

ACTA MYCOLOGICA
Vol. 44 (2): 239–248
2009

*Dedicated to Professor Krystyna Czyżewska
in honour of 40 years of her scientific activity*

Notes on *Caloplaca lucifuga* (Teloschistales, Ascomycota) in Poland

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Kubiak D., Zalewska A.: *Notes on Caloplaca lucifuga (Teloschistales, Ascomycota) in Poland*. Acta Mycol. 44 (2): 239–248, 2009.

The current knowledge on the occurrence of *Caloplaca lucifuga*, a rare lichen with an inconspicuous crustose sorediate thallus, is discussed. Both previous and new localities are presented. The most important data on the ecology and general distribution of the species are given. Diagnostic characters related to the morphology, anatomy and chemistry of *C. lucifuga* that help to differentiate it from similar species are described.

Key words: lichenized fungi, sorediate species, *Caloplaca*, distribution, N Poland

INTRODUCTION

Caloplaca lucifuga belongs to a group of crustose, sterile sorediate lichens that are relatively poorly known in Poland (Nowak, Tobolewski 1975; Śliwa, Tønberg 1995; Śliwa 1996; Kukwa 2005a, b, 2006; Kukwa, Szymczyk 2006; Kukwa, Kubiak 2007). Despite its small-sized thallus, this very rare species has distinct, characteristic morphological and chemical features that help to distinguish it from other similar taxa. Its special ecological requirements also make the species noteworthy. *C. lucifuga* is associated with the bark of old deciduous trees, especially oaks. It seems to have potential indicator properties that may be used to identify high-biodiversity sites and forest communities of special value for protection purposes (cf. Rose 1992; Arup 1997; Nordén et al. 2007).

Caloplaca lucifuga was first reported in Poland by Lipnicki (1993) from the Bory Tucholskie forest. Its localities were later noted in the Puszcza Borecka forest by Zalewska (2000) and in the Puszcza Białowieska forest by Sparrius (2003). Specimens of *C. lucifuga* were collected from the Puszcza Białowieska forest by H. Sipman and P. van den Boom as early as in 1988; however, the exact location of the

sites is unknown (unpubl. data acc. to Sparrius 2003; Sparrius, pers. comm. 2009). Data on the occurrence of *C. lucifuga* in north-east Poland are provided in a study by Cieśliński (2003), who cites unpublished materials by J. Nowak from the Puszcza Białowieska forest.

The available scarce data on the distribution of *Caloplaca lucifuga* in Poland are given in this study and its new localities recorded in the Pojezierze Olsztyńskie lake-land are presented on the map.

Habitat requirements of *C. lucifuga* identified so far suggest that further localities of the species are likely to occur in Poland. The aim of the study was to present the species and to indicate the most important diagnostic characters that help to find it in field studies and to recognise it in herbarium materials.

MATERIAL AND METHODS

The material was collected in 1995–1997 and 2005–2008. Specimens were identified with standard morphological and anatomical methods as well as using spot colour reaction tests to differentiate secondary metabolites (Purvis et al 1992; Orange et al. 2001). The square number of the modified ATPOL grid (Cieśliński, Fałtynowicz 1993) was given for all localities. The nomenclature of lichens follows Fałtynowicz (2003) and Diederich et al. (2009). The material was deposited in the Herbarium of the Department of Mycology, Warmia and Mazury University in Olsztyn (OLTC-L) and in the Herbarium of the Department of Botany and Nature Protection, Warmia and Mazury University in Olsztyn (OLS-L).

RESULTS

Caloplaca lucifuga Thor, Lichenologist 20 (2): 175 (1988).

Morphology. *Thallus* endophloedic, inconspicuous or visible as a thin grey film with scattered small blisters. *Photobiont* chlorococcoid 7–14 μm diam., algal cells in clusters (in the thallus section). *Soralia* numerous, 0.15–0.35 mm in diam., forming by a break-up of blisters, pale yellow, yellowish grey to dirty yellow-orange-brown, delimited, but sometimes lying very close to one another, rounded or flexuose, flat, ulcerose or slightly elevated, when erumpent through the bark (Fig. 1). *Soredia* granular or farinose 17–24 μm diam. *Apothecia* not seen so far, including the Polish material.

Chemistry. According to Thor (1988), the species produces hydroxyanthraquinone derivatives: parietin (major) and fallacinal (minor). Spot test reactions: thallus C–, K–, PD–; soralia C–, K+ violet-red, PD–.

Ecology. *Caloplaca lucifuga* was recorded in old oak-lime-hornbeam and oak-hornbeam forests in Poland, at sun-exposed or moderately shaded sites with a relatively high air humidity. The species occurred on the bark of old oaks and hornbeams

(usually with a trunk girth of over 300 cm) growing by mid-forest roads, less frequently inside forest communities.

The species was observed on the bark of *Quercus robur* together with *Acrocordia gemmata*, *Arthonia byssacea*, *Calicium adspersum*, *C. salicinum*, *C. viride*, *Chrysothrix candelaris*, *Cliostomum corrugatum*, *Lecanora expallens*, *Lepraria incana*, *L. vouauxii*, *Lobaria pulmonaria*, *Ochrolechia turneri*, *Pertusaria amara*, *Phlyctis argena* and *Ramalina* sp. in the Pojezierze Olsztyńskie lakeland.

The group of accompanying taxa in the Puszcza Borecka forest included species such as *Buellia griseovirens*, *Chaenotheca trichialis*, *Pertusaria albescens*, *P. coccodes* and *P. hemisphaerica* on oaks, as well as *Arthonia didyma*, *A. ruana*, *Bacidia subincompta*, *Bacidina assulata*, *Lecanora intumescens*, *L. glabrata*, *Opegrapha varia*, *O. viridis*, *Pyrenula laevigata* and *P. nitida* on the bark of hornbeams.

According to literature sources, *Caloplaca lucifuga* clearly prefers the bark of old deciduous trees in woodland tree stands described in different parts of Europe as „wooded pastures” or „wooded meadows” (Thor 1988). Such ecosystems consist of more or less scattered, aged trees and a mosaic of grazing or, less frequently, mowing meadows (Kirby et al. 1995). Known mostly from Scandinavia and Great Britain, they also occur in, for instance, Estonia. These sites have for a long time functioned as extensive pastures and are characterised by a specific ecological continuity. They are important habitats of many rare lichens everywhere (Thor 1988; Laundon 1992; Lepik, Jüriado 2008). *C. lucifuga* is an indicator species of such areas (Arup 1997; Coppins, Coppins 2002). *C. lucifuga* also finds similar conditions in very old parks (Thor 1988; Laundon 1992; Hallingbäck 1995). Furthermore, it occurs in denser forests, although usually on the bark of trees growing on the forest edge, e.g. by forest roads.

Caloplaca lucifuga usually colonises deeply cracked bark of very old oaks (*Quercus robur*, *Q. petraea*) with a breast diameter of 1–2 m. It was observed on the bark of *Castanea*, *Fagus*, *Tilia* and *Ulmus* considerably less frequently (Thor 1988). The species is also known from the bark of *Aesculus hippocastanum* (Brunialti et al. 2001; Aptroot et al. 2001), *Acer pseudoplatanus* (Palice et al. 2003), *Carpinus betulus* (Lipnicki, pers. comm. 2009; Zalewska 2000), *Castanea sativa* (Poelt 1994; Lopez De Silanez et al. 1999), *Fagus sylvatica* (Spier et al. 2008), *Tilia cordata* (Türk, Wunder 1999) and *Ulmus glabra* (Berger, Türk 1993). *C. lucifuga* was also recorded on dead wood (Clerc 2004).

Thor (1988) stresses the species preference for high air-humidity areas (e.g. near lakes, the seaside). He also notes that the lichen mostly grows in deep bark cracks in well-lit sites while it also occurs outside the cracks on flat, raised surfaces, when the shading is greater. The majority of records of *C. lucifuga* from oak bark are reported for trees with natural properties of the periderm, not impregnated with dusts (Thor 1988; Thor, Arvidsson 1999; Ek, Johannesson 2006). Data from more diversified habitats (Bratli, Haugan 1997) suggest a slightly broader ecological amplitude of the species. Based on studies conducted in the Östergötland county in south-east Sweden on sun-exposed precipices overgrown by oaks, Ek et al. (1995) report that the breast diameter of 62% of old trees with fissured bark colonised by *C. lucifuga* ranged from 27 to 92 cm. Therefore, the age of the tree and, to a lesser degree, its trunk diameter seem to be major factors conditioning the occurrence of *C. lucifuga* (Thor 1988).

Caloplaca lucifuga grows in relatively rich epiphytic communities abundant in rare lichen species. Of taxa mostly accompanying *C. lucifuga* on old oaks, *Arthonia byssacea*, *A. vinosa*, *Buellia violaceofusca*, *Calicium quercinum*, *Chaenotheca hispidula*, *Cliostomum corrugatum*, *Cyphelium sessile*, *Lecanographa amylacea*, *Ramalina baltica* incl. *obtusata*, *Schismatomma decolorans* and *S. pericleum*, are particularly interesting (Thor, Arvidsson 1999; Ek, Johannesson 2006). According to Wirth (1995), *C. lucifuga* is a component of communities of the order *Chrysothricetalia candelaris* Wirth, represented by, e.g., numerous „calicioid lichens”.

World distribution. *Caloplaca lucifuga* occurs mostly in Europe, where it has a broad distribution range. The species is known from Denmark, France, Germany, Sweden, Great Britain and Italy (Thor 1988) as well as from Luxembourg (Diederich 1989), Belgium (Diederich et al. 1991), Estonia (Ekman et al. 1991), Austria (Berger, Türk 1993), Poland (Lipnicki 1993), Portugal (van den Boom and Giralt 1996), Norway (Bratli, Haugan 1997), Finland (Vitikainen et al. 1997), Spain (Etayo 1991), Latvia (Sundin, Thor 1990), the Czech Republic (Palice et al. 2003), Lithuania (Motiejūnaitė et al. 2003), Switzerland (Clerc 2004), Slovakia (Palice et al. 2006), Bulgaria (Spier et al. 2008) and Croatia (Partl 2009).

It seems that the occurrence range of *C. lucifuga* in Europe is related to the distribution of deciduous forests of the temperate zone. Localities of the species in Sweden and Norway in the Scandinavian Peninsula are situated only in its southern part belonging to the nemoral zone. The lichen also occurs in the sub-Mediterranean zone in the south of Europe, probably at localities situated mostly in the mountains (cf. López De Silanes et al. 1999; Brunialti et al. 2001).

Outside Europe, *C. lucifuga* is known only from South America. Two specimens of the lichen were collected by H. Sipman and J. Aguirre in Columbia (Lichen Herbarium Berlin, BGBM – WWW).

Caloplaca lucifuga is usually known from few localities in individual countries. It is locally very frequent only in southern Sweden (Hultengren 1994; Ek et al. 1995), from where Thor and Arvidsson (1999) report ca 200 localities. On the other hand, Ek and Johannesson (2006) report as many as 400 records (58% of all records in Sweden) only from the Östergötland county in south-east Sweden. It is also a fairly frequent lichen in the Vosges in France (Aptroot et al. 2001).

REMARKS. As the number of its localities is small, *C. lucifuga* is considered to be vulnerable in many countries. It is classified as critically endangered (CR) in Finland (Rassi et al. 2001) and is believed to be endangered (EN) in Austria (Türk, Haffelner 1999), Denmark (Søchting, Alstrup 2002), Switzerland (Scheiddeger et al. 2002) and the Czech Republic (Liška et al. 2008). It is classified as vulnerable (VU) in Great Britain (Woods, Coppins 2003) and Norway (Timdal et al. 2006). It is thought to be near threatened (NT) in Sweden (Gärdenfors 2005) and Estonia (Randlane et al. 2008). The species has not been red-listed in Poland due to very scarce data (Cieśliński et al. 2006). However, as habitats characteristic of *C. lucifuga* are becoming extinct and the number of its localities is small, the taxon seems to fully deserve to be included in the next edition of the red list.

Distribution in Poland. *C. lucifuga* is known from ten localities in northern and north-east Poland. It occurs in the Bory Tucholskie forest (Lipnicki 1993), Puszcza Borecka forest (Zalewska 2000), Puszcza Białowieska forest (Sparrius 2003; Cieśliński 2003) and in the Pojezierze Olsztyńskie lakeland (present work) (Fig.2).

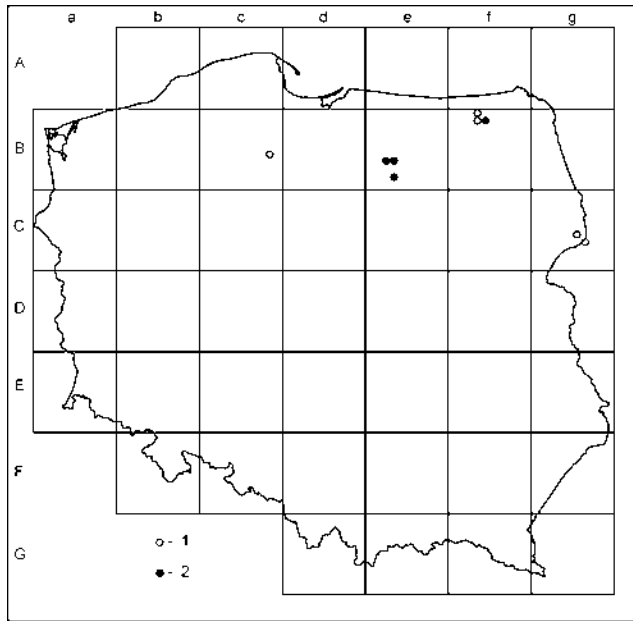


Fig. 2. Distribution of *Caloplaca lucifuga* in Poland (in the ATPOL square grid): 1 – known records; 2 – new records.

Localities known prior to this paper. ATPOL grid square **Bc 58** – Bory Tucholskie forest, vicinity of the ‘Krzywe Koło w pętli Wdy’ reserve (Lipnicki 1993). **Bf 03** and **Bf 13** – Pojezierze Ełckie Lakeland, Puszcza Borecka forest (Zalewska 2000; Cieśliński 2003). **Cg 55** – Równina Bielska plain: Puszcza Białowieska forest (Cieśliński 2003, locality cited as pers. comm. by J. Nowak). **Cg 66** – Puszcza Białowieska forest, Białowieża, Białowieża forest inspectorate, near the road bordering on forest sections Nos 452B and 453A (Sparrus 2003; L. Sparrus, pers. comm. 2009).

SPECIMENS EXAMINED. **Be 62** – Pojezierze Olsztyńskie lakeland: Las Warmiński nature reserve, forest section No 705d, 53°38'59.7"N, 20°30'03.1"E, 8 July 2008, leg. *D. Kubiak* (OLTC-L 3042). **Be 63** – ‘Las Warmiński’ nature reserve, forest section No 214l, 53°46'49.0"N, 20°25'30.3"E, 1 May 2005, leg. *D. Kubiak* (OLTC-L 1864). **Be 83** – Pojezierze Olsztyńskie lakeland, ‘Dęby Napiwodzkie’ nature reserve, 30 July 2008, leg. *D. Kubiak* (OLTC-L 3227). **Bf 03** – Pojezierze Ełckie lakeland, Puszcza Borecka forest, Borki forest inspectorate, Diabla Góra forest district, local square 38, 54°08'N, 22°05'E, at the edge of the oak-lime-hornbeam forest by the ‘Dębowa Linia’ forest road, 18 July 1996, leg. *A. Zalewska* (OLS-L); local square 40, 54°08'N, 22°09'E, 13 June 1996, leg. *A. Zalewska* (OLS-L), rev. *B. J. Coppins*, 1998. **Bf 13** – Puszcza Borecka forest, Borki forest inspectorate, Lipowo forest district, ‘Borki’ nature reserve, forest section No 19a, local square 48, 54°07'N, 22°06'E, 18 July 1997, leg. *A. Zalewska* (OLS-L). **Bf 14** – Puszcza Borecka Forest, Czerwony Dwór forest inspectorate, Rogonie forest district, local square 61, 54°06'N, 22°11'E, 13 July 1995, leg. *A. Zalewska* (OLS-L).

DISCUSSION

Although it forms diminutive and inconspicuous thalli, *Caloplaca lucifuga* is a fairly characteristic species. It is distinguished by a pale-grey, very thin endophloedic thallus and delimited soralia, yellow-grey to dirty yellowish-orange-brown reacting with K+ violet-red.

Caloplaca chrysophthalma Degel. bears the greatest resemblance to *C. lucifuga*. The former differs from *Caloplaca lucifuga* by having a thicker, epiphloedic thallus, grey to yellow (Thor 1988), yellowish-green, yellow-green or grey (Wetmore 2004), with distinct and delimited, usually bright orange-yellow soralia. It rarely produces immersed, poorly developed thalli with scattered, light yellow soralia (Laundon 1992; Wetmore 2004). Furthermore, *C. chrysophthalma* produces bright orange apothecia, not always present (Thor 1988; Laundon 1992; Wetmore 2004). Clusters of algal cells, present in *C. lucifuga*, are absent on cross section (Thor 1988). Both species have slightly different chemical properties. *C. chrysophthalma* also contains parietin (major) as well as additional substances: emodin (minor) and fragilin (minor), instead of fallacinal. Soralia and apothecia react with K+ violet-red. The distribution of both taxa also differs. *C. chrysophthalma* is mostly known from North America (Wetmore 2004) and from northern Europe, where it occurs in Great Britain (Laundon 1992), Norway (Ihlen 1997) and Denmark, Estonia and Sweden (Thor, Arvidsson 1999). It has few localities in other European countries as well as in Mongolia (cf. sources cited by Culberson et al. 2008) and China (Wetmore 2004). This species has been not recorded in Poland so far (cf. Fałtynowicz 2003). Moreover, *Caloplaca chrysophthlma* differs from *C. lucifuga* by its ecological preferences. It is usually associated with trees having natural eutrophic or enriched, dusted bark. In Europe, it is known from such phorophytes as *Acer*, *Fraxinus*, *Tilia*, *Ulmus* or less frequently from *Quercus* growing in roadside alleys or other open sites (Hallingbäck 1995; Thor, Arvidsson 1999). In North America, it is a forest epiphyte often found on, old trees of *Populus tremuloides* (Wetmore 2004).

TLC analysis is not helpful in species identification when fine thalli, such as the ones used in this study, with a very low content of accessory substances, are examined (cf. Thor 1988). Thallus thickness and colour as well as the colour of soralia remain major characters differentiating *C. lucifuga* from *C. chrysophthalma*. Habitat data which should, however, be interpreted with care (cf. Bratli, Haugan 1997), may also be useful. It seems that some characters in the descriptions of the morphology and ecology (Thor 1988; Laundon 1992; Wetmore 2004) of both representatives of the genus *Caloplaca* slightly overlap. The lack of more extensive data available on the frequency of chemical substances recorded and their influence on the colour of soralia as well as data on the structure of fruitbodies and picnidia, not found in *C. lucifuga* so far, causes some confusion. More wide-ranging chemo-taxonomic examinations of very large collections belonging to 400 records from Östergötland (Ek, Johannesson 2006) and from North America (405 collections, see Wetmore 2004) could be helpful. An analysis of the genetic similarity of both taxa could also provide interesting results.

Buellia violaceofusca Thor & Muhr, another sorediate species, can be found together with *Caloplaca lucifuga* on old oak trees growing in forests. The former has a similar, pale grey endophloedic thallus with slightly elevated soralia, often confluent

and clearly darker, brown tinged violet. The species is known to be sterile (apothecia and picnidia have not been observed). All spot test reactions on the thallus and soralia of *B. violaceofusca* are negative (Thor, Muhr 1991).

It is finally worth mentioning that the status of *C. lucifuga* is not clear since, similarly to many other sterile representatives, the species was placed in the genus *Caloplaca* mostly based on the presence of antraquinones, parietin and fallacinal. These substances occur together with emodin also in other *Teloschistales* belonging to chemosyndrome A (Arup, Grube 1999). Based on molecular studies, Søchting and Lutzoni (2003) have recently shown that the morphological form of the thallus and the development type of its lower cortex are not good taxonomic characters differentiating the genera *Caloplaca*, *Xanthoria* and *Fulgensia*. It was proven that, for instance, some species of the genus *Caloplaca* with crustose thalli should be transferred to the genus *Xanthoria*.

CONCLUSIONS

Based on the current knowledge on the identification and ecology of *C. lucifuga* and *C. chrysophthalma* as well as the distribution rate of characteristic habitats preferred by them, it may be suggested that *Caloplaca lucifuga* is considerably more widespread in Poland but has been poorly differentiated (cf. Wirth 1997). Detailed observations of old oak tree stands, especially within large forest complexes in NE Poland, should be conducted. It seems possible that *C. chrysophthalma* could also be found in Poland.

Acknowledgements. The authors are indebted to B. J. Coppins (Edinburgh) for the confirmation of identification of specimen from the Puszcza Borecka forest. We would like to express our sincere thanks to S. Cieśliński (Kielce), L. Lipnicki (Gorzów Wlkp.) and L. Sparrius (Gouda) for the detailed data on localities they supplied. Data were used for mapping. The anonymous reviewer is warmly thanked for valuable comments on the manuscript.

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Uwagi o występowaniu *Caloplaca lucifuga* (Teloschistales, Ascomycota) w Polsce

Streszczenie

Caloplaca lucifuga jest porostem znanym z Europy oraz z dwóch niepublikowanych notowań z Ameryki Południowej (Kolumbia). Pomimo szerokiego zasięgu występowania na kontynencie europejskim, gatunek ten podawany jest w poszczególnych krajach zwykle z niewielu stanowisk. W Polsce zarejestrowany został łącznie na dziesięciu stanowiskach w północnej i północno-wschodniej części kraju. W pracy przedstawiono dotychczas znane oraz nowe stanowiska tego gatunku stwierdzone w latach 2005–2008 na Pojezierzu Olsztyńskim. Uzyskane wyniki oraz przegląd danych dotyczących ekologii tego gatunku wskazują, iż może być on bardziej rozpowszechniony w dużych kompleksach leśnych z udziałem starych drzew liściastych, zwłaszcza dębów. Ze względu jednak na zanikanie siedlisk charakterystycznych dla *C. lucifuga*, gatunek ten zasługuje na umieszczenie go na krajowej „Czerwonej Liście” porostów zagrożonych wymarciem. Porost ten ma potencjalne właściwości lichenindykacyjne, dotychczas w Polsce niewykorzystane, mogące mieć zastosowanie w wyznaczaniu miejsc o wysokiej bioróżnorodności oraz najcenniejszych zbiorowisk leśnych. Epifit ten, pomimo drobnych rozmiarów ma bardzo charakterystyczne cechy morfologiczne i chemiczne pozwalające odróżnić go od innych podobnych taksonów. Najbardziej istotne cechy diagnostyczne tego gatunku to jasnoszara, endofloedyczna plecha oraz liczne, zaokrąglone lub nieregularne, nie zlewające się ze sobą, jasnożółtawe, żółtawoszare do brudno żółto-pomarańczowo-brunatnych soralia, barwiące się od KOH na karminowo-czerwono.

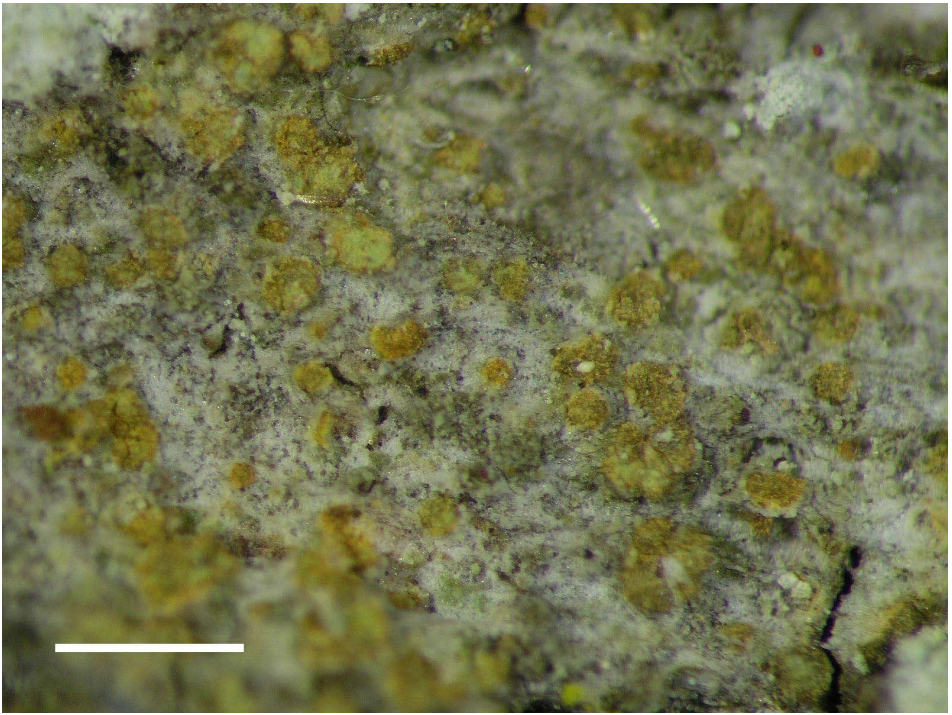


Fig. 1. Habit of *Caloplaca lucifuga* (OLTC-L 3227); scale bar = 1 mm.