

The genus *Cladonia* in some archaeological areas of A Garda (SW Galicia, Spain)

Daniel Fernández-Costas

Department of Mycology, Real Jardín Botánico (CSIC), E-28014 Madrid, Spain.

Author for correspondence: dfc.fernandez210@gmail.com

Received: 12 March 2024. **Accepted:** 15 October 2024. **Published on line:** 18 octubre 2024

Edited by: Marta Recio Criado

Abstract

We provide the first records of a chemotype of *Cladonia cyathomorpha* with a secondary metabolite (cyat) that has never been reported from the Iberian Peninsula. A total of 21 species were identified from archaeological sites in south-western Galicia.

Key words: archaeological areas, Cladoniaceae, chorology, secondary metabolites.

Resumen

El género Cladonia en algunas áreas arqueológicas de A Garda (SO Galicia, España)

Se aportan las primeras citas de un quimiotipo de *Cladonia cyathomorpha*, el cual presenta un metabolito secundario (cyat) que nunca se había reportado en la península Ibérica. Se han identificado un total de 21 especies en yacimientos arqueológicos del suroeste de Galicia.

Palabras clave: áreas arqueológicas, Cladoniaceae, corología, metabolitos secundarios.

Cladoniaceae is a family that includes the highly representative *Cladonia* genus, which is one of the most significant genera of terrestrial lichens (Pino-Bodas & Burgaz, 2021). Extensive studies have been carried out on this genus in the Iberian Peninsula (Burgaz & Ahti, 2009; Burgaz et al., 2020), giving us a good knowledge of the diversity of the region. In Galicia, the last detailed work on the genus was carried out by Valcárcel et al. in 1991. Despite this, new species continue to be discovered (Pino-Bodas et al., 2013, 2014), and the distribution of many others is expanding. Burgaz (2015) compiled material reporting a total of 62 species for the genus *Cladonia* in Galicia. However, from an ecological point of view, the species of this genus have never been observed in archaeological sites in Galicia.

In Galicia, work has been carried out on different archaeological sites and different types of monuments (Carballal et al., 2001; Lamas et al., 1995; Prieto et al., 1994), but the specimens present have not been identified to species level. Outside the Galician territory, in a study carried out in the archaeological site of Siega Verde (Salamanca) in the Iberian Peninsula (Paz-Bermúdez et al., 2018), up to 4 species of the genus *Cladonia* were found: *C. cervicornis*, *C. firma*, *C. foliacea* and *C. rangiformis*.

It is important to identify the lichens in this area because they can colonise it. Removing these lichens from monuments can damage or deteriorate them (Paz-Bermúdez et al., 2021; Pozo-Antonio et al., 2021). A study in Galicia identified several species of the genus *Cladonia* in an area of SW Galicia, where different species were reported in an area of archaeological sites (Fernández-Costas et al., 2022).

The aim of this work is to provide informative records of the *Cladonia* genus in the vicinity of some archaeological sites in Galicia.

The specimens were collected in four localities of A Garda (Table 1), examined morphologically using a Nikon SMZ1000 stereomicroscope and identified using the current keys for this genus (Burgaz & Ahti, 2009; Burgaz *et al.*, 2020). Secondary metabolites of each specimen were analysed by thin layer chromatography (TLC) according to standardised methods (White & James, 1985; Orange *et al.*, 2001) using solvents A and C. The material was deposited in the MACB herbaria.

Table 1. Collection locality codes with coordinates and habitat characteristics.

Tabla 1. Códigos de localidad de recolección con coordenadas y características del hábitat.

Locality Code	Coordinates	Habitat characteristics
AG1	41.922136/-8.860089	Galicia, Pontevedra, A Garda, Castro Pico da Bandeira, 179 m, granitic rocks on acid soil with pine plantations and a mixture of deciduous trees.
AG2	41.917305/-8.872809	Galicia, Pontevedra, A Garda, Petroglifos do Corniño, 247 m, granitic rocks on acid soil with pine plantations and a mixture of deciduous trees.
AG3	41.892901/-8.869768	Galicia, Pontevedra, A Garda, Castro de Santa Tecla, 251 m, granitic rocks and acidic, antropised soils, with sparse herbaceous vegetation and shrubland.
AG4	41.886333/-8.870327	Galicia, Pontevedra, A Garda, Castro de Santa Tecla, 281 m, granitic rocks and acidic, antropised soils, with sparse herbaceous vegetation and shrubland.

A total of 21 species have been identified, including small thalli that have been observed growing on the rocks of the archaeological areas, such as *C. diversa*, *C. macilenta*, and *C. ramulosa*.

***Cladonia caespiticia* (Pers.) Flörke**

Our specimens correspond to the chemotype: Pd+ (red), K–, C–, KC–, UV–, containing fumarprotocetraric acid. In the Iberian Peninsula, *C. caespiticia* is mainly found in the northernmost areas (Burgaz *et al.*, 2020). It was collected in just one sampling area.

Sampling collection: AG2 (125213 MACB).

***Cladonia coniocraea* (Flörke) Spreng**

Our specimens are Pd+ (red), K–, C–, KC–, UV–, containing fumarprotocetraric acid. *C. coniocraea* has been recorded several times in the Iberian Peninsula, but most records are concentrated in the north (Burgaz *et al.*, 2020). It is a common species in the study area.

Sampling collection: AG1 (125215 MACB), AG2 (125216 MACB), AG3 (125217 MACB), AG4 (125214 MACB).

***Cladonia crispata* (Ach.) Flot.**

Our specimens are Pd–, K–, KC–, C–, UV+ white, containing squamatic acid. *C. crispata* has been recorded several times in the Iberian Peninsula, with most records concentrated in the north (Burgaz *et al.*, 2020). However, it should be noted that most of these records correspond to var. *cetrariiformis*, making var. *crispata* a rare taxon in the Iberian Peninsula.

Sampling collection: AG2 (125219 MACB), AG4 (125218 MACB).

***Cladonia cyathomorpha* Stirt. ex Walt. Watson**

The specimens possess a persistent primary thallus with large scamules that in some instances, a faint yellowish-brown venation is discernible. The podocia gradually widen and have a corticated surface with

scattered granules inside the scyphy. Our specimens are Pd+ red, K–, KC–, C–, UV–, containing fumarprotocetraric acid and another substance. Jolle (1977) mentions a substance called cyat, which appears as a grey spot on the TLC plate and turns brown with time. Therefore, some of our specimens in addition to fumarprotocetraric acid would have this substance called cyat (with an Rf class on TLC plates of 2 : 3, in solvents A and C respectively).

C. cyathomorpha has a restricted distribution in Western Europe. It is likely that this species has been confused with others in the same group and therefore its distribution is misrepresented. On the Iberian Peninsula it has a wide distribution (Burgaz *et al.*, 2020). Abundant in the study area.

Sampling collection: AG1 (125222, 125223 MACB), AG3 (125220 MACB), AG4 (125221, 125224 MACB).

Cladonia dimorpha S. Hammer

Our specimens are Pd+ red, K–, KC–, C–, UV–, containing fumarprotocetraric acid. Apparently widespread in south-western Europe, although its original distribution is in western North America (Burgaz *et al.*, 2020). Its presence has been documented in several localities in the Iberian Peninsula and the Canary Islands (Burgaz & Ahti, 2009; Fernández-Costas & Burgaz, 2024; Sicilia *et al.*, 2009). Rare in the area of the study.

Sampling collection: AG4 (125225 MACB).

Cladonia diversa Asperges ex S. Stenroos

Our specimens are Pd–, K–, KC+ yellow, C–, UV–, containing usnic acid and zeorin. The species is widely distributed in the northern hemisphere and Macaronesia, although its exact distribution is not well known (Ahti & Stenroos, 2013). In the Iberian Peninsula, records are distributed throughout the central and northern regions (Burgaz *et al.*, 2008). Abundant in the study area

Sampling collection: AG1 (125228 MACB), AG2 (125227 MACB), AG4 (125226 MACB).

Cladonia fimbriata (L.) Fr.

Our specimens are Pd+ red, K–, KC–, C–, UV–, containing fumarprotocetraric acid. *C. fimbriata* is a common species in the Mediterranean region (Ahti & Stenroos, 2013). In the Iberian Peninsula it is widely reported (Llimona & Hladun, 2001; Burgaz *et al.*, 2020). Rare in the study area.

Sampling collection: AG4 (125229 MACB).

Cladonia floerkeana (Fr.) Flörke

Our specimens are Pd–, K+ reddish, KC–, C–, UV–, containing barbatic acid. *C. floerkeana* is commonly found in oceanic areas (Ahti & Stenroos, 2013). In the Iberian Peninsula, it is mainly recorded in the north and to some extent towards the centre (Burgaz *et al.*, 2020).

Sampling collection: AG4 (125230 MACB).

Cladonia furcata (Huds.) Schrad.

Our specimens are Pd+ red, K–, KC–, C–, UV–, containing fumarprotocetraric acid and sometimes traces of physodalic. The species is widely distributed across all latitudes and is also prevalent in much of the Mediterranean Region and the Iberian Peninsula (Llimona & Hladun, 2001; Burgaz *et al.*, 2020). Abundant in the study area.

Sampling collection: AG2 (125231 MACB), AG3 (125232 MACB), AG4 (125233 MACB).

Cladonia glauca Flörke

Our specimens are Pd–, K–, KC–, C–, UV+ white, containing squamatic acid. This species has a wide distribution in the Northern Hemisphere, particularly in oceanic areas (Ahti & Stenroos, 2013). In the Iberian Peninsula, it is mainly distributed in the north and also in the Canary Islands (Burgaz *et al.*, 2020; Fernández-Costas & Burgaz, 2024; Sicilia *et al.*, 2009).

Sampling collection: AG3 (125234 MACB), AG4 (125235 MACB).

Cladonia humilis (With.) J.R. Laundon

Our specimens are Pd+ red, K+ yellow, KC–, C–, UV–, containing atranorin and fumarprotocetraric acid. This species has a subcosmopolitan distribution (Ahti & Stenroos, 2013). The Iberian Peninsula has numerous records of the widely distributed species (Burgaz *et al.*, 2020). Abundant in the study area

Sampling collection: AG3 (125230 MACB), AG4 (125236, 125237, 125238 MACB).

Cladonia macilenta Hoffm.

Our specimens are Pd+ yellow, K+ yellow, KC–, C–, UV–, containing barbatic and thamnolic acids. The species is widely distributed in hilly and mountainous areas of the Eurosiberian Region and in humid areas of the Mediterranean Region, in both hemispheres (Burgaz *et al.*, 2020). Records from the Iberian Peninsula are mostly concentrated in the north (Burgaz *et al.*, 2020). Abundant in the study area.

Sampling collection: AG1 (125242 MACB), AG2 (125239, 125240 MACB), AG4 (125241 MACB).

Cladonia mediterranea P. A. Duvign. & Abbayes

Our specimens are Pd–, K–, KC–, C–, UV+ pale blue, containing perlatolic and usnic acids. *C. mediterranea* is frequently found in humid and warm territories of the Eurosiberian region and widely distributed in the Mediterranean region (Burgaz *et al.*, 2020). Its population is currently declining due to progressive habitat alteration. It is widely distributed in the Mediterranean region of the Iberian Peninsula and some isolated localities in Galicia (Llimona & Hladun, 2001; Burgaz *et al.*, 2020). Rare in the study area.

Sampling collection: AG1 (125243 MACB).

Cladonia merochlorophaea Asahina

Our specimens are Pd–, K–, KC+ pink, C+ pink, UV–, containing merochlorophaeic and 4'-O-methylcryptochlorophaeic acids. The taxon is subcosmopolitan and is frequently cited in the Mediterranean basin and the Iberian Peninsula. However, its presence is often underestimated due to difficulties in identification and confusion with other species (Burgaz *et al.*, 2020). Rare in the study area.

Sampling collection: AG1 (125244 MACB).

Cladonia portentosa (Dufour) Coëm.

Our specimens are: i) Pd–, K–, KC–, C–, UV+ pale blue, containing perlatolic and usnic acids, ii) Pd–, K–, KC–, C–, UV+ pale blue, containing perlatolic acid. *C. portentosa* is a widespread species found mainly in the Northern Hemisphere. It has been reported numerous times throughout the Iberian Peninsula (Llimona & Hladun, 2001; Burgaz *et al.*, 2020).

Sampling collection: AG4 (125251, 125252 MACB).

Cladonia pyxidata (L.) Hoffm.

Our specimens are Pd+ red, K–, KC–, C–, UV–, containing fumarprotocetraric acid. The species is cosmopolitan. It has been cited numerous times throughout the Iberian Peninsula, according to Llimona & Hladun (2001) and Burgaz *et al.* (2020). However, it is possible that it has been misidentified under this name as a different species. Abundant in the study area.

Sampling collection: AG1 (125249 MACB), AG2 (125250 MACB), AG4 (125248 MACB).

Cladonia ramulosa (With.) J.R. Laundon

Our specimens are Pd+ red, K–, KC–, C–, UV–, containing fumarprotocetraric acid. The species has a cosmopolitan distribution and can be found in various environments (Ahti & Stenroos, 2013). It has been reported numerous times throughout the Iberian Peninsula (Llimona & Hladun, 2001; Burgaz *et al.*, 2020). Abundant in the study area.

Sampling collection: AG1 (125257 MACB), AG2 (125256 MACB), AG3 (125255 MACB), AG4 (125254 MACB).

Cladonia rangiformis Hoffm.

Our specimens are Pd–, K+ yellow, KC–, C–, UV–, containing atranorina and rangiformic acid. This species has a wide distribution in the Northern Hemisphere, even in areas far from the Mediterranean region (Burgaz *et al.*, 2020). There are numerous records of this species in the Iberian Peninsula (Limona & Hladun, 2001; Burgaz *et al.*, 2020). Abundant in the study area.

Sampling collection: AG1 (125253 MACB), AG2 (125247 MACB), AG3 (125246 MACB), AG4 (125245 MACB).

***Cladonia squamosa* (Scop.) Hoffm.**

Our specimens are: i) Pd–, K–, KC–, C–, UV+ white, containing squamatic acid, the most common; ii) Pd+ yellow, K+ yellow, C–, UV–, containing thamnolic acid. The species discussed is subcosmopolitan and tends to inhabit oceanic or sub-oceanic areas (Ahti & Stenroos, 2013). It has been observed in various locations throughout the Iberian Peninsula, with a higher concentration in the Eurosiberian Region (Limona & Hladun, 2001; Burgaz *et al.*, 2020). Abundant in the study area.

Sampling collection: AG1 (125260 MACB), AG2 (125262 MACB), AG4 (125261 MACB).

***Cladonia subcervicornis* (Vain.) Kernst.**

Our specimens are Pd+ red, K–, KC–, C–, UV–, containing fumarprotocetraric acid and atranorin. *C. subcervicornis* is widely distributed in Western Europe and is also found in areas near the Mediterranean coast. In the Iberian Peninsula, it is most commonly found in the western region, but it is also widespread throughout the area (Burgaz *et al.*, 2020).

Sampling collection: AG3 (125259 MACB).

***Cladonia subulata* (L.) Weber ex F.H. Wigg.**

Our specimens are Pd+ red, K–, KC–, C–, UV–, containing fumarprotocetraric acid. The species is subcosmopolitan, commonly found in continental areas and the Mediterranean region. In the Iberian Peninsula, it has been recorded in the north, centre, and some southern localities (Limona & Hladun, 2001; Burgaz *et al.*, 2020).

Sampling collection: AG4 (125258 MACB).

Conflict of interest

None.

Acknowledgements

I thank the Council of A Garda, particularly the Environment Department, for their cooperation in allowing us to collect in the areas of this study and I would like to thank Ph. Dr. Ana Rosa Burgaz for her assistance in identifying some uncertain specimens.

References

- Ahti, T. & Stenroos, S. (2013). Cladoniaceae. In T. Ahti, S. Stenroos & R. Moberg (eds.), *Nordic Lichen Flora* vol. 5. Uppsala: Uddevalla.
- Burgaz, A. R. (2015). Asientos de flora liquenológica ibérica: Cladoniaceae. *Clementeana*, 16, 3–158.
- Burgaz, A. R. & Ahti, T. (2009). Cladoniaceae. *Flora Liquenológica Ibérica*, vol. 4. Madrid: Sociedad Española de Liquenología (SEL).
- Burgaz, A. R., Ahti, T. & Pino-Bodas, R. (2020). *Mediterranean Cladoniaceae*. Madrid: Sociedad Española de Liquenología (SEL).
- Carballal, R., Paz-Bermúdez, G., Sanchez-Biezma, M. J. & Prieto, B. (2001). Lichen colonization of coastal churches in Galicia: biodeterioration implications. *International biodeterioration & biodegradation*, 47(3), 157–163.
- Fernández-Costas, D. & Burgaz, A. R. (2024). New records of the genus *Cladonia* (Lecanorales, Ascomycota) for the Canary Islands. *Acta Botanica Malacitana*. <https://revistas.uma.es/index.php/abm/article/view/17212>

- Fernández-Costas, D., García-Molares, A., Morán, P., & Burgaz, A. R. (2022, July). Morphological, phytochemical and genetic study of the genus *Cladonia* P. Browne in the municipality of O Rosal (Pontevedra, NW Spain) XXIII Symposium of Cryptogamic Botany, Valencia, España. doi: <https://doi.org/10.13140/rg.2.2.13970.32966>
- Jolle, O. H. (1977). Ny lav. for norge og sverige: *Cladonia cyathomorpha*. *Blyttia*, 35, 163–166.
- Lamas, B. P., Brea, M. R. & Hermo, B. S. (1995). Colonization by lichens of granite churches in Galicia (northwest Spain). *Science of the Total Environment*, 167(1-3), 343–351.
- Llimona, X. & Hladun, N.L. (2001). Checklist of the lichens and lichenicolous fungi of the Iberian Peninsula and Balearic Islands. *Bocconea*, 14, 1–581.
- Orange, A., James, P.W. & White, F.J. (2001). *Microchemical methods for the identification of lichens*. London: British Lichen Society.
- Paz-Bermúdez, G., Calviño-Cancela, M., López De Silanes, M. E. & Prieto, B. (2021). Lichen saxicolous communities on granite churches in Galicia (NW Spain) as affected by the conditions of north and south orientations. *The Bryologist*, 124(3), 414–428.
- Paz-Bermúdez, G., Carballal, R., Marques, J. & López De Silanes, M. E. (2018). Catalogue of saxicolous lichens (Ascomycota) of the archaeological area of Siega Verde (Salamanca, Spain). *Anales del Jardín Botánico de Madrid*, 75(2), e076. <https://doi.org/10.3989/ajbm.2465>
- Pino-Bodas, R., Ahti, T. & Burgaz, A.R. (2014). *Cladonia islandica* (Cladoniaceae, Ascomycota) a species newly discovered in Spain, Alaska and Canada. *Botanica Complutensis*, 38, 25–28.
- Pino-Bodas, R. & Burgaz, A. R. (2021). Chorological novelties of the genus *Cladonia* in Toledo province (Spain). *Botanica Complutensis*, 45, 1–4.
- Pino-Bodas, R., Martín, M.P., Stenroos, S. & Burgaz, A.R. (2013). *Cladonia verticillata* (Cladoniaceae, Ascomycota), new record to Iberian Peninsula. *Botanica Complutensis*, 37, 21–25.
- Pozo-Antonio, J. S., Barreiro, P., Paz-Bermúdez, G., González, P. & Fernandes, A. B. (2021). Effectiveness and durability of chemical-and laser-based cleanings of lichen mosaics on schists at archaeological sites. *International Biodeterioration & Biodegradation*, 163, 105276.
- Prieto, B., Silva, B., Carballal, R. & de Silanes, M. L. (1994). Colonization by lichens of granite dolmens in Galicia (NW Spain). *International biodeterioration & biodegradation*, 34(1), 47–60.
- Sicilia, D., Hernandez, C. & Burgaz, A. R. (2009). The genus *Cladonia* in Garajonay National Park, La Gomera, Canary Islands. *Cryptogamie Mycologie*, 30(3), 305–316.
- Stenroos, S., Pino-Bodas, R., Hyvöonen, J., Lumbsch, H.T. & Ahti, T. (2019). Phylogeny of the family Cladoniaceae (Lecanoromycetes, Ascomycota) based on sequences of multiple loci. *Cladistics*, 35, 351–384. doi:10.1111/cia.12363
- White, F.J. & James, P. (1985) *A new guide to microchemical techniques for the identification of lichen substances*. London: British Lichen Society Bulletin.