KRAM); Arnold, *Lich. Exsicc.* 446b (as *Physcia decipiens*) (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. KOTLINA ŻYWIECKA BASIN, Żywiec town, shore of Soła River below Mały Grojec Mt., alt. 346 m, 49°40'39"N, 19°11'47"E, 31 Aug. 2005, *K. Wilk 3798* (KRAM); Przybędza village, sandstone outcrops near Soła River, alt. 423 m, 49°37'30"N, 19°08'42"E, 31 Aug. 2005, *K. Wilk 3758* (KRAM). GORCE MTS, below Rabska Góra Mt., by railway, alt. 600 m, 7 July 1966, *K. Glanc* (KRAM L-27519); Cymnowa Góra Mt., S slope, above Knuruwa, alt. 660 m, 6 Aug. 1968, *K. Glanc* (KRAM L-27522). BESKID WYSPOWY MTS, Kasinka Mała village, alt. 440 m, 14 Sep. 1995, *J. Nowak* (KRAM L-42530). PIENINY WŁAŚCIWE MTS, Popieska Skalka outcrops by Jezioro Sromowieckie

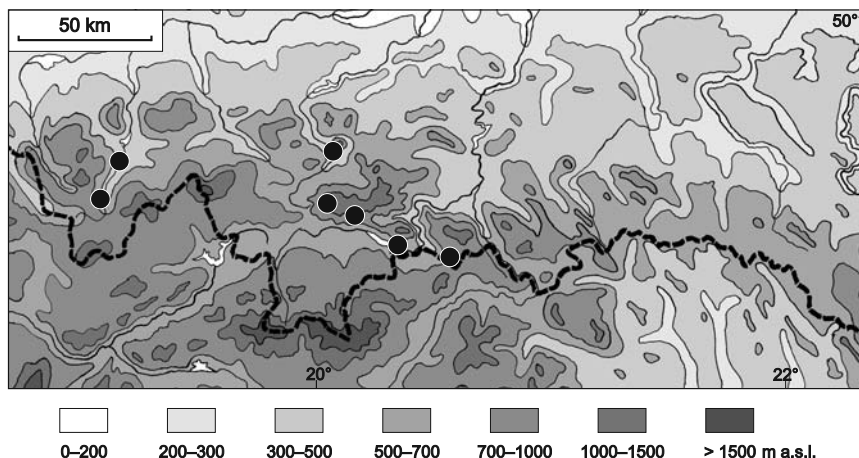


Fig. 31. Distribution of *Caloplaca decipiens* (Arnold) Blomb. & Forssell in the Polish Western Carpathians.

lake, alt. 560 m, 49°24'48"N, 20°19'50"E, 5 June 2005, *K. Wilk* 3459 (KRAM), *ibid.*, 15 Feb. 2000, *J. Kozik s.n.* (PPN); Czorsztyn, Góra Zamkowa, 6 May 1955, *J. Nowak* (KRAM L-2662, 42653). MAŁE PIENINY MTS, Wąwóz Homole canyon near Jaworki village, 3 May 1957, *J. Nowak* (KRAM L-2402).

ADDITIONAL MATERIAL EXAMINED. POLAND. WESTERN CARPATHIANS. BESKID WYSPOWY MTS, Kasinka Mała, Ciże, alt. 440 m, 14 Sep. 1995, *J. Nowak* (KRAM L-42527). MASURIAN LAKE DISTRICT. Pisz County, Borki village near Kałużyna, 2 June 1974, *L. Olesiński* (KRAM L-30642).

Caloplaca flavescens (Huds.) J. R. Laundon

Figs 14A & 32

Lichenologist 16: 53. 1984. – *Lichen flavescens* Huds., Fl. Anglica: 445. 1762.

Thallus lobate, placodioid, up to 3 cm diam., single or grouped, tightly adnate, yellowish orange or deep orange, sometimes blanching in central part of thallus, especially if growing in deep shade, epruinose or faintly pruinose. Marginal lobes long, 5–10 mm long and 0.3–0.5 mm wide, convex, abundantly branched, separated by furrows, narrow, broadened at the tips. Center of thallus areolate or with contorted and congested lobes. Thalline cortex thick, prosoplectenchymatous, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface, inside with wide layer of grey crystals (pol+, insoluble in K, slowly

soluble in N); algae layer discontinuous, algae cells in groups; medulla prosoplectenchymatous, without crystals. *Apothecia* zeorine, usually abundant, mainly in center of thallus, scattered or crowded, round or angular and flexuous by compression, up to 1.2 mm diam.; disc flat to convex, deep orange to brownish orange, epruinose; proper margin thin, raised or level with the disc, even, paler than disc; thalline margin soon excluded, sometimes visible at base of apothecia. Parathecium well developed, distinct, prosoplectenchymatous, anthraquinone crystals present. Amphithecium reduced, algae abundant, cortex ± thick, paraplectenchymatous, with anthraquinone crystals. Epihymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 80–115 µm high. Paraphyses simple to slightly branched, apical cells not thickened, or slightly thickened. Hypothecium hyaline, prosoplectenchymatous, with many oil droplets. Asci 8-spored, spores polarilocular, thin-walled, lemon-shaped, 8–15 × 6.0–11.5 µm, isthmus (2–)3–4 µm wide. *Pycnidia* often abundant, orange, immersed; conidia bacilliform, 3.5–5.5(–7.5) × 1 µm.

HABITAT AND DISTRIBUTION. The species occurs on calcareous rock, most often on limestone in open, sun-exposed and dry situations, and was noted rarely at moderately shaded sites. It grows at the base but also on the uppermost parts of rocks.

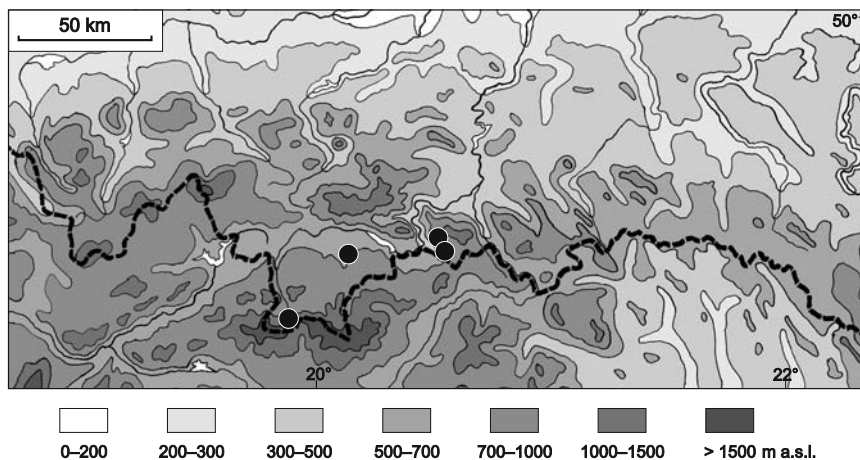


Fig. 32. Distribution of *Caloplaca flavescens* (Huds.) J. R. Laundon in the Polish Western Carpathians.

It usually occurs abundantly, forming populations of many individuals.

The species is scattered in the Carpathians. Most records originate from the Pieniny Mts (Pieniny Właściwe, Małe Pieniny) and West Tatras, where calcareous rock occurs most often. Apparently it is not common in the other parts of the mountain ranges; the other records are from only the Beskid Sądecki Mts and Carpathian foothills.

DISCUSSION. *Caloplaca flavescens* is characterized by its long, narrow, convex marginal lobes and its lemon-shaped spores. The thalline cortex is obscured by a wide continuous layer of grey crystals clearly seen under polarized light (Fig. 4).

The species belongs to the *C. aurantia* group (Søchting & Arup 2002; Gaya *et al.* 2008), which includes taxa producing lemon-shaped spores: *C. aegaea* Sipman, *C. aurantia*, *C. flavescens* and *C. thallicola* (Wedd.) Du Rietz.

Caloplaca aurantia and *C. flavescens* are the only species of the group represented in the Polish lichen biota, but *C. aurantia* was not confirmed in the studied area; all Carpathian specimens labelled *C. aurantia* are in fact *C. flavescens*. *Caloplaca aurantia* differs from *C. flavescens* by having a lighter and often color-zonated thallus. The thalline lobes of *C. aurantia* are flat, distinctly broadened at the tips, and closely adjacent to each other. Regarding microscopic characters, *C. aurantia* has a distinctly

thinner thalline cortex without a crystalline layer inside, and the spores differ. For a more detailed discussion of the two taxa see Šoun and Vondrák (2008), Śliwa and Wilk (2008) and Gaya (2009).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. BESKID SĄDECKI MTS, Pasma Radziejowej range, Szlachtowa, alt. 550 m, 2 May 1991, *L. Śliwa s.n.* (KRA). PIENINY SPISKIE MTS, Skalice Nowotarskie, N slope of Kramnica Mt., alt. 640 m, 24 June 1968, *J. Kiszka s.n.* (KRAP). PIENINY WŁAŚCIWE MTS, Wąwóz Homole canyon, 49°23'54"N, 20°33'20"E, 30 Aug. 2000, *C. Wetmore 85268* (MIN). MAŁE PIENINY MTS, Biała Woda reserve, 1 June 1999, *J. Kiszka s.n.* (KRAP); Dziobakowe Skały outcrops, SE of Jaworki village, alt. 738 m, 49°23'21"N, 20°34'05"E, 4 June 2005, *K. Wilk 3429, 3435* (KRAM); Sołtysie Skałki outcrops near Jaworki village, alt. 580 m, 49°24'20"N, 20°32'30"E, 3 June 2005, *K. Wilk 3423* (KRAM). WEST TATRA MTS, Dolina Kościeliska valley: 3 km SW of Zakopane, 49°14'30"N, 19°51'46"E, 9 May 1997, *C. Wetmore 77318* (MIN), near Wyżnia Pisana Polana glade, alt. ca 1100 m, 13 July 2004, *K. Wilk 2129*; Wąwóz Kraków canyon, alt. ca 1100 m, 15 July 2004, *K. Wilk 2147, 2149* (KRAM).

ADDITIONAL SPECIMENS EXAMINED. POLAND. WYŻYNA KRAKOWSKO-CZĘSTOCHOWSKA UPLAND. Dolina Będkowska valley, alt. 380 m, 1 May 1956, *J. Nowak* (KRAM L-18770); Dolina Kluczwoły valley, 19 Dec. 1992, *J. Nowak* (KRAM L-31608), *ibid.*, Zamkowa Skała rock, alt. 320 m, 15 June 1994, *J. Nowak* (KRAM L-28036); Dolina Kobyłańska valley, Kula rock, alt.

350 m, 2 May 1995, *J. Nowak* (KRAM L-40213); Nielepice village near Rudawa, 6 km EES of Krzeszowice town, N slope of Chełm hill, alt. 280 m, 30 Sep. 1986, *J. Nowak* (KRAM L-30454); 12 km NW of Krakow, limestone quarry by road to Olkusz, 50°09'12"N, 19°47'06"E, 6 May 1997, *C. Wetmore* 77251 (MIN). BULGARIA. CZARNATICA. Biolocerkowski Rid, Biala Cerka, alt. 1300 m, 29 Sep. 1975, *J. Nowak* (KRAM L-34966, 34968). SLOVAKIA. SPISZ, Drevenik near Spissky Hrad, alt. 600 m, 3 July 1993, *U. Bielczyk* (KRAM L-23972).

***Caloplaca proteus* Poelt** Figs 14B & 33

Mitt. Bot. Staatssamml. München 8: 329. 1953.

Thallus lobate, 2–7 mm diam., 130–225 µm thick, single or grouped, yellow orange, intensive orange or red orange, epruinose, sorediate; without prothallus. Marginal lobes short, distinct, 0.8–2.2 mm long, 0.1–0.4 mm wide, convex, branched, usually separated from each other, finger-like or only slightly broadened at the tips. Soralia diffuse towards base of lobes; soredia concolorous with thallus (K+ red), 25–100 µm diam. Thalline cortex thick, 20–70 µm, paraplectenchymatous, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface; algal layer continuous; medulla indistinct, loose. *Apothecia* zeorine, very rare, in center of thallus, directly on rock between thalline granules or on surface of areoles, round, up to ca 0.8 mm diam.;

disc flat, dark orange; margin without superficial differentiation between proper and thalline margins, prominent. Parathecium thin, prosoplectenchymatous, anthraquinone crystals present. Amphithecium with many algae, anthraquinone crystals present. Epithemium interspersed with reddish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 80 µm high. Paraphyses simple, 1–2 apical cells thickened, up to 7.5 µm wide. Hypothecium hyaline, with oil droplets. Asci 8-spored, spores polarilocular, thin-walled, 11–15 × 6.5–8.0 µm, isthmus 3.0–4.5 µm wide. *Pycnidia* slightly visible, immersed; conidia 1.5–6.5 × 1.0–1.5 µm.

HABITAT AND DISTRIBUTION. It occurs on limestone in open and sun-exposed situations or less frequently at slightly shaded sites. It inhabits vertical rock walls and the upper parts or base of outcrops. It was noted from sites of various aspect. It occurs at 1000–1640 m a.s.l.

The species is known from the Małe Pieniny Mts, West Tatras and High Tatras.

DISCUSSION. *Caloplaca proteus* is characterized by its lobate, bright orange or orange red, sorediate thallus. The marginal lobes are short and finger-like. The soralia are concolorous with the thallus.

The thallus of *C. proteus* varies in shape: having regular rosettes with lobes ± touching

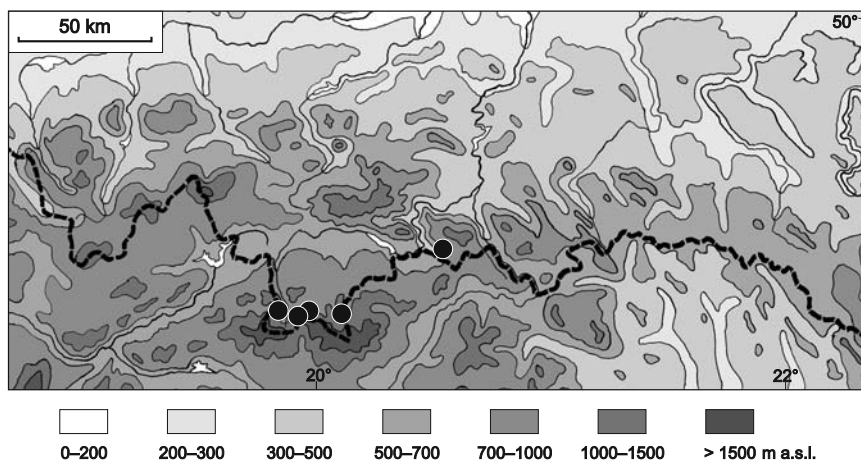


Fig. 33. Distribution of *Caloplaca proteus* Poelt in the Polish Western Carpathians.

each other; irregular, composed of finger-like lobes in a net-like arrangement; less frequently, a regular arrangement of short marginal lobes and convex areoles mixed with soralia in the central part. Apothecia are uncommon in *C. proteus*. According to Poelt (1954) they are located in the center of the thallus on a net-like white layer. The morphology of fertile thalli differs slightly from those producing only soralia; the differences regard for example the lobes, which are flat and broad at the tips, and tightly adnate to substrate in fertile specimens.

Unlike *C. proteus*, *C. cirrochroa* has an orange or yellow orange thallus, and citrine yellow soralia, and its lobes are longer. Navarro-Rosinés and Roux (1994) gave detailed information on the two species. *Caloplaca decipiens* differs from *C. proteus* by having a yellow, thicker thallus, longer lobes, and yellow, lip-shaped soralia. For more details see Gaya (2009).

EXSICCATE SEEN. Poelt, *Lich. Alpium* 252 (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. MAŁE PIENINY MTS, Jaworki village, 1888, *W. Boberski* (KRAM L-11345). WEST TATRA MTS, Dolina Chochołowska valley: Polana Huciska glade, alt. 1000 m, 27 Aug. 1971, *J. Nowak* (KRAM L-24187); Mnichy Chochołowskie crags above Skorusi Żleb, alt. 1470 m, 9 Oct. 1987, *J. Nowak* (KRAM L-24370); S slope of Mnichy Chochołowskie crags, alt. 1488 m, 49°14'40"N, 19°47'42"E, 19 July 2004, *K. Wilk 2187* (KRAM); Mnichy Chochołowskie crags, above Dolina Chochołowska valley, alt. 1510 m, 26 Aug. 1971, *J. Nowak* (KRAM L-21490); Wielkie Koryciska, alt. 1000 m, 19 Jun 1998, *U. Bielczyk* (KRAM L-44471); Dolina Kondratowa valley, slope below Giewont Mt., alt. 1350 m, 14 May 1959, *J. Nowak* (KRAM L-2252); Dolina ku Dziurze valley, alt. 1000 m, 12 Apr. 1999, *U. Bielczyk* (KRAM L-44638); Dolina za Bramką valley, alt. 1057 m, 49°16'15"N, 19°54'59"E, 22 July 2004, *K. Wilk 2221* (KRAM); Wąwóz Kraków canyon, slope of Saturn, alt. 1500 m, 29 May 1959, *J. Nowak* (KRAM L-8884); Dolina Małej Łąki valley, alt. 1150 m, 11 Aug. 1971, *J. Nowak* (KRAM L-19428); Koryciańskie Turnie crags, S slope, alt. 1005 m, 49°16'08"N, 19°48'22"E, 24 July 2004, *K. Wilk 2243, 2245a, 2247* (KRAM); Koryciańskie Turnie crags, alt. 1196 m, 49°16'12"N, 19°47'55"E, 24 July 2004, *K. Wilk 2249* (KRAM); S of Jasiowe Turnie crags, alt. 1244 m, 49°15'58"N, 19°54'59"E, 22 July 2004, *K. Wilk 2231* (KRAM);

Jasiowe Turnie crags, alt. 988 m, 49°16'35"N, 19°55'03"E, 19 July 2004, *K. Wilk 2237* (KRAM); Bobrowiec Mt., alt. 1640 m, Aug. 1982, *K. Toborowicz* (KTC). HIGH TATRA MTS, Gęsia Szyja Mt., alt. 1440 m, 10 Aug. 1971, *J. Nowak* (KRAM L-19430); Gęsia Szyja Mt., alt. 1480 m, 49°15'30"N, 20°04'35"E, 11 Oct. 2005, *K. Wilk 4054a, 4066, 4075a, 4086, 4089* (KRAM); Łysa Skałka range, 49°15'50"N, 20°06'50"E, 12 Oct. 2005, *K. Wilk 4098, 4109, 4110, 4112* (KRAM).

Caloplaca pseudofulgensia Gaya & Nav.-Ros.

Figs 14C & 34

in Gaya, *Biblioth. Lichenol.* **101**: 69. 2009.

Thallus lobate, placodioid, 2–14 mm diam., 100–400 µm thick, single or often forming bigger congregations, yellow, creamy yellow, ocher, orange ocher, sometimes pale yellow to greenish yellow in shade, thallus in the center often whitish, surface rough, matte, pruinose (pruina concolorous with thallus); without prothallus and vegetative propagules. Marginal lobes long, distinct, 0.5–2.0 mm long and 0.1–0.5(–0.8) mm wide, convex near the center of thallus, but flat at the tips, richly and rather irregularly branched, closely adjacent to each other, slightly broadened at the tips, surface of lobes wrinkled and with delicate furrows along. Internal areoles flat to convex, irregular or resembling small sublobules; young thallus often lacking internal areoles, and then lobes forming from the center. Thalline cortex distinct, thin or sometimes thick, paraplectenchymatous, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface, and with colorless crystals (pol+, insoluble in K, soluble in N), without necral layer; algal layer ± continuous; medulla dense, with many colorless crystals (pol+, insoluble in K, soluble in N). *Apothecia* zeorine, in center of thallus, sessile from the beginning, crowded, rarely scattered, round or angular and flexuous by compression, 0.2–0.8(–1.0) mm diam.; disc flat, then convex, dark orange or brownish orange, epruinose or slightly pruinose; proper margin persistent, slightly paler than disc; thalline margin ± reduced, thick, even or slightly cracked, pruinose; sometimes thalline margin excluded from the beginning and only proper margin visible. Parathecium thin or thick, 25–60 µm, prosoplectenchymatous, cell

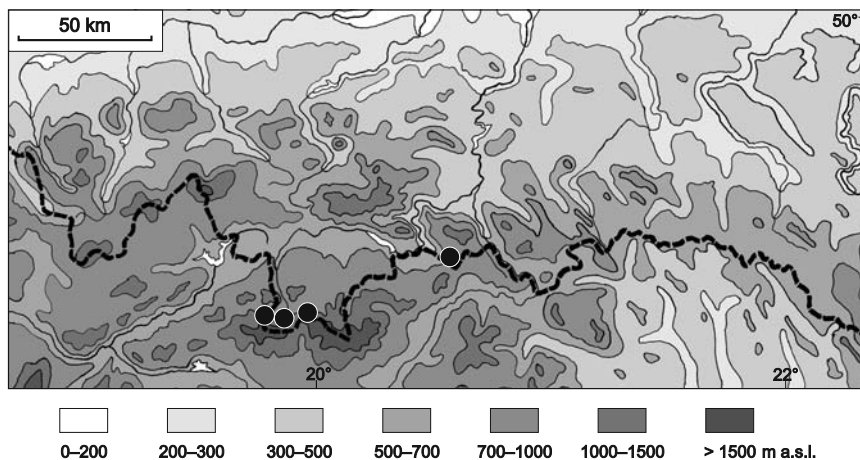


Fig. 34. Distribution of *Caloplaca pseudofulgensia* Gaya & Nav.-Ros. in the Polish Western Carpathians.

lumina oval, anthraquinone crystals present. Amphithecium well developed or \pm reduced, algae in groups or forming a continuous layer, sometimes amphithecial tissue loose and with holes, cortex paraplectenchymatous with anthraquinones and colorless crystals (pol+, insoluble in K, soluble in N). Epithemium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 65–90 μm high. Paraphyses simple to seldom slightly branched, 1–2(–3) apical cells thickened, up to 6.5(–7.5) μm wide. Hypothecium hyaline, with numerous oil droplets, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, 7–13 \times 3.0–6.5 μm , isthmus 2.5–5.0 μm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It grows on limestone in sun-exposed to shaded situations, mostly on vertical rock walls. It occurs at 500–1700 m a.s.l.

The species is known from the Małe Pieniny Mts and West Tatras, where it is common.

DISCUSSION. *Caloplaca pseudofulgensia* is characterized by its placodioid, yellow to pale orange thallus covered by a distinct concolorous pruina. The marginal lobes are flat and broadened at the tips; the lobe surface is wrinkled and furrowed. Dark orange apothecia contrast against the thallus.

The species belongs to the *C. saxicola* group (Gaya 2009). Morphologically, *C. pseudofulgensia* is very similar to *C. aurea*, but the latter produces characteristic 1-cellular or polarilocular spores with pointed ends and a much reduced isthmus. Its spores are also considerably bigger (up to 20 μm long), it has a thicker, epruinose thallus, and it does not form the rosettes typical of *C. pseudofulgensia*. See also Wilk (2011). *Caloplaca pseudofulgensia* is similar to *C. pusilla*, but the latter has robust, convex, bigger and less branched lobes with no wrinkles or furrows on the surface. The thallus of *C. pusilla* is often salmon-colored and white pruinose. Its apothecia are initially immersed in the thallus and they produce bigger spores. *Caloplaca saxicola* differs from *C. pseudofulgensia* by having an intense orange, epruinose thallus. The thalline lobes are usually short to highly reduced, convex and slightly ascending from rock. The apothecia of *C. saxicola* are initially immersed in the thallus, then sessile and aggregated, and they produce bigger spores.

EXSICCATE SEEN. Arnold, Lich. Exsicc. 1372 (as *Physcia pusilla*) (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. MAŁE PIENINY MTS, near Jaworki village, Sołtysie Skałki outcrops, alt. 580 m, 49°24'20"N, 20°32'30"E, 3 June 2005, K. Wilk 3415 (KRAM). WEST TATRA MTS, Dolina Kościeliska valley, 16 July 1912, W. Augustynowicz (KRAM L-571), *ibid.*, alt. 1000 m,

25 July 2004, *K. Wilk 2264* (KRAM); Stoły above Dolina Kościeliska valley, S slope, alt. 1400 m, 26 July 2004, *K. Wilk 2277* (KRAM); Wąwóz Kraków canyon: slope of Saturn, alt. 1500 m, 29 May 1959, *J. Nowak* (KRAM L-8868), alt. 1100 m, 15 July 2004, *K. Wilk 2155* (KRAM); Kominy Tylkowe, by trail from Przełęcz Iwaniacka pass, alt. 1700 m, 5 July 1955, *J. Nowak* (KRAM L-4796); Kalacka Turnia, above Suchy Żleb, 9 July 1957, *J. Nowak* (KRAM L-2472); Kalacka Turnia, alt. 1300 m, 9 July 1957, *J. Nowak* (KRAM L-122); below Mnichy Chochołowskie crags, E of Skorusi Żleb, alt. 1300 m, 49°14'29"N, 19°47'43"E, 19 July 2004, *K. Wilk 2178* (KRAM); W slope of Wielka Świstówka, in the direction to Kobylaszowy Żleb, 27 June 2004, *A. & M. Ronikier* (KRAM L-55074).

ADDITIONAL MATERIAL EXAMINED. SLOVAKIA. SPIŠ. Lubovňa Castle, *s.d., s.coll.* (KRAM L-20803).

Caloplaca pusilla (A. Massal.) Zahlbr.

Figs 14D & 35

Annal. Naturhist. Hofmuseums Wien 4: 353. 1889. – *Physcia pusilla* A. Massal., Atti Istit. Veneto, ser. 2, 3(App. 3): 59. 1852 (see Gaya 2009).

Thallus lobate, placodioid, 2–10 mm diam., 300–400 µm thick, single or usually forming bigger congregations, yellow ocher, pinkish or salmon, often whitish in the center, surface white pruinose, especially in the center of thallus, where necrosis may also occur; without prothallus and vegetative propagules. Marginal lobes long, distinct,

0.5–2.0 mm long and 0.2–0.5 mm wide, convex or flat, closely adjacent to each other or sometimes imbricate, broadened at the tips. Internal areoles convex, rounded to elongated, or areoles absent and lobes forming from the center. Thalline cortex thin to thick, 13–80 µm, paraplectenchymatous, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface, without necral layer; algal layer discontinuous; medulla loose, colorless crystals sometimes present. *Apothecia* zeorine, in center of thallus, crowded or scattered, immersed at first, then sessile and often constricted at the base, rounded or angular by compression, 0.2–1.0 mm diam.; disc flat or slightly convex, dark orange, brownish orange or blood-red, less frequently reddish orange, sometimes slightly white pruinose; proper margin persistent, slightly raised or level with disc, concolorous with disc or slightly paler; thalline margin persistent or disappearing, sometimes heavily white pruinose. Parathecium thin, 30–42 µm, prosoplectenchymatous, anthraquinone crystals present. Amphithecium with numerous algae in groups or forming a continuous layer, sometimes amphithecial hyphae loose, cortex thick, with anthraquinone crystals, and colorless crystals (pol+). Epithemium interspersed with yellowish orange or reddish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 60–90 µm high. Paraphyses simple to slightly branched, 1–2(–4) apical cells

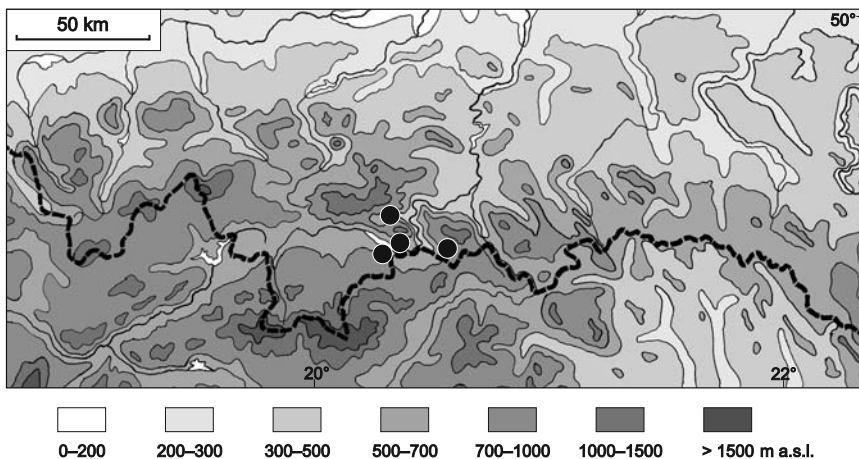


Fig. 35. Distribution of *Caloplaca pusilla* (A. Massal.) Zahlbr. in the Polish Western Carpathians.

thickened, up to 8(–10) μm wide. Hypothecium hyaline, without oil droplets and crystals, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, 8.5–15.0 \times 4.0–8.5 μm , isthmus 2.5–5.0 μm wide. *Pycnidia* infrequent, inconspicuous, immersed; conidia ellipsoid to bacilliform, 3.0 \times 1.5 μm .

HABITAT AND DISTRIBUTION. It grows on limestone and calcareous sandstone and commonly on concrete in sun-exposed situations. It has been recorded up to 980 m a.s.l.

The species is known from the Gorce Mts and Pieniny Mts (Pieniny Spiskie, Pieniny Właściwe, Małe Pieniny).

DISCUSSION. *Caloplaca pusilla* is characterized by its placodioid, yellow ocher, pinkish or salmon-colored thallus with long and \pm convex marginal lobes tightly adnate to substrate.

The species belongs to the *C. saxicola* group (Gaya 2009). *Caloplaca pusilla* was treated as a synonym of *C. saxicola* for many years and was just recently recovered by Gaya (2009). *Caloplaca saxicola* differs from *C. pusilla* by having an epruinose thallus with short to highly reduced lobes distinctly ascending from the rock, and bigger apothecia, strongly aggregated, forming clusters. The spores of *C. saxicola* are longer and narrower than in *C. pusilla*. For the distinction between *C. pusilla* and *C. pseudofulgensia* see remarks under that species. For more comments on the species see Wilk (2011).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. GORCE MTS, Boginka rock, above valley of Lubański stream, alt. 680 m, 15 Aug 1967, *K. Glanc* (KRAM L-27476). PIENINY SPISKIE MTS, Zielone Skałki range by Jezioro Czorsztyńskie lake, NE of Falsztyn, alt. 588 m, 49°25'56"N, 20°17'35"E, Nov. 2005, *K. Wilk 4131* (KRAM). PIENINY WŁAŚCIWE MTS, Popieska Skałka outcrops by Jezioro Sromowieckie lake, alt. 560 m, 49°24'48"N, 20°19'50"E, 5 June 2005, *K. Wilk 3457* (KRAM); Trzy Korony Mt., 4 May 1957, *J. Nowak* (KRAM L-3786, 3790); Czorsztyn, *s.d.*, *s.coll.* (KRAM L-20787); Podłaźce, 10 Oct. 1999, *J. Kozik* (PPN); Ociemny Wierch, 5 May 1955, *J. Nowak* (KRAM L-3245). MAŁE PIENINY MTS, Zabaniszczce, Góra Trzy Skałki Mt., alt. 740 m, Aug. 1980, *K. Toborowicz s.n.* (KTC).

ADDITIONAL MATERIAL EXAMINED. POLAND. POJEZIERZE WSCHODNIOBAŁTYCKIE LAKELAND. Giżycko County, Szymonka village, 11 June 1974, *L. Olesiński* (KRAM L-30631).

Caloplaca saxicola (Hoffm.) Nordin

Figs 14E & 36

Caloplaca, sect. *Gasparrinia* i Nordeuropa (Uppsala): 87. 1972. – *Psora saxicola* Hoffm., Descr. Adumb. Pl. Lich. 1(3): 82. 1790.

Thallus lobate, placodioid, 3–15 mm diam., 150–270 μm thick, single or grouped, yellow ocher, yellow orange or orange, epruinose, rough with parietine crystals; without prothallus and vegetative propagules. Marginal lobes short to highly reduced, 0.2–1.2 mm long, 0.2–0.8 mm wide, convex, closely adjacent to each other or sometimes imbricate, broadened and crenate at the tips, visibly ascending from rock. Center of thallus areolate or with small sublobules, almost entirely covered by apothecia. Thalline cortex thin or thick, 15–50 μm , paraplectenchymatous, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface, necral layer absent; algal layer discontinuous; medulla dense or loose, without crystals. *Apothecia* zeorine, abundant, crowded, in center of thallus, strongly aggregated, forming clusters, initially immersed, then sessile and distinctly constricted at base, round or flexuous, 0.2–1.2 mm diam.; disc firstly flat, then strongly convex, dark orange; proper margin, thin, slightly paler than disc; thalline margin present or disappearing, thin, sometimes rough. Parathecium thin, 20–30 μm , prosoplectenchymatous, cell lumina long and narrow, anthraquinone crystals present. Amphithecium well developed, algae numerous, algae sometimes in groups, medulla loose, cortex distinct, ca 30 μm thick, with anthraquinone crystals, microsoredia present on cortex. Epihymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 60–80 μm high. Paraphyses simple or slightly branched, 1–3 apical cells strongly thickened, up to 8(–10) μm wide. Hypothecium hyaline, sometimes with oil droplets, prosoplectenchymatous. Asci 8-spored, spores polarilocular,

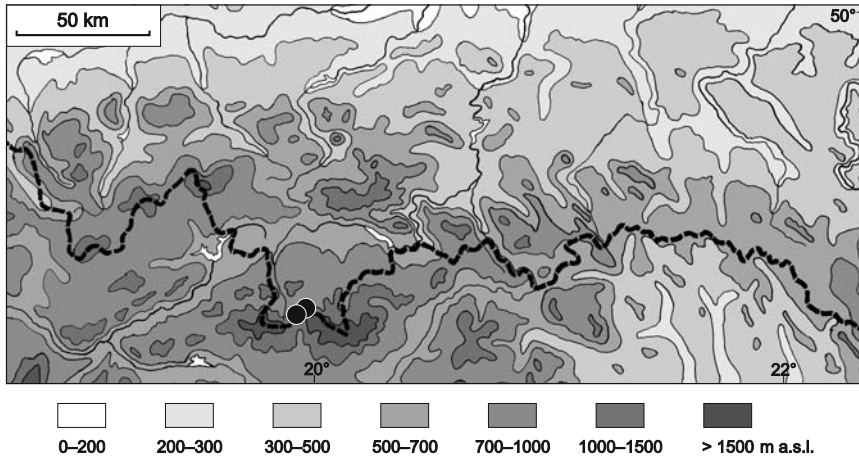


Fig. 36. Distribution of *Caloplaca saxicola* (Hoffm.) Nordin in the Polish Western Carpathians.

thin-walled, $9\text{--}13 \times 4.5\text{--}6.5 \mu\text{m}$, isthmus $3\text{--}4 \mu\text{m}$ wide. *Pycnidia* immersed, weakly visible.

HABITAT AND DISTRIBUTION. It grows on limestone in sun-exposed situations. It inhabits south-facing vertical rock walls.

The species is known from the West Tatras.

DISCUSSION. *Caloplaca saxicola* is characterized by its placodioid, yellow orange, epruinose thallus, and short to highly reduced lobes distinctly ascending from the rock. The apothecia are abundant, initially immersed in the thallus, large and strongly aggregated, forming clusters. The spores of this species are long and wide.

The taxon is the type species for the *C. saxicola* group (Gaya 2009). Gaya (2009) and Gaya *et al.* (2011) recently studied the taxonomy and phylogeny of this group in detail. The most important earlier works treating the subgenus *Gasparrinia* are by Poelt (1969), Nordin (1972) and Wetmore and Kärnefelt (1998).

Caloplaca saxicola is most similar to *C. pusilla*. The two species are compared in the description of *C. pusilla*. Unlike *C. saxicola*, *C. pseudofulgensia* has a yellow or yellow orange thallus, heavily yellow pruinose. *Caloplaca pseudofulgensia* has distinct lobes which are long, flat, broadened at the tips, and wrinkled. Abundant colorless crystals (pol+) occur in thalline cortex, medulla and at the base of apothecia.

Caloplaca saxicola may be confused with *C. arnoldii* subsp. *obliterata*. The latter differs in having a yellow or orange prothallus, flat thalline lobes and smaller spores (see also Gaya 2009).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. WEST TATRA MTS, Długi Giewont Mt., S slope, alt. 1773 m, $49^{\circ}15'11''\text{N}$, $19^{\circ}56'32''\text{E}$, 21 July 2004, K. Wilk 2214 (KRAM); Rzędy, S slope of Ciemiński Mt., alt. ca 1800 m, $49^{\circ}13'75''\text{N}$, $19^{\circ}53'80''\text{E}$, 11 July 2004, K. Wilk 2110 (KRAM).

ADDITIONAL MATERIAL EXAMINED. POLAND. WESTERN CARPATHIANS. POGÓRZE PRZEMYSKIE FOOTHILLS, Kupiatycze, by the road to Hermanowice, 27 July 1984, J. Kiszka & J. Piórecki (KRAM L-29989).

Caloplaca subgenus *Gyalolechia* (A. Massal.) Boist.

! *Caloplaca crenulatella* (Nyl.) H. Olivier

Figs 15A & 37

Mémoire. Soc. Nation. Scienc. Natur. Cherbourg **37**: 110. 1909. – *Lecanora crenulatella* Nyl., Flora **69**: 461. 1886.

Thallus areolate, usually poorly developed, forming scattered granules or areoles, yellow, or almost endolithic, usually with whitish or other coating; without prothallus and vegetative propagules. Thalline cortex thin, indistinct, with a yellowish orange crystals (pol+, K+ red, soluble;

anthraquinones) at the surface; algal layer continuous. *Apothecia* zeorine, abundant, scattered or crowded, round or angular by compression, sessile, 0.2–0.7 mm diam.; disc at first slightly concave, then flat, may be slightly convex in old apothecia, pale to dark orange, or intensive yellow in young apothecia, epruinose, sometimes slightly rough; proper margin persistent, thin, level with disc, slightly paler than disc; thalline margin thick and prominent in young apothecia, then more or less reduced and visible at base of apothecia or hardly visible, less frequently remaining well developed and crenulate. Parathecium prosoplectenchymatous, 50–100 μm , anthraquinone crystals present. Amphithecium with many algae, anthraquinone crystals present. Epihymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 85–100(–120) μm high. Paraphyses simple to slightly branched, apical cells not thickened or 1–2(–3) cells slightly thickened, up to 6 μm wide. Hypothecium hyaline, sometimes with a few oil droplets, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, (13.5–)15.0–20.0(–22.0) \times (5–)6–9(–10) μm , isthmus 1.0–3.5 μm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It grows on limestone rock, calcareous sandstone and slate, usually in open and well insolated areas (e.g.,

forest glades), less frequently in shaded places. It was collected from upper parts of outcrops and vertical rock walls of various aspect. It often grows near streams or rivers, often in periodically flooded places. It was also collected in seminatural environments such as quarries. It occurs at 350–1800 m a.s.l.

The species is widely distributed in the studied area; it occurs in the Pogórze Cieszyńskie foothills, Kotlina Żywiecka basin, Beskid Mały Mts, Pieniny Spiskie Mts, Pieniny Właściwe Mts, Pogórze Spisko-Gubałowskie foothills and West Tatras.

DISCUSSION. *Caloplaca crenulatella* is characterized by its yellow areolate thallus. The apothecia are orange, with a yellow, more or less well developed and crenulate thalline margin.

Caloplaca crenulatella belongs to the *C. lactea* group (Navarro-Rosinés & Hladun 1996), which includes species producing spores with a very thin isthmus, usually not exceeding 3 μm wide (except *C. aquensis* Houmeau & Roux) and with a poorly formed, usually inconspicuous thallus [except *C. interfulgens* (Nyl.) Steiner and sometimes *C. crenulatella*]. Species of the group occur mainly on limestone rock. In the *C. lactea* group, Navarro-Rosinés and Hladun (1996) distinguished seven species occurring mainly in Mediterranean and/or Central European areas: *C. aquensis*, *C. crenulatella*, *C. ferrari* (Bagl.) Jatta, *C. interfulgens*,

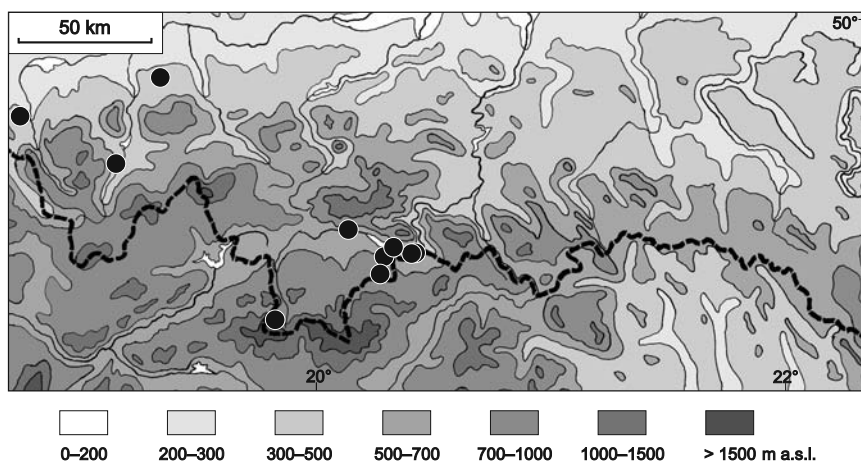


Fig. 37. Distribution of *Caloplaca crenulatella* (Nyl.) H. Olivier in the Polish Western Carpathians.

C. lactea, *C. lacteoides* Nav.-Ros. & Hladun and *C. marmorata*. Later Navarro-Rosinés *et al.* (2001) described another species, *C. nashii* Nav.-Ros., Gaya & Hladun, having the narrowest spores of the group. Most recently the group was phylogenetically studied by Vondrák *et al.* (2011), who described the new species *C. diffusa* Vondrák & Llimona and expanded the group with additional species such as *C. borysthenica* Khodos. & S. Y. Kondr., *C. ochracea* (Schaer.) Flagey and *C. tominii* Savicz.

In Europe, *C. crenulatella* has often been misidentified as *C. lactea* (Navarro-Rosinés & Hladun 1996). The latter species occurs mainly in the Mediterranean region, whereas *C. crenulatella* is widely distributed in Europe (Navarro-Rosinés & Hladun 1996; Vondrák *et al.* 2011). *Caloplaca lactea* differs from *C. crenulatella* mostly in having broadly ellipsoid and shorter spores usually not exceeding 15 µm in length, with a slightly thicker isthmus. *Caloplaca lactea* has smaller apothecia up to 0.5 mm in diam. and the thalline margin is not visible macroscopically. When present, the thallus in *C. lactea* consists of greyish granules and is K-. *Caloplaca ferrarii* is another taxon closely resembling *C. crenulatella*. The former differs in having larger apothecia up to 1.5 mm in diam., with the proper margin thin and not prominent and the thalline margin not distinguishable macroscopically. The spores in *C. ferrarii* are longitudinally ellipsoid, of mean length 20 µm, and the isthmus is very thin, ca 1.5 µm. The thallus, when present, does not form areoles, is ochre in color and K-. *Caloplaca ferrarii* mainly occurs in the Mediterranean region (Navarro-Rosinés & Hladun 1996; compare Vondrák *et al.* 2011). *Caloplaca crenulatella* may also be misidentified as *C. lacteoides*. *Caloplaca lacteoides* differs from *C. crenulatella* by having smaller apothecia up to 0.5 mm in diam., pale yellow, rarely orange, and in not having a visible thalline margin. The thallus in this species, when present (usually it is endolithic), is whitish and inconspicuous. In *C. lacteoides* the parathecium is distinctly paraplectenchymatous in the outermost parts and the paraphyses are usually simple, with apical cells strongly thickened, up to 9 µm

wide. *Caloplaca lacteoides* has a mainly Mediterranean distribution (Navarro-Rosinés & Hladun 1996; compare Vondrák *et al.* 2011). *Caloplaca nashii*, which is also similar to *C. crenulatella*, has orange apothecia but of smaller diameter 0.2–0.4(–0.5) mm, usually a white or less frequently slightly yellow thallus, granular or continuous, rarely cracked on the areoles and K-. *Caloplaca nashii* differs from *C. crenulatella* by having shorter and narrower spores, (10.0–) 11.5–16.0(–19.0) × (4.0–) 4.5–6.0 µm, and an almost not visible amphithecium with algae restricted to the base of apothecia (Navarro-Rosinés *et al.* 2001). *Caloplaca interfulgens*, similarly to *C. crenulatella*, forms an epilithic, yellow orange thallus, but the former always has a well developed areolate-squamulose thallus. Its apothecia are small, 0.3–0.5(–0.6) mm diam., without a thalline margin. *Caloplaca interfulgens* is known from North Africa, the Near East and Central Asia (Navarro-Rosinés & Hladun 1996; Vondrák *et al.* 2011). The North American species *C. fracissima* H. Magn. is very similar to *C. crenulatella*. It is very common in the U.S.A., growing on calcareous rock including manmade substrates such as mortar. The distinction between the two species needs to be studied.

The majority of the Carpathians specimens previously identified as *C. lactea* appear to be *C. crenulatella*.

EXSICCATE SEEN. Arnold, *Lich. Exsicc.* 829 (as *Calopisma lacteum* f. *aestimabile*) (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. POGÓRZE CIESZYŃSKIE FOOTHILLS, E slope of Góra Jasieniowa Mt., limestone quarry, alt. 1535 m, 49°43'34"N, 18°44'41"E, 25 Aug. 2005, *K. Wilk* 3714 (KRAM). KOTLINA ŻYWIECKA BASIN, limestone quarry above Radziechowy village, alt. 524 m, 49°39'08"N, 19°06'60"E, 11 Sep. 2005, *K. Wilk* 3880, 3885 (KRAM); Żywiec town, bank of Soła River below Mały Grojec Mt., periodically flooded site, alt. 346 m, 49°40'54"N, 19°11'49"E, 31 Aug. 2005, *K. Wilk* 3787 (KRAM); Radziechowy-Wieprz municipality, trail between Radziechowy and Przybędza villages, alt. 472 m, 49°38'12"N, 19°07'51"E, 11 Sep. 2005, *K. Wilk* 3893 (KRAM); Radziechowy-Wieprz municipality, abandoned limestone quarry near Przybędza village, alt. 493 m, 49°38'06"N, 19°07'45"E, 11 Sep. 2005, *K. Wilk* 3900

(KRAM). BESKID MAŁY MTS, abandoned limestone quarry in Inwałd, alt. 384 m, 49°51'01"N, 19°23'01"E, 27 Aug. 2005, *K. Wilk 3756* (KRAM). KOTLINA ORAWSKO-NOWOTARSKA BASIN, Łopuszna, near Tetmajer Manor, 12 July 1997, *D. Baraniak s.n.* (KRAP). PIENINY SPISKIE MTS, Zielone Skałki range by Jezioro Czorsztyńskie lake, 6 June 2005, *K. Wilk 3478, 3491* (KRAM), *ibid.*, *J. Kozik s.n.* (PPN). PIENINY WŁAŚCIWE MTS, Długa Grapa outcrops, alt. 694 m, 49°24'59"N, 20°20'42"E, 5 June 2005, *K. Wilk 3442, 3443* (KRAM), *ibid.*, 21 June 1988, *J. Kiszka s.n.* (KRAP); Czorsztyn Castle, 6 June 2005, *J. Kozik s.n.* (PPN); limestone outcrops by Czorsztyn Castle, alt. 560 m, 49°26'11"N, 20°18'48"E, 5 June 2005, *K. Wilk 3471* (KRAM); Polana pod Dużym Lachem glade, 21 June 1987, *J. Kiszka s.n.* (KRAP); Polana Przyzamecze glade, 11 July 1987, *J. Kiszka s.n.* (KRAP); Podłaźce, 1999, *J. Kozik s.n.* (PPN); Polana za Zamczyskiem glade, 21 June 1988, *J. Kiszka s.n.* (KRAP); Polana Miedza glade, 10 July 1987, *J. Kiszka s.n.* (KRAP); Polana pod Kirą glade, 8 Sep. 1987, *J. Kiszka s.n.* (KRAP); Polana Wydziorki glade, 8 July 1987, *J. Kiszka s.n.* (KRAP); Podskalnia Góra Mt., 31 Aug. 2005, *J. Kozik s.n.* (PPN). MAŁE PIENINY MTS, Bystrzyk Mt., 12 & 16 June 1999, *J. Kozik s.n.* (PPN). POGÓRZE SPISKO-GUBAŁOWSKIE FOOTHILLS, Magura Spiska, Potok Kacwinianka stream, alt. 595 m, 23 June 1970, *J. Kiszka* (KRAP 10971). WEST TATRA MTS, Dolina Chochołowska valley: Polana Jamy glade, 49°15'21"N, 19°49'15"E, 16 July 2004, *L. Śliwa 3185, 3199* (KRAM), *ibid.*, *K. Wilk 2158* (KRAM), Polana Huciska glade, 49°15'28"N, 19°49'19"E, 19 June 2004, *L. Śliwa 2589* (KRAM), Polana Chochołowska glade, alt. 1125 m, Aug. 1982, *K. Toborowicz s.n.* (KTC).

ADDITIONAL MATERIAL EXAMINED. POLAND. KOTLINA SANDOMIERSKA BASIN. Narol municipality, Ruda Różaniecka, 13 Aug. 1991, *J. Kiszka s.n.* (KRAP).

Caloplaca lactea (A. Massal.) Zahlbr.

Figs 15B & 38

Österr. Botan. Zeitschrift **51**: 347. 1901. – *Callopsisma luteoalbum* var. *lacteam* A. Massal., Schedul. Critic. **7**: 133. 1856.

Thallus endolithic, sometimes small granules or areoles present, pale grey; without prothallus and vegetative propagules. Thalline cortex thin, indistinct (K–). *Apothecia* zeorine, scattered or crowded, round or angular by compression, sessile, 0.3–0.5(–0.9) mm diam.; disc at first slightly concave, then flat, orange, epruinose; proper margin well developed, persistent, raised above disc in young apothecia, thinner and slightly reduced in mature apothecia, slightly paler than disc; thalline margin visible only in young apothecia. Parathecium well developed, prosoplectenchymatous, 85–120 µm, anthraquinone crystals present. Amphithecium strongly reduced, algae not abundant. Epihymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 70 µm high. Paraphyses simple or slightly branched, 1–2 apical cells thickened, up to 6.8 µm wide. Hypothecium hyaline, prosoplectenchymatous. Asci 8-spored,

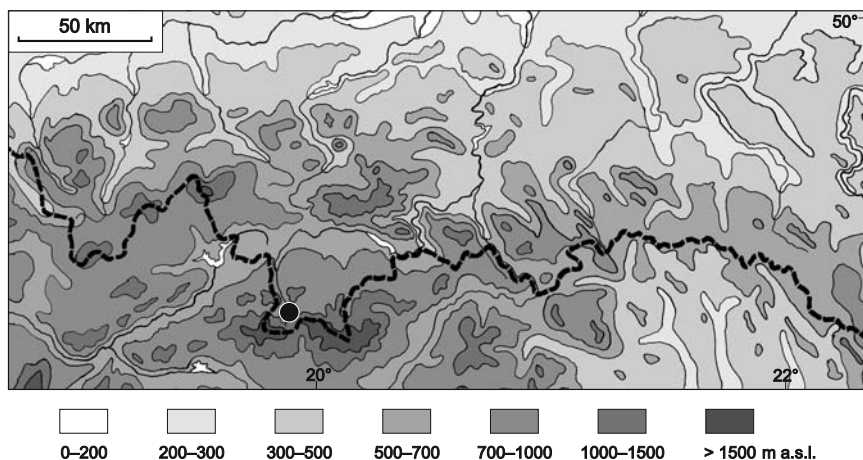


Fig. 38. Distribution of *Caloplaca lactea* (A. Massal.) Zahlbr. in the Polish Western Carpathians.

spores polarilocular, thin-walled, $11.0\text{--}13.5 \times 5.0\text{--}6.8 \mu\text{m}$, isthmus $1.7\text{--}3.4 \mu\text{m}$ wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It grows on limestone rock in open and well insolated areas (e.g., forest glades). It occurs at 1000–1200 m a.s.l.

The species is known from the West Tatras.

DISCUSSION. *Caloplaca lactea* is characterized by its endolithic thallus and orange apothecia with proper margin well developed. The spores of this species are short and broadly ellipsoid.

Caloplaca lactea resembles *C. crenulatella*. My revision indicates that most of the Carpathian specimens earlier identified as *C. lactea* are *C. crenulatella*. The misidentification is due to poor knowledge of this species; hence the confusing definition of *C. lactea* in keys to European taxa (Clauzade & Roux 1985; Laundon 1992a; Wirth 1995) characterized the species as possessing a very thin isthmus and large spores. Navarro-Rosinés and Hladun (1996) clearly differentiated the two species, pointing out that *C. lactea* has shorter and broadly ellipsoid spores usually not exceeding $15 \mu\text{m}$ long, with a slightly thicker isthmus ($2\text{--}3 \mu\text{m}$ wide). *Caloplaca holocarpa* can also be mistaken for *C. lactea*, but the former has a distinctly wider spore isthmus.

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. WEST TATRA MTS, Dolina Kościeliska valley: Polana Pisana glade, alt. 1040 m, $49^{\circ}14'33''\text{N}$, $19^{\circ}51'53''\text{E}$, 14 July 2004, *L. Śliwa 2945* (KRAM), Wyżnia Miętusia Polana glade, alt. 1160 m, $49^{\circ}15'09''\text{N}$, $19^{\circ}53'44''\text{E}$, 17 June 2004, *L. Śliwa 2401* (KRAM).

Caloplaca marmorata (Bagl.) Jatta

Figs 15C & 39

Sylloge Lich. Ital.: 251. 1900. – *Calloposma marmoratum* Bagl., Nuovo Giorn. Botan. Ital. 11: 84. 1879.

Thallus endolithic, without prothallus and vegetative propagules. **Apothecia** pseudolecaneorine, abundant, scattered or crowded, immersed in rock at first, then sessile, round or slightly angular by compression, $0.2\text{--}0.7 \text{mm}$ diam.; disc flat or slightly convex, less frequently strongly convex,

rust to brownish orange, epruinose; proper margin at first thick, then thinner, even, slightly paler than disc; thalline margin absent. Parathecium well developed, thick, $85\text{--}170 \mu\text{m}$, prosoplectenchymatous, cell lumina oval, some algae present at base of parathecium, anthraquinone crystals present. Amphithecium absent. Epithemium interspersed with reddish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, $85\text{--}110 \mu\text{m}$ high. Paraphyses simple or slightly branched, with irregular lumina, $1\text{--}4$ apical cells slightly thickened, up to $5 \mu\text{m}$ wide. Hypothecium hyaline, without crystals and oil droplets, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, $12.5\text{--}17.0 \times 5.5\text{--}8.5 \mu\text{m}$, isthmus $1.5\text{--}3.5 \mu\text{m}$ wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It grows on limestone in sun-exposed situations at 500–1000 m a.s.l.

The species is known from the Pieniny Właściwe Mts and Małe Pieniny Mts.

DISCUSSION. *Caloplaca marmorata* is characterized by its endolithic thallus, rust or brownish orange, small apothecia, and thick proper margin. The epithemium is reddish orange.

The species belongs to the *C. lactea* group (Navarro-Rosinés & Hladun 1996), within which *C. marmorata* can be confused with *C. lactea*, *C. lacteoides*, and *C. nashii*. Unlike *C. marmorata*, *C. lactea* has orange apothecia, a thinner proper margin and broadly ellipsoid spores. The amphithecium in *C. lactea* is well developed with abundant algae.

For a comparison with other similar species see Navarro-Rosinés and Hladun (1996), Navarro-Rosinés *et al.* (2001) and Wilk (2011).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. PIENINY WŁAŚCIWE MTS, Trzy Korony Mt., 4 May 1957, *J. Nowak* (KRAM L-4401). MAŁE PIENINY MTS, Dolina Białej Wody valley, near Jaworki village, 8 June 1968, *J. Nowak* (KRAM L-18696); near Jaworki village, Sołtysie Skalki outcrops, alt. 580 m, $49^{\circ}24'20''\text{N}$, $20^{\circ}32'30''\text{E}$, 3 June 2005, *K. Wilk 3395* (KRAM); Jaworki village, 1888, *W. Boberski* (KRAM L-20914).

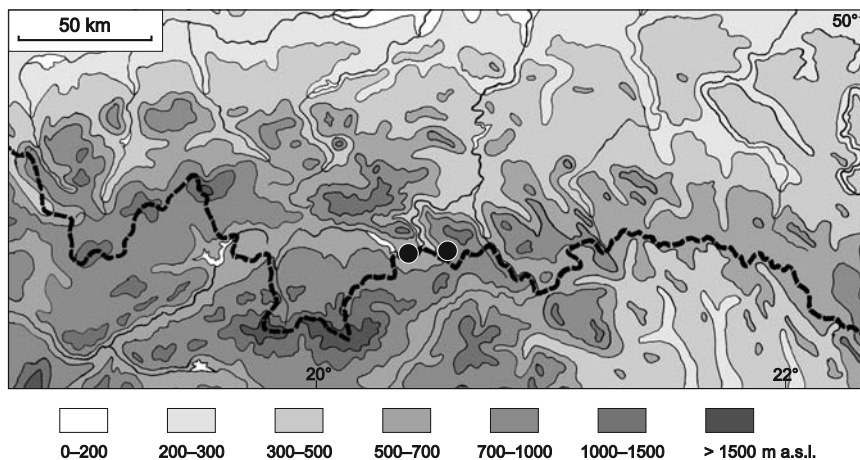


Fig. 39. Distribution of *Caloplaca marmorata* (Bagl.) Jatta in the Polish Western Carpathians.

ADDITIONAL MATERIAL EXAMINED. UKRAINE. KAMELNITSKYI REGION. Kamianets poilskyi district, National Park 'Podolskyi Tovtry', Chotiri Kavalyeri near Vyerbka, 13 km N of Kamianets Podilskyi, alt. 289 m, 48°48'24"N, 26°35'54"E, 25 June 2003, *J. Kiszka* (KRAM L-49147); Kitaihorod, 15 km SE of Kamianets Podilskyi, alt. 141 m, 48°38'25"N, 26°46'58"E, 24 June 2003, *M. Kukwa* (KRAM L-48718); Tovtra Vyerbyetska Reserve, alt. 289 m, 48°48'24"N, 26°35'54"E, 25 June 2003, *L. Śliwa* 1964 (KRAM), *ibid.*, *A. Zalewska* (KRAM L-49328).

Caloplaca Th. Fr. subgenus *Caloplaca*

!! *Caloplaca albolutescens* (Nyl.) H. Olivier Figs 16A & 40

Mémoir. Soc. Nation. Scienc. Natur. Cherbourg 37: 127. 1909. – *Lecanora albolutescens* Nyl., Flora 64: 377. 1881.

Thallus rimose-areolate, thin, ca 200 µm, white to pale grey, sorediate; without prothallus. Surface of thallus tartareous; soredia diffuse covering large areas of the thallus, soredia coarse and violet-grey (K+, N+ violet; sedifolia-grey). Thalline cortex absent, instead many colorless crystals present (pol+, insoluble in K); algal layer continuous; medulla with many colorless crystals (pol+, insoluble in K). *Apothecia* zeorine, scattered or crowded, sessile from the beginning, round to somewhat irregular, old apothecia often flexuous,

up to 1 mm diam.; disc flat, orange to reddish, epruinose; proper margin persistent, at first thick and raised above disc, then thin and ± level with disc, glossy, concolorous with or slightly paler than disc; thalline margin much reduced, white. Parathecium distinct, moderately thick, up to 85 µm, prosoplectenchymatous, cell lumina narrow and long, anthraquinone crystals present. Amphithecium with many algae, ± reduced, sometimes with yellowish crystals (pol+, insoluble in K). Epithemium interspersed with yellowish orange or reddish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 75–95 µm high. Paraphyses richly branched, apical cells not or very slightly thickened, up to 3.5 µm wide. Hypothecium hyaline, sometimes with oil droplets, prosoplectenchymatous, with characteristic intercellular spaces (Fig. 8). Asci 8-spored, spores polarilocular, thin-walled, (13.5–)15.0–18.7(–20.4) × (6.8–)8.0–10.5(–12.0) µm, isthmus 2.4–3.4 µm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It grows on calcareous sandstone often in the vicinity of rivers.

The species is known from the Kotlina Żywiecka basin and the Beskid Makowski Mts, Beskid Wyspowy Mts, Gorce Mts and Beskid Niski Mts.

DISCUSSION. *Caloplaca albolutescens* is characterized by its thin, tartareous, white to pale grey

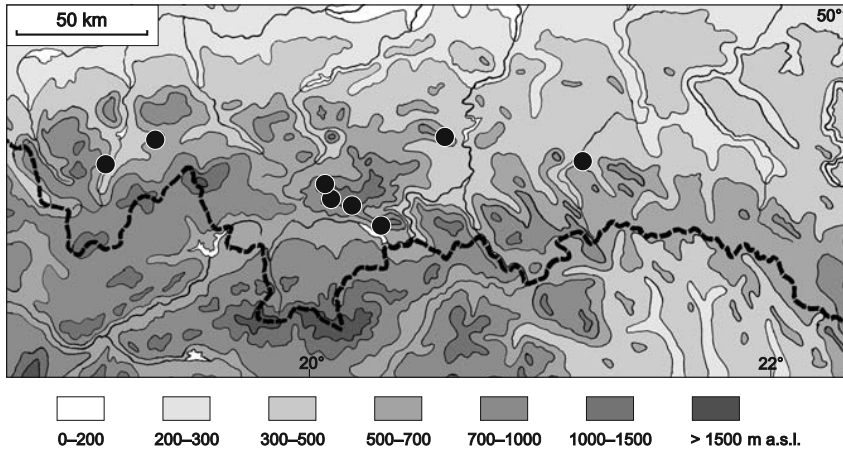


Fig. 40. Distribution of *Caloplaca albolutescens* (Nyl.) H. Olivier in the Polish Western Carpathians.

thallus. The thallus is dissolved partly into coarse, bluish soredia. The apothecia are orange to reddish, with a prominent proper margin and reduced white thalline margin. The spores are broadly ellipsoid with moderately thin isthmus. The paraphyses are slightly thickened on the tips.

It is one of the sorediate *Caloplaca* lacking anthraquinones in the thallus (Vondrák & Hrouzek 2006). This species seems problematic; some authors have treated it as a synonym of *C. teicholyta* (Laundon 1992a; Coppins 2002), while others deem it a separate species (e.g., Wade 1965; Clauzade & Roux 1985; Wirth 1995; Vondrák *et al.* 2007). *Caloplaca albolutescens* requires detailed taxonomic studies, including genetic analyses, in the context of the whole group of related species (e.g., *C. aetnensis* B. de Lesd., *C. erythrocarpa*, *C. soralifera*, *C. teicholyta*). The literature data on *C. albolutescens* are sparse.

Caloplaca albolutescens material from the Carpathians has often been misidentified as *C. erythrocarpa* but the latter has a thicker, distinctly chalky white and esorediate thallus. The apothecia in *C. erythrocarpa* are smaller, uniformly red and initially immersed in the thallus. See also the comments under *C. erythrocarpa*. *Caloplaca teicholyta* differs from *C. albolutescens* by having a thicker thallus, obscurely lobed on the margins and scurfy-granular in the central part. The thallus in *C. teicholyta* is corticate at least at the margins

and more greyish. *Caloplaca soralifera* may be confused with *C. albolutescens*, but the former differs in having a corticate, distinctly areolate, grey thallus with delimited soralia occurring on the margin of areoles. Another poorly known taxon, *C. aetnensis*, differs from *C. albolutescens* by having scattered areoles and a different ecology and distribution; it grows on silicic rock in the Mediterranean region (Egea 1984).

EXSICCATE SEEN. Nowak, *Lich. Polon. Merid. Exsicc.* 204 (as *C. erythrocarpa*) (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. KOTLINA ŻYWIECKA BASIN, Przybędza village, sandstone outcrops near Soła River, alt. 423 m, 49°37'30"N, 19°08'42"E, 31 Aug. 2005, *K. Wilk* 3770 (KRAM). BESKID MAKOWSKI MTS, Pasma Pewelskie range, S slope of Janikowa Grapa, sandstone outcrops by Koszarawa River, alt. 397 m, 49°39'34"N, 19°19'08"E, 28 Sep. 2005, *K. Wilk* 4030 (KRAM). BESKID WYSPOWY MTS, Łososina Dolna, Sadowa village, above Łososina River, alt. 285 m, 27 June 1967, *J. Nowak* (KRAM L-2160, 42641). GORCE MTS, Dolina Dunajca valley, below Szlembark-Dębno town, alt. 520 m, 27 July 1968, *K. Glanc* (KRAM L-27503); Bukowina Mt., SW slope, alt. 900 m, 3 Aug. 1968, *K. Glanc* (KRAM L-27502); Gajówka Mikołaja by Łopuszanka stream, alt. 850 m, 12 Nov. 1997, *P. Czarnota* (GPN 1785/94, GPN 1926/94). BESKID NISKI MTS, Sanok Province, Besko, rocks in Wisłok River, alt. 315 m, 23 Aug. 1974, *J. Nowak* (KRAM L-32137). PIENINY WŁAŚCIWE MTS, S slope of Wdźar Mt., abandoned quarry near RTV

station, alt. 421 m, 49°27'19"N, 20°19'13"E, 7 June 2005, *K. Wilk 3514* (KRAM).

ADDITIONAL MATERIAL EXAMINED. POLAND. WYŻYNA KIELCKA UPLAND, Bodzechów village, SE of Ostrowiec Świętokrzyski, 1992, *E. Sadza s.n.* (KTC); Przedgórze Iłżeckie: Ożarów, 21 June 1978, *K. Toborowicz s.n.* (KTC), Kichary, Opatówka River valley, July 1978, *K. Toborowicz s.n.* (KTC). TURKEY. BLACK SEA COAST. Tuapse, 17 May 2007, *J. Vondrák 6451* (CBFS). SEA OF MARMARA COAST. Tekirdag, valley of small brook near Gazikoy, 11 Apr. 2007, *J. Vondrák 6524* (CBFS). RUSSIA. BLACK SEA COAST. Taman Peninsula, 20 May 2007, *J. Vondrák 6225* (CBFS). UNITED KINGDOM, ENGLAND, Tyneside, Northumberland, Stocksfield, 1878, *W. Johnson* (HOLOTYPE, H-Nyl. 29845).

Caloplaca citrina (Hoffm.) Th. Fr.

Figs 16B & 41

Lich. Arct.: 118. 1860 (= Nova Acta Regiae Soc. Sci. Upsal., ser. 3, 3: 218. 1861). – *Verrucaria citrina* Hoffm., Deutschl. Fl.: 198. 1796.

Thallus areolate, thin or thick, 90–300 µm, yellow, citrine yellow, yellow orange or orange, in shade greenish yellow, occasionally whitish pruinose, sorediate; without prothallus. Areoles crowded or scattered, more or less convex, rarely flat, irregular or roundish, sometimes slightly crenate; soralia on the margin and surface of areoles, soralia irregularly distributed, or areoles completely

dissolved into soredia; soredia concolorous with thallus or rarely slightly paler (K+ red), fine, 15–85 µm diam. Thalline cortex thin, 5–40 µm, indistinctly paraplectenchymatous, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface, without necral layer; algal layer continuous. *Apothecia* zeorine, infrequent or absent, sessile, round, up to 1 mm diam.; disc flat, dark orange; proper margin persistent, concolorous with disc; thalline margin present or excluded, even, often sorediate. Parathecium prosoplectenchymatous, cell lumina elongate, anthraquinone crystals present. Amphithecium slightly reduced, with many algae, anthraquinone crystals present. Epihymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 60–90 µm high. Paraphyses simple to slightly branched, 1–3 apical cells thickened, up to 6–8 µm wide, with oil droplets. Hypothecium hyaline, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, 7.5–15.0 × 4.0–6.5(–8.0) µm, isthmus 2–6 µm wide. *Pycnidia* partially immersed in thallus; ostiolum dark orange; conidia bacilliform, 2.5–3.0 × 1.0–1.5 µm.

HABITAT AND DISTRIBUTION. It occurs on limestone rock, calcareous sandstone or shale in well insolated or shaded places. It occupies the surface of vertical rock walls, rock crevices

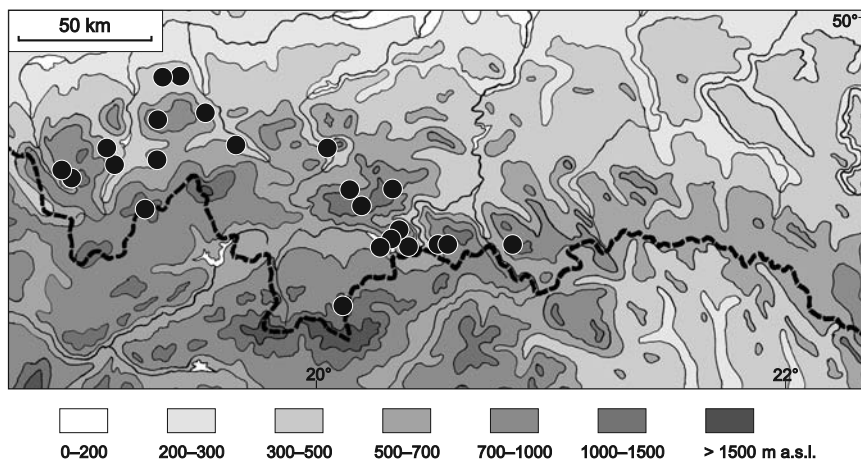


Fig. 41. Distribution of *Caloplaca citrina* (Hoffm.) Th. Fr. in the Polish Western Carpathians.

and stones. It was collected on banks of rivers or streams, often in periodically flooded places or in quarries. It occurs at sites of various aspect at 350–1200 m a.s.l.

The species is widely distributed in the Beskidy Zachodnie Mts (Beskid Śląski Mts, Kotlina Żywiecka basin, Beskid Mały Mts, Beskid Makowski Mts, Beskid Wyspowy Mts, Beskid Żywiecki Mts, Gorce Mts, Beskid Sądecki Mts) and also in the Pieniny Właściwe Mts, Małe Pieniny Mts and High Tatras.

DISCUSSION. *Caloplaca citrina* is characterized by its yellow, areolate and sorediate thallus. The thalline areoles are convex. The soralia are marginal or laminal and are arranged irregularly. The soredia are concolorous with the thallus.

The *C. citrina* group, uniting species characterized by their yellow sorediate thallus, occurring often in sterile form, has been studied by Wetmore (2001), Arup (2006a) and most recently Vondrák *et al.* (2009). The latter authors suggested numerous taxonomic novelties. They distinguished three types of soralia in species of the *C. citrina* group which seemed helpful in identification: *C. confuse*-type, *C. flavocitrina*-type and *C. limonia*-type.

Caloplaca flavocitrina is closely related to *C. citrina*, but the former differs in having a usually more orange thallus and yellow soralia contrasting with the thallus. The thalline areoles in *C. flavocitrina* are flat and the soralia are located on their margins, which lift slightly at the edge. The soralia in *C. flavocitrina* are spread in a more regular pattern than in *C. citrina*. Also, in *C. flavocitrina* the spores are slightly bigger than in *C. citrina*, and the isthmus/spore length ratio is somewhat higher in *C. flavocitrina* (for more details see Arup 2006a). *Caloplaca xanthostigmoidea* differs from *C. citrina* by having a different type of vegetative diaspores: it produces isidioid blastidia. *Caloplaca xanthostigmoidea* has no or very few algae in the apothecial margin. In terms of chemistry, the thallus of *C. xanthostigmoidea* is often partially olive green due to the presence of cinereorufagreen pigment (K–, N+ violet), and it contains an infrequent chemosyndrome, 7-chloroemodin (Søchting & Tønberg 1997; Wetmore 2001).

Unlike *C. citrina*, *C. dichroa* produces spores with distinctly thickened walls. It also forms different vegetative diaspores – blastidia – and the thallus frequently is bicolored (yellow and orange, often side by side). Sterile *C. dichroa* specimens with a thin and weakly developed thallus might be difficult to distinguish from *C. citrina* (see also Arup 2006a). *Caloplaca arcis* (Poelt & Vězda) Arup differs from *C. citrina* by having a sublobate thallus and coarse blastidia mixed with apothecia in the central part of the thallus (Arup 2006a). *Caloplaca limonia* Nimis & Poelt replaces *C. citrina* in the Mediterranean region and on the Black Sea shore. It differs from *C. citrina* by having a pale yellow thallus, areoles dissolved into blastidia, a thick apothecial margin covered by blastidia/soredia, and its ecology: it occurs mainly on rocks along the seashore (Vondrák *et al.* 2009). *Caloplaca britannica* R. Sant. is similar to *C. citrina* but produces a blastidiate-isidiate thallus. It is very problematic and it needs further studies (Laundon 1992b; Aptroot & van Herk 2004; Vondrák *et al.* 2009). For a comparison of *C. citrina* with *C. chrysodeta* and *C. xatholyta* see the comments under those species. Some other taxa besides the ones discussed above resemble *C. citrina*, for example *C. soropelta* (E. S. Hansen, Poelt & Søchting) Søchting (Søchting 1992), *C. sorediella* Arup (Arup 2006b) and *C. gyalolechiiformis* Szatala (Kondratyuk *et al.* 2002; Vondrák *et al.* 2010). For discussions of this particular species see the references cited.

EXSICCATE SEEN. Wetmore, *Telos. Exsicc.* 30 (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. BESKID ŚLĄSKI MTS, Barania Góra range: Dorkowa Skała outcrops above Szarcuła pass, alt. 483 m, 49°36'19"N, 18°55'17"E, 8 Sep. 2005, *K. Wilk* 3822, 3824, 3837 (KRAM), near the crossroads to Łączyna, Pietraszonka and Stecówka, alt. 440 m, 49°34'48"N, 18°57'04"E, 8 Sep. 2005, *K. Wilk* 3828 (KRAM). KOTLINA ŻYWIECKA BASIN, quarry of limestone above Radziechowy village, alt. 524 m, 49°39'08"N, 19°06'60"E, 11 Sep. 2005, *K. Wilk* 3877 (KRAM); Żywiec town, shore of Soła River below Mały Grojec Mt., alt. 346 m, 49°40'39"N, 19°11'47"E, 31 Aug. 2005, *K. Wilk* 3784, 3796, 3797 (KRAM), *ibid.*, alt. 345 m, 49°40'54"N, 19°11'49"E, 6 Sep. 2005, *K. Wilk* 3812 (KRAM); Przybędza village, sandstone outcrops by Soła River, alt. 423 m, 49°37'30"N, 19°08'42"E, 31 Aug.

2005, *K. Wilk 3779* (KRAM). BESKID MAŁY MTS, Andrychów community: abandoned quarry of limestone in Inwałd town, alt. 478 m, 49°51'07"N, 19°23'26"E, 25 Sep. 2005, *K. Wilk 3981* (KRAM), *ibid.*, alt. 384 m, 49°51'01"N, 19°23'01"E, 27 Aug. 2005, *K. Wilk 3729, 3752* (KRAM); Roczniny Pod Górąmi, quarry of limestone at the base of Złota Górka Mt., alt. ca 430 m, 49°49'47"N, 19°18'21"E, 24 Sep. 2005, *K. Wilk 3968* (KRAM); abandoned quarry of limestone in Roczniny, ca 430 m, 27 Aug. 2005, *K. Wilk 3738* (KRAM); Zamczysko to the N of Łysina village, alt. 756 m, 49°44'52"N, 19°18'17"E, 22 Sep. 2005, *K. Wilk 3944, 3945a* (KRAM). BESKID MAKOWSKI MTS, Żurawnica Mt., Kozie Skały outcrops, alt. 720 m, 49°45'42"N, 19°30'51"E, 20 Sep. 2005, *K. Wilk 3930* (KRAM); Pasma Pewelskie range, E of Koleby village, sandstone outcrops by railway above Koszarawa River, alt. 397 m, 49°40'16"N, 19°15'20"E, 29 Sep. 2005, *K. Wilk 4051* (KRAM); S slope of Janikowa Grapa, limestone rocks on the bank of Koszarawa River, periodically flooded habitat, alt. 397 m, 49°39'34"N, 19°19'08"E, 28 Sep. 2005, *K. Wilk 4045* (KRAM). BESKID WYSPOWY MTS, Kasinka Mała, Cize, between Bydłoniowa and Gródek, alt. 410 m, 20 May 1967, *J. Nowak* (KRAM L-5361). BESKID ŻYWIECKI MTS, Pilsko Mt., sandstone outcrops in forest between Hala Miziowa and Hala Jodłowcowa, alt. 1253 m, 49°32'38"N, 19°18'29"E, 27 Sep. 2005, *K. Wilk 4013* (KRAM), *ibid.*, alt. 1200 m, 10 Sep. 2005, *K. Wilk 3874* (KRAM); Pasma Jałowca range, Grzechynia, alt. 480 m, 22 Sep. 1965, *J. Nowak* (KRAM L-15582). GORCE MTS, by Kamiénica near old GPN building in Rzeki, alt. 700 m, 12 July 1999, *P. Czarnota* (GPN 2201); Poręba Wielka near Niedźwiedz, alt. 525 m, 16 Sep. 1994, *J. Nowak* (KRAM L-32160), *ibid.*, 17 Sep. 1994, *J. Nowak* (KRAM L-32113); Lubań, Koci Zamek, alt. 600 m, 15 Aug. 1967, *K. Glanc* (KRAM L-27512); Furców Wierch Mt., S slope, above Ochotnica, alt. 875 m, 6 Aug. 1968, *K. Glanc* (KRAM L-27511); Starmaszcze on the western slopes of Witowa, alt. 550 m, 10 June 1999, *P. Czarnota* (GPN 1971/94); 'Koniński Baca' outcrop below Kudłoń Mt., alt. 1120 m, 29 Sep. 1995, *P. Czarnota* (GPN 1728/94); Ku Samorodom outcrops below Sredniak glade, alt. 1080 m, 3 Sep. 1997, *P. Czarnota* (GPN 1624/94); Poręba Wielka, manor park, alt. 540 m, 27 June 1999, *P. Czarnota* (GPN 1969/94). BESKID SADECKI MTS, Żebracze reserve, alt. 840 m, 29 Sep. 1995, *P. Czarnota* (GPN 2579). PIENINY WŁAŚCIWE MTS, limestone outcrops by the Czorsztyn Castle, alt. 560 m, 49°26'11"N, 20°18'48"E, 5 June 2005, *K. Wilk 3469a, b* (KRAM); Długa Grapa outcrops, alt. 694 m, 49°24'59"N, 20°20'42"E, 5 June 2005, *K. Wilk 3450, 3451* (KRAM); the Czorsztyn

Castle, 6 June 2005, *J. Kozik s.n.* (PPN); Skała pod Orłem, 9 Apr. 2000, *J. Kozik s.n.* (PPN); Podskalnia Mt., 26 June 1999, *J. Kozik s.n.* (PPN). MAŁE PIENINY MTS, Sołtysie Skałki outcrops near Jaworki village, alt. 580 m, 49°24'20"N, 20°32'30"E, 3 June 2005, *K. Wilk 3393, 3401, 3422a, 3422b* (KRAM); Dziobakowe Skały outcrops, SE of Jaworki village, alt. 738 m, 49°23'21"N, 20°34'05"E, 4 June 2005, *K. Wilk 3436, 3440* (KRAM); Bystrzyk Mt., 19 June 1999, *J. Kozik s.n.* (PPN). HIGH TATRA MTS, Łysa Skałka range, 49°15'50"N, 20°06'50"E, 12 Oct. 2005, *K. Wilk 4100, 4105* (KRAM).

ADDITIONAL MATERIAL EXAMINED. POLAND. WESTERN CARPATHIANS. BESKID MAŁY MTS, Nadole village near Świnna Poręba, alt. 280 m, 12 Oct. 1995, *J. Nowak* (KRAM L-42216, 42220); Targanice, alt. 500 m, 10 May 1962, *J. Nowak* (KRAM L-9494). Beskid Makowski Mts, Pcim, Mizerówka village, alt. 340 m, 22 Aug. 1996, *J. Nowak* (KRAM L-42980); Łętownia, Saguchowa village, alt. 520 m, 11 Oct. 1996, *J. Nowak* (KRAM L-43279).

Caloplaca coccinea (Müll. Arg.) Poelt

Figs 16C & 42

Mitt. Bot. Staatssamml. München **12**: 5. 1975. – *Blasenia coccinea* Müll. Arg., *Flora* **50**: 366. 1867.

Thallus endolithic to faintly epilithic and then composed of very small granules immersed in the rock, orange (K+ red); without prothallus and vegetative propagules. *Apothecia* biatorine, not abundant, scattered or in small groups, initially immersed in rock, then ± sessile, round or slightly angular by compression, 0.2–0.6 mm diam.; disc flat, then slightly convex, carmine red with orange tint, rough; proper margin persistent, distinct, moderately thick, even, slightly paler than disc; thalline margin absent. Parathecium well developed, thick, prosoplectenchymatous, with anthraquinone crystals. Amphithecium absent. Epithemium interspersed with reddish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, small, 60–70 µm high. Paraphyses simple or sometimes with few branches, apical cells slightly thickened, up to 5 µm wide. Hypothecium hyaline, without oil droplets and crystals, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled (only young slightly thickened), 8.5–13.5 × 5.5–7.5 µm,

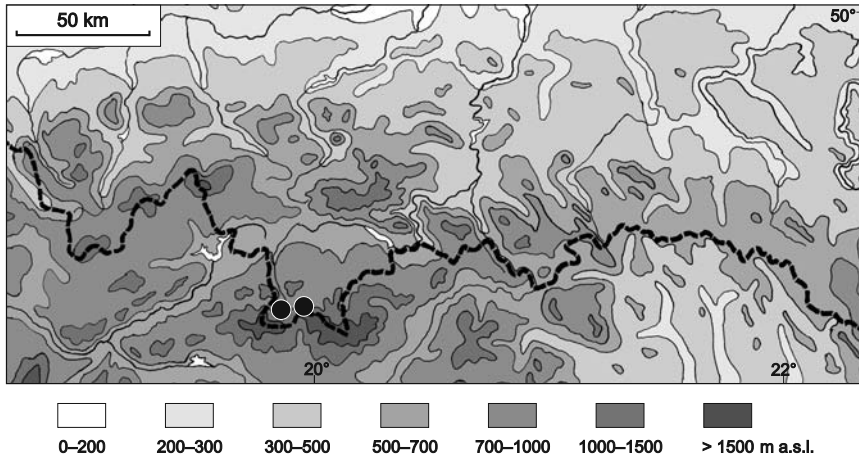


Fig. 42. Distribution of *Caloplaca coccinea* (Müll. Arg.) Poelt in the Polish Western Carpathians.

isthmus 2–5 μm wide. *Pycnidia* usually abundant, partially immersed; ostiolum orange red; conidia bacilliform, $2.5\text{--}3.5 \times 1.5 \mu\text{m}$.

HABITAT AND DISTRIBUTION. It occurs on sun-exposed vertical limestone walls facing south and southwest.

The species is known from the West Tatras.

DISCUSSION. *Caloplaca coccinea* is characterized by its orange thallus consisting of small granules immersed in rock. The apothecia are carmine red, persistently or only initially immersed in rock and later becoming sessile. The species has biatorine apothecia with a persistent, even and thick proper margin.

Caloplaca coccinea resembles *C. keissleri* but the latter differs in having a yellow to yellow orange thallus and apothecia. In *C. keissleri* the apothecia are persistently immersed in rock, never sessile, the proper margin is distinctly thinner and flexuous, and the parathecium and hypothecium are paraplectenchymatous. *Caloplaca tavaresiana* Nav.-Ros. & Cl. Roux also resembles *C. coccinea* but it differs in having a white thallus, larger spores and a wider isthmus. It also has a different ecology and occurs only in the Mediterranean area (Navarro-Rosinés & Roux 1993).

The literature data on *C. coccinea* are sparse.

EXSICCATES SEEN. Poelt, *Lich. Alpium* 81 (as *C. ar-*

noldiana) (KRAM); Suza, *Lich. Bohemoslov.* 149 (as *C. nubigena*) (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. WEST TATRA MTS, Rzędy, S slope of Ciemiński Mt., alt. ca 1800 m, $49^{\circ}13'75''\text{N}$, $19^{\circ}53'80''\text{E}$, 11 July 2004, K. Wilk 2122 (KRAM); Wielka Turnia, 8 July 1925, J. Motyka (KRAM L-3161).

ADDITIONAL MATERIAL EXAMINED. SLOVAKIA. BIELSKIE TATRY MTS. Zadné Jatky, alt. 2020 m, 22 July 1956, Z. Tobolewski (POZ 41).

Caloplaca coronata (Kremp. ex Körb.)

J. Steiner

Figs 16D & 43

Verh. Zool.-bot. Ges. Wien **69**: 71. 1919. – *Calloposma aurantiacum* var. *coronatum* Kremp. ex Körb., *Parerga Lichenol.*: 66. 1859.

Thallus areolate, 220–250 μm thick, dark yellow, yellow orange to reddish orange (all colors may occur on the same specimen), isidiate; without prothallus. Isidia unbranched, longitudinal or roundish. Thalline cortex very thin, indistinct, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface; algal layer continuous. *Apothecia* zeorine, rare, round or slightly angular, sessile, 0.2–0.4 mm diam.; disc flat, brownish or reddish orange; proper margin thin and weakly visible, slightly paler than disc; thalline margin persistent, crenulate. Parathecium thin, prosoplectenchymatous, anthraquinone crystals present. Amphithecium

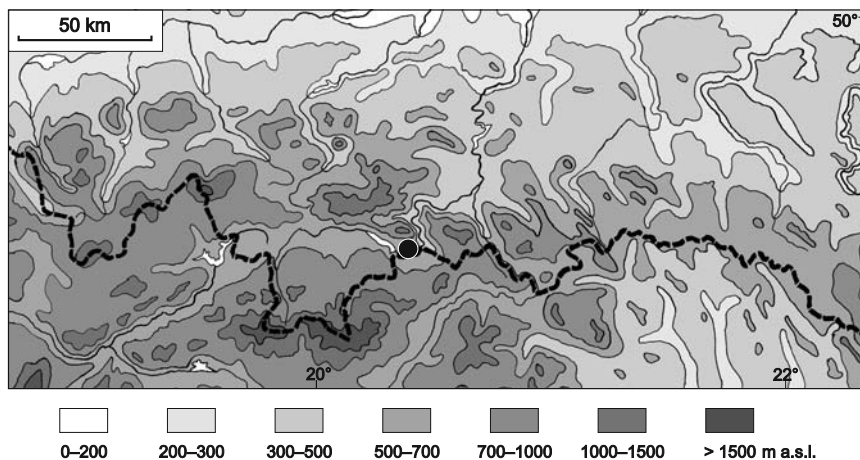


Fig. 43. Distribution of *Caloplaca coronata* (Kremp. ex Körb.) J. Steiner in the Polish Western Carpathians.

with many algae, anthraquinone crystals present. Epihymenium interspersed with reddish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, small, 60–70 μm high. Paraphyses simple to slightly branched, apical cells slightly thickened. Hypothecium hyaline, without crystals and oil droplets, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, 10.0–13.5 \times 6.5–8.5 μm , isthmus 3.5–5.0 μm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It grows on limestone rock in sunny places. It often inhabits the upper parts of limestone outcrops.

The species is known from the Pieniny Właściwe Mts.

DISCUSSION. *Caloplaca coronata* is characterized by its isidiate, dark orange thallus. Apothecia are infrequent in this species; they produce thin-walled spores.

Caloplaca coronata is unusual in producing isidia, which are not very common in the genus *Caloplaca*. The recently described species *C. dichroa* differs from *C. coronata* in producing larger, thick-walled spores, and soredia and blastidia instead of true isidia. The two taxa also differ in their geographical distribution; *C. coronata* occurs mainly in southern Europe, while *C. dichroa* is more widespread in Europe. For more details see Arup (2006a).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. PIENINY WŁAŚCIWE MTS, Macelak Mt., 5 May 1955, *J. Nowak* (KRAM L-1476); Sokolica Mt., alt. 740 m, 5 May 1957, *J. Nowak* (KRAM L-3010); Cyrłowa Mała, alt. 825 m, 6 May 1957, *J. Nowak* (KRAM L-2410).

Caloplaca dichroa Arup

Figs 16E & 44

Lichenologist 38: 13. 2006.

Thallus areolate or sometimes sublobate, 100–400 μm thick, yellow, yellowish orange or dark orange, often occurs with yellow and orange thalli side by side, prothallus seldom present (concolorous with thallus), blastidiate. Areoles crowded to scattered, irregular, flat to convex, often with slightly crenate margins; blastidia, soredia and fine granules numerous on the surface and margin of areoles, usually covering most of the thallus, 30–90 μm diam. Thalline cortex very thin, up to 10 μm , with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface; medulla with many yellow crystals. *Apothecia* zeorine, present or absent, not numerous, scattered in center and near margins of thallus, slightly immersed at first, then sessile, round or flexuous when old, 0.5–1.5 mm diam.; disc flat, somewhat convex in old apothecia, orange; proper margin concolorous with disc or slightly paler, smooth; thalline margin thick and prominent at first,

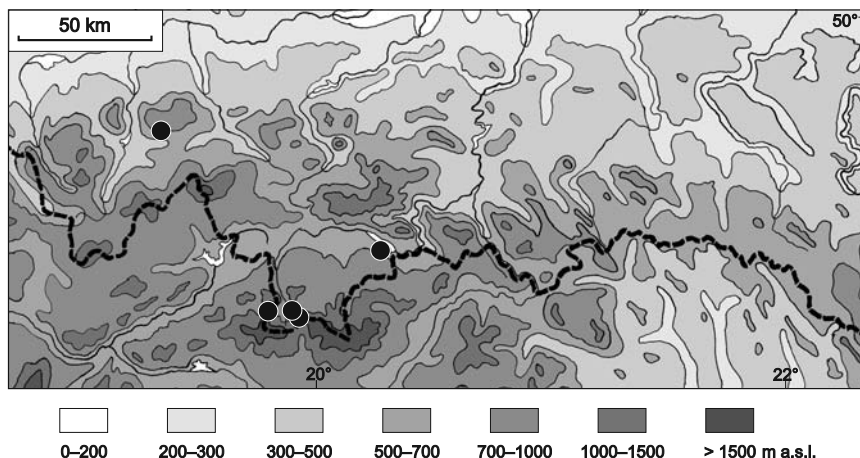


Fig. 44. Distribution of *Caloplaca dichroa* Arup in the Polish Western Carpathians.

becoming reduced and visible at base of apothecia, even or crenulate, or alternatively \pm persistent and only slightly reduced. Parathecium thin or thick, prosoplectenchymatous, cell lumina oval or round, anthraquinone crystals present. Amphithecium often reduced and visible at base of apothecium, algae abundant, anthraquinone crystals present. Epihymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 65–95 μm high. Paraphyses simple, slightly branched or anastomosing, with oil droplets, 1–3(–5) apical cells thickened, up to 5–8 μm wide, or apical cells not thickened. Hypothecium hyaline, with oil droplets, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thick-walled (1–2 μm), 10–15 \times 5–8 μm , isthmus 2.0–4.5 μm wide. *Pycnidia* common, numerous, immersed; ostiolum orange; conidia bacilliform, 2–3(–4) \times 1 μm .

HABITAT AND DISTRIBUTION. It grows on limestone and calcareous sandstone, mainly in sun-exposed situations. Usually it occurs on south-facing vertical rock walls or the upper part of rock outcrops. It grows at 500–1800 m a.s.l.

The species is known from the Beskid Mały Mts, Pieniny Spiskie Mts and West Tatras. It seems to be common in those areas.

DISCUSSION. *Caloplaca dichroa* is characterized by its yellow or dark orange areolate thallus

(often both color morphs occur side by side). It produces vegetative propagules such as blastidia that usually cover the thallus entirely. The spore walls are distinctly thickened in this species.

Caloplaca dichroa is included in the *C. citrina* group (Arup 2006a). It may be confused with *C. citrina*, but the latter has a distinctly sorediate, yellow thallus, and thin-walled spores. *Caloplaca arcis* differs from *C. dichroa* by having a thicker thallus with marginal areoles distinctly lobed, and also thin-walled spores. According to Arup (2006a), *C. dichroa* has often been confused with *C. coronata*, which has a more distinctly isidiate thallus and produces smaller, thin-walled spores.

For more comments on the species see Wilk (2011).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. BESKID MAŁY MTS, Zameczysko above Łysina village, alt. 756 m, 49°44'52"N, 19°18'17"E, 22 Sep. 2005, *K. Wilk 3945b* (KRAM). PIENINY SPISKIE MTS, Zielone Skałki range by Jezioro Czorsztyńskie lake, NE of Falsztyn, alt. ca 580 m, 49°25'56"N, 20°17'35"E, 6 June 2005 and 12 Nov. 2005, *K. Wilk 3484, 3485, 4137, 4138* (KRAM). WEST TATRA MTS, Wąwóz Kraków canyon, alt. 1100 m, 15 July 2004, *K. Wilk 2141* (KRAM); below Mnichy Chochołowskie crags, E of Skorusi Żleb, alt. 1300 m, 49°14'29"N, 19°47'43"E, 19 July 2004, *K. Wilk 2177* (KRAM); Mnichy Chochołowskie crags, S slope, alt. 1488 m, 49°14'40"N, 19°47'42"E, 19 July 2004, *K. Wilk 2183* (KRAM); Rzędy below Ciemniak

Mt., alt. 1800 m, 49°13'75"N, 19°53'80"E, 11 July 2004, *K. Wilk 2109b, 2111* (KRAM).

ADDITIONAL MATERIAL EXAMINED. UKRAINE. KAMELNITSKYI REGION. Kamianets Podilskyi district, National Park 'Podilskyi Tovtry', Privorita near Makiv, 10 km N of Kamianets Podilskyi, alt. 223 m, 48°47'27"N, 26°38'41"E, 25 June 2003, *U. Bielczyk* (KRAM L-48993).

Caloplaca dolomitica (Hue) Zahlbr.

Figs 16F & 45

Cat. Lich. Univ. 7: 115. 1930. – *Lecanora dolomitica* Hue, Annal. Mycol. 13: 83. 1915.

Thallus areolate or sublobate, thin or thick, when thick often divided by deep furrows, irregular, dark yellow, yellow orange, epruinose; without prothallus and vegetative propagules. Areoles often crenate, surface uneven. Thalline cortex thick or thin, distinct, 25–95 µm, paraplectenchymatous, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface; medulla paraplectenchymatous; algal layer discontinuous. *Apothecia* zeorine, abundant, sometimes completely covering the thallus, crowded, at first immersed, then sessile, usually angular and flexuous by compression, seldom round, 0.2–1.0 mm diam.; disc flat, then slightly convex, epruinose, slightly glossy, orange to dark orange; proper margin persistent, thin, even, slightly glossy, paler than disc;

thalline margin ± reduced, crenate. Parathecium moderately thick, 85–100 µm, distinct, prosoplectenchymatous, cell lumina oval, anthraquinone crystals present. Amphithecium well developed, with many algae, anthraquinone crystals present. Epihymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 85–100 µm high. Paraphyses simple to slightly branched, surrounded by gel substances (squash preparation), apical cells not thickened or slightly thickened, up to 5.5 µm wide. Hypothecium hyaline, without cysts, sometimes with oil droplets, prosoplectenchymatous; below hypothecium a layer of small paraplectenchymatous thick-walled cells is present. Asci 8-spored, spores polarilocular, thin-walled, 8.5–12.5 × 5.0–9.5 µm, isthmus 2.5–5.0 µm wide. *Pycnidia* immersed in thallus, slightly visible; ostiolum orange; conidia 3.5–5.0 × 1 µm.

HABITAT AND DISTRIBUTION. It grows on limestone and calcareous sandstone in sun-exposed or slightly shaded situations, mostly south-facing. The species grows at 520–1140 m a.s.l.

It is known from the Kotlina Żywiecka basin, Gorce Mts, Małe Pieniny Mts and West Tatras.

DISCUSSION. *Caloplaca dolomitica* is characterized by its areolate, dark yellow thallus and abundant, crowded apothecia. The spores are sub-spherical and have moderately wide isthmus.

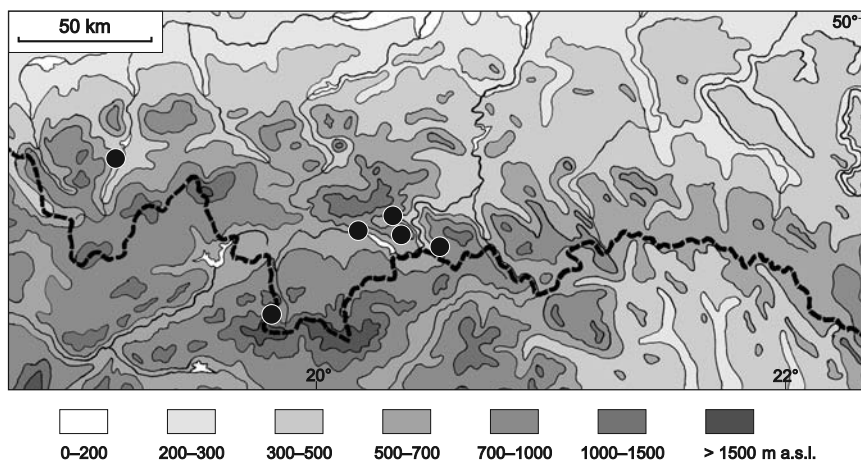


Fig. 45. Distribution of *Caloplaca dolomitica* (Hue) Zahlbr. in the Polish Western Carpathians.

Caloplaca dolomiticola closely resembles *C. velana* and some authors have treated them as synonyms (e.g., Nimis & Poelt 1987; Randlane & Saag 2004) or consider *C. dolomiticola* to be a form of *C. velana* (Clauzade & Roux 1985). *Caloplaca dolomiticola* together with *C. velana* forms a very problematic complex greatly in need of detailed taxonomic and nomenclatural studies. Some *C. dolomiticola* specimens with a well developed thallus and marginal areoles distinctly lobed may resemble species of the subgenus *Gasparrinia*.

Caloplaca velana differs from *C. dolomiticola* by having a less developed, areolate thallus with \pm convex areoles, and no lobed marginal areoles at all (Clauzade & Roux 1985; Arup 1990). *Caloplaca glomerata* Arup is very similar to *C. dolomiticola* but differs by having spores with distinctly thickened apical walls (spores of the *Physcia* type). The apothecia of *C. glomerata* are more crowded; they form aggregates separated by deep crevices. Moreover, *C. glomerata* does not produce marginal lobes (Arup 1990; Navarro-Rosinés *et al.* 1996). *Caloplaca polycarpa* also resembles *C. dolomiticola* but differs in having a thinner orange thallus usually surrounded by a concolorous prothallus. Moreover, the former produces ellipsoid spores (not subspherical as in *C. dolomiticola*), and has a different ecology: it is a parasite species occurring on endolithic species of *Verrucaria* s.l. *Caloplaca subsoluta* (Nyl.) Zahlbr. [= *C. irrubescens* (Nyl.

ex Arnold) Zahlbr.; Wetmore 2003] differs from *C. dolomiticola* in having smaller apothecia (up to 0.5 mm diam.), sessile from the beginning, a flat apothecial disc and a paraplectechymatous parathecium. It also has a different ecology, occurring on siliceous rocks (Clauzade & Roux 1985).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. KOTLINA ŻYWIECKA BASIN, Grojec Mt. near Żywiec city, alt. 610 m, 15 June 1966, *J. Nowak* (KRAM L-17067). GORCE MTS, Boginka rock, above right slope of valley of Lubański stream, alt. 680 m, 15 Aug. 1967, *K. Glanc* (KRAM L-27480, 27481); Lubań, Koci Zamek, N slope, alt. 600 m, 8 Aug. 1967, *K. Glanc* (KRAM L-27479); Dolina Dunajca valley, near Dębno, alt. 520 m, 27 July 1968, *K. Glanc* (KRAM L-27493). MAŁE PIENINY MTS, Wąwóz Homole canyon near Jaworki village, 3 May 1957, *J. Nowak* (KRAM L-4397), *ibid.*, May 1891, *s.coll.* (KRAM L-21947). WEST TATRA MTS, Dolina Chochołowska valley, Polana Chochołowska glade, alt. 1140 m, 1 Dec. 1995, *J. Nowak* (KRAM L-42353).

Caloplaca flavocitrina (Nyl.) H. Olivier

Figs 17A & 46

Mémoir. Soc. Nation. Scienc. Natur. Cherbourg 37: 110. 1909. – *Lecanora flavocitrina* Nyl., Flora 69: 461. 1886.

Thallus areolate, thin or thick, yellow orange, orange, or less frequently yellow, sore-diate; without prothallus. Areoles crowded or

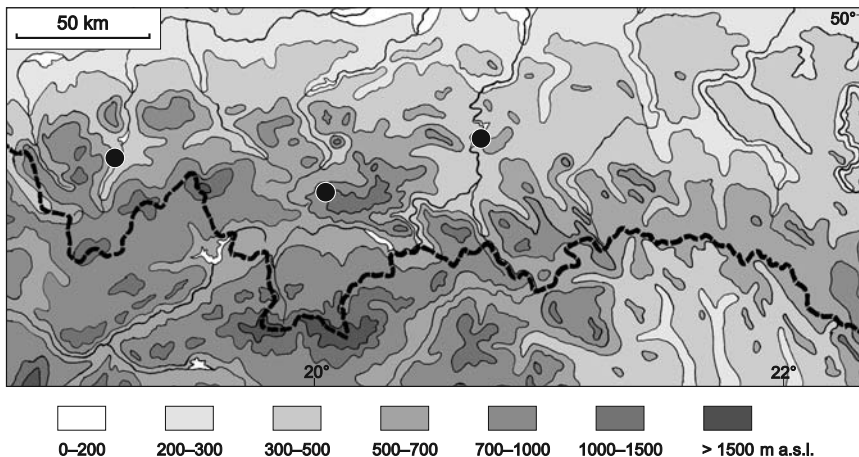


Fig. 46. Distribution of *Caloplaca flavocitrina* (Nyl.) H. Olivier in the Polish Western Carpathians.

scattered, irregular, flat, undulate, rarely convex, crenate, margin of areoles often turned slightly upwards. Soralia usually marginal, rarely on the surface of areoles, \pm regularly distributed; soredia yellow, usually contrasting against the orange thallus. Thalline cortex thin, indistinct, 15–30 μm , paraplectenchymatous, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) in the upper part. *Apothecia* zeorine, infrequent or absent, scattered, round, sessile, 0.3–0.5 mm diam.; disc flat or slightly convex, dark orange; proper margin persistent, at first raised, then level with disc, concolorous with disc; thalline margin reduced, sorediate. Parthecium prosoplectenchymatous, anthraquinone crystals present. Amphithecium with many algae, slightly reduced, anthraquinone crystals present. Epihymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 45–90 μm high. Paraphyses branched and anastomosing, apical cells moderately thickened, up to 6 μm wide. Hypothecium hyaline, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, 9–14 \times 4.5–7.5 μm , isthmus 3–6 μm wide. *Pycnidia* immersed; ostiolum orange; conidia bacilliform, 2.5–3.0 \times 1.0–1.5 μm .

HABITAT AND DISTRIBUTION. It grows on calcareous sandstone and limestone in very sunny places. It was often collected from outcrops on river banks, in periodically flooded places. It occurs at 320–600 m a.s.l.

The species is known from the Kotlina Żywiecka basin, Gorce Mts and Pogórze Rożnowskie foothills.

DISCUSSION. *Caloplaca flavocitrina* is characterized by an areolate, yellow orange or orange, sorediate thallus. The thalline areoles are flat. The soralia are arranged \pm regularly on the margins of areoles which often are lifted slightly at the edge. The soredia are yellow, contrasting against the thallus.

The species belongs to the *C. citrina* group (Arup 2006a). Detailed data on the group are given by Wetmore (2001), Arup (2006a) and Vondrák *et al.* (2009). For a long time many authors treated

C. flavocitrina as a synonym of *C. citrina*, but recent studies have provided more morphological and genetic evidence for separating the two taxa (see comments under *C. citrina*; compare also Arup 2006a). Vondrák *et al.* (2009) recently described the cryptospecies (e.g., *C. confusa* Vondrák, Arup & Søchting and *C. nigromarina* Vondrák, Arup & Søchting), which are distinguished from *C. flavocitrina* only by genetic analyses. The studied Carpathian materials have not been analyzed genetically.

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. KOTLINA ŻYWIECKA BASIN, Żywiec city, shore of Soła River below Mały Grojec Mt., periodically flooded habitat, alt. 346 m, 49°40'54"N, 19°11'49"E, 31 Aug. 2005, *K. Wilk 3780, 3782* (KRAM), *ibid.*, alt. 346 m, 49°40'39"N, 19°11'47"E, 31 Aug. 2005, *K. Wilk 3800* (KRAM). GORCE MTS, Sieniawa, at the base of Rabska Góra Mt., alt. 600 m, 7 July 1966, *K. Glanc* (KRAM L-27508). POGÓRZE ROŻNOWSKIE FOOTHILLS, Sienna above Dunajec, by Jezioro Rożnowskie lake, alt. 320 m, *R. Kozik* (KRAM L-21304).

ADDITIONAL MATERIAL EXAMINED. POLAND. WESTERN CARPATHIANS. Gorce Mts, Dolina Dunajca valley, near Huba settlement, by Nowy Targ-Krościenko road, alt. 520 m, 27 July 1968, *K. Glanc* (KRAM L-27507). WARMIAN-MASURIAN VOIVODESHIP. Kętrzyn County, Podgórzyn near Garbno, 17 May 1974, *L. Olesiński* (KRAM L-31390).

Caloplaca flavovirescens (Wulfen) Dalla Torre & Sarnth. Figs 17B & 47

Flecht. Tirol: 180. 1902. – *Lichen flavovirescens* Wulfen, Schrift. Gesellsch. Naturforsch. Freunde Berlin 8: 122. 1787.

Thallus areolate, thin or thick, up to 500 μm , pale yellow or rarely greenish yellow to grey yellow, occasionally whitish and only partially yellowish, prothallus sometimes present, blackish; without vegetative propagules. Areoles with uneven surface. Thalline cortex thin, ca 30 μm , with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface; algal layer continuous; medulla with many colorless crystals (pol+, insoluble in K). *Apothecia* zeorine, numerous, crowded or rarely scattered, round to

slightly angular by compression, 0.3–1.3 mm diam., distinctly contrasting against the yellow thallus; disc at first concave, than flat to strongly convex, orange to brownish orange, paler and with orange or greenish yellow pruina in young apothecia; proper margin persistent, thin, at first raised, then level with disc, concolorous with disc; thalline margin reduced, usually visible at base of apothecia. Parathecium well developed, prosoplectenchymatous, uniform, cell lumina long and narrow, or longitudinally oval, 70–135 μm , anthraquinone crystals present. Amphithecium reduced, algae not numerous, anthraquinone crystals present. Epithemium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 85–120 μm high. Paraphyses simple to dichotomically branched, apical cells slightly thickened, up to 3.5 μm wide. Hypothecium hyaline, without oil droplets and crystals, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, 10.0–20.5 \times 6–12 μm , isthmus 3.5–10.0 μm wide. *Pycnidia* usually present, immersed; ostiolum orange; conidia bacilliform, 2.5–5.0 \times 1.0–1.5 μm .

HABITAT AND DISTRIBUTION. The species grows on limestone, calcareous sandstone and slate in sun-exposed situations, and has been noted rarely in moderately shaded sites. It often inhabits the

upper parts of rock outcrops or vertical walls facing northwest, south and west. The species often grows by river banks, and was also collected in quarries. It occurs at 300–1300 m a.s.l.

Caloplaca flavovirescens is widely distributed in the Beskidy Zachodnie Mts (Kotlina Żywiecka basin, Beskid Mały Mts, Beskid Makowski Mts, Beskid Wyspowy Mts, Beskid Żywiecki Mts, Gorce Mts, Beskid Sądecki Mts, Beskid Niski Mts), Kotlina Orawsko-Nowotarska basin, Pieniny Właściwe Mts, Małe Pieniny Mts, Pogórze Spisko-Gubałowskie foothills, West Tatras and High Tatras.

DISCUSSION. *Caloplaca flavovirescens* is characterized by its areolate, pale yellow thallus distinctly contrasting with dark orange apothecia. The spores are broadly ellipsoid to subspherical, with a very wide isthmus.

Caloplaca velana differs from *C. flavovirescens* by having an orange thallus, and apothecia \pm concolorous with the thallus. Moreover, the former produces smaller spores with distinctly thinner isthmus. Sometimes *C. flavovirescens* may resemble *Protoblastenia rupestris* (Scop.) J. Steiner with its dark orange, convex apothecia, but anatomical studies easily distinguish the two species, as the latter has 1-cellular spores.

The obligate epiphytic species *C. flavorubescens* (Huds.) J. R. Laundon is very similar to

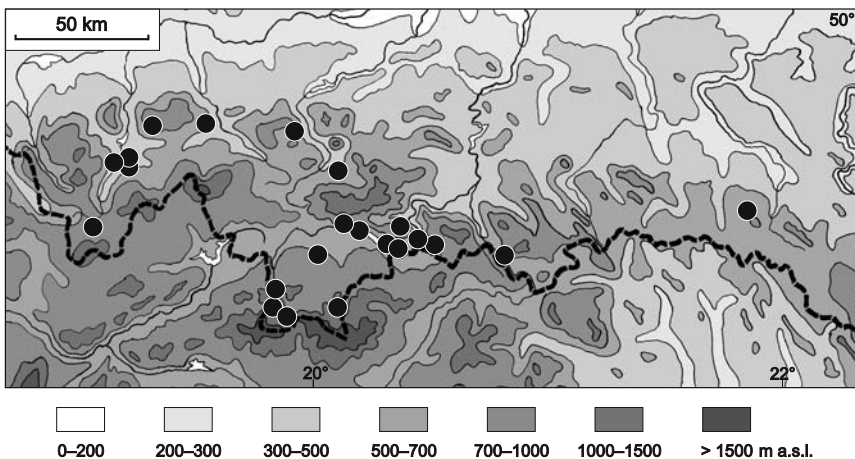


Fig. 47. Distribution of *Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth. in the Polish Western Carpathians.

C. flavovirescens. The former differs in having a uniformly crustose thallus and larger, paler apothecia. Some authors treated the two as synonymous (Wade 1965). Laundon (1976) distinguished them and emphasized the need for further studies of this complex.

EXSICCATES SEEN. Arnold, *Lich. Exsicc.* 1376 (as *Calloplisma flavovirescens*) (KRAM); Lojka, *Lich. Reg. Hung. Exsicc.* 29 (as *Lecanora erythrella*) (KRAM); Nowak, *Lich. Polon. Merid. Exsicc.* 196 (KRAM); Rabenhorst, *Lich. chinenses* 11 (as *Calloplisma aurantiacum* var. *flavovirescens*) (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. KOTLINA ŻYWIECKA BASIN, Mutne village, above Żywiec-Jeleśnia road, alt. 304 m, 49°39'36"N, 19°18'35"E, 1 Sep. 2005, *K. Wilk 3804* (KRAM); Sporysz, quarry, alt. 420 m, 24 Sep. 1964, *J. Nowak* (KRAM L-16308, 16422, 16664). BESKID MAŁY MTS, 'Zamczysko' near Łysina, alt. 650 m, 10 Aug. 1960, *J. Nowak* (KRAM L-7829). BESKID MAKOWSKI MTS, Tokarnia, Proszkowiec Potok stream, alt. 450 m, 28 Apr. 1966, *J. Nowak* (KRAM L-17350); Grupa Żurawnicy, Kozie Skały outcrops, alt. 720 m, 49°45'42"N, 19°30'51"E, 20 Sep. 2005, *K. Wilk 3926* (KRAM); Pasma Pewelskie range, S slope of Janikowa Grapa, sandstone outcrops by Koszarawa River, alt. 397 m, 49°39'34"N, 19°19'08"E, 28 Sep. 2005, *K. Wilk 4028* (KRAM). BESKID WYSPOWY MTS, Niedźwiedź, shore of Porębianka River, alt. 500 m, 16 Sep. 1994, *J. Nowak* (KRAM L-32167). BESKID ŻYWIECKI MTS, Wielka Racza massif, Rajcza, Hutyrów Mt., alt. 740 m, 8 Aug. 1964, *J. Nowak* (KRAM L-17218); Wielka Racza massif, Rycerka Dolna, at the base of Łysica Mt., alt. 550 m, 5 Aug. 1964, *J. Nowak* (KRAM L-17007). GORCE MTS, Twarogi Mt.: S slope, 'Nad Kucami' rocks, alt. 740 m, 5 July 1967, *K. Glanc* (KRAM L-27496), S slope, by the road from Ochotnica Dolna to ridge, alt. 520 m, 3 July 1967, *K. Glanc* (KRAM L-27489), near Ochotnica village, alt. 800 m, 6 Sep. 1960, *K. Glanc* (KRAM L-27492); Tylmanowa, slope above road, alt. 440 m, 10 May 1959, *K. Glanc* (KRAM L-27491); village above Dunajec River, alt. 400 m, 10 May 1959, *K. Glanc* (KRAM L-27488); above Ochotnica Dolna Brysiówka housing estate, S slope of Twarogi Mt., alt. 520 m, 5 Aug. 1999, *P. Czarnota* (GPN 2258); S slope of Twarogi Mt. above Ochotnica Dolna Barbarówka housing estate, alt. 530 m, 5 Nov. 2005, *P. Czarnota* (GPN 2166). BESKID SADECKI MTS, Zawodzie near Krościenko above Dunajec River, 7 May 1955, *J. Nowak* (KRAM L-464); Gryń Mt., Szlachtowa, Oct.

1891, *s.coll.* (KRAM L-20299, 20634); Szlachtowa, *s.d.*, *W. Boberski* (KRAM L-11427); Szlachtowa, 1888, *s.coll.* (KRAM L-22357); Żęgiestów, 1889, *W. Boberski* (KRAM L-20552); Kunie, 1889, *W. Boberski* (KRAM L-11429); Kunie, *s.d.*, *W. Boberski* (KRAM L-20555). BESKID NISKI MTS, Wisłoczek near Rymanów (distr. Sanok), alt. 525 m, 27 Oct. 1974, *J. Nowak* (KRAM L-43829). KOTLINA ORAWSKO-NOWOTARSKA, Dębno: near 'Dębina' inn, 7 June 1997, *D. Baraniak s.n.* (KRAP), *ibid.*, 22 Oct. 1996, *D. Baraniak s.n.* (KRAP), by the mouth of Dunajec to Jezioro Czortyńskie lake, 22 Sep. 1997, *D. Baraniak s.n.* (KRAP); Ostrowsko, 24 May 1997, *D. Baraniak s.n.* (KRAP). PIENINY WŁAŚCIWE MTS, limestone outcrops by the Czorsztyń Castle, alt. 560 m, 49°26'11"N, 20°18'48"E, 5 June 2005, *K. Wilk 3468* (KRAM); Czorsztyń, *s.d.*, *s.coll.* (KRAM L-20568); Popieska Skałka outcrops by Jezioro Sromowieckie lake, alt. 560 m, 49°24'48"N, 20°19'50"E, 5 June 2005, *K. Wilk 3464* (KRAM); Trzy Korony Mt., 4 May 1957, *J. Nowak* (KRAM L-42654); Długa Grapa outcrops, 6 May 1957, *J. Nowak* (KRAM L-4396); Polana Głębiów Kał glade, 3 Sep. 1989, *J. Kiszka s.n.* (KRAP); Polana Podskalnia Góra glade, 26 June 1999 & 2 Sep. 1988, *J. Kiszka s.n.* (KRAP, PPN); Podłaźce, 10 Oct. 1999, *J. Kozik s.n.* (PPN); Polana Koło Ogrodnika glade, 4 July 1987, *J. Kiszka s.n.* (KRAP); Toporzyska, 17 Sep. 1957, *K. Glanc* (KRAM L-27483). MAŁE PIENINY MTS, Dziobakowe Skały outcrops, SE of Jaworki village, alt. 738 m, 49°23'21"N, 20°34'05"E, 4 Jun 2005, *K. Wilk 3428* (KRAM); Sołtysie Skałki outcrops near Jaworki village: alt. 580 m, 49°24'20"N, 20°32'30"E, 3 June 2005, *K. Wilk 3416* (KRAM), alt. 617 m, 49°24'24"N, 20°32'29"E, 3 June 2005, *K. Wilk 3368* (KRAM); Szczawnica, shore of Dunajec River near Sokolica Mt., 18 Sep. 1969, *J. Nowak* (LOD 436); Jaworki village, May 1891, *s.coll.* (KRAM L-22402); Szczawnica town, 1888, *s.coll.* (KRAM L-19861, 22413). POGÓRZE SPISKO-GUBAŁOWSKIE FOOTHILLS, Bańska Niżna, shore of Biały Dunajec River, alt. 650 m, 19 July 1969, *J. Kiszka s.n.* (KRAP), *ibid.*, alt. 665 m, 19 July 1963, *J. Kiszka s.n.* (KRAP); Kojcówka, shore of Dunajec River, alt. 845 m, 18 Aug. 1967, *J. Kiszka s.n.* (KRAP). WEST TATRA MTS, below Mnichy Chochołowskie crags, E of Skorusi Żleb, alt. ca 1300 m, 49°14'29"N, 19°47'43"E, 19 July 2004, *K. Wilk 2164, 2168* (KRAM); Dolina Kościeliska valley, by trail to Jaskinia Raptowiecka cave, alt. ca 1140 m, 13 July 2004, *K. Wilk 2124* (KRAM); Polana Chochołowska glade, alt. 1120 m, Aug. 1982, *K. Toborowicz s.n.* (KTC). HIGH TATRA MTS, Łysa Skałka range, 49°15'50"N, 20°06'50"E, 12 Oct. 2005, *K. Wilk 4095* (KRAM).

Caloplaca holocarpa (Ach.) A. E. Wade

Fig. 17C & 48

Lichenologist 3: 11. 1965. – *Lichen holocarpus* Ach., Lich. Suec. Prod: 73. 1798 (see Arup 2009).

Thallus areolate, thin, usually strongly reduced or endolithic, yellow or yellow orange; without prothallus and vegetative propagules. Thalline cortex poorly developed, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface. *Apothecia* zeorine, abundant, scattered or crowded, sessile, small, round or angular by compression, 0.2–0.8 mm diam.; disc flat to slightly convex, epruinose, yellow to orange; proper margin persistent, thin, ± concolorous with disc; thalline margin much reduced, visible at the base of apothecia, or excluded. Parathecium moderately thick, 50–70 µm, prosoplectenchymatous, anthraquinone crystals present. Amphithecium with many algae, usually reduced, anthraquinone crystals present. Epihymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 55–80 µm high. Paraphyses simple to distinctly branched, 1–3 apical cells slightly thickened, up to 5.0(–6.8) µm wide. Hypothecium hyaline, without crystals and oil droplets, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, 10.2–13.6 × 6.8–8.5(–9.2) µm, isthmus 3.4–5.6(–6.8) µm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It grows on calcareous sandstone.

The species is known from the Beskid Mały Mts, Beskid Żywiecki Mts, Beskid Sądecki Mts, and Gorce Mts. Probably it is more widely distributed in the studied area, but more material needs to be revised.

DISCUSSION. The species is characterized by its weakly developed, yellow to orange yellow, areolate or endolithic thallus. The apothecia are orange with a persistent proper margin, ± concolorous with the disc, and disappearing thalline margin. The spores have a distinctly wide isthmus, ca 4–6 µm.

The species belongs to the *C. holocarpa* group (Arup 2009). Arup (2009) recently discussed the whole group in detail. For a long time the species remained problematic and widely misinterpreted: different authors treated *C. holocarpa* as one variable species or as at least three taxa: *C. holocarpa*, *C. lithophila* H. Magn. and *C. pyracea* (Ach.) Th. Fr. Then Arup (2009) redefined *C. holocarpa* and clarified its taxonomy, maintaining that *C. pyracea* is a separate species and that *C. lithophila* probably is a synonym of *C. vitellimula* (Nyl.) H. Olivier.

Caloplaca pyracea has a better developed thallus and a more prominent thalline margin than *C. holocarpa*; also, it usually occurs on tree

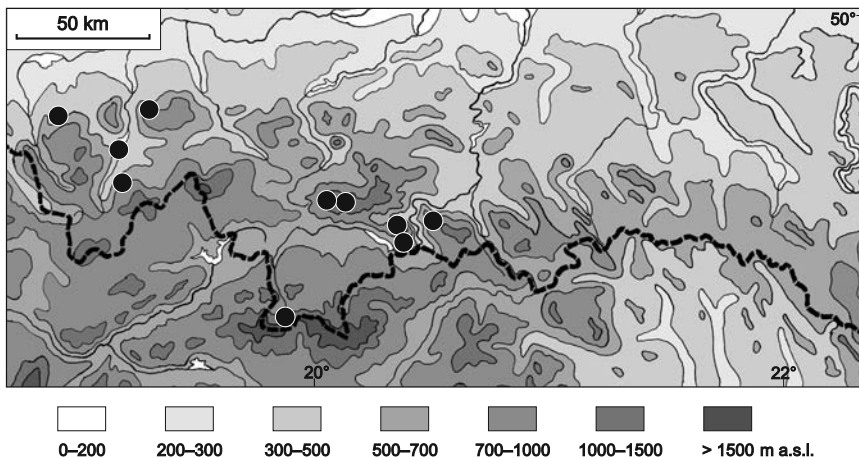


Fig. 48. Distribution of *Caloplaca holocarpa* (Ach.) A. E. Wade in the Polish Western Carpathians.

bark (for more details see Arup 2009). *Caloplaca vitellinula* differs from *C. holocarpa* by having a thin but distinct areolate thallus, often surrounded by a prothallus, scattered apothecia and smaller spores. *Caloplaca oasis* is very similar to *C. holocarpa*, but differs from *C. holocarpa* mainly by having a more prominent thallus circular in outline, distinctly thinner apothecial margin and narrower spore isthmus. See also comments under *C. oasis*.

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. BESKID ŚLĄSKI MTS, Błatnia Mt., alt. 823 m, 6 Aug. 1964, *J. Kiszka s.n.* (KRAP). KOTLINA ŻYWIECKA BASIN, Sporysz, quarry, alt. 420 m, 24 Sept. 1964, *J. Nowak* (KRAM L-16696). BESKID MAŁY MTS, Żywiecki Groń below Przełęcz Kocierska pass, 10 Apr. 1961, *J. Nowak* (KRAM L-7834). BESKID ŻYWIECKI MTS, Żabnica village SE of Węgierska Górka town, glade above Tokarnia settlement, alt. 890 m, 28 Sept. 1964, *J. Nowak* (KRAM L-16649, 16650). GORCE MTS, Kiczora Mt., NE slope, alt. 1275 m, 1 Apr. 1959, *K. Glanc* (KRAM L-28322); between Młynne and Gorcowe valleys, alt. 700 m, 9 July 1966, *K. Glanc* (KRAM L-28320); Lubań Mt., alt. 1200 m, 11 May 1960, *K. Glanc* (KRAM L-28312); Czoło Turbacza Mt., S slope, alt. 1250 m, 30 June 1967, *K. Glanc* (KRAM L-28318); Hala Turbacza, alt. 1260 m, 7 Sept. 1959, *K. Glanc* (KRAM L-28321). BESKID SADECKI MTS, Jaworzynka stream, 18 Aug. 1960, *J. Nowak* (KRAM L-9188). PIENINY WŁAŚCIWE MTS, Sromowce Wyżne, Dunajec riverside, 16 July 1996, *J. Kiszka* (KRAM L-55968). WEST TATRA MTS, Dolina Kościeliska valley, Wyżnia Miętusia Polana glade, 49°15'09"N, 19°53'44"E, 17 June 2004, *L. Śliwa 2324* (KRAM).

ADDITIONAL SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. BESKID MAŁY MTS, Targoszów, alt. 500 m, 11 May 1960 *J. Nowak* (KRAM L-7835); Wielka Puszcza, alt. 400 m, 7 Aug. 1960, *J. Nowak* (KRAM L-7833). BESKID MAKOWSKI MTS, Peim, valley of Kaczanka stream, alt. 470 m, 26 Apr. 1966, *J. Nowak* (KRAM L-17453). BESKID ŻYWIECKI MTS, Pilsko, 'Turniczka', alt. 1400 m, 10 Sept. 1964, *J. Nowak* (KRAM L-14915); Hutyrów Mt., alt. 700 m, 6 Aug. 1964, *J. Nowak* (KRAM L-14418). GORCE MTS, Sieniawa, Rabska Góra Mt., 1 July 1966, *K. Glanc* (KRAM L-28319); Ochotnica village, alt. 450 m, *K. Glanc* (KRAM L-28316); Lubań Mt., N slope, above Lubański stream, alt. 700 m, 12 Sept. 1960, *K. Glanc* (KRAM L-28323).

Caloplaca keissleri (Servit) Poelt

Figs 17D & 49

Mitt. Bot. Staatssamml. München 5: 261. 1964. – *Blasenia keissleri* Servit, Hedwigia 74: 149. 1934.

Thallus endolithic to faintly epilithic and then composed of very small granules immersed in rock, yellow (K+ red); without prothallus and vegetative propagules. *Apothecia* biatorine, scattered, ± immersed in rock, round, 0.3–0.5 mm diam.; disc flat, orange; proper margin persistent, distinctly thin, slightly flexuous, paler than disc; thalline margin absent. Parathecium thin, weakly developed, paraplectenchymatous, cell lumina large, anthraquinone crystals present. Amphithecium absent. Epihymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, low, ca 80 µm. Paraphyses simple, apical cells slightly thickened. Hypothecium hyaline, without oil droplets and crystals, low, paraplectenchymatous, with large lumina cells. Asci 8-spored, spores polarilocular, thin-walled (only in young spores slightly thickened), 11.5–13.5 × 5–8 µm, isthmus 2.5–5.0 µm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It grows on limestone in sun-exposed situations. It inhabits vertical limestone walls facing west.

The species is known from the West Tatras.

DISCUSSION. *Caloplaca keissleri* is characterized by its thallus consisting of fine granules immersed in rock and apothecia persistently immersed in rock. The apothecia are biatorine and they have a thin, flexuose proper margin and paraplectenchymatous parathecium and hypothecium.

Caloplaca keissleri was accepted by Poelt (1964). Clauzade and Roux (1977) considered the species as *C. nubigena* var. *keissleri*, maintaining that the taxon differs from *C. nubigena* s.str. by having a low amount of anthraquinones in the thallus, causing it to have a negative or almost negative reaction with K. Other authors, including Renobales and Barreno (1989) and Renobales (1996), accepted that concept. This monograph adopts Poelt's view. The studied specimens of *C. keissleri* differ from *C. nubigena* by having

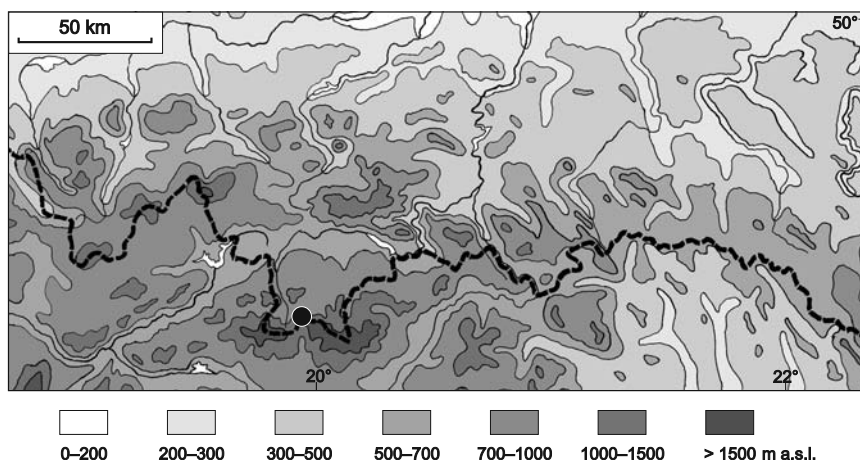


Fig. 49. Distribution of *Caloplaca keissleri* (Servit) Poelt in the Polish Western Carpathians.

a distinctly paraplectenchymatous hypothecium and thinner proper margin. *Caloplaca nubigena* produces pseudolecanorine apothecia with few algae present at the base of the apothecial margin. The two species need further study, including genetic analyses. See also comments under *C. nubigena*.

Caloplaca coccinea resembles *C. keissleri* due to its partially endolithic thallus consisting of fine granules immersed in rock, but *C. coccinea* has darker, orange red apothecia and an orange thallus, and its apothecia are initially immersed in rock, then often sessile. *Caloplaca coccinea* has a distinctly thicker, not flexuous proper margin and a prosoplectenchymatous hypothecium. *Caloplaca dalmatica* (A. Massal.) H. Olivier (syn. *C. dolomiticola* f. *nubigenoides* Clauzade & Cl. Roux) is very similar to *C. keissleri*. According to the literature, *C. dalmatica* is characterized by its epilithic, yellow, thin, continuous thallus. Its apothecia are persistently immersed in rock, the spores are broadly ellipsoid and $9\text{--}15 \times 5\text{--}10 \mu\text{m}$ in dimensions, with an isthmus $3\text{--}6 \mu\text{m}$ wide. More studies are needed to clarify the taxonomy of the two species (Clauzade & Roux 1977, 1985; Egea 1984).

EXSICCATE SEEN. Arnold, *Lich. Exsicc.* 584b (as *Callopsima nubigenum*) (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CAR-

PATHIANS. WEST TATRA MTS, Rzędy in the Czerwone Wierchy massif, slopes from the side of Hala Tomanowa, alt. 2000 m, 13 June 1963, *J. Nowak* (KRAM L-18582); Mnichowe Turnie crags above Niżnia Świstówka, alt. ca 1550 m, $49^{\circ}14'37''\text{N}$, $19^{\circ}55'42''\text{E}$, 20 July 2004, *K. Wilk 2199* (KRAM).

***Caloplaca nubigena* (Kremp.) Dalla Torre & Sarnth.** Figs 17E & 50

Flecht. Tirol: 184. 1902. – *Callopsima ochraceum* var. *nubigenum* Kremp., Denkschrift. Kgl. Bayr. Botan. Gesellsch. 4(2): 163. 1861.

Thallus endolithic to faintly epilithic, with very small granules forming a continuous layer on substrate, thin, irregular or less frequently circular in outline, orange or yellow orange (K+ red); without prothallus and vegetative propagules. *Apothecia* pseudolecanorine, numerous, scattered, initially immersed in thallus, then \pm broadly sessile, round, 0.2–0.6 mm diam.; disc flat to slightly convex, dark orange or brown orange; proper margin persistent, at first thick, then thinner, glossy, sometimes slightly flexuous, paler than disc; thalline margin absent. Parathecium ca 140 μm , distinct, paraplectenchymatous, with few algae at base of parathecium, anthraquinone crystals present. Amphithecium absent. Epithemium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 70–100 μm high. Paraphyses simple, apical cells thickened

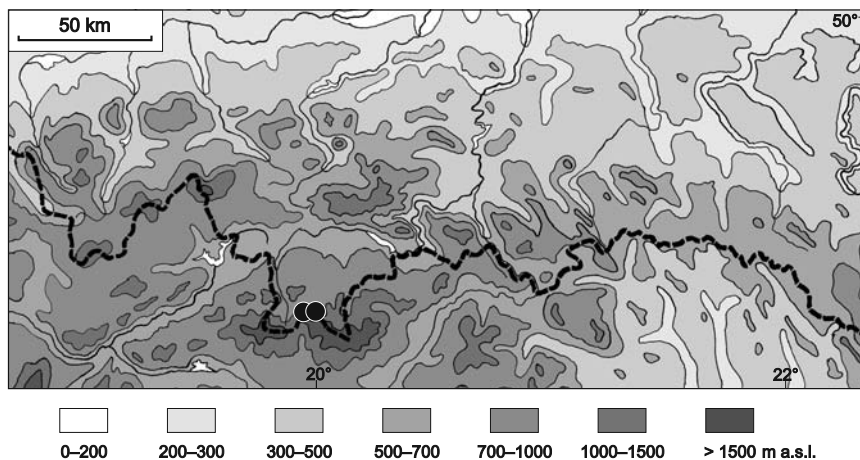


Fig. 50. Distribution of *Caloplaca nubigena* (Kremp.) Dalla Torre & Sarth. in the Polish Western Carpathians.

up to 7 μm wide. Hypothecium hyaline, prosoplectechymatous, indistinct. Asci 8-spored, spores polarilocular, thin-walled, $10\text{--}13 \times 7 \mu\text{m}$, isthmus 2.5–5.0 μm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. The species grows on limestone in sun-exposed situations. It inhabits vertical rock walls facing south and west. It was recorded at 1500–1800 m a.s.l.

The species is known from the West Tatras.

DISCUSSION. *Caloplaca nubigena* is characterized by its orange thallus forming a continuous layer of fine granules. The apothecia are initially immersed in the thallus, then usually broadly sessile. Apothecia are pseudolecanorine with a persistent and thin proper margin, with few algae at the base. The parathecium is distinctly paraplectenchymatous and the hypothecium is prosoplectenchymatous.

Caloplaca nubigena, together with *C. keissleri*, *C. coccinea* and *C. dalmatica*, forms a group of similar and rare species which are in need of nomenclatural and taxonomic studies. Probably this group is related to the *C. velana* group, itself one of the most problematic groups in the genus *Caloplaca* (e.g., Clauzade & Roux 1985; Arup 1990). Data on *C. nubigena* are very sparse in the literature.

Caloplaca keissleri is most similar to *C. nubigena*; some authors treated *C. keissleri* as

a variety of *C. nubigena* containing a smaller amount of anthraquinones in the thallus. For more information on the distinction between the two taxa see the comments under *C. keissleri*. *Caloplaca coccinea* differs from *C. nubigena* by having a thallus of scattered, dark orange granules immersed in rock and dark orange apothecia with a thick proper margin, immersed in rock but with a tendency to be sessile. *Caloplaca nubigena* seems very similar to *C. dalmatica*. For the distinction between both taxa, see remarks under *C. keissleri*.

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. WEST TATRA MTS, below Kondracka pass, 10 July 1957, *J. Nowak* (KRAM L-2485); Giewont Mt., alt. 1750 m, 24 May 1959, *J. Nowak* (KRAM L-2249), *ibid.*, 10 July 1957, *J. Nowak* (KRAM L-1226); Długi Giewont Mt., S slope, alt. 1773 m, $49^{\circ}15'11''\text{N}$, $19^{\circ}56'32''\text{E}$, 21 July 2004, *K. Wilk* 2211 (KRAM); Mnichowe Turnie crags above Niżnia Świstówka, alt. ca 1550 m, $49^{\circ}14'37''\text{N}$, $19^{\circ}55'42''\text{E}$, 20 July 2004, *K. Wilk* 2192, 2195 (KRAM); Dolina Mułowa valley, alt. ca 1800 m, 9 July 2004, *K. Wilk* 2072a (KRAM); Rzędy, S slope of Ciemniak Mt., alt. ca 1800 m, 11 July 2004, *K. Wilk* 2091 (KRAM).

***Caloplaca oasis* (A. Massal.) Szatala**

Figs 17F & 51

Magyar Bot. Lapok 31: 120. 1932. – *Calloposma aurantiacum* var. *oasis* A. Massal., Sched. Crit. Lich. Exs. Ital. 7: 134. 1856.

Thallus granular-areolate, very thin, circular in outline, usually highly reduced to small granules or areoles scattered between numerous apothecia, pale yellow (K+ red); without prothallus and vegetative propagules. *Apothecia* zeorine, numerous, crowded, sessile, round or angular by compression, 0.1–0.3 mm diam.; disc flat or slightly convex, orange, epruinose; proper margin very thin, not prominent, concolorous with or slightly paler than disc; thalline margin only in young apothecia visible. Parathecium thin, ca 60 μm , prosoplectenchymatous, hyphae radiating with oval to elongated cells, anthraquinone crystals present. Amphithecium reduced, with numerous algae, cortex poorly developed, anthraquinone crystals present. Epithemium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 75–85 μm high. Paraphyses simple to slightly branched, 1–2 apical cells thickened, up to 7 μm wide. Hypothecium hyaline, without crystals or oil droplets, prosoplectenchymatous, hyphae irregular, ca 40–50 μm high. Asci 8-spored, spores polarilocular, thin-walled, 8.5–13.5 \times (4.0–)4.8–6.8 μm , isthmus 3–5 μm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It grows on limestone rocks, calcareous sandstone and concrete.

The species is known from the Gorce Mts and Małe Pieniny Mts.

DISCUSSION. *Caloplaca oasis* is characterized by its yellow, highly reduced thallus and small dark orange apothecia with thin proper margins. It is known as a free-living or parasitic lichen growing on endolithic species of *Verrucaria* s.l.

Arup (2009) discussed this species in detail in a recent taxonomic treatment of the *C. holocarpa* group, and suggested that *C. oasis* is related to the *C. citrina* group.

Caloplaca oasis has often been misidentified as *C. holocarpa*, especially when growing on man-made substrates (Arup 2009), but the latter can be distinguished by its yellower apothecia and thicker, more prominent proper margin. Also, the spore isthmus of *C. holocarpa* is wider on average (see Arup 2009). Well developed parasitic specimens of *C. oasis* may also be confused with *C. polycarpa*, but the latter is distinguishable by its larger apothecia with thicker margins and more distinct, thicker orange thalli (Arup 2009; Wilk 2011).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. GORCE MTS, manor park, Poręba Wielka, alt. 550 m, 5 Oct. 1993, P. Czarnota (GPN 49/94). MAŁE PIENINY MTS, Biała Woda reserve, 25 Sep. 1998, J. Kiszka (KRAM L-55967).

ADDITIONAL SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. TATRA MTS, Dolina Kościeliska valley, Polana Nędzówka glade, 8 July 2004, L. Śliwa 2778 (KRAM). POGÓRZE WIELICKIE FOOTHILLS, Skawina town, alt. 240 m, 11 Oct. & 11 Nov.

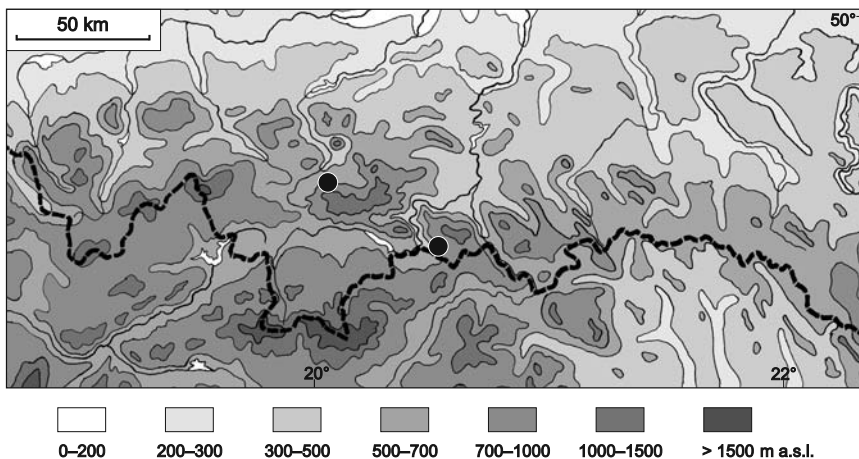


Fig. 51. Distribution of *Caloplaca oasis* (A. Massal.) Szatala in the Polish Western Carpathians.

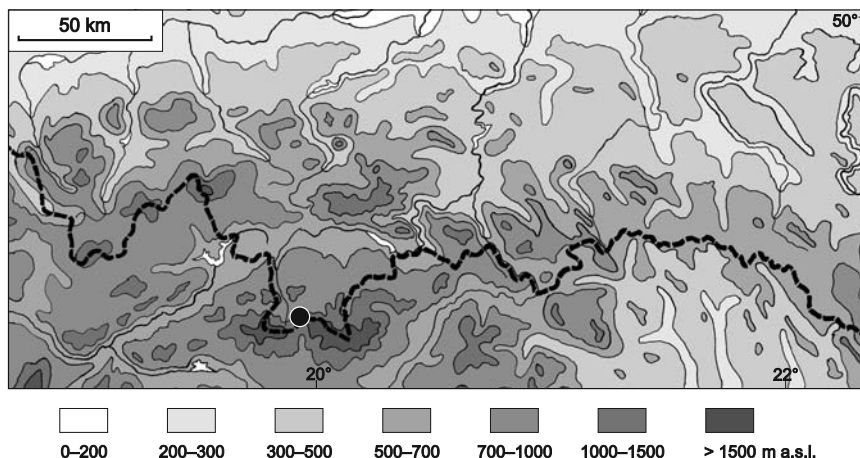


Fig. 52. Distribution of *Caloplaca percrocata* (Arnold) J. Steiner in the Polish Western Carpathians.

1964, *s. coll.* (KRAP). KOTLINA SANDOMIERSKA BASIN, Łętowice, 8 Oct. 1961, *J. Kiszka s.n.* (KRAP). POJEZIERZE POŁUDNIOWOPOMORSKIE LAKELAND, Wdzydze Landscape Park, Czarlina village, near bus stop, 13 Sep. 2006, *K. Wilk 7271* (UGDA); southern part of Wdzydze Tucholskie village, 53°58'05"N, 17°55'32"E, 13 Sep. 2006, *E. Adamska, W. Gruszka & L. Śliwa 3668a* (UGDA).

Caloplaca percrocata (Arnold) J. Steiner

Figs 18A & 52

in Halácsy, Denkschr. Kaiserl. Akad. Wiss., Math.-Naturwiss. Kl. **61**: 523. 1894. – *Blastenia percrocata* Arnold, Flora **67**: 309. 1884.

Thallus rimose-areolate, irregular in outline, thin, thicker in central part, thinner towards margin, grey or brownish grey, prothallus infrequent, thin, dark grey; without vegetative propagules. *Thallus* surface plane to undulate especially in older part. *Thalline* cortex paraplectenchymatous, 15–35 μm thick, obscured by colorless crystals (pol+, insoluble in K, soluble in N), K– or K+ weakly violet, N+ weakly violet (sedifolia-grey); medulla obscured by colorless crystals (pol+, insoluble in K, partly soluble in N). *Apothecia* zeorine, numerous, crowded, in groups, at first immersed, then sessile, adnate, round or mostly angular and flexuous by compression, 0.4 to 1.3 mm diam.; disc flat, dark, brownish orange to brownish red, contrasting against pale, yellowish

orange proper margin; proper margin persistent, thick, raised above disc, distinctly paler than disc; thalline margin much reduced, yellowish due to the presence of anthraquinone crystals. Parathecium thin, ca 85 μm , prospoplectenchymatous, with radiating hyphae, anthraquinone crystals present. Amphithecium thick, with many algae, with anthraquinone crystals. Epithemium interspersed with brownish yellow crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, up to 120 μm high. Paraphyses simple to slightly branched, apical cells not or slightly thickened, up to 5(–6.5) μm wide. Hypothecium hyaline, with oil droplets, ca 60 μm high. Asci 8-spored, spores polarilocular, thin-walled, 15.0–18.5(–20.0) \times 8.0–10.0(–12.5) μm , isthmus (3–)4–5 μm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It occurs on siliceous shale containing calcium on steep sunny north facing slope at 1900 m a.s.l.

The species is known only from the West Tatras.

DISCUSSION. The species is characterized by its rimose-areolate, grey thallus and prominent orange apothecia. The dark apothecial discs distinctly contrasting against the paler proper margins. The thalline margin is more or less reduced.

According to Magnusson (1944a), *C. percrocata* belongs to the *C. ferruginea* group. The

group includes species with whitish, grey or brown thalli that lack anthraquinones, and apothecia that are red or orange and do contain anthraquinones. They occur on a wide range of substrates including rocks, bark, mosses etc. The species of the *C. ferruginea* group are characterized by their content of chemosyndromes based on 7-chloroemodin (see Söchting & Tønsberg 1997). More recently, Wetmore (1996) established a more restricted *C. siderites* group in which *C. percrocata* was included. It consists of exclusively saxicolous species. He also reported the non-crystallizing pigment sedifolia-grey in most of the treated species, including *C. percrocata*. This pigment reacts violet with K and N.

Caloplaca percrocata might be confused with *C. erythrocarpa*, but the latter has a conspicuous, chalky white thallus and distinctly smaller, uniformly red apothecia with thin proper margins. The apothecia in *C. erythrocarpa* are initially immersed in the thallus, then broadly sessile. *Caloplaca atroflava* (Turner) Mong. also resembles *C. percrocata* but it differs in its ecological preferences (it is acidophilous and hygrophilous) and some morphological details (Clauzade & Roux 1987). *Caloplaca atroflava* forms orange apothecia, with the proper margin slightly paler than the disc. *Caloplaca teicholyta* differs from *C. percrocata* in having a thicker sublobate thallus, scurfy-granular in the central part. *Caloplaca teicholyta* rarely forms apothecia, and they are uniformly red when present.

For more comments see Wilk and Flakus (2006).

The literature data on *C. percrocata* are sparse. Descriptions of the species appear in a number of papers (e.g., Magnusson 1944a; Oksner 1993; Wetmore 1996; Kondryatuk *et al.* 2004).

EXSICCATES SEEN. Poelt, *Lich. Alp.* 50 (KRAM), Wetmore, *Telosch. Exsicc.* 86 (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. WEST TATRA MTS, Twardy Uplaz, N slope below Ciemniak Mt., alt. 1900 m, 49°14'12"N, 19°54'12"E, 30 Aug. 2002, *A. Flakus* 151 (C, KRAM, MIN), *ibid.*, 9 July 2004, *A. Flakus* 2251 with *K. Palka* & *B. Cykowska* (KRAM).

Caloplaca polycarpa (A. Massal.) Zahlbr.

Figs 18B & 53

Oesterr. Bot. Zeitschr. **68**: 317. 1919. – *Callopsisma aurantiacum* var. *polycarpum* A. Massal., *Symm. Lich.*: 31. 1850.

Thallus rimose-areolate, often sublobate, ± circular in outline, 15 mm diam., 150–250 µm thick, single or grouped, yellow orange or orange, epruinose, usually well-delimited by a distinct orange prothallus (sometimes additionally surrounded by a hyaline film-like belt); without vegetative propagules. Areoles crowded, roundish to irregular, often crenate. Thalline cortex thin or thick, up to 50 µm, paraplectenchymatous, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface, sometimes with necral layer; algal layer ± continuous; medulla dense, with many colorless crystals. *Apothecia* zeorine, numerous, scattered or grouped, round or angular by compression, up to 0.8 mm diam.; disc dark orange, flat or slightly convex in old apothecia; proper margin persistent, thick, first raised, then level with disc, paler than disc; thalline margin highly reduced. Parathecium thin, prosoplectenchymatous, anthraquinone crystals present. Amphithecium well developed, with many algae, anthraquinone crystals present. Epiphymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 75–100 µm high. Paraphyses simple or slightly branched, 1–3(–4) apical cells slightly thickened, up to 5.0(–6.5) µm wide. Hypothecium hyaline, with many oil droplets. Asci 8-spored, spores polarilocular, thin-walled, 8–13 × 5–8 µm, isthmus 3.0–6.5 µm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It grows on endolithic thalli of representatives of *Verrucaria* s.l., or less frequently is free-living. It inhabits limestone at open and sun-exposed sites, on the upper parts of outcrops or on vertical walls. It was recorded at 580–1500 m a.s.l.

The species is known from the Małe Pieniny Mts and High Tatras.

DISCUSSION. *Caloplaca polycarpa* is characterized by its circular patches, often delimited by

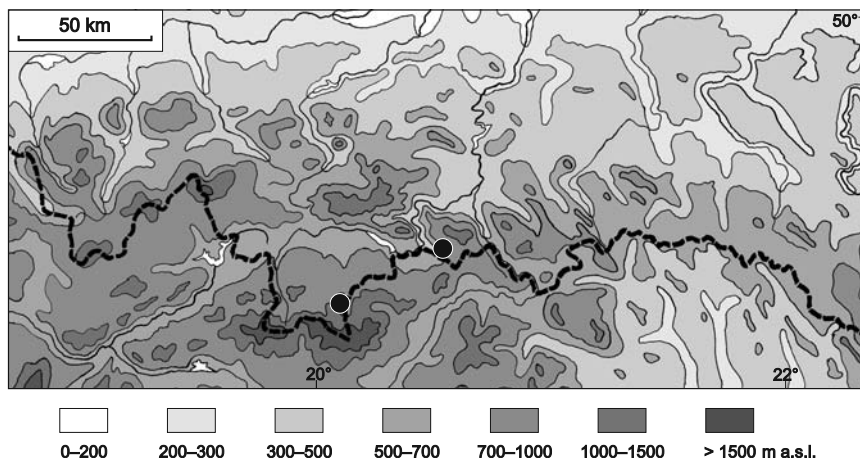


Fig. 53. Distribution of *Caloplaca polycarpa* (A. Massal.) Zahlbr. in the Polish Western Carpathians.

lobed marginal areoles and distinct orange prothallus. The apothecia have a rather thick proper margin and reduced thalline margin. It has a characteristic ecology: it usually occurs as a parasitic lichen growing on endolithic species of *Verrucaria* s.l.

According to Arup (2009), *C. polycarpa* seems related to the *C. citrina* group. *Caloplaca polycarpa* is known to occur on *Verrucaria calciseda* auct. (Clauzade & Roux 1985; Wirth 1995; Hafellner & Obermayer 2001) and *Bagliettoa* spp. (John & Nimis 1998) but also as free-living (Vondrák *et al.* 2007). There are very few data on *C. polycarpa* in the literature.

Caloplaca polycarpa is most similar to *C. oasis*, but the latter produces a smaller, thinner thallus, smaller apothecia with a thinner proper margin, and excluded thalline margin. In the revised material, *C. polycarpa* was often misidentified as *C. saxicola*. The latter differs by having a lobed and placodioid thallus, bigger and strongly aggregated apothecia forming clusters and initially immersed in the thallus, and different spores. The lobes in *C. saxicola* are slightly ascending from rock. *Caloplaca polycarpa* can also be confused with *C. velana*, but the latter has an areolate and irregular thallus without a well-defined margin. In *C. velana* the shape (almost subspherical) and dimensions of the spores are different.

EXSICCATES SEEN. Poelt, *Lich. Alpium* 214 (as *C. tenuatula*) (KRAM, S); Erik P. Vrang, *Lichenes exsiccati* 49 (as *Calloposma polycarpum*) (S); Vězda, *Lichenes selecti exsiccati* 667 (S).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. MAŁE PIENINY MTS, Sołtysie Skałki outcrops near Jaworki village, alt. 580 m, 49°24'20"N, 20°32'30"E, 3 June 2005, K. Wilk 3409 (KRAM), *ibid.*, alt. 617 m, 49°24'24"N, 20°32'29"E, 3 June 2005, K. Wilk 3374a (KRAM); Wąwóz Homole canyon, 5 May 1957, J. Nowak (KRAM L-5253). HIGH TATRA MTS, Gęsia Szyja Mt., alt. 1480 m, 49°15'30"N, 20°04'35"E, 11 Oct. 2005, K. Wilk 4080 (KRAM); Łysa Skałka range, 49°15'50"N, 20°06'50"E, 12 Oct. 2005, K. Wilk 4120 (KRAM).

ADDITIONAL MATERIAL EXAMINED. ITALY. VENETO, VERONA PROV., San Giorgio NE of Ambrogio di Valpolicella, SE-facing slope NE of Biotto, on limestone, alt. ca 420 m, 9 March 2007, U. Arup L07128 (LD). PUGLIA, LECCE PROV., S. Cesarea Terme, Adriatic coast, 9 Apr. 1996, P. L. Nimis & M. Tretiach (S L-46234).

Caloplaca soralifera Vondrák & Hrouzek

Figs 18C & 54

Graphis Scripta 18: 8. 2006.

Thallus areolate, irregular in outline, ± thin, 150–250 µm, pale to dark grey, usually white pruinose, sorediate; without prothallus. Areoles flat to strongly convex, scattered or crowded, soralia marginal, soredia dark violet-grey (K+ violet, N+

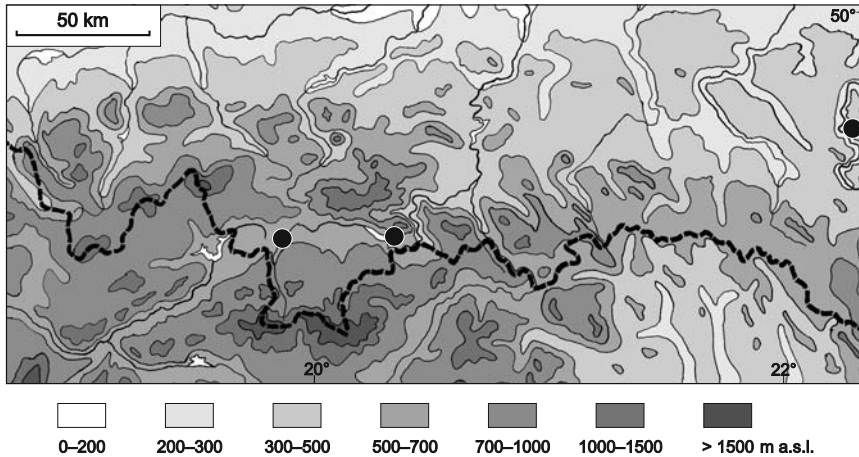


Fig. 54. Distribution of *Caloplaca soralifera* Vondrák & Hrouzek in the Polish Western Carpathians.

violet; sedifolia-grey), 20–50 μm diam. Thalline cortex inconspicuous, almost completely obscured by colorless crystals (pol+, insoluble in K, soluble in N), or seldom cortex well visible, up to 35 μm wide, paraplectenchymatous, pale greyish toward the surface (K+, N+ violet; sedifolia-grey), with necral layer *ca* 5.0–8.5 μm wide; algal layer continuous, with distinct isodiametric fungal cells, without crystals. Apothecia zeorine, crowded to less frequently scattered, sessile, round or angular and flexuous by compression, 0.3–0.8 mm diam.; disc flat, orange to dark orange; proper margin persistent, thick, raised above disc, paler than disc; thalline margin thin, usually white pruinose. Parathecium well developed, 85–100(–110) μm , prosoplectenchymatous, cell lumina elongated and narrow, anthraquinone crystals present. Amphithecium with abundant algae, cortex indistinct, with colorless crystals (pol+, insoluble in K, soluble in N). Epithemium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 68–77(–110) μm high. Paraphyses simple to slightly branched, apical cells not or slightly thickened, up to 5 μm wide. Hypothecium hyaline, with irregular hyphae, sometimes with oil droplets. Asci 8-spored, spores polarilocular, thin-walled, 12.0–15.3(–17.0) \times 5.0–8.5(–10.0) μm , isthmus 3.4–5.4(–6.8) μm wide. Pycnidia inconspicuous, immersed in thallus; conidia ellipsoid, 2.5–3.5 \times *ca* 1.5 μm .

HABITAT AND DISTRIBUTION. It grows on calcareous sandstone.

The species is known from the Kotlina Orawsko-Nowotarska basin, Pieniny Właściwe Mts and Pogórze Przemyskie foothills. It may be much more widespread in the area but undercollected.

DISCUSSION. *Caloplaca soralifera* is characterized by its areolate, grey, often white pruinose thallus. The apothecia are zeorine, with an orange proper margin and grey thalline margin. Its dark violet-grey soredia produced on the margin of thalline areoles and the presence of a thalline cortex are the most diagnostic characters.

The species is included in the group of sorediate *Caloplaca* lacking anthraquinones in the thallus, according to Vondrák and Hrouzek (2006), who stated that *C. soralifera* closely resembles *C. xerica* Poelt & Vězda. The latter differs in having an esorediate, isidiate thallus and a quite different ecology: it occurs mainly in xerothermic habitats and occupies siliceous rock. *Caloplaca chlorina* (Flot.) H. Olivier is another similar taxon but it is distinguished by its typical lecanorine apothecia, rarely pruinose thallus, and ecology; it occurs mainly on nutrient-rich siliceous stones and rock (Vondrák & Hrouzek 2006). For the distinction between *C. soralifera* and *C. albolutescens*, see remarks under that species.

The material from the studied area was often misidentified as *C. teicholyta*, which in fact is quite different from *C. soralifera*. It has a thick sublobate thallus, scurfy-granular in the center and circular in outline. Moreover, *C. teicholyta* rarely forms apothecia; they are distinctly reddish when present.

For more comments see Wilk and Śliwa (2012).

EXSICCATES SEEN. Wetmore, *Telosch. Exsicc.* 89, 90, 91 (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. KOTLINA ORAWSKO-NOWOTARSKA BASIN, Czarny Dunajec town, 8 Aug. 1999, *B. Repa s.n.* (KRAP). PIENINY WŁAŚCIWE MTS, Wdźar Mt. above Czorsztyń, 17 June 1993, *J. Kiszka s.n.* (KRAP). POGÓRZE PRZEMYSKIE FOOTHILLS, Rybotycze town, by Wiar River, 7 Sept. 1993, *J. Nowak* (KRAM L-34222), *ibid.*, 10 Sep. 1985, *J. Kiszka* (KRAM L-31524).

ADDITIONAL MATERIAL EXAMINED. POLAND. POMERANIA PROVINCE, Wdzydze Landscape Park, Borsuk village, 53°56'60"N 17°55'35"E, 13 Sept. 2006, *L. Śliwa 3638b* with *E. Adamska & W. Gruszka* (KRAM). WARMIA-MASURIA PROVINCE, Nizina Sępopolska lowland, Silginy, 4 May 1989, *J. Nowak* (KRAM L-26309). Masurian Lakeland, Równina Mazurska plain, ca 1 km to W from Rustkowo village, by Nidzica-Wielbark road, 30 Apr. 1989, *J. Nowak* (KRAM L-26198). WYŻYNA KIELECKA UPLAND, Przedgórze Iłżeckie, Klarnerowo, ca 2.5 km to N from Starachowice, Aug. 1988, *A. Lenard*

s.n. (KTC). CZECH REPUBLIC, CENTRAL BOHEMIA, Rakovník Distr., Křivoklát, Kalubice, by the small pond in the village, alt. 348 m, 50°02'56.3"N 13°49'30.4"E, on horizontal side of concrete wall, 28 Dec. 2004, *J. Vondrák 3332* (HOLOTYPE, PRM).

Caloplaca teicholyta (Ach.) J. Steiner

Figs 18D & 55

Sitzungsber. Akad. Wiss. Wien, Math.-Naturwiss. Kl., Abt. 1, **104**: 388. 1895. – *Lecanora teicholyta* Ach., Lich. Univ.: 425. 1810.

Thallus sublobate, circular in outline, up to 30 mm diam., thick, 200–300 μm, grey, pruinose, sorediate; without prothallus. Center of thallus rough in appearance, with coarse granules and white, fine soredia formed by erosion of the thallus surface. Thalline cortex well developed, thick, up to 60 μm, paraplectenchymatous, obscured by colorless crystals (pol+, insoluble in K, soluble in N), K-, N-; algal layer discontinuous; medulla with many colorless crystals (pol+, insoluble in K, soluble in N). *Apothecia* zeorine, very rare, sessile, adnate, round, up to 0.5 mm diam.; disc at first concave, then flat, carmine red; proper margin thin, concolorous with disc; thalline margin present, pruinose. Parathecium prosoplectenchymatous, ca 85 μm, with anthraquinones. Amphithecium with many algae, with many colorless crystals. Epithemium interspersed with reddish orange

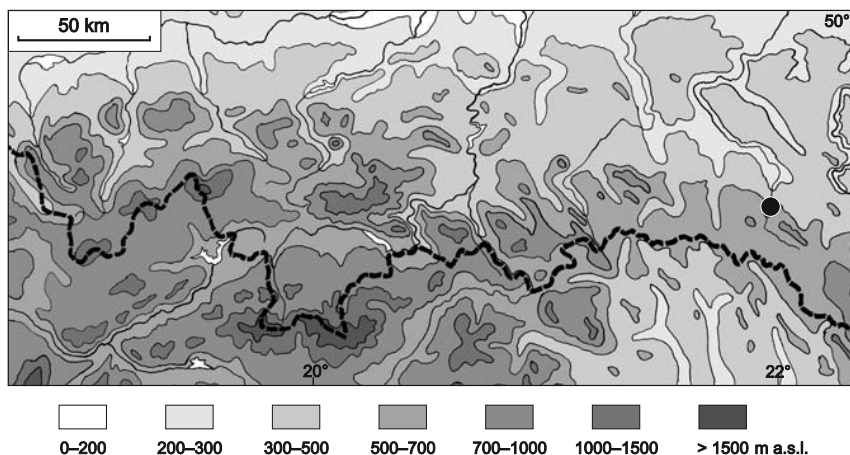


Fig. 55. Distribution of *Caloplaca teicholyta* (Ach.) J. Steiner in the Polish Western Carpathians.

crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 70–90 µm high. Paraphyses simple to branched, apical cells not thickened. Hypothecium hyaline, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, 14.0–18.5×6.0–8.5 µm, isthmus 4.3–6.8 µm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. It grows on calcareous sandstone on river banks at *ca* 350 m a.s.l.

The species is known from the Beskid Niski Mts.

DISCUSSION. *Caloplaca teicholyta* is characterized by its grey, sublobate thallus, with coarse granules and white soredia in the central part. The thalline cortex is present at least in the margin. Apothecia are very rare in this species.

Vondrák and Hrouzek (2006) included *C. teicholyta* in the heterogenous group of sorediate species not containing anthraquinones in the thallus and soredia. There are a few taxa which closely resemble *C. teicholyta*: *C. aetnensis*, *C. albolutescens* and *C. erythrocarpa*. Some authors treat *C. albolutescens* as a synonym of *C. teicholyta*. The former differs from *C. teicholyta* by having a rimose-areolate thallus dissolved into coarse violet-grey soredia, the absence of marginal lobes and the lack of a thalline cortex (see also comments under *C. albolutescens*) (Wirth 1995; Vondrák *et al.* 2007).

Unlike *C. teicholyta*, *C. erythrocarpa* does not produce vegetative propagules at all. Its thallus is chalky white, and its apothecia are common and numerous, initially immersed in the thallus. *Caloplaca aetnensis* differs from *C. teicholyta* by having scattered thalline areoles and a different ecology: it occurs on silicic rock in the Mediterranean region (Egea 1984).

SPECIMEN EXAMINED. POLAND. WESTERN CARPATHIANS. BESKID NISKI MTS, Sieniawa near Rymanów (distr. Krosno), by Wisłok riverside, alt. 340 m, 4 Sep. 1977, J. Nowak (KRAM L-23028).

ADDITIONAL MATERIAL EXAMINED. POLAND. POJEZIERZE KUJAWSKIE LAKELAND, Wrząca Wielka, 19 Oct. 1983, Z. Tobolewski & J. Sierakowska s.n. (POZ). ISRAEL. JORDAN VALLEY, Beth-Shean, 22 June 1996, J. J. Wójcicki & M. Sugiera (KRAM L-44784).

Caloplaca velana complex Figs 18E & 56

INCLUDING: *C. velana* (A. Massal.) Du Rietz; Gotländ. Vegetationsst.: 45. 1925. – *Callopsisma aurantiacum* var. *velanum* A. Massal., Atti Istit. Veneto, ser. 2, 3(App. 3): 74. 1852.

Thallus granular-areolate, weakly developed, yellow or yellow orange, epruinose; without prothallus and vegetative propagules. Thalline cortex with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface. *Apothecia* zeorine, abundant, crowded, sessile from the beginning, round or angular by compression, 0.2–1.2 mm diam.; disc flat to slightly convex, epruinose, slightly glossy, orange or dark orange; proper margin persistent, thick, slightly raised above disc, paler than disc; thalline margin ± reduced, even, yellow orange. Parathecium thin or thick, *ca* 100 µm, prosoplectenchymatous, anthraquinone crystals present. Amphithecium with many algae, slightly reduced, anthraquinone crystals present. Epithymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 60–100 µm high. Paraphyses simple or slightly branched, 1–2 apical cells moderately thickened, up to 7 µm wide. Hypothecium hyaline, without crystals, sometimes with oil droplets, prosoplectenchymatous. Asci 8-spored, spores polarilocular, thin-walled, 10.0–13.5 × 6.5–8.5 µm, isthmus 3.5 µm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. The species of the *C. velana* complex occur on limestone rock in sunny places.

Members of the complex apparently are widespread in the Western Carpathians, but only specimens from the West Tatras have been studied.

DISCUSSION. Members the *C. velana* complex are characterized by their areolate or granular, epruinose, orange or yellow orange thallus. The apothecia are orange, sessile with a persistent and thick proper margin, and with a slightly reduced thalline margin. The spores are subspherical.

Clauzade and Roux (1985) distinguished several taxa of lower rank within *C. velana* (A. Massal.) Du Rietz: var. *velana* (thallus consists of only a few granules around ± crowded apothecia), var.

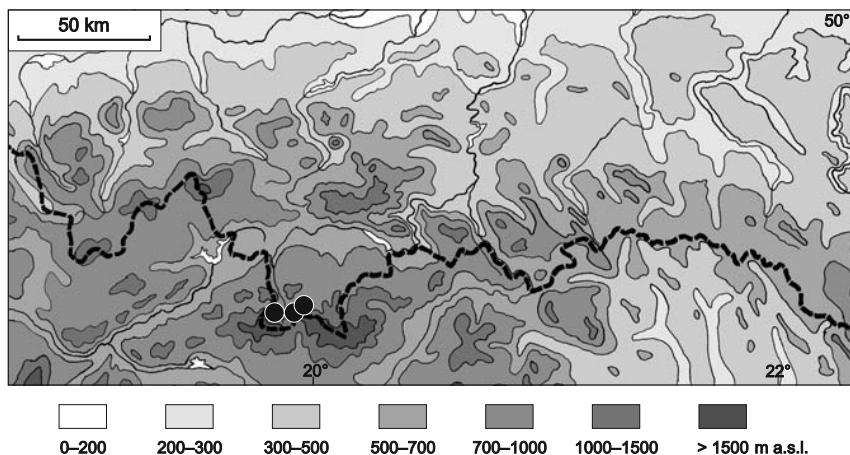


Fig. 56. Distribution of the *Caloplaca velana* complex in the Polish Western Carpathians.

dolomiticola (thallus areolate, areoles with an uneven surface, divided by long deep fissures), var. *placidia* (A. Massal.) Clauzade & Cl. Roux (thallus well developed, cracked-areolate), var. *schaereri* (Flörke) Clauzade & Cl. Roux (thallus well visible, continuous, with only few fissures, granular on the surface) and var. *dalmatica* (A. Massal.) Clauzade & Cl. Roux (apothecia persistently \pm immersed, abundant, crowded, thallus continuous, with numerous fissures). Many authors now treat *C. velana* var. *dolomiticola* and var. *dalmatica* as separate species: respectively, *C. dolomiticola* and *C. dalmatica*. The *C. velana* complex is one of the most problematic groups of the genus. It requires detailed taxonomic study (Clauzade & Roux 1985; Nimis 1993; Renobales 1996).

Caloplaca velana closely resembles *C. dolomiticola*. For a comparison the two taxa see the notes under *C. dolomiticola*. *Caloplaca dalmatica* differs from *C. velana* by having a yellow, continuous, slightly cracked thallus, and apothecia persistently immersed in the thallus. Other species resembling the *C. velana* complex are *C. glomerata* and *C. latzelii* (Servit) Clauzade & Cl. Roux. Both species differ by having spores with distinctly thickened apical walls, and apothecia immersed in the thallus at least initially (Arup 1990; see also the notes under *C. dolomiticola*). *Caloplaca polycarpa* can also be misidentified as *C. velana*, but the latter has an often sublobate thallus surrounded by a distinct

orange prothallus. The former species has also a different habit: it occurs mainly as a parasite on endolithic species of *Verrucaria* s.l. The two species differs also in shape and size of spores (see comments under *C. polycarpa*).

EXSICCATE SEEN. Arnold, *Lich. Exsicc.* 1253 (as *Callophisma aurantiacum*) (KRAM).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. WEST TATRA MTS, Dolina Kościeliska valley, Polana Pisane glade, 49°14'33"N, 19°51'53"E, 14 July 2004, *L. Śliwa* 2947 (KRAM); Dolina Chochołowska valley, polana Dudowa glade, 49°14'58"N, 19°49'37"E, 16 July 2004, *L. Śliwa* 3128 (KRAM); Dolina Strążyska valley, *s.d.*, *s.coll.* (KRAM L-18019).

Caloplaca vitellinaria Szatala Figs 18F & 57

Ann. Hist.-Nat. Mus. Natl. Hungarici, ser. nov. 7: 276. 1956.

Thallus absent or very scanty, pale orange (K+ red), over the thallus or apothecia of the host *Candelariella vitellina* (Hoffm.) Müll. Arg. *Apothecia* zeorine, abundant, usually grouped, round or angular by compression, up to 1 mm diam.; disc flat to slightly convex, orange; proper margin thin, at first raised, then level with disc, paler than disc; thalline margin excluded. Parathecium prosoplectenchymatous with radiating hyphae, anthraquinone crystals present. Amphithecium with many algae, anthraquinone crystals

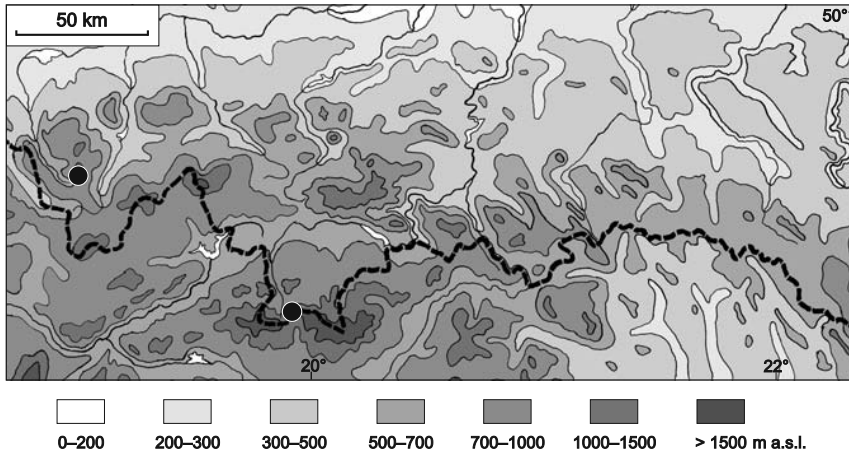


Fig. 57. Distribution of *Caloplaca viellinaria* Szatala in the Polish Western Carpathians.

present. Epihymenium interspersed with yellowish orange crystals of anthraquinones (pol+, K+ red, soluble). Hymenium hyaline, 60–70 μm high. Hypothecium hyaline, ca 30 μm . Paraphyses branched, 1–2 apical cells slightly thickened, up to 5 μm wide. Asci 8-spores, spores polarilocular, thin walled, 9–14 \times 5–8 μm , isthmus (3–)4–5 μm wide. *Pycnidia* not observed.

HABITAT AND DISTRIBUTION. The species colonizes the thallus of *Candelariella vitellina* growing on sandstone and shale containing calcium.

The species is known from the Beskid Śląski Mts and West Tatras.

DISCUSSION. The species is characterized by its orange apothecia and highly reduced thallus. It is a parasite occurring on the thallus of *Candelariella* spp.

The species is very problematic since it is quite similar to *C. holocarpa*. The complex needs further taxonomic and genetic studies (Arup 2009). It is recognized here based mainly on its ecology and some other distinguishing characters such as the size and arrangement of apothecia (bigger and aggregated in *C. vitellinaria*). Most recently, *C. vitellinaria* was suggested to be a synonym of *C. holocarpa* (Vondrák *et al.* 2010), and this concept should be followed in the future.

For more comments on the species see Wilk and Flakus (2006).

SPECIMENS EXAMINED. POLAND. WESTERN CARPATHIANS. BESKID ŚLĄSKI MTS, Barania Góra range, Pietraszyna village, Koczy Zamek Mt., alt. 847 m, 49°32'54"N 18°58'32"E, 9 Sep. 2005, *K. Wilk* 3838 (KRAM). WEST TATRA MTS, Twardy Uplaz, N slope below Ciemniak Mt., alt. 1900 m, 49°14'14"N 19°54'13"E, 30 July 2005, *A. Flakus* 5120 (KRAM).

ADDITIONAL MATERIAL EXAMINED. HUNGARY. VESPREM. Supra balneas Tihany prope lacum Balaton, alt. 220 m, 17 Aug. 1964, *A. Vězda* (KRAM L-28050).

***Caloplaca xanthostigmoidea* (Räsänen) Zahlbr.**

Figs 19 & 58

Cat. Lich. Univ. **10**: 631. 1940. – *Placodium xanthostigmoideum* Räsänen, Ann. Missouri Bot. Gard. **20**: 15. 1933.

Thallus areolate, thin, ca 150–350 μm , yellow K+ red; anthraquinones), blastidiate; without prothallus. Areoles scattered, flat or convex, surface with aggregated isidioid blastidia, often olive green (K–, N+ violet; cinereorufa-green). Thalline cortex thin, 5–20 μm , paraplectenchymatous, with yellowish orange crystals (pol+, K+ red, soluble; anthraquinones) at the surface, necral layer present; algal layer continuous; medulla dense, without crystals. *Apothecia* not observed. *Pycnidia* abundant; ostiolum orange; conidia 3–4 \times 1.5 μm .

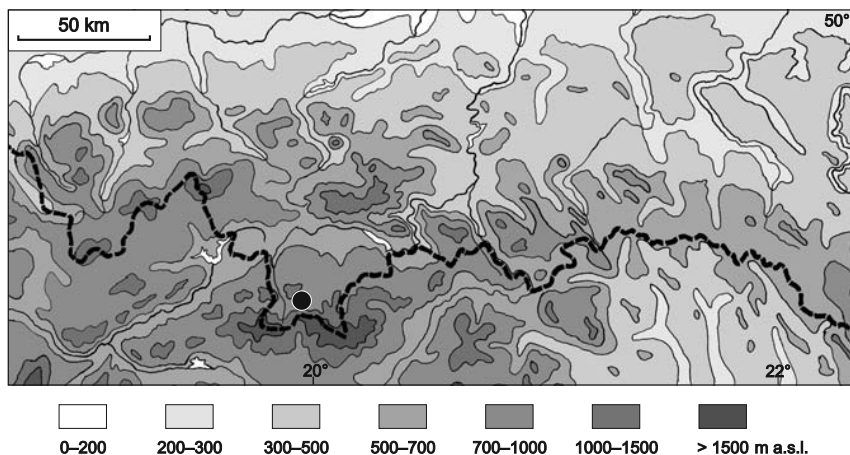


Fig. 58. Distribution of *Caloplaca xanthostigmoidea* (Räsänen) Zahlbr. in the Polish Western Carpathians.

HABITAT AND DISTRIBUTION. It grows on bryophytes on limestone in sun-exposed situations. The species also may occur directly on rock surfaces.

The species is known from the West Tatra Mts.

DISCUSSION. *Caloplaca xanthostigmoidea* is characterized by its yellow, areolate thallus. The areole surface has isidioid protuberances speckled with olive green spots.

The species was discussed in detail by Söchting and Tønsberg (1997) and Wetmore (2001). The olive green color of the isidioid protuberances is from cinereorufa-green pigment in this species. The pigment reacts violet with N (see also Wetmore 2001). *Caloplaca xanthostigmoidea* rarely produces apothecia, but when present they have an apothecial margin with sparse algae or without algae. The rare 7-chloroemodin chemosyndrome occurs in the thallus of this species (Söchting & Tønsberg 1997).

Unlike *C. xanthostigmoidea*, *C. citrina* produces typical soralia on the surface of areoles; the soredia are fine and yellow without an olive green tinge. The chemistry of *C. citrina* also differs; the species does not contain 7-chloroemodin (Söchting & Tønsberg 1997; Wetmore 2001).

SPECIMEN EXAMINED. POLAND. WESTERN CARPATHIANS. WEST TATRA MTS, Sarnia Skala, 1 km S of

Zakopane, 49°15'51"N, 19°56'30"E, 10 May 1997, *C. Wetmore* 77363 (MIN).

ADDITIONAL MATERIAL EXAMINED. SVALBARD. SABINE LAND. Tempelfjorden at Schoultzhamna, alt. 2 m, on beach, 12 Aug. 1986, *U. Söchting* 5636 (MIN).

SPECIES NOT CONFIRMED

A few species earlier reported from the area were not found in the studied material: *Caloplaca alociza*, *C. aurantia*, *C. erythrocarpa* and *C. subochracea*. Nor were they found during recent field studies in the Carpathians. The occurrence of those species in the Polish Western Carpathians was not confirmed.

Caloplaca alociza (A. Massal.) Mig.

Caloplaca alociza closely resembles *C. albopruinosa*. Many authors treat *C. albopruinosa* as a synonym of *C. alociza* but the most recent work (Muggia *et al.* 2008) differentiates the two taxa. For a comparison of the species see the comments under *C. albopruinosa*.

Caloplaca alociza was reported from the Tatra Mts (Alstrup & Olech 1988, 1992). In the available herbarium material no specimens of the species were found, so the occurrence of *C. alociza* in the Tatras could not be confirmed.

Caloplaca aurantia (Pers.) Hellb.

Caloplaca aurantia is most similar to *C. flavescens*. The two have been misidentified (revision revealed that the Carpathian specimens earlier identified as *C. aurantia* were *C. flavescens*) but they are easily distinguishable. *Caloplaca flavescens* differs from *C. aurantia* by having a distinct layer of grey crystals inside cortex (pol+). Further features separating the two taxa are included in the comment to *C. flavescens* and in a paper by Śliwa and Wilk (2008).

The species *C. aurantia* was reported from the Tatra Mts (Tobolewski 1957; Alstrup & Olech 1992) and Pieniny Mts (Tobolewski 1958; Kiszka 2000). All available herbarium material was revised and the species was not confirmed.

EXSICCATE SEEN. Pišút, *Lich. Slov. Exsicc.* 226 (as *C. aurantia* var. *heppiana*) (KRAM).

Caloplaca erythrocarpa (Pers.) Zwackh

Caloplaca erythrocarpa may be confused with *C. albolutescens*. Both taxa belong to the very problematic *C. ferruginea* group, which needs detailed taxonomic revision including genetic analyses. The Carpathian specimens identified earlier as *C. erythrocarpa* have more or less developed soredia. The presence of soredia is a diagnostic feature of *C. albolutescens*. For comparison of the two taxa see comments under *C. albolutescens*.

The species was reported from the Beskid Wyspowsy Mts (Bielczyk 2003), Beskid Niski Mts (Nowak 1995) and Pieniny Mts (Kiszka 1997a). The species was not confirmed in the herbarium material available to me for revision.

ADDITIONAL MATERIAL EXAMINED. CROATIA. ISTRIA. Poreč, Špadići, 11 Sep. 2009, *J. Vondrák s.n.* (CBFS). SPAIN. ANDALUCÍA, Ronda, limestone outcrops at road between Ronda and El Burgo, alt. ca 1000 m, 28 Feb. 2008, *J. Vondrák s.n.* (CBFS).

Caloplaca subochracea (Wedd.) Werner

Caloplaca subochracea is a diverse species characterized by an epilithic, continuous to rimose-areolate, pale yellow or whitish thallus.

The apothecia are sessile, rust red or brownish red (see also Clauzade & Roux 1977, 1985; Egea 1984; Nimis 1992). The species is most similar to *C. coccinea* and *C. nubigena*, both of which have apothecia immersed (in rock and thallus respectively) at least at the beginning of development. *Caloplaca coccinea* has an orange thallus, poorly developed and consisting of fine granules immersed in rock. *Caloplaca nubigena* differs from *C. subochracea* by having a yellow orange thallus and apothecia. Specimens of *C. subochracea* with a whitish thallus could be confused with *C. erythrocarpa*, which differs by having longer and wider spores with a wider isthmus (see also Egea 1984). *Caloplaca subochracea* occurs mainly along the Mediterranean shore (Nimis 1993).

Caloplaca subochracea was reported from the Tatra Mts by Alstrup and Olech (1988, 1992). It was not found in the available herbarium material, so its occurrence in the Tatras is not confirmed.

ACKNOWLEDGEMENTS. I warmly thank my adviser Lucyna Śliwa (Kraków, Poland) for sharing her knowledge of lichen taxonomy, invaluable discussions and help during the work on this study, and for constructive comments during preparation of the monograph.

I thank the Curators of the following herbaria for loaning material for study: CBFS, GPN, H, KRA, KRAM, KRAP, KTC, LD, MIN, LOD, OLTC, POZ, POZG, PPN, PRM, S, TRN, UGDA, WA and WRSL.

For help and assistance during field studies I thank my husband Tomasz Wilk, my sister Grażyna Skórka-Awsiukiewicz, Joanna Kozik, Janusz Skórka, Lucyna Śliwa, Grzegorz Mrózek, Andrzej Pietyra, Jerzy Pukowski and Joanna Sosnowska. For confirming the identification of some species and constructive discussions I thank Ulf Arup (Lund, Sweden), Ester Gaya (Durham, North Carolina, U.S.A.) and Clifford Wetmore (St. Paul, Minnesota, U.S.A.). I thank Clifford Wetmore and Imke Schmitt (St. Paul, Minnesota, U.S.A.) additionally for allowing me to study the collection of *Caloplaca* in MIN and for their hospitality during my visit. I thank Ulrik Søchting (Copenhagen, Denmark) for performing TLC and analyzing the results for *C. percrocata*, Urszula Bielczyk (Kraków), Krystyna Czyżewska (Łódź) and Stanisław Cieśliński (Kielce) for fruitful discussions on some aspects of the work, Jan J. Wójcicki (Kraków) for friendly co-operation during the editorial work, and Dorota Hollitzer-Zielińska (Kraków) for technical assistance with the distribution maps.

Finally I wish to thank my husband Tomasz Wilk for his encouragement and active support and my sons Maciej and Szymon Wilk for their patience.

Financial support was provided by the Ministry of Science and Higher Education (2008–2009, grant no. N N303 294334), National Science Centre (grant no. N N303 821740), and the W. Szafer Institute of Botany, Polish Academy of Sciences, through its statutory fund.

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Received 12 July 2011