

## THREE NEW RECORDS OF THE GENUS *LAURENCIA* (CERAMIALES, RHODOPHYTA) FROM THE PERSIAN GULF SEASHORES IN IRAN

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Despite numerous studies, the genus *Laurencia* J. V. Lamouroux (Ceramilales, Rhodomelaceae) is still one of the most complex genera of Rhodophyta. In recent years some species of the genus have been transferred to other genera. However some species of this genus have only been introduced based on morphological characters from south of Iran, but modern molecular studies combined with morphological and anatomical studies can resolve most problems of this complicated groups of organisms. In this study *Laurencia obtusa* var. *mollissima*, *L. obtusa* var. *compacta* and *L. dendroidea* are reported for the first time from Bandar-Lengeh, Hengam and Qeshm Islands respectively in southern coastlines of Iran. Morpho-anatomical studies revealed the typical characteristics of the genus *Laurencia*, including four pericentral cells per each axial segment, presence of *corpse en cerise* per superficial cortical cell, parallel arrangement of tetrasporangia, presence of secondary pit connections and other specific features of this genus.

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**Key words:** *Laurencia*; Rhodophyta; seaweeds; Persian Gulf; Iran

سه گزارش جدید از جنس *Laurencia* (جلبک های قرمز راسته Ceramilales) در سواحل خلیج فارس، ایران  
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علی رغم مطالعات متعدد در مورد جنس *Laurencia* J.V. Lamouroux از راسته Ceramilales و خانواده Rhodomelaceae این جنس همچنان یکی از پیچیده ترین جنس های جلبک های قرمز از نظر سیستماتیک به حساب می آید و در سال های اخیر تعدادی از گونه های این جنس به سایر جنس ها منتقل شده اند. تا به حال چندین گونه از این جنس در سواحل جنوبی ایران گزارش شده که تنها بر اساس صفات ریخت شناسی بوده است، درحالیکه با توجه به متغیر بودن ویژگی های ریخت شناسی، استفاده از صفات تشریحی در شناسایی صحیح گونه های این جنس بسیار حائز اهمیت است. *L. obtusa* var. *mollissima* و *L. obtusa* var. *compacta* و *L. dendroidea* برای اولین بار به ترتیب از سواحل بندر لنگه، جزیره هنگام و جزیره قشم در جنوب ایران جمع آوری شده اند، گزارش می گردند. صفات ریخت شناسی و تشریحی متمایزکننده این جنس مشتمل بر چهار سلول پری سنترال حول هر سلول محوری، حضور *corpse en cerise* در سلول های کورتیکال سطحی، آرایش موازی تتراسپورها، وجود ارتباطات نانویه بین سلولی و سایر ویژگی های خاص این جنس در این مطالعه مورد بررسی قرار گرفتند.

### INTRODUCTION

*Laurencia* J. V. Lamouroux is a worldwide genus of red algae with 418 taxa of which 129 have been flagged as currently accepted taxonomically (Guiry & Guiry 2014). Since the genus *Laurencia* was established by Lamouroux in 1813 with the original recognition of eight species, using vegetative and reproductive structures, the taxonomy of the genus has undergone several changes by adding new characters and cladistic

analyses to segregate genera, subgenera and sections (Garbary & Harper 1998; Nam 1999, 2006, 2007; Nam & Saito 1995; Cassano et al. 2012a). Currently, the *Laurencia* complex comprises six genera: *Laurencia* J.V. Lamouroux (1813), *Osmundea* Stackhouse (1809), *Chondrophycus* (Tokida & Saito) Garbary & Harper (1998), *Palisada* (Yamada) Nam (2007), *Yuzurua* (Nam) Martin-Lescanne (2010) and *Laurenciella* Cassano, Gil-Rodríguez, Sentíes, Díaz-Larrea, Oliveira

& Fujii (2012a).

Due to intertidal biomass of the *Laurencia*, species of the genus have important role in providing food, oxygen and shelter for other intertidal organisms. Members of the genus *Laurencia* are also potential sources of halogenated secondary metabolites such as sesquiterpenes, diterpenes, triterpenes and acetogenins, which make them diverse chemically rich group of red algae. Their secondary metabolites have potential antifouling (Jung et al. 2009; Paradas et al. 2010; Suzuki & Vairappan 2005; Erickson 1983) and medical applications such as antitumor, antibacterial, antifungal and antiviral activities (Mohammed et al. 2004; Vairappan et al. 2004; Morales et al. 2006; Sakemi et al. 1986; Waraszkiewicz & Erickson 1974; Wratten & Faulkner 1977; Caccamese et al. 1980; König & Wright 1997).

Several species of the genus *Laurencia* have been reported from the coastlines of Hormozgan province in south of Iran (Sohrabipour & Rabii 1999; Sohrabipour et al. 2004; Gharanjik & Rohani Ghadicolaei 2010), mainly based on morphological characters, while using anatomical characters for valid identification of these species is essential. In the present study *L. obtusa* var. *mollissima*, *L. obtusa* var. *compacta* and *L. dendroidea* collected respectively from Bandar-Lengeh area, Hengam and Qeshm islands are reported as new records for the Iran algal flora.

## MATERIALS AND METHODS

The samples were collected from July 2012 till June 2013 in the intertidal zone of the stations of Hormozgan province (fig. 1). Samples were transported to the laboratory of Isfahan University in insulated containers with ice. In Laboratory the collected specimens were carefully cleaned from epiphytes and washed several times with tap and distilled water. Some specimens were preserved in 4% formaldehyde for anatomical studies, some of them were dried, pressed and mounted on herbarium sheets as herbarium samples which are deposited in the Herbarium of Isfahan university (HUI). Transverse and longitudinal hand-sections were obtained by a razor blade and stained with 0.5% aqueous aniline blue solution acidified with 1 N HCl (Tsuda & Abbott 1985). A calibrated ocular micrometer was used for microscopic measurements. The photomicrographs were taken with a SONY - Carl Zeiss digital camera coupled to a Carl Zeiss microscope. The morpho-anatomical characters used for analysis were thallus length, arrangement of branches and branchlets, number of pericentral cells encircled axial segment, secondary pit connections between epidermal cells, lenticular thickenings in

medullary cells, tetrasporangial origin, tetraspore arrangement, *corps en cerise*, anastomosis between branches and etc. Identification of samples were based on the following taxonomic references: Agardh, (1852); Okamura (1909); Cribb (1958); Cassano et al. 2012b; Metti et al. (2013); Oliveira et al. (2013).

## RESULTS

Algal collection were made from different sites along the coastlines of Persian Gulf identified as presented in the literatures, checked for synonyms and latest accepted names using the latest upgraded www.algaebase.org database. Description of the species in the present study is based on Cribb (1958), Cassano et al. (2012b) and Metti et al. (2013) identification keys.

The characteristics of two varieties were compared with the typical *L. Obtuse* on the following characters: forming loose clump to 8 cm high with one to several erect axes from a discoid holdfast without accessory stoloniferous attaching branches; soft and fleshy, adhering strongly to paper; pale green to olive-fawn when fresh; frond more or less terete; branching predominantly opposite or subopposite, sometimes irregularly alternate or subverticillate, the branching wide-angled, usually at 45°-90°; final sterile branchlets cylindrical to cylindro-clavate, often distinctly truncate, 375-600 µ diameter, to 1750 µ long; main axes terete, 850-1700 µ diameter; tetrasporic branchlet systems mostly simple and resembling sterile branchlets; in the final branchlets surface cells strongly protruding, in transverse section not radially elongate, in main axes and branches in surface view longitudinally elongate; medullary cells without lenticular thickenings (Cribb, 1958).

*Laurencia obtusa* var. *mollissima* A.B.Cribb, Cribb 1958, p. 173, 174, Pl. 9.

The algae usually fawn to pale olive-yellow color when fresh; thallus about 13 cm in height, bushy and erect with one to several erect axes from a small discoid holdfast without accessory stoloniferous attaching branches; soft and fleshy in texture, adhering strongly to paper; frond more or less terete; branching mainly irregularly alternate, sometimes subopposite, with up to 3 orders of branching from the main axis, with the branches diverging at usually 30°-90°; ultimate branchlets clavate or obtuse, slightly projected; the secondary and tertiary branches gradually decrease in length towards the apices; final branchlets cylindrical or cylindro-clavate, often distinctly truncate; main axes terete, 1-2 mm. diameter;

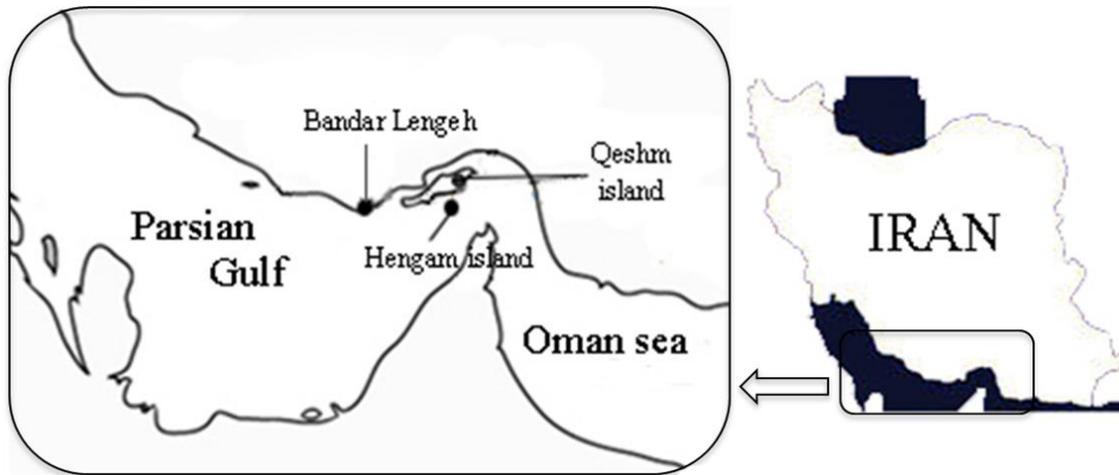


Fig. 1. Collection localities of *Laurencia* species alongside the Persian Gulf, Iran. Bandar-Lengeh area ( $54^{\circ} 52' N$ ,  $26^{\circ} 32' E$ ), Hengam Island ( $55^{\circ} 51' N$ ,  $26^{\circ} 36' E$ ) and Qeshm Island ( $55^{\circ} 23' N$ ,  $26^{\circ} 34' E$ ).

tetrasporic branchlets systems simple or with a pair of alternate or subopposite branchlets or occasionally subcorymbose or subumbellate, the final branchlets resembling the sterile branchlets; cystocarpic branchlets not seen; in the final branchlets surface cells not protruding; cortical cells in a transverse section are not palisade-like; vegetative axial cells cut off four pericentral cells; medullary cells without lenticular thickenings of the walls; secondary pit-connections present; tetrasporangia parallel to the axis in the apical portion of the ultimate branchlets; presence of one or two *corps en cerise* per cortical cell (figs. 1 & 2).

Habitat: Reef flats and subtidal zone.

Ecology: This species has been only found in Bandar-Lengeh area

Herbarium number in HUI: 19532

***Laurencia obtusa* var. *compacta*** A.B.Cribb, Cribb 1958, p. 174, Pl. 7.

The branches of algae usually appear with mainly greenish color, but apices usually pink or fawn; thallus about 4 cm in height, forming low clumps, often cushion-like, not sharply divided into prostrate and erect axes but with the much branched intricate decumbent axes, suberect or erect and generally adhering by haptera at numerous points to substratum; contiguous branches often fused to form a firm colony, fleshy, crisp and brittle when fresh; all branches terete or subterete; branching irregularly alternate, rarely opposite; final branchlet systems simple or sometimes with a few to numerous usually crowded shortly

subcylindric or wart-like branchlets; main axes 625-1125  $\mu$  diameter; tetrasporic branchlet systems similar to sterile ones; spermatangial branchlets subturbinate, about 875  $\mu$  diameter, crowded as in tetrasporic and sterile fronds; cystocarpic branchlets not seen; in the final branchlets surface cells not protruding, in transverse section not radially elongate; vegetative axial cells cut off four pericentral cells each; medullary cells without lenticular thickenings of the walls; cortical cells in a transverse section neither elongated radially nor arranged like palisade; secondary pit-connections present; tetrasporangia parallel to the axis in the apical portion of the ultimate branchlets; presence of one or two *corps en cerise* per cortical cell (figs. 1 & 3).

Habitat: Reef flats and subtidal zone.

Ecology: This species grows in the lower portions of the intertidal zone on rocky substrates or shallow subtidal zones. It has been found in Hengam Island.

Herbarium number in HUI: 19533

***Laurencia dendroidea*** J. Agardh, Agardh, J.G. 1852, p. 753.

Cassano et al. 2012b, 47(1): 67-81; Metti et al. 2013, 68: 98-104; Okamura 1909, Vol. II pp. 21-40, Plates LVI-LX; Oliveira et al. 2013, 52(2): 130-136.

Homotypic Synonym: *L. obtusa* var. *dendroidea* (J.Agardh) Yamada 1931.

Heterotypic Synonym: *L. scoparia* J. Agardh 1852, *L. obtusa* var. *majuscula* Harvey 1863, *L. flagellifera* Kützing 1865, *L. majuscula* (Harvey) A. H. S. Lucas 1935, *L. kuetzingii* A. J. K. Millar 2005.



Fig. 2. *Laurencia obtusa* var. *mollissima*: a, Habit; b & c, arrangement of branchlets; d & e, transverse section through a vegetative axial showing an axial cell (a) with four pericentral cells (p); f, longitudinal section through an ultimate branchlet, showing epidermal cells, secondary pit connections (black arrows) and nonprojecting cortical cells; g & h, surface image showing one to two corpus en cerise per epidermal cell; i, herbarium specimen; j, a tetrasporic branchlet; k, the detail of tetrasporic branchlet.



Fig. 3. *Laurencia obtusa* var. *compacta*: a, habit; b&c, axes and holdfast; d, surface image showing one to two corpi en cerise per epidermal cell; e & f, transverse section through a vegetative axial showing an axial cell, a, with four pericentral cells(p); g, longitudinal section through an ultimate branchlet, showing epidermal cells, secondary pit connections (black arrows) and nonprojecting cortical cells; h, a tetrasporic branch; I, the detail of tetrasporic branchlet; j, herbarium specimen.



Fig. 4. *Laurencia dendroidea* J. Agardh. a & b, habit, c, surface image showing two corps en cerise per epidermal cell, d & e, transverse section through a vegetative axial showing an axial cell, (a) with four pericentral cells, (p), f) anastomosis, g, longitudinal section through an ultimate branchlet, showing epidermal cells and secondary pit connections (black arrows), h, transverse section of old portion of the thallus showing filling cells, i, detail of a branch showing scar of released branchlet (arrows), j, a tetrasporic branch, note scars of released branchlets (arrows), k, projecting cortical cells.

The algae colors range from dark red to orange-red to bright pink-red, but most are dark red color with very few plants showing slightly green main axes;

thallus about 4–20 cm in height; soft and fleshy in texture, adhering strongly to paper; the habit outline generally, is pyramidal, particularly in higher branch

orders by a small discoid holdfast with accessory stoloniferous attaching branches, the number of stolons varies from none to many; branching radial and generally subterete; percurrent axes present; possess adventitious branchlets or ultimate ramuli; the thalli are 0.9–2.8 mm in diameter in the middle portion of the main axis; presence of intercellular spaces in the younger portions, and many filling cells in the older portions of the main axes; presence of deciduous branches and branchlets which left scars on the axes following detachment; epidermal cells are slightly projecting at apices; epidermal cells are isodiametric to pyramidal in shape, 17 – 29 µm in width and 20 – 27 µm in length; vegetative axial cells cut off four pericentral cells each; presence of anastomose between branches; lenticular thickenings can be abundant, rare, or completely absent; cortical cells in a transverse section are not palisade-like; secondary pit-connections present; tetrasporangia parallel to the axis in the apical portion of the ultimate branchlets; presence of one or two (or three), *corps en cerise* per cortical cell (figs 1 & 4.).

Habitat: Reef flats and intertidal to subtidal zone.

Ecology: This species grows in the lower portions of the intertidal zone on rocky substrates or shallow subtidal zones. It has been found in Qeshm Island.

Herbarium number in HUI: 19530

## DISCUSSION

In this study, *L. dendroidea* and two varieties of *L. obtusa* are reported as new records for Iran. While in previous researches some species such as *L. intricata* and *L. majuscula* were reported from Hormozgan province, specially Bandar-Lengeh area (Sohrabipour et al. 2004; Gharanjik & Rohani Ghadicolaei 2010), they did not confirmed in that area in the present study. Although *L. obtusa* var. *mollissima* has a discoid holdfasts, fawn to pale olive-yellow color and 13 cm height, *L. intricata* has a discoid holdfast with stoloniferous attaching branches, its average height is about 5.7 cm, even though in Taylor (1928) it was reported about 2 cm and different color, purplish pink (Saito 1967). In addition, *L. majuscula* was differentiated from *L. obtusa* var. *mollissima* by projecting cortical cells that is similar to *L. dendroidea* (Cassano et al. 2012b). The above recorded specimens did not observed in new collections. Consequently, in order to optimally confirm and recognize *L. intricata* and *L. majuscula* in Bandar-Lengeh an extensive collection and molecular examination is requisite. Moreover, *L. obtusa* var. *mollissima* was differentiated from other species by higher length and arrangement of branchlets.

Additionally, like the Cribb's (1958) study in Moreton Bay, *L. obtusa* var. *mollissima* and typical *L. obtusa* were growing side by side in Bandar-Lengeh area and appear quite distinct without any intermediate forms. This variety was distinctly distinguished by its greater branch diameter, predominantly alternate branching, and its fawn to olive yellow color which are in contrast to the pale green or olive fawn of plants of *L. obtusa* (Cribb 1958). Finally, based on morphological and anatomical studies, it was concluded that the previously attributed species to the Bandar-Lengeh coast *L. intricata* and *L. majuscula* can be identified as *L. obtusa* var. *mollissima*.

*L. obtusa* var. *compacta* has been characterized by the obscure axes and specific holdfast of numerous type in addition to the size and color of this variety.

Considering the difference between their habitat and ecology, it seems that using the entities of these two taxa at variety level through recognition of precise anatomical and morphological studies is beneficial. The two varieties of *L. obtusa* have been introduced by Cribb (1958) and subsequently other researchers have only utilized the entities of these two taxa (Lewis 1984; Millar 1990; Millar & Kraft 1993; Phillips 1997,2002; Silva et al. 1996 and Bostock & Holland 2010).

The specific features of *L. dendroidea* are existence of many filling cells in older portions of the main axes, scars of released branchlets and presence or absence of lenticular thickenings in the walls of the medullary cells (Cassano & al. 2012). J. Agardh (1876) regarded *L. majuscula* and *L. dendroidea* as synonymous, but *L. majuscula* has a different habit, a relatively soft texture, a distinctly projected cortical and lacks lenticular thickenings (Saito & Womersley 1974; Cassano & al. 2012b).

Our report shows the necessity of an extensive revision for the species of *Laurencia* in the south shores of Iran.

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