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Taxonomic reassessment of *Gracilaria cearensis* (Rhodophyta, Gracilariales), a poorly defined yet common flattened species based on morphological and molecular analysis including topotype collections

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Abstract

The genus *Gracilaria* is the major source of agarose in the world today and is one of the most species-rich genera in the Rhodophyta. Flat *Gracilaria* species are among the most taxonomically challenging taxa due to their widespread phenotypic plasticity among all species. *Gracilaria cearensis* is a flat species described in 1965 from Brazil. Its original description is not conducive to accurate taxonomic identifications and the delineation of this taxon remains elusive. New samples of *G. cearensis* were collected across a coastal length of 500 km including its type locality. Universal Plastid Amplicon (UPA) and the *rbc*L gene were used to confirm the phylogenetic and taxonomic status of this poorly known species. Results showed that this is a distinct species despite morphological similarities to *G. hayi*, *G. cuneata*, *G. curtissiae*, *G. brasiliensis* and *G. galetensis*. *G. cearensis* is sister to *G. hayi* yet the genetic divergence between these two species was 2% for *rbc*L and 1.08% for UPA, enough to consider them distinct taxa. However, newly generated molecular data placed *G. smithsoniensis*, another morphologically similar species, as conspecific with *G. cearensis* with only 0.07% *rbc*L sequence divergence between them.

Key words: biodiversity, *rbc*L, taxonomy, UPA

Introduction

Gracilaria cearensis (A.B. Joly & F.C. Pinheiro 1965: 81) A.B. Joly & F.C. Pinheiro (1966: 131) is a tropical intertidal species with flat, strap-shaped branched thalli and commonly occurring in shallow reefs along the northeastern Brazilian coast (Pinheiro-Vieira & Ferreira 1968). In Brazil, *G. cearensis* has industrial potential as a source of agar and has attracted biotechnological interest due to its hemagglutination and antibiotic activity (Pinheiro-Vieira & Caland-Noronha 1971, Ainouz & Sampaio 1991).

The species was originally described as *Tylotus cearensis* Joly & Pinheiro (1965: 81) based on material collected in Fortaleza, Ceará state, Brazil. The genus *Tylotus* J. Agardh (1876: 428) was excluded from the Gracilariaceae by Dawson (1949) based on the presence of zonate tetrasporangia in the type species, *T. obtusatus* (Sonder 1845: 56) J. Agardh (1876: 428). Later, Pinheiro & Joly (1966) transferred *T. cearensis* to *Gracilaria* Greville (1830: 121) in the light of its cruciately divided tetrasporangia. *G. cearensis* shows other main characters such as tubular nutritive cells present in both pericarp and the cystocarp floor, and spermatangial conceptacles described as "usually not confluent" as observed in most *Gracilaria* species. Since its description no further taxonomic or morphological studies have been performed in order to ascertain the status of this taxon, despite its purportedly widespread distribution in northeastern Brazil, from Ceará (Joly & Pinheiro 1965) to Bahia state (Nunes 2005).

Morphologically, *G. cearensis* is similar to *G. brasiliensis* Gurgel & Yoneshigue-Valentin (2008: 255), *G. cuneata* Areschoug (1854: 351), *G. galetensis* Gurgel, Fredericq & J. Norris (2004: 181), *G. hayi* Gurgel, Fredericq & J. Norris

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cortex and medulla. Our morphological analysis showed that this feature is variable even in the same specimen, depending on sectioned part of the thallus. Among Brazilian specimens of *G. cearensis,* plants with different thallus width can be observed, including specimens from the type locality. Some of the smallest specimens can be easily confused with *G. smithsoniensis*. Allied to these observations, the *rbc*L sequences of *G. smithsoniensis* and *G. cearensis* placed these two species in a single clade with an uncorrected genetic divergence of only 0.07% suggesting that *G. smithsoniensis* is a morphological variant of *G. cearensis*. In the light of the results herein, we propose the synonymy of *G. smithsoniensis* with *G. cearensis.*

Molecular data have continued advancing the taxonomy of flat *Gracilaria* species around the world. *Gracilaria cuneata* is a name that has been used extensively to identify large, flat *Gracilaria* specimens in the western Atlantic Ocean. However, based on molecular-assisted phylogenetic analyses, Gurgel *et al*. (2004) described *G. hayi* based on material from Caribbean Panama previously identified as *G. cuneata* and *G. cearensis* could be considered a synonym of *G. cuneata* based on the results obtained by Bellorin *et al.* (2002). Our results supported the former but rejected the latter hypothesis, and showed that *G. cearensis*, *G. cuneata and G. hayi* are three morphologically and molecularly distinct species.

Conclusion

Field identifications of flat Gracilariaceae species are often difficult due to the wide morphological variability and phenotypic overlap among taxa. Consequently, we are moving towards a taxonomic practice where only combined molecular and morphological analyses allow the characterization and precise identification of closely related species. Under this modern framework this study was the first to provide molecular data from *G. cearensis*, revise its taxonomy and contribute to a better understanding of the systematics of the genus *Gracilaria* in the western Atlantic Ocean.

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