

Phylogenetic re-evaluation of the *Laurencia* complex (Rhodophyta) with a description of *L. succulenta* sp. nov. from Korea

K.W. Nam

Department of Marine Biology, Pukyong National University, Busan 608–737, Korea

e-mail: kwnam@pknu.ac.kr

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Abstract

Laurencia succulenta sp. nov. (Rhodophyta) is described from Korea. This species exhibits vegetative and reproductive structures typical of the genus, but is distinct from similar species in its epiphytic habitat and the fleshy, robust, thick and subcompressed thalli with basically distichous branching. In addition, it is readily distinguished from the most similar species, such as *L. nipponica* Yamada and *L. okamurae* Yamada, by the cystocarps with a somewhat protuberant ostiole. In a phylogenetic analysis of 47 species of the *Laurencia* Lamouroux complex from various localities around the world based on 49 morphological characters, four major clades (*Laurencia*, *Chondrophycus palisadus* (Yamada) Nam group, *C. cartilagineus* (Yamada) Garbary et Harper group and *Osmundea* Stackhouse assemblage), each of which forms a monophyletic group, were recognized. Among these, the *Laurencia* clade is basal to the overall assemblage, and is defined by the vegetative axis with four rather than two pericentral cells. The *Osmundea* clade is supported by autapomorphic characters for the genus, features associated with spermatangial formation of the filament type and tetrasporangial production from epidermal cells. By contrast, *Chondrophycus*, a genus characterized by a combination of features (vegetative axis with two pericentral cells, trichoblast-type spermatangial development and tetrasporangial production from pericentral cells), is paraphyletic, and the species were separated into two well-supported clades, the *C. palisadus* group and *C. cartilagineus* group. These clades are distinguished from each other by the position of the first pericentral cell relative to the trichoblast, the presence or absence of fertility at the second pericentral cells and number of sterile pericentral cells in the tetrasporangial axis, the pattern of formation of spermatangial branches on trichoblasts, post-fertilization feature associated with the formation time of the auxiliary cell, and, probably, the number of pericentral cells in the procarp-bearing segment. Of these features, the side position of the first pericentral cell in the latter group (a synapomorphy for the *C. cartilagineus* group plus *Osmundea*) suggests that the *C. cartilagineus* group is more closely related to *Osmundea* than to the *C. palisadus* group. This cladistic analysis indicates that *Chondrophycus* is not monophyletic, suggesting that the *C. palisadus* group should be separated from *Chondrophycus* at the genus level. Based on this result, *Palisada* (Yamada) stat. nov. is proposed for the group, together with an emendation of the generic delineation of *Chondrophycus*, and relevant nomenclatural changes for several *Chondrophycus* species are also included. In addition, *Corynecladia* J. Agardh is reinstated for the type species *L. clavata* Sonder.

Introduction

The *Laurencia* complex Lamouroux (Rhodophyta) has been separated into three genera: *Laurencia*, *Chondrophycus* (Tokida et Saito) Garbary et Harper and *Osmundea* Stackhouse, based on vegetative and

reproductive structures (Garbary and Harper, 1998; Nam, 1999). These genera share the typical and superficial rhodomelacean morphology with apical cells sunk in apical pits of branchlets, a recognizable axial cell row only near the apical cell and an extensive cortex (Kylin, 1956). However, *Osmundea* is

readily distinguished from *Laurencia* and *Chondrophycus* in having filament-type rather than trichoblast-type spermatangial development and tetrasporangial production from random epidermal cells rather than particular pericentral cells (Nam et al., 1994; Nam, 1999). *Laurencia* is delimited from *Chondrophycus* by the vegetative axial segment feature of four instead of two pericentral cells (Nam, 1999). Of these genera, *Laurencia* has a worldwide distribution, although the majority of species are found in the Southern Hemisphere (McDermid, 1988). By contrast, *Osmundea* shows a disjunct distribution, occurring in Pacific North America, Brazil, the Mediterranean Sea, Atlantic Europe, India, Australia (?) and probably North Africa (Harper and Garbary, 1997; Serio et al., 1999; Nam et al., 2000; Yoneshigue-Valentin et al., 2003; Furnari et al., 2004), and currently fifteen species are recognized in those areas (Nam et al., 1994, 2000). *Chondrophycus* has been reported mainly in the Pacific (Garbary and Harper, 1998; Nam, 1999). This genus is the most diverse, and seems to be actively evolving within the complex, considering the number of species and infrageneric categories which have been established based on morphological features with phylogenetic significance (Nam, 1999).

Recently, a morphological phylogenetic analysis of this complex was reported (Garbary and Harper, 1998). However, some features with phylogenetic importance were not considered in the analysis. Subsequently, the vegetative and reproductive structures of *L. clavata* Sonder, which may phylogenetically link the *Laurencia* complex and *Chondria* C. Agardh, were clarified (Nam and Choi, 2001). Nam et al. (2000) and McIvor et al. (2002) also carried out phylogenetic analyses, but their work was focused largely on *Osmundea*.

In this study, the Korean *L. succulenta* sp. nov. is described, and, in order to reevaluate phylogenetic relationships among the assemblages within the *Laurencia* complex, a cladistic analysis of 47 species including *L. clavata* from various localities around the world was performed based on 49 morphological characters including the additional elaborate features (such as the position of the first pericentral cell relative to trichoblast, the fertility or sterility of the second pericentral cell and number of sterile pericentral cells in tetrasporangial axis, and the formation pattern of spermatangial branches on trichoblasts), which are of major phylogenetic significance (Nam, 1999; Nam and Choi, 2000) but were not considered in the previous works (Garbary and Harper, 1998; Nam et al., 2000; McIvor et al., 2002).

Materials and methods

Data for the new species were obtained from liquid-preserved and herbarium specimens collected from Korea. Methods for microscopic examination of anatomical features are the same as those given in Nam and Saito (1990, 1991b). For phylogenetic analysis, 47 species including the type species of each genus of the *Laurencia* complex, *Laurencia obtusa* (Hudson) Lamouroux, *Chondrophycus cartilagineus* (Yamada) Garbary et Harper and *Osmundea osmunda* (S.G. Gmelin) Nam et Maggs were selected from various localities around the world (Figure 1) (Table 1). *Chondria* C. Agardh based on *C. tenuissima* (Goodenough et Woodward) C. Agardh (type species) and *C. dasyphylla* (Woodward) C. Agardh (Gordon-Mills, 1987) was adopted as the outgroup. 49 morphological characters were used in the analysis (Table 2). Cladistic analysis was carried out using PAUP* v.4.0b10 for the Macintosh (Swofford, 2002) by the maximum parsimony method and optimum trees were searched for the heuristic algorithm with the options Simple additions, TBR swapping, COLLAPSE (max), MULTREES and Steepest descent (No). Character optimization on trees was made by ACCTRAN.

Results and discussion

Laurencia succulenta sp. nov. (Figures 2–6)

Type locality: Sungsanpo (33°27'N, 126°56'E), Korea
Distribution: Korea (Sungsanpo, Ulleungdo, Tongbaeksum in Busan)

Representative specimens examined: N860105♂♀ ⊕ (holotype) and N860107 ⊕ (paratype) deposited in the Herbarium of the Department of Marine Biology, Pukyong National University, Korea. Busan (6.vi.1986, N860106 sterile); Ulleungdo (9. ix.1986, N960230 sterile), Sungsanpo (21.v.1985, N861116♂).

Etymology: The epithet is derived from the comparatively fleshy thalli.

Habitat: Epiphytic on coarse algae near lower tidal zone

Description: *Thalli epiphytici, caespites laxos facientes, subcompressi, fusci, carnosi, subcartilaginei, affixa ad substratum per ramos stoloniformes accessorios numerosos; axes erecti unus vel pluri ramulis repentibus basalibus exorientes; ramificatio disticha; cellulae epidermales leviter procurentes vel non procurentes*