



## Spread of the introduced species *Laurencia caduciramulosa* (Rhodomelaceae, Rhodophyta) to the northwest Atlantic: A morphological and molecular analysis

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### Abstract

Introduction of species is a common problem in marine environments; marine macroalgae in particular have been reported to be introduced in all oceans, mainly through transport in ballast water, ship fouling and aquarium trade. The majority of the reported alien seaweeds belong to the Rhodophyta. Recently several species of the *Laurencia* complex have been reported, contributing to an increase of the number of red algae being successfully introduced. Since its description as a new species from Vietnam in 1997, *Laurencia caduciramulosa* has been spreading steadily with disjunct reports consistently finding specimens close to harbors or major ports. Biscayne Bay, Florida, home to one of the largest ports in USA, and surrounded by the Miami metropolis, is prone to receiving introduced species. This study reports the first introduction of *L. caduciramulosa* in Biscayne Bay, and its spread to the NW Atlantic. Morphological analysis demonstrated that the specimens collected in Crandon Park, Biscayne Bay, are similar to other specimens of the same species described for Vietnam (original description), Brazil, the Canary Islands and Cuba. Furthermore, molecular analysis using chloroplast-encoded *rbcL* DNA sequences corroborated the morphological identification. The phylogenetic results suggested that populations in Brazil, Canary Islands and Cuba are recent introductions, while the position of the Florida clade can be interpreted as a distinct and earlier introduction. Due to the level of expertise and knowledge of the *Laurencia* complex available, we suggest that in the future this group can be used as a model to conduct population genetics analysis of all described introductions in relation to native populations in order to describe patterns of expansion and provide an insight of marine invasions processes.

**Key Words:** Florida, introduced species, morphology, *rbcL*, macroalgae

### Introduction

Non-indigenous species introductions are among the most common threats in marine and terrestrial ecosystems altering community structure and ecological processes (Booth *et al.* 2007, Vellend *et al.* 2007, Pysek *et al.* 2008). In marine environments, species introductions, including animals and plants, are well-documented with many species having negative effects on local communities (Ruiz & Fofonoff 2000). Furthermore, it is expected that species introduction events will increase in coastal ecosystems as traffic across the world increases (Cohen & Carlton 1998, Rilov & Crooks 2009, Geller *et al.* 2010). Therefore, documentation of new introductions as well as possible mechanisms of introductions is essential in order to manage potential critical areas, such as those close to ports with heavy ship traffic.

Marine macroalgae are known to be introduced in many coastal waters causing significant ecological and economic problems, and the most common vectors include the aquarium trade, ballast water and fouling in ships (Wallentinus 2002, Cormaci *et al.* 2004, Booth *et al.* 2007, Williams & Smith 2007, Geller *et al.* 2010, Gravili *et al.* 2010). By 2007 Williams & Smith listed a total of 277 introduced macroalgae gleaned from a total of 408 reported events. Among all species reported, an overwhelming majority of introduced species belong to Rhodophyta (167 species out of 277).

alongside native specimens are needed. We recognize that there is an acute need to increase our efforts through international collaborations that will use standardized molecular, morphological and ecological approaches in order to discover cryptic introductions and elucidate the introduction history of the species (Proven *et al.* 2004, 2007, Geller *et al.* 2010). To our knowledge this is the fourth species of the *Laurencia* complex group, and third of the genus *Laurencia* to be reported as introduced species. The taxonomic interest in the *Laurencia* complex among several international researchers can be used as a model that will help increase our understanding of the functional characteristics as well as vectors of transportation in order to better predict and control future introductions, and also have a better general understanding of marine invasions, as well as biodiversity and biogeographic processes of marine algal species.

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