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Resolving the phylogenetic affinities of *Kappaphycus inermis* within the genus *Kappaphycus* (Gigartinales, Solieriaceae) using mitochondrial and plastid markers

RICHARD V. DUMILAG & ARTURO O. LLUISMA

Marine Genomics and Molecular Genetics Laboratory, Marine Science Institute, University of the Philippines-Diliman, Philippines; rvdumilag@gmail.com; aolluisma@upd.edu.ph

Abstract

Although the phylogeny of the genus *Kappaphycus* has been the subject of a number of published studies, the phylogenetic placement of *Kappaphycus inermis* within the genus has remained unresolved. In this study, we sought to determine the phylogenetic affinities of *K. inermis* with the other congeneric species using mitochondrial (*cox*1 and *cox*2–3 spacer) and plastid (*rbc*L and RuBisCo spacer) markers, using specimens collected from northwestern Philippines. Morphological observations of the collected materials confirmed the presence of key morphological features that distinguish *K. inermis* from the other members of *Kappaphycus*. Molecular analyses based on the organellar genetic markers revealed that *K. inermis* is indeed phylogenetically distinct from *K. alvarezii*, *K. striatus, K. cottonii* and *K. malesianus*, a species which was recently erected based on specimens from Malaysia. The Philippine *K. inermis* specimens formed a sister clade to *K. malesianus* (also referred to as "Aring-aring" in Malaysia) in phylogenetic trees inferred from *cox*1, *cox*2–3 spacer and *rbc*L, but not the RuBisCo spacer whose sequence is identical in both *K. inermis* and *K. malesianus*. The analysis also revealed that specimens of unidentified *Kappaphycus* species collected from two other sites in the Philippines and referred to as "Aring-aring" by local farmers/traders were varieties of *K. alvarezii* and *K. striatus*.

Key words: *cox*1, *cox*2–3 gene spacer, *Kappaphycus* sp. "Aring-aring", phylogeny, *rbc*L, RuBisCo spacer, taxonomy

Introduction

Kappaphycus inermis (F. Schmitz) M. S. Doty *ex* H.D. Nguyen & Q.N. Huynh in Abbott (1995: 233) was originally described as *Eucheuma inerme* by Schmitz (1895: 139) based on dried materials from Dar es Salaam, Zanzibar, Tanzania. Since its original description, the species has been mentioned sporadically in various reports from east Africa (Doty 1988, Silva *et al.* 1996) to southeast Asia (Doty 1988, Nguyen & Huynh 1995) and from the Gulf of Mexico (Fredericq *et al.* 2009). In the Philippines, although the distribution of *Kappaphycus* M.S. Doty in Abbott (1988: 171) species has been fairly documented (Silva *et al*. 1987; Trono 1997), the exact collection sites of Philippine *K. inermis* materials have never been mentioned in the literature.

The taxonomy of *K. inermis* has remained poorly understood. Originally, Weber van-Bosse (1928) placed *K. inermis* (as *E. inerme*) in *Eucheuma* sect. Axifera A. Weber van-Bosse (1928: 404) which included species with a central axis of compact filaments. She distinguished *K. inermis* from the other members of this section by the presence of rough surfaces. Subsequently, *Eucheuma* sect. Axifera was placed into synonymy with *Eucheuma* sect. *Eucheuma* Doty & Norris by Doty & Norris (1985: 55); however, *K. inermis* (as *E. inerme*) was not included in this new section, but instead was transferred by Doty (1988) to the newly erected genus *Kappaphycus*. The study of Santos (1989) confirmed that κ-carrageenan was the dominant form of carrageenan in *K. inermis,* consistent with Doty's (1988) assignment of this species to the genus *Kappaphycus*.

K. inermis was also known to be morphologically similar to *K. striatus* (F. Schmitz) M.S. Doty *ex* P.C. Silva in P.C. Silva, Basson & Moe (1996: 334) (Weber van-Bosse 1928; Mshigeni 1984). Based on morphological criteria and range of distribution of these two species, Mshigeni (1984) merged them into a single taxon, favoring the

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are used by seaweed farmers/traders to refer to different *Kappaphycus* varieties. Development of a publicly available resource that would make possible the consistent naming of varieties based on genetic evidence will provide significant benefits for researchers and seaweed farmers/traders alike.

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