Note

Algae 2013, 28(3): 233-240

<http://dx.doi.org/10.4490/algae.2013.28.3.233>

Open Access

Grateloupia jejuensis (Halymeniales, Rhodophyta): a new species previously confused with *G. elata* and *G. cornea* in Korea

Su Yeon Kim¹, Eun Gyu Han², Myung Sook Kim^{2,*}, Jung Kwang Park¹ and Sung Min Boo¹

¹Department of Biology, Chungnam National University, Daejeon 305-764, Korea

²Department of Biology and Research Institute for Basic Sciences, Jeju National University, Jeju 690-756, Korea

Despite specimens' large size and ease of collection in northeast Asian waters, the species diversity of the genus *Grateloupia* still needs more research in Korea. We investigated plastid *rbcL* sequences and carried out detailed morphological observation on flattened halymeniacean red alga collected in twelve locations around Korea and Japan. We describe *Grateloupia jejuensis* sp. nov. based on the distinct clade with high support in our *rbcL* tree. *Grateloupia jejuensis* is characterized by solitary or caespitose habit and flattened thalli with discoid holdfast, cartilaginous texture, and blunt or bifid axis. *Grateloupia jejuensis* was distantly related to *G. elata* and *G. cornea*, which have been morphologically confused with the former, and it formed a sister relationship with *Prionitis filiformis* from California, USA in the *rbcL* tree.

Key Words: *Grateloupia*; *Grateloupia jejuensis*; Halymeniales; Korea; new species; Rhodophyta

INTRODUCTION

The genus *Grateloupia* was established by C. Agardh (1822) based on *G. filicina* (J. V. Lamouroux) C. Agardh. *Grateloupia* is distinguished by *Grateloupia*-type auxiliary cell ampullae with a single primary ampullar filament and two or three 7- to 13-celled secondary ampullar filaments of a conical out line (Chiang 1970, Kawaguchi 1989, Wang et al. 2000). Recent studies combining morphological and molecular data have resulted in several taxonomic changes. *Pachymeniopsis* Y. Yamada, *Prionitis* J. Agardh, *Dermocorynus* P. L. Crouan & H. M. Crouan, and *Phyllymenia* J. Agardh have been merged into *Grateloupia* (Kawaguchi 1997, Wang et al. 2001, De Clerck et al. 2005b, Wilkes et al. 2005) while *G. intestinalis* (Harvey) Setchell moved to *Glaphyrosiphon* Hommersand & Leister (Hommersand et al. 2010).

Grateloupia elata (Okamura) S. Kawaguchi & H. W. Wang was described based on specimens under the name

Prionitis elata Okamura (type locality: Shirahama, Chiba Prefecture, located at the Pacific side of Japan). In Korea, Cotton (1906) reported this species (as *Prionitis elata*) for the first time at Wonsan on the northeast coast of the Korean peninsula. Afterwards, *G. elata* was reported between Busan and Gangneung on the east coast of Korea and Gapado on Jeju Island (Lee and Kang 2001).

Grateloupia cornea Okamura (1913) was transferred to the genus *Carpopeltis* and then changed to *Prionitis cornea* (Okamura) E. Y. Dawson (Dawson 1958). However, Wang et al. (2001) reinstated the original name, *Grateloupia cornea*, when they merged *Prionitis* into *Grateloupia*. In Korea, Kang (1966) reported this species on the east to south coasts and on Jeju Island. Subsequently, this species has been reported in many floristic reports (Lee and Kang 2001).

© This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Received April 12, 2013, Accepted August 21, 2013

*Corresponding Author

E-mail: myungskim@jejunu.ac.kr

Tel: +82-64-754-3523, Fax: +82-64-756-3541

The taxonomy of the genus *Grateloupia* remains confused due to the low taxonomic utility of vegetative morphological characteristics, such as surface morphology, thallus habit and texture, and frequency of proliferations (Wang et al. 2001, De Clerk et al. 2005a, Wilkes et al. 2005). Recent studies show that the *rbcL* gene is a suitable marker for taxonomic study of *Grateloupia* (Wang et al.

2000, Faye et al. 2004, Lee et al. 2009, Yang et al. 2013). In the present study, we analyzed *rbcL* from unidentified specimens in Korea as well as other species and observed morphological characters. As a result, we describe *Grateloupia jejuensis* sp. nov. and discuss the phylogenetic relationships of *G. jejuensis* with the other species of the genus.

Table 1. Materials used in the present study

Taxa	Collection data	Voucher No.	GenBank accession No.
<i>Grateloupia jejuensis</i> sp. nov.	Donghae, East coast, Korea; Oct 27, 2012	SKKU6	KF156729
	Yangyang, East coast, Korea; Oct 27, 2012	SKKU15	KF156729
	Gijang, East coast, Korea; Feb 28, 2010	P2433, CNU74	KF156729
	Hado, Jeju, Korea; Oct 4, 2009	G7034, G7035	KF156729
	Jinhae, South coast, Korea; Jun 12, 2009	G1169	KF156729
	Dodu, Jeju, Korea; Jun 4, 2009	G1482	KF156729
	Yongwoondong, Jeju, Korea; Jul 11, 2011	SH205, SH207	KF156729
	Sungsan, Jeju, Korea; Apr 4, 2010	GT096	KF156729
	Sungsan, Jeju, Korea; May 5, 2010	G119	KF156729
	Ilkwa, Jeju, Korea; Nov 29, 2009	G024	KF156729
	Jongdal, Jeju, Korea; Apr 4, 2010	GT093, GT074	KF156729
	Jongdal, Jeju, Korea; May 29, 2010	G117	KF156729
	Udo, Jeju, Korea; Nov 8, 2009	G012	KF156729
	Misaki, Japan; Apr 30, 2010	MI29, MI15	KF156729
<i>G. americana</i> S. Kawaguchi & H. W. Wang	Strawberry, Oregon, USA; Jun 17, 2003	G227	KF156730
<i>G. angusta</i> (Okamura) S. Kawaguchi & H. W. Wang	Beomseom, Jeju, Korea; Mar 26, 2011	GAJ-1	KF156731
<i>G. asiatica</i> Kawaguchi & Wang	Dadaepo, Geojae, Korea; Aug 24, 2009	G3827	KF156733
	Gijang, Busan, Korea; Feb 5, 2011	SH162	KF156732
<i>G. divaricata</i> Okamura	Jeoncheon, Donghae, Korea; Feb 7, 2010	G3745	KF156734
<i>G. catenata</i> Yendo	Hupohang, Uljin, Korea; Jan 11, 2002	G51	KF156735
<i>G. elliptica</i> Holmes	Gamchusa, Donghae, Korea; Mar 14, 2010	SH16	KF156737
	Vladivostok, Russia; Jul 25, 2002	G075	KF156736
<i>G. imbricata</i> Holmes	Gimnyoung, Jeju, Korea; Aug 24, 2006	G1971	KF156739
	Daesambudo, Yeosu, Korea; Sep 10, 2006	G667	KF156738
<i>G. lanceolata</i> (Okamura) Kawaguchi	Uhran, Haenam, Korea; Jan 21, 2010	G3759	KF156740
	Jeoncheon, Donghae, Korea; Feb 7, 2010	G3744	KF156741
<i>G. subpectinata</i> Holmes	Gamchusa, Donghae, Korea; Mar 14, 2010	SH14	KF156743
	Dalian, China; Oct 14, 2008	G1693	KF156742
<i>G. turuturu</i> Yamada	Sodol, Gangneung, Korea; Mar 14, 2010	G3861	KF156744
	Uhran, Haenam, Korea; Jan 21, 2010	G3768	KF156745
<i>Prionitis filiformis</i> Kylin	A sunset at pescadero state beach, California, USA; May 27, 2010	A671	KF156746
	Bodega, California, USA; May 28, 2010	P2762	KF156747
<i>Polyopes affinis</i> (Harvey) Kawaguchi & Wang	Uhran, Haenam, Korea; Jan 21, 2010	G3772	KF156748

MATERIALS AND METHODS

In total, 38 specimens of 13 species in the Halymeniaceae were collected from Korea, China, Japan, Russia, and USA. Field observation and collections of *Grateloupia jejuensis* were made at intertidal zone of 12 locations around Korea and Japan from 2009 to 2012.

Specimens were sectioned with a freezing microtome (FX-801; Yamato Kohki Industrial Co. Ltd., Tokyo, Japan). Photographs were taken with a DP-71 camera (Olympus, Tokyo, Japan) attached to a microscope (BX 51; Olympus). Voucher specimens are housed at the herbarium of Chungnam National University, Daejeon, Korea (CNUK).

We analyzed 84 sequences representing 48 Halymeniaceae species, including 38 new sequences and 46 GenBank sequences. Information for specimens, their collection data, and GenBank accession numbers of *rbcL* sequences are given in Table 1. DNA extraction, PCR amplification, and sequencing follow the procedures in Boo et al. (2010). For amplification and sequencing reaction of the *rbcL* gene, specific primer pairs were *rbcLF145-rbcLR898* and *rbcLF762-rbcLR1442* (Kim et al. 2010). Electropherogram outputs from each sample were edited using Chromas version 1.45 (<http://www.technelysium.com.au/chromas.html>). Eighty-nine *rbcL* sequences were collated and aligned using Se-Al (version 2.0a11), as per Rambaut (2002). Maximum likelihood analyses were conducted using RAxML (Stamatakis 2006) with the GTR + Γ evolutionary model. We performed 200 independent tree inferences using the *-#* option with default *-I* (automatically optimized SPR rearrangement) and *-c* (25 distinct rate categories) option in the program to identify the best tree. To generate bootstrap values for the best phylogeny, we used 1,000 replications under the same program with the same model settings.

RESULTS

Grateloupia jejuensis S. Y. Kim, E. G. Han & S. M. Boo sp. nov. (Fig. 1)

Thallus solitariam aut caespitosa, applanatis et dichotomis calami, saepe flabellatae in adumbration, apice cum terminus in obtusus aut bifida, cartilaginous in textum. Cortex cum 7-8 compactus corticales cellululis, sphaericus in intimus cellululis et angulata superficies cellululis. Medulla cum parvos sphaericus cellululis, 5-7 μ m in diametros. Tetrasporic sporophylls, tenuis et parvos, oblongae, acumina-tus ad basin, seriatum per duo marginibus. Tetrasporangi-

is cruciatis dividiuus, plasmatio ex corticales cellam iacuit in the proliferous ramulis.

Thallus solitary or caespitose, flattened and dichotomous branches, often flabellate in outline, apex with ending in blunt or bifida, cartilaginous in texture. Cortex with 7-8 compact cortical cells, spherical in innermost cells and angulated surface cells. Medulla with small spherical cells, 5-7 μ m in diameter. Tetrasporic sporophylls, thin and small, oblong, tapering at base, seriated along both margins. Tetrasporangia cruciately divided, forming from cortical cell layer in the proliferous branchlets.

Holotype. CNU040218, intertidal zone of Hado (33°31' N 126°54' E), Jeju, Korea, Oct 4, 2009 (Fig. 1A), Herbarium of Chungnam National University (CNUK), Daejeon, Korea. Isotypes: CNU040217, -19, -220-1, NIBRAL0000138259-60.

Etymology. The specific epithet refers to Jeju Island, Korea, where the type was collected.

Distribution. Found from Gangneung on the east coast to Jinhae on the south coast, and from Ilkwari to Sungsan around Jeju Island. *Grateloupia jejuensis* was frequently found throughout the year on rocks in tide pools and sheltered places in lower tidal zones. Specimens were collected in February, June, July, October, and December; tetrasporophytes were collected in May and October. Gametophytes were not found.

Korean name. 땃잎도박

Morphology. Plants are solitary or caespitose, arising from discoid holdfast, and cartilaginous in texture. The thallus is dark purple to red in color and bright red in the upper portion. The thallus is 8-16 cm high, 0.2-0.4 cm wide, and 200-350 μ m thick, with a short stipe (0.5-1 cm long). Branches are divided up to eight times dichotomously, and apex endings are blunt or bifid. The marginal branches produce proliferous branchlets that are often irregular and small (up to 5 mm long and 1 mm wide), scattered over the middle part of the thallus except for the stipe and basal part. The internal thallus is composed of compacted cortex and dense medulla. The cortex is 7-8 cell layers and is 5-20 μ m in diameter. The outer cortex is composed of 3-4 layers with narrowly ellipsoidal cells, and the inner cortex is composed of 3-4 layers with irregular or rounded transparent cells. The medulla is composed of filamentous cells (5-7 μ m in diameter). Tetrasporangia are formed from the cortical cell layer in the proliferous branchlets. The mature tetrasporangia are cruciately divided, narrowly ellipsoidal in shape, and 30-40 μ m long by 10-15 μ m wide.

Phylogeny of *rbcL*. 1,094-nucleotide portions of the *rbcL* gene were aligned for 84 sequences (38 new se-

Fig. 1. *Grateloupia jejuensis* S. Y. Kim, E. G. Han & S. M. Boo sp. nov. (A) Holotype (CNU040218, tetrasporophyte) of *Grateloupia jejuensis* collected from Hado, Jeju, Korea on Oct 4, 2009, deposited in the Herbarium of Chungnam National University (CNUK), Daejeon, Korea. (B) Close-up view of tetrasporic sporophylls (ts). (C) Cross section of thallus showing cortex (c) and medullar layers (m). (D) Longitudinal section of thallus showing cortex (c) and medullar layers (m). (E) Cross section of tetrasporic sporophylls. (F) Close-up view of a tetraspore (t). Scale bars represent: A, 2 cm; B, 5 mm; C, 100 µm; D & E, 50 µm; F, 20 µm.

quences), representing 48 species of Halymeniaceae. All sequences of *G. jejuensis* from 12 sites in Korea and Japan were identical. The *rbcL* difference of *G. jejuensis* with *Prionitis filiformis* Kylin was 14-15 bp (1.28-1.37%), while *G. jejuensis* differed by 27-29 bp (2.28-2.45%) from *G. elata* and 63 bp (5.48%) from *G. cornea*.

In the phylogenetic tree (Fig. 2), *Grateloupia jejuensis* was placed in a single clade and clearly separated from the other species of the genus. The sister species of *G. jejuensis* was *Prionitis filiformis* (86% for maximum likelihood). *Grateloupia cornea* was resolved as a sister taxon of *G. chiangii* from Japan with 91% bootstrap support. *Grateloupia angusta* shows sister relationships with *G. elliptica* and *G. lanceolata*.

DISCUSSION

The main finding of the present study is the discovery of a new species, *Grateloupia jejuensis*, in Korea based on *rbcL* sequence data and morphological evidence. It had previously been misidentified as *G. elata* (Lee 2008) or *G. cornea* (Lee 1987) because of similarity in cartilaginous texture, and erect, linear, compressed habit. In this context, the existence of *G. elata* and *G. cornea* in Korea may be questionable.

The comparative morphology of *Grateloupia jejuensis* with similar species is summarized in Table 2. *Grateloupia elata* is much larger in thallus size than *G. jejuensis* (20-50 cm vs. 8-16 cm). Kawaguchi et al. (2001) reported that the difference in size is the one of main characteristics to distinguish *G. asiatica* from *G. filicina* (10-30 cm vs. 9-12 cm). The width of *G. elata* is less than that of *G. jejuensis* (1.5-2.5 mm vs. 2-4 mm). The difference in habitat is also a remarkable characteristic between the two species: *G.*

elata occurs in deep waters (Okamura 1899), whereas *G. jejuensis* usually occurs in tide pools and / or intertidal zone. *Grateloupia cornea* is also similar to *G. jejuensis* in having cartilaginous texture and linear habit. However, *G. jejuensis* has 7-8 cortical cell layers, while *G. cornea* has 13-15 cortical cell layers. The structure of medullary cells of *G. jejuensis* is more densely constructed than those of *G. cornea*.

Okamura (1899) stated that *G. elata* resembles *G. angusta* (Okamura) S. Kawaguchi & H. W. Wang in structure, habit, and substance, but differed in fruit-bearing (tetraspores and cystocarps) portion and cells of the intermediated layer. *G. angusta* is distinguished from *G. jejuensis* by composition of medulla and number of cortical cells. *G. jejuensis* has a densely composed medulla with 7-8 cortical cells, while *G. angusta* has a very densely composed medulla with 14-16 cortical cells.

Wang et al. (2001) merged *Prionitis* to *Grateloupia*; however, the formal proposals were not for all species of *Prionitis*. The genus *Prionitis* is still used in the Halymeniaceae. In our *rbcL* tree, *P. filiformis* was the sister of *G. jejuensis* and grouped together with all other *Grateloupia* species with high bootstrap support. It is therefore suggested that *P. filiformis* can be transferred to *Grateloupia*. Before taxonomic revision, a more detailed morphological study of *P. filiformis* is needed.

In the phylogenetic tree (Fig. 2), ten Korean species were grouped into four different subclades with strong bootstrap support. *Grateloupia jejuensis* was included in subclade I. *Prionitis filiformis*, *P. sternbergii* (C. Agardh) J. Agardh, *Grateloupia americana* from the northeast Pacific and *Grateloupia acuminata* Holmes, *G. asiatica*, *G. divaricata*, *G. elata*, *G. jejuensis*, *G. livida* (Harvey) Yamada, *G. patens* (Okamura) S. Kawaguchi & H. W. Wang, *G. schmitziana* (Okamura) S. Kawaguchi & H. W. Wang from

Table 2. Morphological comparison between *Grateloupia jejuensis* and the morphologically similar species

	<i>G. jejuensis</i> sp. nov.	<i>G. elata</i> (Okamura) S. Kawaguchi & H. W. Wang	<i>G. angusta</i> (Okamura) S. Kawaguchi & H. W. Wang	<i>G. cornea</i> Okamura
Texture	Cartilaginous	Rigid-cartilaginous	Strongly cartilaginous	Cartilaginous
Color	Dark purple to red	Red	Deep-blood red	Vinose-purple
Habit	Cespitose, flattened	Densely cespitose, linear	Flattened and compressed	Cespitose, linear
Height (cm)	8-16	20-50	10-30	15-20
Width (mm)	2.0-4.0	1.5-2.5	1.5-2 up to 5	1.0-2.0
Cortex (cells)	7-8	7-8	14-16	13-15
Medulla	Densely	Very dense	Very dense	Loosely set
Habitat	Tide pools, intertidal zones	Deep waters	Near low tide	Near high tide
Type locality	Hado, Jeju, Korea	Shirahama, Japan	Misaki, Japan	Kadzusa, Japan
Reference	This study	Okamura (1899)	Okamura (1912)	Okamura (1913)

Fig. 2. Maximum likelihood (ML) tree inferred from *rbcL* sequences calculated using the GTR + Γ evolution model. Values above branches refer to ML bootstrap values. Bolded samples show the species which was newly analyzed in this study.

the northwest Pacific, were mixed within this subclade, suggesting that many species were likely to have diverged in the north Pacific Ocean. *Grateloupia cornea* and *G. angusta* formed subclade II. Given the morphological similarity to *G. jejuensis*, the habit similarity is a result of convergence. This result is consistent with previous studies (Wang et al. 2001, De Clerck et al. 2005a, Wilkes et al. 2005, Lee et al. 2009). Thallus habits are homoplasious within *Grateloupia*; thus, additional taxon sampling will provide a better understanding of phylogenetic relationships of the species.

ACKNOWLEDGEMENTS

We thank Shigeo Kawaguchi for comments on the present work. This research was supported by MarineBio21 program grants from the Ministry of Maritime Affairs & Fisheries, Korea to S. M. Boo and the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE), Korea to M. S. Kim for collecting specimens.

REFERENCES

- Agardh, C. A. 1822. *Species algarum rite cognitae, cum synonymis, differentiis specificis et descriptionibus succinctis. Volumen primum pars posterior.* ex officina Berlin-giana, Lundae [Lund], pp. 169-398.
- Boo, S. M., Kim, S. Y., Hong, I. S. & Hwang, I. K. 2010. Re-examination of the genus *Pterocladia* (Gelidiaceae, Rhodophyta) in Korea based on morphology and *rbcL* sequences. *Algae* 25:1-9.
- Chiang, Y. -M. 1970. Morphological studies of red algae of the family Cryptonemiaceae. *Univ. Calif. Publ. Bot.* 58:1-95.
- Cotton, A. D. 1906. Marine algae from Corea. *Bull. Misc. Inform. Kew.* 1906:366-373.
- Dawson, E. Y. 1958. Notes on Pacific coast marine algae, VII. *Bull. South. Calif. Acad. Sci.* 57:65-80.
- De Clerck, O., Gavio, B., Fredericq, S., Barbara, I. & Coppejans, E. 2005a. Systematics of *Grateloupia filicina* (Halymeniaceae, Rhodophyta), based on *rbcL* sequence analyses and morphological evidence, including the reinstatement of *G. minima* and the description of *G. capensis* sp. nov. *J. Phycol.* 41:391-410.
- De Clerck, O., Gavio, B., Fredericq, S., Cocquyt, E. & Coppejans, E. 2005b. Systematic reassessment of the red algal genus *Phyllymenia* (Halymeniaceae, Rhodophyta). *Eur. J. Phycol.* 40:169-178.
- Faye, E. J., Wang, H. W., Kawaguchi, S., Shimada, S. & Masuda, M. 2004. Reinstatement of *Grateloupia subpectinata* (Rhodophyta, Halymeniaceae) based on morphology and *rbcL* sequences. *Phycol. Res.* 52:59-67.
- Hommersand, M. H., Leister, G. L., Ramírez, M. E., Gabrielson, P. W. & Nelson, W. A. 2010. A morphological and phylogenetic study of *Glaphyrosiphon* gen. nov. (Halymeniaceae, Rhodophyta) based on *Grateloupia intestinalis* with descriptions of two new species: *Glaphyrosiphon lindaueri* from New Zealand and *Glaphyrosiphon chilensis* from Chile. *Phycologia* 49:554-573.
- Kang, J. W. 1966. On the geographical distribution of marine algae in Korea. *Bull. Pusan Fish. Coll.* 7:1-125.
- Kawaguchi, S. 1989. The genus *Prionitis* (Halymeniaceae, Rhodophyta) in Japan. *J. Fac. Sci. Hokkaido Univ. Ser. V (Bot.)* 14:193-257.
- Kawaguchi, S. 1997. Taxonomic notes on the Halymeniaceae (Gigartinales, Rhodophyta) from Japan. III. Synonymization of *Pachymeniopsis* Yamada in Kawabata with *Grateloupia* C. Agardh. *Phycol. Res.* 45:9-21.
- Kawaguchi, S., Wang, H. W., Horiguchi, T., Sartoni, G. & Masuda, M. 2001. A comparative study of the red alga *Grateloupia filicina* (Halymeniaceae) from the Northwestern Pacific and Mediterranean with the description of *Grateloupia asiatica*, sp. nov. *J. Phycol.* 37:433-442.
- Kim, M. S., Kim, S. Y. & Nelson, W. 2010. *Symphyocladia lithophila* sp. nov. (Rhodomelaceae, Ceramiales), a new Korean red algal species based on morphology and *rbcL* sequences. *Bot. Mar.* 53:233-241.
- Lee, H. B. 1987. A systematic study of Halymeniaceae (Rhodophyta, Cryptonemiales) in Korea. Ph.D. dissertation, Seoul National University, Seoul, Korea, 412 pp.
- Lee, J. I., Kim, H. G., Geraldino, P. J. L., Hwang, I. K. & Boo, S. M. 2009. Molecular classification of *Grateloupia* (Halymeniaceae, Rhodophyta) in Korea. *Algae* 24:231-238.
- Lee, Y. 2008. *Marine algae of Jeju*. Academy Publication, Seoul, 477 pp.
- Lee, Y. & Kang, S. 2001. *A catalogue of the seaweeds in Korea*. Cheju National University Press, Jeju, pp. 473-474.
- Okamura, K. 1899. Contributions to the knowledge of Japan III. *Bot. Mag. Tokyo* 13:4-5.
- Okamura, K. 1912. *Icones of Japanese algae. Vol. 2.* Kazamashobo, Tokyo, pp. 66-68.
- Okamura, K. 1913. *Icones of Japanese algae. Vol. 3.* Kazamashobo, Tokyo, pp. 63-64.
- Rambaut, A. 2002. Se-Al: Sequence alignment editor. Available from: <http://tree.bio.ed.ac.uk/software/seal/>. Accessed Apr 1, 2013.
- Stamatakis, A. 2006. RAxML-VI-HPC: maximum likelihood-

- based phylogenetic analyses with thousands of taxa and mixed models. *Bioinformatics* 22:2688-2690.
- Wang, H. W., Kawaguchi, S., Horiguchi, T. & Masuda, M. 2000. Reinstatement of *Grateloupia catenata* (Rhodophyta, Halymeniaceae) on the basis of morphology and *rbcL* sequences. *Phycologia* 39:228-237.
- Wang, H. W., Kawaguchi, S., Horiguchi, T. & Masuda, M. 2001. A morphological and molecular assessment of the genus *Prionitis* J. Agardh (Halymeniaceae, Rhodophyta). *Phycol. Res.* 49:251-261.
- Wilkes, R. J., McIvor, L. M. & Guiry, M. D. 2005. Using *rbcL* sequence data to reassess the taxonomic position of some *Grateloupia* and *Dermocorynus* species (Halymeniaceae, Rhodophyta) from the north-eastern Atlantic. *Eur. J. Phycol.* 40:53-60.
- Yang, M. Y., Han, E. G. & Kim, M. S. 2013. Molecular identification of *Grateloupia elliptica* and *G. lanceolata* (Rhodophyta) inferred from plastid *rbcL* and mitochondrial COI genes sequence data. *Genes Genomics* 35:239-246.