Rediscovering of *Chara braunii* (Characeae, Charophyta) in Madeira (Macaronesian region, Portugal)

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**Abstract.** *Chara braunii* C.C. Gmelin (Characeae, Charophyta) was found in Madeira Island (Portugal) in a water channel in an agricultural area. This constitutes the first record of that species since 1944 in the Macaronesian region (Azores, Madeira and Canary archipelagos).

**Keywords:** Algae, Charophyta, Chara braunii, Madeira, Portugal, Macaronesia.

[es] Redescubrimiento de *Chara braunii* (Characeae, Charophyta) en Madeira (Región Macaronésica, Portugal)

**Resumen.** *Chara braunii* C.C. Gmelin (Characeae, Charophyta) ha sido encontrado en un canal de riego de la isla de Madeira (Portugal) en una zona de intensa actividad agrícola. Se trata de la primera cita de esta especie desde 1944 en la región Macaronésica, formada por los archipiélagos de Azores, Madera y Canarias.

**Palabras clave:** Algae; Charophyta, Chara braunii, Madeira, Portugal, Macaronesia.

**Introduction**

*Chara braunii* C.C. Gmelin (= *Charopsis braunii* (C.C. Gmelin) Kütz.; *Chara coronata* Ziz ex Bischoff) is a monoecious polymorphic (Kato et al. 2008) and cosmopolitan taxon (Krause 1997, Urbaniak, 2007), which occurs between 65°N and 35°S according to Wood (1965), although GBIF (2021) shows a wider distribution area. A European detailed map was published by Urbaniak (2007) and a more recent world map by Korsch (2018).

*Chara braunii* occurs scarcely in wild aquatic habitats being more frequent in secondary and anthropogenous habitats such as shallow fish-ponds, rice fields, man-made ponds and water channels, all of them corresponding to fresh or oligohaline to sub-saline (0,01-1,12 mS/cm), alkaline or calcium rich waters, with medium to high eutrophication levels (Boira & Carretero 1985, Carretero 1993, Cirujano et al. 1999, Soulie-Mäsche & Vautier 2004, Cirujano et al. 2007, Urbaniak 2007, Kato et al. 2008). Muller et al. (2017) refers that *Ch. braunii* tolerates desiccation of the water-bodies, periodical or even annual, recovering its populations from the underground deepest nodes of the oldest plants. Romanov et al. (2019) found *Ch. braunii* in a karstic temporary pool of northern Sicily.

This macrophytic algae was first cited in mainland Portugal by Gonçalves da Cunha (1934) and later found in the Azorean archipelago, although identified as *Nitella ornithopoda* A. Braun, by Gonçalves da Cunha (1941). The distribution and ecology in the Iberian Peninsula of this taxon has been studied by Cirujano et al. (1999), and later additions to the Iberian distribution range are due to Ortega González et al. (2002) and Cirujano et al. (2007). No published references for both Madeira and the Canarian Archipelagos are known. However, Charophytes are not included in the biodiversity checklists of Canarias (Arechavaleta et al. 2010), Madeira (Borges et al. 2008) and Azores (Borges et al. 2010). In the African Atlantic region of Morocco Muller et al. (2017) refers to a unique locality of this taxon near Casablanca.

**Materials and methods**

Plants collected in the field were preserved first in alcohol 70 °c and later in Copenhagen Mixture (Brison & Forman 1998) to be studied under a binocu-
lar microscope and preserved as herbarium specimens. Collected plants are kept at MA, UMAD and UPS Herbaria. A Macaronesian distribution data set of *Ch. braunii* specimens from herbaria specimens were downloaded from GBIF (2021). JSTOR Global Plants database was consulted without success for Macaronesian specimens.

RESULTS

New localities

PORTUGAL, MADEIRA: Ilha da Madeira, Calheta, Estrada Regional 101 - Arco da Calheta, 32°42’34.6”N 17°08’58.0”W, 128 m, num canal de irrigação, 15 En. 2018, P. Nascimento (MA-Algae 11239, UMAD); Ilha da Madeira, Calheta, canal de rega num bananal ao sul e abaixo da estrada ER101 de Calheta para a Madalena do Mar, 32°42’35.95”N 17°09’13.8”W, 129 m, 13 May 2021, C. Gois-Marques, M. Gouveia, P. Jardim, P. Nascimento & M. Sequeira MS10553 (MA-Algae 11250, UMAD).

Studied specimens

PORTUGAL, MADEIRA: Portugal, Madeira: Le- vada das Hortas, Funchal, Apr.1892, s.c., MADJ -as Tolypellopsis; Levada, Jul. 1927, Barreto, MADJ -11 duplicates -as *Ch. coronata* Ziz, S. Roque do F.al [Funchal], num poço na Alegria, 14 Sept. 1944, s.c., MADJ; Madeira, 2000 fot hőjd i båckar [2000 feet high in brooks], Nov. 1890, J.R. Junger, UPS A-001373 –as Chara braunii.

Studied digitalized specimens

PORTUGAL, MADEIRA: Portugal, Madeira: Ma- deira, 18 Mar. 1882, G. Zander, LD 2104755 -as *Ch. Coronata*; Madeira, i båckar. 2000 fot hőjd [in brooks at 2000 feet altitude], Nov. 1890, J.R. Junger, LD 2104819 -as *Chara braunii* Gmel. f. microcarpa;

The second population, found first in 2018, but corresponding to material collected in 2021, was found c. 100 meters upstream in the same channel, however this part of the channel being simply dug out in the ground. In May 2020 the population was found reduced to a few thalli as a result of prolonged drying of the water channel caused by water diversion. In March 2021 this second population was visited again and found to be fully recovered, with mature thalli forming a dense bed in the water channel (Fig. 3).

In this upper location *Ch. braunii* lives with other hygrophytic plants as *Apidium nodiflorum* (L.) Lag., *Rorippa nasturtium-aquaticum* (L.) Hayek, *Callitriche stagnalis* Scop. and *Lemma* sp. Amphibious or hygrophytic plants in the channel slopes are *Ageratina adenophora* (Spreng.) R.M. King & H.Rob. (*), *Adiantum capillus-veneris* L., *Polygonum capitatum* Buch.-Ham. ex D. Don (*), *Parietaria judaica* L., *Rumex pulcher* subsp. *woodsii* (De Not.) Arcang., *Christella dentata* (Forssk.) Brownsey & Jersey, *Commelina diffusa* Burm. f. (*), *Cardiospermum grandiflorum* Sw. (*), and *Cyperus eragrostis* Lam. (*), corresponding most of these plants to exotic taxa (*) (Menezes de Sequeira et al. 2011) showing a high degree of hemeroby of these plant communities.

A long segment of about 250 m of the water channel, downstream, upstream and between both localities, has been surveyed in order to evaluate meta-population size, without success apart from the two already known locations.

Previous ancient and scarce references to this species are restricted to Madeira Island and correspond to herbarium specimens collected between 1882 and 1944. However only a few specimens include a detailed location, namely as “levada das Hortas”, “S. Roque de Funchal” and “Alegria”, all corresponding to localities close to the city of Funchal (Fig. 2), therefore about 22 km away of the recently found localities. All this peri-urban landscape has been deeply transformed due to the major increase in urban area that took place uphill along the second half of the XXth century, therefore reducing the surviving chances of these old populations.

Discussion

The upstream population of *Ch. braunii* could derive from an original nucleus living in the upper hillside, where there is a permanent spring. However, no other populations have been found in the water line, both upstream and downstream. The downstream dispersal of black spores from the upstream population could explain the recovery of the downstream population in 2021 after the removal of sediments in 2019. Downstream diaspora has already been indicated as an important factor for the maintenance and dispersal of riparian species (Merrit & Whohl 2006, Hyslop & Trowsdale 2012) and for aquatic plants and charophytes in rivers (Bornette et al. 1998, Cellot et
al. 1998). Although there is no information of dispersal on man-made channels and even more for this reduced size of irrigation networks. This specific type of aquatic habitat does not allow water birds as a vector to facilitate long dispersal of the diaspora, as has been indicated for other types of wetlands (Proctor 1970). The unique estimated dispersal way could be the downstream flow along the channel and those through the local irrigation network that exchange water downstream between channels at different altitude. In addition, other even lesser important water bodies, and tanks for irrigation, are common in the nearest agriculture landscape, but they are subject to a strong level variation that could avoid the persistence of charophytes.

The transformation of the island landscape of Madeira has been progressively produced since XVth century, with the increase of the technical and mechanical resources for agriculture (Almeida et al. 2003, Kiesow & Bork 2017) and, in more recent years, for human infrastructures (Baioni 2011) related to tourism economy. This has led to the decline of the agricultural land use in Madeira since 1986 (Baioni 2011, Kiesow & Driesen 2017), what consequently has allowed recovery of a secondary forest and scrub vegetation in marginal agriculture areas, both in the upper limit and in the high slope low lands (Capelo et al. 2005, Kiesow & Driesen 2017).

This transformation has already affect to the scarce number and diversity of Madeiran wetlands, with the disappearance of the freshwater riverine and estuarine, and saline seaside water bodies, as Sequeira (2003 tab. 4.1) has related for the Madeiran “lagos” of Porto Moniz, Paul do Mar, Lugar de Baixo and Santo da Serra. This complete destruction of wetlands is directly related to the intensive human occupation of the low lands and seashore (Hughes 2005). As a consequence, the refugees of the wild aquatic flora in Madeira have been reduced to a few natural habitats, with different levels of disturbance, and to the more frequent man-made secondary habitats which are not management under the diversity and ecological criteria. Hughes & Malmqvist (2005) have pointed up, regarding to the aquatic invertebrate fauna but in the same way to the aquatic vegetation, that conservation and restoring strategies of the European Water Framework Directive should take into account for its implementation the rarity and diversity of the reduced types of wetlands placed in a high slope volcanic island, always in a synergy process with the Habitats Directive (Bolpagni et al. 2018).

Western Mediterranean (Spain and Portugal) fresh-water vegetation of Charetum braunii Corillon (Charion vulgaris (Krause ex Krause & Lang 1977) Krause 1981, Charetea intermediae F. Fukarek 1961) belongs to the charophyte pioneer and ephemeral communities of neutral, basophilic to saline fresh-water mainly colonized by Chara species, following Rivas Martinez et al. (2001, 2002) and Mucina et al. (2016). In the other hand Felzines & Lambert (2012) include this association, for France, in the Nitellion flexilis W. Krause 1969 on neutral permanent waters, excluding it from the Atlantic and sub-Atlantic communities. The Charetum braunii is thus assigned to this alliance but with an exceptional ecology of pioneer, monospecific communities on oligo-mesotrophic and neutral waters, that seems to adjust better to these non-natural Madeiran communities due to water volcanic characteristics and the absence of the observed mineral encrustation on the thallus. These Chara communities are referred then to the EUR 3140 habitat “Hard oligo-mesotrophic waters with benthic vegetation of Chara spp” of lakes and pools (EUR 2013), that is not mentioned for the Macaronesian Biogeographical Region (EUR 2010). However, and as Guarino et al (2019) points out, the presence of a Chara stand is no enough to stabilish the presence of this Habitat 3140. In the same way, we cannot consider the monospecific studied community as a representation on this habitat in the Macaronesian Biogeographical Region. However, conservation status of Ch. braunii in Madeira island should be evaluated in order to guarantee its conservation and to contribute to stablish a Charophyte Red List for this Biogeographical European Region, as has been consider as VU in the Baltic Countries (HELCOM 2013) under B2ab(iii) criteria, and in Norway (Lanngangen 2021). Portugal and Spain States have not included, to this time, these taxa under protection laws or national red lists.

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References

Almeida, B. de, Vieira da Costa, J., Bisca, R., Conceição, J., Pires, M. & A.G. Castro (eds.). 2003. Plano Regional da Água Da Madeira. Relatório Técnico. Versão para Consulta Pública. Região Autônoma de Madeira. Funchal.
Arechavaleta, M., Rodriguez, S., Zurita, N. Garcia, A. (coords.). 2010. Lista de especies silvestres de Canarias. Hongos, plantas y animales terrestres. 2009. Gobierno de Canarias. 579 pp.
Baioni, D. 2011. Human activity and damaging landslides and floods on Madeira Island. Nat. Hazards Earth Syst. Sci. 11: 3035-3046. https://doi.org/10.5194/nhess-11-3035-2011
Boira, H. & Carretero, J.L. 1985. Las carofíceas de las provincias de Castellón y Valencia. Collect. Bot. (Barcelona) 16: 13-19.
Bolpagni, R., Laini A., Stanzani, C. & Chiarucci, A. 2018. Aquatic Plant Diversity in Italy: Distribution, Drivers
and Strategic Conservation Actions. Front. Plant Sci. 9: 116. https://doi.org/10.3389/fpls.2018.00116

Borges, P.A.V., Abreu, C., Aguiar, A.M.F., Carvalho, P., Jardim, R., Melo, I., Oliveira, P., Sérgio, C., Serrano, A.R.M. & Vieira, P. (eds.). 2008. A list of the terrestrial fungi, flora and fauna of Madeira and Selvagens archipelagos. Direcção Regional do Ambiente da Madeira and Universidade dos Açores, Funchal and Angra do Heroísmo, 440 pp.

Borges, P.A.V., Costa, A., Cunha, R., Gabriel, R., Gonçalves, V., Martins, A.F., Melo, I., Parente, M., Raposeiro, P., Rodrigues, P., Santos, R.S., Silva, L., Vieira, P. & Vieira, V. (eds.). 2010. A list of the terrestrial and marine biota from the Azores. Principia, Cascias, 432 pp. https://doi.org/10.1046/j.1365-2427.1998.00273.x

Bornette, G., Amoros, C. & Lamourous, N. 1998. Aquatic plant diversity in riverine wetlands: the role of connectivity. Freshw. Biol. 39: 267-283. https://doi.org/10.1046/j.1365-2427.1998.00273.x

Bridson, D. & Forman, L. 1998. The herbarium handbook, 3rd ed. Royal Botanic Gardens, Kew 346 pp.

Capelo, J., Sequeira, M., Jardim, R., Mesquida, S. & Costa, J.C. 2005. The vegetation of Madeira Island (Portugal). A brief overview and excursion guide. Querceteca 7: 95-122.

Carretero, J.L. 1993. Aportaciones a la distribución y ecología de las caroofíceas de la provincia de Valencia. Acta Bot. Malac. 18: 31-36. https://doi.org/10.24310/abm.v18i1.8959

Cellot, B.; Mouillot, F.; Henry, C.P. 1998. Flood drift and propagule bank of aquatic macrophytes in a riverine wetland. J. Veg. Sci. 9: 631-640. https://doi.org/10.2307/3237281

Cirujano, S., García Murillo, P., Meco, A. & Fernández Zamudio, R. 2007. Los carótidos ibéricos. Anales Jard. Bot. Madrid 64: 87-102. http://dx.doi.org/10.3989/ajbm.2007.v64.i1.57

Cirujano, S., Medina, L., Sánchez Gullón, E. & García Murillo, P. 1999. Chara braunii (Characeae, Charophyceae) in the Peninsula Ibérica. Anales Jard. Bot. Madrid 57: 398-400.

EUR. 2010. Terrestrial Macaronesian Region Reference List. Natura 2000. Available from: https://ec.europa.eu/environment/nature/natura2000/sites_hab/biogeog_regions/docs/Macaronesia_ref_list.pdf

EUR. 2013. Interpretation Manual of European Union Habitats, version EUR 28. European Commission, DG-ENV. Available from: http://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/Int_Manual_EU28.pdf

GBIF. 2021. GBIF Chara braunii Occurrences, Downloaded on 22 February 2021 from: https://doi.org/10.15468/dlf.fbb3mp and https://doi.org/10.15468/dlf.8635gu.

Goñalves da Cunha, A. 1934. Liste des Characées du Portugal. Arq. Univ. Lisboa 15: 5-18.

Goñalves da Cunha, A. 1941. Additions à la flore charologique du Portugal. Bull. Soc. Portugaise Sci. Nat. 13: 153-156.

Guarino, R., Marenco, C., Iaridi, V., Mannino, A.M. & Troia, A. 2019. One Chara does not make Charetea in the Mediterranean aquatic vegetation. Webbia 74: 139-147. https://doi.org/10.1080/00837792.2019.1607142

HELCOM. 2013. Chara braunii Species Information sheet. Red List Macrophyte Expert Group 2013. Available from: https://helcom.fi/media/red%20list%20species%20information%20sheet/HELCOM-Red-List-Chara-braunii.pdf

Hughes, S.J. & Malmqvist, B. 2005. Atlantic island freshwater ecosystems: challenges and considerations. Following the EU Water Framework Directive. Hydrobiology 544:289–297. https://doi.org/10.1007/s10750-005-1695-y

Hughes, S.J. 2005. Application of the Water Framework Directive to Macaronesian freshwater systems. Biology & Environment. Proc. Roy. Irish Acad 105B: 185-193. https://doi.org/10.3318/BIOE.2005.105.3.185

Hyslop, J. & Trowsdale, S. 2012. A review of hydrochory (seed dispersal by water) with implications for riparian rehabilitation. J. Hydrol.(N. Z.): 51: 137-152.

Jean-Claude Felzines, J.-C. & Lambertz, E. 2012. Contribution au prodrome des végétations de France: les Charetea fragilis F. Fukarek 1961. J. Bot. Soc. Bot. France 59: 133-188.

Kato, S., Sakayama, H., Sano, S., Kasai, F., watanahe, M., Tanaka, J. & Nozaki, H. 2008. Morphological variation and intraspecific phylogeny of the ubiquitous species Chara braunii (Charales, Charophyceae) in Japan. Phycology 47: 191-202. https://doi.org/10.2216/07-27.1

Kiesow, S. & Bork, H-R. 2017. Agricultural terraces as a proxy to landscape history of the Madeira Island, Portugal. Let História 71: 127-152.

Kiesow, S. & Dierssen, K. 2017. Vegetation analysis as a source of historic information. The case of Madeira Island. In: Vaz, E., Melo, C.J., de, & Pinto, L.C. (eds.). Environmental History in the Making: Volume I: Explaining. Basel.123-142. Springer International Publishing.

Korsh, H. 2018. The worldwide range of the Charophyte species native to Germany. Rostock. Meeresbiol. Beitr. 28: 45-96.

Kraus, W. 1997. Charales (Charophyceae). Süßwasserflora von Mitteleuropa, vol. 18. Fischer Verlag, Stuttgart 208 pp.

Langangen, A. 2021. Lokalitetsliste 2021 Status pr. 1. februar 2021. Norges Kransalger Hefte 13: 1-63.

Menezes de Sequeira, M., Espírito-Santo, D., Aguiar, C. Capelo, J. & Honrado, J. (coords.). 2011. Checklist da Flora de Portugal (Continental, Açores e Madeira). Associação Lusitana de Fitossociologia. Lisboa.

Merritt, D.M. & Wohl, E.E. 2006. Plant dispersal along rivers fragmented by dams. River Res. Applic. 22: 139-147. https://doi.org/10.1080/00837792.2019.1607142
Captions

Figure 1. Landscape of the irrigation channel of the upper new population near Calheta.
Figure 2. Georeferenced ancient herbarium specimens of *Chara braunii* in Funchal area (circle) at “Levada das Hortas”, “Sao Roque de Funchal” and “Alegría”, and new populations (square) in western Madeira Island.

Figure 3. *Chara braunii* stand on the upstream population near Calheta.