Wilfred John E. Santiañez*, Erasmo C. Macaya, Kyung Min Lee, Ga Youn Cho, Sung Min Boo and Kazuhiro Kogame

Taxonomic reassessment of the Indo-Pacific Scytosiphonaceae (Phaeophyceae): *Hydroclathrus rapanuii* sp. nov. and *Chnoospora minima* from Easter Island, with proposal of *Dactylosiphon* gen. nov. and *Pseudochnoospora* gen. nov.

<https://doi.org/10.1515/bot-2017-0089>

Received 25 October, 2017; accepted 15 December, 2017

Abstract: A new and putatively endemic species of *Hydroclathrus*, *Hydroclathrus rapanuii*, is described from the geographically isolated Easter Island in the southeastern Pacific based on morphological and molecular phylogenetic data. It is distinguished from other *Hydroclathrus* by thalli of unevenly furrowed thin membranes, and angular, block-like plurangial sori. Our phylogenetic analyses indicated that *H. rapanuii* is closely related to the generitype *Hydroclathrus clathratus*. We also report on the morphology and phylogeny of *Chnoospora minima* from Easter I. and elsewhere in the Indo-Pacific Ocean, noting the previously unreported presence of hollow portions in its medulla. Although not collected from Easter I., we herein propose the recognition of two new genera, *Dactylosiphon* gen. nov. and *Pseudochnoospora* gen. nov., based on our three-gene phylogeny and their known morphologies and anatomies. *Dactylosiphon* is based on the three species currently assigned to *Colpomenia* (*C. bullosa*, *C. durvillei*, and *C. wynnei*) that are genetically and morphologically (i.e. thalli with erect and finger-like tubes arising from a common saccate base) distinct from other members of

Colpomenia. The monotypic genus *Pseudochnoospora* is represented by the decumbent, branching, and inter-adhesive species currently known as *Chnoospora implexa*. With the above proposals, we further increase the genus-level diversity of Scytosiphonaceae in the Indo-Pacific Ocean.

Keywords: *Dactylosiphon* gen. nov.; Easter Island; Indo-Pacific Ocean; *Pseudochnoospora* gen. nov.; Scytosiphonaceae.

Introduction

Easter Island, locally known by its Polynesian name as “Rapa Nui”, is a geographically isolated volcanic island located in the South Pacific Ocean. Owing largely to its remoteness, its macroalgal flora has been subjected to several floristic and biogeographical studies (e.g. Børgesen 1924, Santelices and Abbott 1987, Ramírez and Müller 1991, Santelices and Meneses 2000), which has resulted in a present total of 143 recorded species (Fernández et al. 2014). Some 14% of the species appear to be endemic to the island and, collectively, its flora has an Indo-Pacific affinity (Santelices and Abbott 1987, Ramírez and Müller 1991, Santelices and Meneses 2000). Somewhat unexpectedly, the flora seems to share more common elements with Nha Trang, Vietnam (ca. 16,000 km) than with the relatively near Juan Fernández Archipelago (ca. 3200 km away) (Santelices and Abbott 1987). The stark differences between the flora of Easter Island and Juan Fernández Archipelago have been attributed to the isolating effects of ocean currents and temperatures that intervene between these localities, especially the cold Humboldt Current (Santelices and Abbott 1987, Santelices and Meneses 2000).

Recent assessment of the diversity of the brown algal genus *Hydroclathrus* Bory de Saint-Vincent suggested that species diversity is high within the Indo-Pacific Ocean (Santiañez et al. 2018), with four out of the five currently known species originally described from

*Corresponding author: Wilfred John E. Santiañez, Department of Natural History Sciences, Graduate School of Science, Hokkaido University, Sapporo 060-0810, Japan, e-mail: wjesantianez@gmail.com

Erasmo C. Macaya: Laboratorio de Estudios Algales (ALGALAB), Departamento de Oceanografía, Casilla 160-C, Universidad de Concepción, Concepción, Chile; and Millennium Nucleus: Ecology and Sustainable Management of Oceanic Island (ESMOI), Coquimbo, Chile

Kyung Min Lee: Department of Ecology and Genetics, University of Oulu, Oulu 90014, Finland

Ga Youn Cho: National Institute of Biological Resources, Incheon 22689, South Korea

Sung Min Boo: Department of Biology, Chungnam National University, Daejeon 305-764, South Korea

Kazuhiro Kogame: Department of Biological Sciences, Faculty of Science, Hokkaido University, Sapporo 060-0810, Japan

the area. These include *Hydroclathrus tenuis* Tseng et Lu from Paracel Islands in the South China Sea (Tseng and Lu 1983), *Hydroclathrus stephanosorus* Kraft from Lord Howe I., Australia, *Hydroclathrus tumulis* Kraft et Abbott from Necker I. in the Northwestern Hawaiian Islands, USA (Kraft and Abbott 2003), and the most recently described *Hydroclathrus minutus* Santiañez et Kogame from Okinawa, Japan (Santiañez et al. 2018). As previous taxonomic studies on *Hydroclathrus* focused on the northern hemisphere and as pseudo-cryptic species were present in the genus (Santiañez et al. 2018), we extended our work into the southern Pacific, particularly at Easter I., Chile.

With respect to scytosiphonacean algae, Easter I. is geographically important as it represents the southeastern Pacific distribution limit of *Chnoospora minima* (K. Hering) Papenfuss and is second only to Juan Fernández Archipelago (Etcheverry 1986) as the easternmost distribution limit of the widely distributed *Hydroclathrus clathratus* (C. Agardh) Howe. As *H. clathratus* is the default species-designation for perforate sac-like Scytosiphonaceae, and as there is a tendency for new *Hydroclathrus* species to be discovered at isolated volcanic islands (Kraft and Abbott 2003, Santiañez et al. 2018), we assessed the identity of the purported “*H. clathratus*” at the remote volcanic Easter Island. We herein describe a new and putatively endemic species of *Hydroclathrus* based on specimens from Vaihu, Easter I. Additionally, we report on the morphology/anatomy and phylogeny of the widely distributed *Ch. minima* collected from the island.

The genus-level taxonomy in the family Scytosiphonaceae has been problematical due to the unresolved relationships of the different taxa as highlighted in phylogenies based on single and multiple genes (e.g. Kogame et al. 1999, Cho et al. 2006, Kogame et al. 2011, West et al. 2015, McDevit and Saunders 2017, Santiañez et al. 2018). These difficulties have been attributed to the frequently broad taxonomic circumscriptions of the genera, resulting in the assignment of species to genera such as *Chnoospora* J. Agardh, *Colpomenia* (Endlicher) Derbès et Solier in Castagne, *Hydroclathrus* Bory de Saint-Vincent, *Petalonia* Derbès et Solier, and *Scytosiphon* C. Agardh despite distinct morpho-anatomical and life history differences from the type species of these genera (Santiañez et al. 2018). Recently, McDevit and Saunders (2017) proposed the recognition of the genus *Planosiphon* McDevit et Saunders to accommodate species previously assigned to *Scytosiphon* [*S. complanatus* (Rosenvinge) Doty, *S. gracilis* Kogame] and *Petalonia* [*P. zosterifolia* (Reinke) Kuntze], which possess flattened, non-constricted blades that are hollow or partially hollow, lack paraphyses among aggregates

of uniseriate plurangia, and whose prostrate sporophyte thalli are *Compsonema*-like and bear only unangia (Santiañez and Kogame 2017). Santiañez et al. (2018) also suggested the possibility of segregating *Chnoospora implexa* J. Agardh from the genus *Chnoospora* based on significant morphological and genetic differences. In the light of these recent developments, we have now reviewed the generic circumscriptions within the family and propose several taxonomic revisions. Based on morpho-anatomical, genetic, and life history differences, we propose the removal of the elongate species of *Colpomenia* [*C. bullosa* (D.A. Saunders) Yamada, *C. durvillei* (Bory de Saint-Vincent) M.E. Ramírez, and *C. wynnei* K.M. Lee, R. Riosmena-Rodriguez, Kogame et S.M. Boo] to the new genus *Dactylosiphon* gen. nov. as well as that of *Ch. implexa* to *Pseudochnoospora* gen. nov.

Materials and methods

Samples of *Hydroclathrus* and *Chnoospora* were collected by snorkeling in Vaihu and Tahai, Easter I. in March and November 2016 (Table S1). A portion of each sample was dried in silica-gel prior to air-drying as herbarium specimens. Voucher specimens are deposited in the Herbarium, Botany Section, Museo Nacional de Historia Natural, Santiago, Chile (SGO) and the Herbarium of the Faculty of Science, Hokkaido University, Sapporo, Japan (SAP).

For morpho-anatomical analyses, sections were made by hand, stained with 0.5% aniline blue with phenol, and mounted in 50% glycerol or 30% Karo in distilled water on glass slides. A Nikon Digital Sight DS-L1 camera (Tokyo, Japan) mounted on a Nikon Optiphot-2 microscope was used for taking photomicrographs.

For molecular analyses, DNA extraction, PCR, and sequencing of the mitochondrial *cox3* as well as the plastid *rbcL* and *psaA* genes, including their respective sequencing primers, followed procedures outlined in Santiañez et al. (2018).

Phylogenetic analyses were conducted using individual genes (*cox3*: 660 bp, *psaA*: 1488 bp, and *rbcL*: 1467) and concatenated (*cox3*: 610 bp, *psaA*: 740 bp, and *rbcL*: 1383 bp = 2733 bp; partitioned by gene and codon) datasets. Newly generated sequence data were analyzed together with sequences of other scytosiphonacean algae downloaded from GenBank. All trees were rooted with *Ectocarpus siliculosus* (Dillwyn) Lyngbye, *Chordaria flagelliformis* (O.F. Müller) C. Agardh, and *Pylaiella littoralis* (Linnaeus) Kjellman (Table S1). ClustalW in MEGA

v.6 (Tamura et al. 2013) was used to align sequences. All datasets were analyzed for Maximum Likelihood (ML) and Bayesian Inference (BI); in both cases, GTR+I+ Γ model, as selected by Akaike Information Criterion (AIC) in MrModeltest 2.3 (Nylander 2004), was used. ML analyses with 1000 bootstrap pseudoreplicates were conducted using RAXML v.8 (Stamatakis 2014) in the CIPRES Phylogenetic Portal (Miller et al. 2010). BI was conducted in MrBayes v3.2.1 (Huelsenbeck and Ronquist 2001). Markov-chain Monte Carlo iterations were run for 25 million generations until the average standard deviations of split frequencies fell below 0.01, indicating convergence of the iterations. A burn-in of 25% was set before calculating the trees.

Results

Phylogenetic analyses

Nine samples of scytosiphonacean algae, representing 13 new sequences, were used in this study (Table S1).

Our phylogenetic analyses based on *cox3* sequence data recovered all *Hydroclathrus* species, with the exception of *Hydroclathrus minutus*, in a highly-supported clade (Figure 1). The genetically identical *Hydroclathrus* specimens from Easter I. clustered with *Hydroclathrus clathratus* but were genetically distinct. We describe this species below as *Hydroclathrus rapanuii* Santiañez,

Figure 1: Maximum likelihood (ML) phylogenetic tree of *Hydroclathrus* and *Chnoospora* from Easter I. based on *cox3* sequences. Support values appended at each node are Bayesian posterior probabilities (PP) and ML bootstrap percentages (BP), respectively. Highly supported nodes (PP: ≥ 0.98 and BP: $\geq 95\%$) are indicated by thickened lines. Values $< 50\%$ BP and < 0.50 PP are removed. Lineages with darkened background are newly proposed taxa.

Macaya *et* Kogame *sp. nov.* Specimens of *Chnoospora minima* from Easter I. were also genetically identical and formed a highly-supported clade with *Ch. minima* from southern Japan (Figure 1). The *Chnoospora* clade, however, did not include *Chnoospora implexa*, which grouped with the recently described taxa *Tronoella ryukyuana* Santiañez *et* Kogame and *H. minutus*, albeit with low support.

Similar to the *cox3* gene-based phylogeny, the concatenated (*cox3/rbcL/psaA*; Figure 2) and plastid gene (Figure S1) phylogenies of the family Scytosiphonaceae showed that *H. rapanuii* was nested within the main *Hydroclathrus* clade. *Hydroclathrus rapanuii* was more closely related with the robust species *H. clathratus* and *Hydroclathrus stephanosorus* than to either of the thinner and fibrous *Hydroclathrus tenuis* or *H. minutus*.

Based on our concatenated tree, two major clades were suggested in the Scytosiphonaceae (Figure 2). One highly supported clade (which we designate as the “Scytosiphon group”) consisted mainly of subtropical to temperate species from the genera *Colpomenia*, *Petalonia*, *Planosiphon*, *Melanosiphon*, *Myelophycus* and *Scytosiphon*. The other unresolved clade (the “Hydroclathrus group”) was

composed of tropical to warm temperate species of the genera *Colpomenia*, *Chnoospora*, *Hydroclathrus*, *Rosenvingea* Børgesen, and *Tronoella* Santiañez *et* Kogame. The relationships of most genera that are closely related to *Hydroclathrus*, including *Chnoospora*, *Colpomenia* and *Rosenvingea*, were unresolved. A particularly pronounced polyphyly was observed among *Chnoospora* species, where *Ch. minima* was consistently recovered as one of the early-diverged taxa within the “Hydroclathrus group” while *Chnoospora implexa* appeared to have diverged later. With respect to the genus *Colpomenia*, three lineages were apparent in our concatenated tree (Figure 2): Lineage 1 is represented by *Colpomenia sinuosa* (Mertens *ex* Roth) Derbès *et* Solier but also possibly includes *Colpomenia tuberculata* D.A. Saunders and *Colpomenia ramosa* W.R. Taylor (Figures 1 and S1); Lineage 2, represented by *Colpomenia peregrina* Sauvageau, includes *Colpomenia claytoniae* S.M. Boo, K.M. Lee, G.Y. Cho *et* W. Nelson and *Colpomenia expansa* (D.A.Saunders) Y.-P. Lee (Figure S1); and Lineage 3, as represented by *Colpomenia bullosa*, also includes *Colpomenia durvillei* and *Colpomenia wynnei* (Figure S1). Lineages 1 and 2 are found within the “Hydroclathrus group” (Figure 2) and, although their

Figure 2: Maximum likelihood (ML) phylogenetic tree of multigene dataset (*cox3*, *rbcL*, *psaA*) of the family Scytosiphonaceae.

Support values appended at each node are Bayesian posterior probabilities (PP) and ML bootstrap percentages (BP), respectively. Highly supported nodes (PP: ≥ 0.98 and BP: $\geq 95\%$) are indicated by thickened lines. Values $< 50\%$ BP and < 0.50 PP are removed. Names of taxa in bold are the newly proposed species names or combinations in the family Scytosiphonaceae.

phylogenetic positions remain ambiguous, both lineages were more closely related to each other than to Lineage 3. The latter clustered with high support in the “*Scytosiphon* group” (Figure 2).

Taxonomic observations

***Hydroclathrus rapanuii* Santiañez, Macaya et Kogame sp. nov. (Figures 3–11)**

Description

Thalli saccate, up to 10 cm in diameter; membranes thin, 60–350 µm thick, surfaces furrowed, perforated with numerous holes. Cortical cells 4.5–12.5 µm by 7–14 µm, narrowly to broadly oblong; medullary cells thin-walled, up to 190 µm wide. Hair primordia in tufts, distally extending into hyaline hairs. Plurangial sori angular, block-like, often confluent with adjacent sori. Plurangia erect, quadriseriate, cylindrical to slightly clavate, 15–23 µm long.

Holotype

SGO168251 (Figures 3–11), Vaihu, Easter I., 1.5–2 m depth, 20 March 2016, E.C. Macaya; deposited in SGO.

Isotypes

SGO168250, SGO168252, Vaihu, Easter I., 20 March 2016, E.C. Macaya; deposited in SGO.

Type locality

Vaihu, Easter Island, Chile (27° 9′ 57.22″ S, 109° 21′ 48.20″ W).

Etymology

Named in honor of the Rapanui people, the indigenous people of Easter Island.

Distribution

Currently only known from the type locality.

Representative sequences

Genbank accession numbers: *cox3* = MG450663, *psaA* = MG450664, *rbcL* = MG251837 (sequenced from SGO168251).

Specimens examined

SGO168250–SGO168255, Vaihu, Easter I., 20 March 2016, E.C. Macaya; EIS3-3095, Vaihu, Easter I., 18 November 2016, E.C. Macaya.

Observations

Thalli yellowish to light brown in color (Figure 4), becoming dark brown when dried on herbarium sheets (Figure 3), initially saccate (when young), later convoluted, attached to the substrate by rhizoids. Membranes 60–350 µm thick, irregularly perforated by holes of various sizes (Figures 3 and 4) rimmed by slightly folded to revolute margins. Membrane surfaces dimpled, furrowed, with hair tufts developing in depressions and creases (Figures 5 and 6).

Membranes composed of a layer of small pigmented cortical cells and 3–6 (rarely 7) layers of clear medullary cells (Figure 7). Cortical cells square or rectilinear to polygonal in surface view, (4–) 5–9 by (5–) 6–12 (–14) µm (Figures 5 and 6); in cross-section, thin-walled, variable in shape but mostly narrowly to broadly oblong, 4.5–12.5 µm wide by 7–14 µm in height (Figure 8), apices smooth, sometimes domed to obtuse, those adjacent to hair primordia often becoming papillate. Medullary cells also thin-walled, progressively larger towards thallus interior, up to 190 µm wide (Figure 7).

Hair primordia slightly clavate, often basally constricted, each extending into long hyaline hairs (Figures 2, 6 and 9), and clustered in groups of 4–20.

Plurangial sori angular and block-like, surrounding or adjacent to hair pits, often merging with nearby sori (Figure 6). Plurangial primordia differentiating from surface cortical cells (Figure 10), forming dense palisades. Mature plurangia cylindrical to slightly clavate, densely aggregated, quadriseriate (biseriate in lateral view), 15–23 µm long, each tier divided into four locules (Figure 11).

Ecology

Usually few individuals found at low to mid-intertidal rocky pools down to shallow subtidal (2 m depth) of protected and semi-protected sites in the island, associated with other brown algae such as *Sargassum*, *Lobophora*, *Colpomenia* and *Stypopodium*.

Chnoospora minima (K. Hering) Papenfuss

Basionym

Fucus minimus K. Hering 1841: 92.

Synonyms

Chnoospora pacifica J. Agardh *vide* Papenfuss 1956: 69.

Chnoospora fastigiata J. Agardh 1848: 171, nom. illeg., *Chnoospora fastigiata* var. *pacifica* (J. Agardh) J. Agardh *vide* Silva et al. 1996: 626.

Figures 3–11: *Hydroclathrus rapanuii* Santiañez, Macaya et Kogame.

(3) Holotype specimen (SGO168251) showing partially saccate portions of the membranous thallus. Thallus is perforated with variously sized holes, larger ones show thickened margins as a result of inrolling. Scale bar = 1 cm. (4) Young and perforated thallus of *H. rapanuii* from Easter I. showing its olive green color and phaeophycean hairs surrounding its thallus (arrowhead). (5) Portion of thallus membrane showing pits and channels that are often interconnected and are sites of hair growth (SGO168251). Scale bar = 100 μ m. (6) Fertile portion of thallus showing plurangial sori formed around hair pits (arrowheads), often with angular margins (SGO168250). Scale bar = 100 μ m. (7) Transverse section through a membrane showing the slightly revolute margins of the thallus, with a layer of pigmented cortical cells towards the outside and several layers of clear medullary cells towards the center (SGO168254). Scale bar = 100 μ m. (8) Transverse section showing the narrowly to broadly oblong cortical cells that are slightly domed (SGO168252). Scale bar = 25 μ m. (9) A group of hair primordia growing in a shallow depression, each extended into hyaline distal hairs (SGO168252). Scale bar = 25 μ m. (10) Transverse section through the fertile portion of the holotype (SGO168251) showing plurangial initials (arrow) derived from cortical cells. Scale bar = 25 μ m. (11) A group of mature plurangia that are arranged in vertical palisades, each divided into four columns (arrowheads) with four layers (arrow) (SGO168250). Scale bar = 25 μ m.

Lectotype

HBG024509 collected by F. Krauss from Port Natal (Durban), South Africa: the lectotype was designated by Papenfuss (1956).

Distribution

Virtually cosmopolitan in tropical to subtropical Indo-Pacific (M.D. Guiry in Guiry and Guiry 2017).

Specimens examined

Easter Island: SGO168260–SGO168262, Tahai, Easter I., 15 March 2016, E.C. Macaya; EIS2-0193, Vaihu, Easter I., 20 March 2016, E.C. Macaya.

Additional specimens examined

Cook Islands: SAP115375, Ngatangiaa, Rarotonga, 13 February 1993, A.D.R. N'Yeurt. Hawaiian Islands: SAP115377,

Figures 12–18: *Chnoospora minima* (K. Hering) Papenfuss.

(12) Exposed thalli of erect *Chnoospora minima* growing on rocks in Ahu Tahai, Easter Island. (13) Pressed herbarium specimen of *Ch. minima* from Easter I. (SGO168262) showing its consolidated holdfast (arrow) and (sub) dichotomous branching. Scale bar = 1 cm. (14) Three irregularly shaped hollow portions (arrowheads) in the medulla of the compressed branch (SGO168260). Scale bar = 100 µm. (15) Closer view of the intercellular space (asterisk) within the medulla (SGO168260). Scale bar = 50 µm. (16) Groups of hair primordia developing on the cortical layer, covered with loosened cuticle (arrowheads) (SGO168261). Scale bar = 50 µm. (17) Cortical layer of a specimen from Cook I. (SAP115375) showing uniseriate and biseriate (asterisk) plurangial initials derived from the outermost cortical cell. Scale bar = 25 µm. (18) Young biseriate plurangia (asterisk) growing adjacent to hairs (arrowheads) (SAP115375). Scale bar = 25 µm.

Wittington Beach Park, Naalehu, 24 January 2008, A. Kurihara; SAP115378, Molokai Beach Park, Kauai, 15 February 2008, A. Kurihara. Japan: SAP115376, Uganzaki, Ishigaki, Okinawa, 10 March 2000, S. Kawaguchi and A. Kato.

Observations

Living thalli yellow-brown (Figures 12–18); drying dark brown basally, lighter distally (Figure 13). Thalli erect, in dense clumps, arising from consolidated holdfasts

(Figure 13) attached in low to mid-intertidal (Figure 12), longer fronds lying prostrate on substratum when exposed during low tide.

Thalli up to 16 cm long, up to seven times (sub-) dichotomously branched, basally subterete, progressively thinner and compressed towards the blunt rounded apices (Figure 13).

Cortex 11–26 μm thick, composed of 2–4 layers of thick-walled, pigmented cells, bounding a medulla of intermixed small and large, thick-walled, clear medullary cells (Figures 14–16). Surface cells narrowly to broadly oblong, slightly domed, those at the inner layer rounded to cuboidal (Figures 14–16). Outer medullary cells rounded, becoming larger and narrowly elliptical internally, up to 150 μm long by 100 μm wide (Figures 14 and 15). Various sized hollow portions occur in the medulla (Figures 14 and 15); these intercellular spaces discontinuous and without particular concentration throughout the thallus.

Hair primordia superficial and initially covered in a cuticle (Figure 14), or developing in deep pits subtended by several layers of small, clear subcortical cells, often forming a distinct arc (Figures 14 and 15), the primordia in dense tufts, usually aligned along the midlines of compressed axes towards the apices and extending into long hyaline hairs (Figures 14 and 15), these creating a whitish halo effect.

Plurangial sori often associated with hairs, covered with cuticles that are loosened as plurangia mature. Plurangial initials differentiating from cortical cells, becoming transversely biseriate (Figures 15 and 16); mature plurangia up to 50 μm long, subdivided into smaller, squarish to rectangular locules 4–5 μm by 2–5 μm in size.

Discussion

Our current understanding of global algal biodiversity and the phylogenetic relationships of macroalgae has been reshaped by the advent of DNA phylogenies. Using molecular phylogenetic tools, reports of high levels of cryptic and/or pseudo-cryptic diversity are common, especially among widespread species, such as *Acinetospora crinita* (Carmichael) Sauvageau (Yaegashi et al. 2015), *Centroceras clavatum* C. Agardh (Schneider et al. 2015), *Gibsmithia hawaiiensis* Doty (Gabriel et al. 2016), *Lobophora variegata* (J.V. Lamouroux) Womersley ex E.C. Oliveira (Vieira et al. 2014, 2016, Schultz et al. 2015), and *Portieria hornemanii* (Lyngbye) P.C. Silva (Payo et al. 2013).

Similarly, our molecular-assisted taxonomic studies of *Hydroclathrus* (Santiañez et al. 2018, this study) highlight the role of molecular tools in identifying and refining morpho-species boundaries among algae that have simple morphologies. Our studies also point to the importance of continuing to challenge the assumption that most, if not all, collections of *Hydroclathrus* made throughout the tropical to warm-temperate waters belong to a single, cosmopolitan, and highly polymorphic species, *Hydroclathrus clathratus*. For example, wide-scale sampling of *Hydroclathrus* in subtropical to warm-temperate coasts of Japan indicated that *H. clathratus* can be sympatric with *Hydroclathrus stephanosorus*; the latter has been overlooked or misidentified, and was shown to be more widely distributed in Japan than the former (Santiañez et al. 2018).

With *Hydroclathrus rapanuii*, we add one more putatively endemic species to the seaweed flora of Easter I. Like *H. stephanosorus* from Lord Howe I., Australia (Kraft and Abbott 2003) and *Hydroclathrus minutus* from Okinawa I. (Santiañez et al. 2018), its type locality is a small Pacific volcanic island, and this is also true of the recently described scytosiphonacean species *Petalonia tatewakii* Kogame et A. Kurihara (Kogame et al. 2011), *Petalonia tenuis* K. Matsumoto et S. Shimada (Matsumoto et al. 2014), and *Tronoella ryukyuana* Santiañez et Kogame (Santiañez et al. 2018). Extensive taxon sampling of volcanic islands will likely result in new taxa discoveries right across the algal phyla.

Specimens of *H. rapanuii* were similar in habit to young *H. clathratus* but can be distinguished based on larger cortical cells, fewer medullary cell layers, and angular to block-like plurangial sori (Table 1). *Hydroclathrus rapanuii* resembles *H. stephanosorus* and *Hydroclathrus tumulis* in the breadth of the membrane surrounding the perforations. However, it can be differentiated from *H. stephanosorus* by its plurangial sori (angular and block-like as opposed to nearly circular soral outline), cortical cell shape (oblong to broadly oblong vs. broadly rounded), and thinner thallus membranes (Table 1). Although the angular and block-like sori of *H. rapanuii* were similar to those of *H. tumulis*, the latter has subapiculate cortical cells, laxly arranged and apparently stalked plurangia, and has an apparent restriction to deep waters (Kraft and Abbott 2003).

Chnoospora minima specimens from Easter I. agree well the reports of the species from Hawaii (Fotos 1981, Abbott and Huisman 2004), Philippines (Trono 1997), French Polynesia (N'Yeurt and Payri 2006), Australia (Kraft 2009), and South Africa (Anderson et al. 2016), except for the presence of hollow areas in the medulla. We observed

Table 1: Morpho-anatomical comparison among known *Hydroclathrus* species.^a

Characters	<i>Hydroclathrus rapanuii</i> Santiañez, Macaya et Kogame	<i>Hydroclathrus</i> <i>clathratus</i> (C. Agardh) Howe	<i>Hydroclathrus</i> <i>stephanosorus</i> Kraft	<i>Hydroclathrus tumulis</i> Kraft et Abbott	<i>Hydroclathrus tenuis</i> Tseng et Lu	<i>Hydroclathrus minutus</i> Santiañez et Kogame
Thallus form	Saccate to convoluted; membranous, irregularly perforated	Strap-shaped to net-like, convoluted; irregularly perforated	Saccate to sheet- like; membranous, perforated by subcircular holes	Saccate to torn, sheet- like; membranous, irregularly perforated	Net-like, convoluted; perforated membranes thin to fibrous	Net-like, convoluted, sometimes inter- adhesive; membrane strands extremely thin and delicate
Membrane thickness (μm)	60–350	100–650	60–520	120–280	40–590	<130
Cortical cells						
No. of cell layers	1 (–2)	1–2 (3)	1–2	1	1–2	1
Shape (surface)	Square or rectilinear to polygonal	Oblong to rectilinear to pentagonal/hexagonal	Oblong to rectilinear to pentagonal	Square to rectilinear to pentagonal	Square to rectilinear	Square to rectilinear to polygonal
Size (surface; width $\times$ length, μm)	(4–) 5–9 $\times$ (5–) 6–12 (–14)	(3–) 4–9 (–11) $\times$ 5–11 (–14)	4–7 (–8) $\times$ (5–) 6–12	7–13 $\times$ 7–15	4–8 $\times$ 6–9 (–11)	3–6 $\times$ (4–) 5–8 (–9)
Shape (cross section)	Oblong to broadly oblong, apices domed to obtuse	Ovate to broadly ovate to papillate	Broadly rounded to ovoid, apices sometimes domed to obtuse	Subacutely papillate	Ovate to broadly ovate, domed to papillate	Broadly obovate to ovate, apices protuberant
Size (cross section; width $\times$ length, μm)	4.5–12.5 $\times$ 7–14	(4.5–) 5–11 (–12) $\times$ (5–) 6–14 (–16)	(4–) 5–11 (–13) $\times$ (5–) 6–10 (–15)	8–10 $\times$ 10–13	5–9 (–10) $\times$ 7–11 (–12)	4–7 (–9) $\times$ 7–9 (–11.5)
Medullary cells	3–6 (–7) layers; thin- walled	5–9 layers; thin-walled	(2–) 3–6 layers; thin- walled	2–4 layers; thin- walled	(3–) 5–6 (–8) layers; thin-walled	1–5 layers; thick- walled
Size (width, μm)	Up to 190	Up to 260	Up to 220	250	Up to 250	Up to 200
Hair primordia						
Nature and arrangement	Occur in groups of up to 20 in depressions, pits, and channels; each usually extended into long hyaline hairs	Occur in groups of not more than 25 in depressions, pits, and channels; often extended into long hyaline hairs	Occur in groups of not less than five in shallow depressions, sometimes in pits; sometimes extended into hyaline hairs	Occur singly or in groups of three to six	Occur in groups of not less than five; often with long hyaline hair extensions	Occur in groups of not more than eight, often with long hyaline hair extensions
Plurangia						
Sori shape and nature	Sori associated with hair tufts, occur in angular and irregular blocks, often merged with adjacent sori	Sori often associated with hair tufts; diffused with angular margins, sometimes confluent	Sori surround hair tufts, discrete, nearly circular in outline; maintain circular margins when merged with adjacent sori	Sori angular to irregularly block-like, rarely confluent	Sori confluent, irregularly shaped with margins angular, may occur extensively across surface; may grow without hairs	Sori often surround hair tufts; generally discrete with subcircular margins, sometimes merged with adjacent sori

Table 1 (continued)

Characters	<i>Hydroclathrus rapanuii</i> Santiañez, Macaya et Kogame	<i>Hydroclathrus</i> <i>clathratus</i> (C. Agardh) Howe	<i>Hydroclathrus</i> <i>stephanosorus</i> Kraft	<i>Hydroclathrus tumulis</i> Kraft et Abbott	<i>Hydroclathrus tenuis</i> Tseng et Lu	<i>Hydroclathrus minutus</i> Santiañez et Kogame
Arrangement	Erect; in lateral view biseriate, each column divided into four locules	Erect; in lateral view biseriate, each column divided into four locules	Erect; in lateral view biseriate, each column divided into four locules	Erect, laxly arranged and often borne on papillate cells; in lateral view biseriate, each column divided into four locules	Erect; in lateral view biseriate, each column divided into four locules	Erect; in lateral view biseriate, each column divided into four locules
Length (cross section, µm)	15–23	10–30	(12–) 18–28	17–20	22–25	Up to 18

^aModified from Santiañez et al. (2018) with additional information from Kraft and Abbott (2003).

these variously sized hollowed areas in the medullas of thalli collected from within the central and western Pacific localities (i.e. southern Japan, Hawaiian Islands, and Cook Islands), as well as in the Indian Ocean (Anderson et al. 2016). The unattached *Ch. minima* reported from the deep waters of New Zealand were slightly longer than our Easter I. specimens and also appear to have hollow portions (Nelson and Duffy 1991, fig. 3), albeit they were not mentioned by the authors. Smaller and relatively thinner thalli of Hawaiian specimens showed inconspicuous medullary gaps, and it is likely that this character may have been overlooked or was thought to be taxonomically insignificant.

No fertile *Ch. minima* specimen was found among our Easter I. collections, but those from Cook and Hawaiian Is. possessed mature plurangia. Similar to those reported by J. Agardh (1848) and Barton (1898) in *Chnoospora fastigiata* J. Agardh (= *Ch. minima*), we also saw the presence of a cuticle on these uni- to biseriate plurangia. Plurangial cuticles in *Ch. minima* have not been mentioned in other reports (Fotos 1981, Trono 1997, Abbott and Huisman 2004, Kraft 2009, Anderson et al. 2016). Kraft (2009) suggested that the plurangia illustrated by Fotos (1981, figs. 4, 11) and Barton (1898, pl. 28, figs. 4, 5) were “anticlinal cortical filaments that are typical of vegetative cells lining the flat faces of the fronds”, as was illustrated in his fig. 38G, H. In contrast to his opinion, we confirm that those illustrated by Fotos and Barton were plurangia, similar to those found in our specimens and the South African specimen (Anderson et al. 2016). We do agree, however, that those illustrated by Kraft (2009, fig. 38I) were plurangial initials and were similar to those we observed (Figures 17 and 18).

When J. Agardh established the genus *Chnoospora* in 1847, he described two species: *Chnoospora pacifica* J. Agardh from Pacific Mexico and *Chnoospora atlantica* J. Agardh from Venezuela. A year later (Agardh 1848) synonymized these two species to *Chnoospora fastigiata* and described two additional species, *Chnoospora implexa* J. Agardh and *Chnoospora pannosa* J. Agardh. On both occasions, he failed to designate the generitype species. Papenfuss (1956: 69) proposed the conspecificity of *Ch. fastigiata* with *Fucus minimus* K. Hering and subsequently combined these names as *Ch. minima* based on Hering’s priority. In the same publication, Papenfuss also designated Hering’s specimen [HBG024509, collected by F. Krauss from Port Natal (Durban), South Africa; currently deposited at the Herbarium Hamburgense of the University of Hamburg, Germany], as the lectotype. He also noted the similarity of Hering’s specimen to the South African *Ch. minima* (as *Ch. fastigiata*) reported by Barton (1898). As mentioned earlier, the *Ch. minima* specimens we examined also agree well with Barton’s specimens, as well as those illustrated in

Anderson et al. (2016) from South Africa. Taking all these observations into consideration, and because it has not been done yet (M.D. Guiry in Guiry and Guiry 2017), we herein designate *Ch. minima* as the generitype of the genus *Chnoospora*.

Similar to previous works on the Scytosiphonaceae (e.g. Cho et al. 2006, Lee et al. 2014a, McDevit and Saunders 2017), two major phyletic groups were apparent (i.e. the “*Scytosiphon* group” and “*Hydroclathrus* group”) in our molecular trees. Species found in the “*Scytosiphon* group” have upright, elongate and terete to flattened thalli that are hollow, partially hollow or solid in construction. Some members of this group produce only unilocular zoidangia in the prostrate sporophyte stage (Kogame et al. 1999, Kogame and Masuda 2001, Cho et al. 2006), and are distributed in subtropical to temperate waters (Kogame et al. 1999). The “*Hydroclathrus* group” includes species of varied morphologies ranging from upright to spreading, of either hollow or solid construction, and saccate to branched, some branches anastomosing to varying degrees. Species in this group are found in tropical to warm temperate waters and have prostrate sporophytes that produce both uni- and plurilocular zoidangia (Kogame et al. 1999, Kogame 2001, Cho et al. 2006).

Paraphyly and polyphyly of some genera have been a consistent theme among the Scytosiphonaceae since the pioneering molecular phylogenetic work by Kogame et al. (1999). Despite numerous follow-up studies, taxonomic revisions to achieve monophyly have been slow. Kogame et al. (1999) suggested that the morphology of prostrate sporophyte thalli (i.e. thallus structure and presence/absence of plurilocular zoidangia) are important taxonomic criteria at the generic level. However, as information on life histories and input of genetic data from other scytosiphonacean species have been scarce, no formal proposals have yet been made to settle the unresolved relationships in the family. Recently, members of the Scytosiphonaceae have received considerable attention, resulting in an increase of information on the life history, morphology and phylogeny of species of *Chnoospora* (Kogame 2001), *Colpomenia* (Kogame and Masuda 2001, Boo et al. 2011, Lee et al. 2012, Lee et al. 2014a), *Hydroclathrus* (Kraft and Abbott 2003, Santiañez et al. 2018), *Melanosiphon* (Lee et al. 2014b), *Myelophycus* (Cho et al. 2006), *Rosenvingea* (West et al. 2010, Lee et al. 2014b) and *Petalonia* (Kogame et al. 2011, Matsumoto et al. 2014). Collectively, these works have provided insights into the taxonomic complexities but have also paved the way to clarifying specific and generic boundaries in the Scytosiphonaceae. In an attempt to partially resolve the non-monophyly in *Petalonia* and *Scytosiphon*, McDevit and Saunders (2017) recently proposed

the recognition of *Planosiphon*. Similar to previously mentioned reports, relationships among species of *Colpomenia*, *Chnoospora*, *Hydroclathrus*, *Rosenvingea* and *Scytosiphon* still remain unresolved.

In the current work, *Colpomenia* did not resolve as monophyletic and was segregated into at least three distinct lineages: two of these (Lineages 1 and 2) were found within the “*Hydroclathrus* group” whereas one (Lineage 3) was within the “*Scytosiphon* group”. The relationships of the *Colpomenia* lineages within the “*Hydroclathrus* group” were not resolved, but these are represented by species with globular/saccate to amorphously contoured, hollow thalli. Meanwhile, *Colpomenia* “Lineage 3”, whose species have upright, elongate (finger-like), hollow thalli, was sister to all other taxa within the “*Scytosiphon* group”. In addition, compared to species of Lineage 1 (e.g. *C. sinuosa*), which has a prostrate sporophyte that produces both uni- and plurilocular zoidangia, *C. bullosa* of “Lineage 3” produces only unilocular zoidangia in its prostrate sporophyte thallus (Kogame et al. 1999). Considering these distinct differences, we believe it is best to remove the three former *Colpomenia* species nested within the “*Scytosiphon* group” to a new genus *Dactylosiphon*.

We have previously suggested the possibility of segregating *Ch. implexa* from the genus *Chnoospora* based on genetic and morphological differences (Santiañez et al. 2018). In our current and in previous studies on the Scytosiphonaceae, the generitype *Ch. minima* was always segregated from *Ch. implexa* by at least representatives of *Rosenvingea* and *Colpomenia*, with moderate to high levels of support. This observed phylogenetic segregation is reflected in the distinct morpho-anatomical and ecological differences among these taxa outlined in Table 2.

Based on morphological and molecular phylogenetic criteria, we herein formally segregate *Ch. implexa* and species in “Lineage 3” of *Colpomenia* from their current generic affiliation and propose that *Pseudochnoospora* gen. nov. and *Dactylosiphon* gen. nov., respectively, be recognized to accommodate them.

Taxonomic proposals

***Pseudochnoospora* Santiañez, G.Y. Cho et Kogame gen. nov.**

Description

Thalli decumbent, branched, with branches attached to the substrata and to other branches at various points; axes solid, terete to compressed. Cortex up to two layers of small, pigmented cells. Medullary cells clear, thin-walled,

Table 2: Comparison among some genera in the family Scytosiphonaceae.^a

Characters	<i>Chnoospora</i>	<i>Pseudochnoospora</i> gen. nov.	<i>Colpomenia</i>	<i>Dactylosiphon</i> gen. nov.	<i>Tronoella</i>	<i>Hydroclathrus</i>	<i>Rosenvingea</i>
Thallus form	Erect; solid to partially hollow, compressed to flattened; branched	Decumbent; solid, terete to compressed; branched, entangled and mat-forming	Saccate and hollow, thallus walls thick; globular to cushion-like, surface sometimes perforated or with protrusions	Erect; finger-like and tubular, thallus walls thin; each tube arising from a common saccate base	Spreading; perforated hollow membranes initially arise as siphonous protrusions	Spreading; membranes perforated, hollow; margins of perforations folded to revolute	Erect to decumbent to mat-forming; hollow, branched, terete to compressed
Holdfast	Discoid, single	Rhizoidal, attached at various points on the surface	Rhizoidal	Rhizoidal	Rhizoidal	Rhizoidal	Discoid, rhizoidal
Cortex	2–5 cell layers; cells thick-walled, pigmented	1–2 cell layers; cells thin-walled, pigmented	1–2 (–3) cell layers, pigmented	1–3 cell layers, pigmented	1–2 cell layers, pigmented	1–3 cell layers, pigmented	1 cell layer, pigmented
Medulla	Clear cells thick-walled with lamellate regions; large and small cells intermixed; with hollow regions	Cells clear and thin-walled, often becoming larger towards the center	3–6 cell layers; clear, thin- to thick-walled	2–5 cell layers; clear, thick-walled to lamellate	1–4 cell layers; clear, thin-walled	1–9 cell layers; clear, generally thin-walled	1–5 cell layers; clear, thin-walled
Phaeophycean hairs	Occur as tufts in deep depressions, extended into hyaline hairs	Occur in pits	Occur in pits, extended into hyaline hairs	Occur in pits, extended into hyaline hairs	Occur in shallow pits, not extended into hyaline hairs	Occur in pits or depressions, generally extended into hyaline hairs	Occur in pits, generally extended into hyaline hairs, absent in some
Plurangial sori	Linear; associated with hairs; covered with cuticle	Irregularly shaped, generally not associated with hairs; may be covered with cuticle	Discrete to confluent, may be associated with hairs or covered with cuticle	Extensive and/or confluent; cuticle absent	Discrete, irregularly shaped, associated with hairs	Discrete to confluent, circular to irregular, angular to block-like, often associated with hairs	Discrete to confluent, shape linear to irregular, may be associated with hairs
Paraphyses	Absent	Absent	Uni- to multicellular; length similar to or longer than plurangia	Unicellular; sometimes shorter, but generally similar to or longer than plurangia	Absent	Absent	Absent
Plurangia	Coherent, cylindrical to clavate, uni- to biseriate (lateral view)	Coherent, cylindrical to clavate, uni- to partially or completely biseriate (lateral view)	Cylindrical to clavate, uni- to biseriate (lateral view)	Cylindrical to subclavate, mostly uniseriate, some partially or completely biseriate; (lateral view)	Firmly coherent and massive	Loosely arranged, cylindrical to clavate, biseriate (lateral view)	Densely arranged, cylindrical to clavate, uni- to biseriate (lateral view)

Table 2 (continued)

Characters	<i>Chnoospora</i>	<i>Pseudochnoospora</i> gen. nov.	<i>Colpomenia</i>	<i>Dactylosiphon</i> gen. nov.	<i>Tronoella</i>	<i>Hydroclathrus</i>	<i>Rosenvingeia</i>
Habitat	Wave-swept, rocky upper to mid-intertidal; epilithic	Mid-intertidal to subtidal; epilithic, rarely epiphytic	Low intertidal to subtidal; epiphytic or epilithic	Low to mid-intertidal; epilithic	Intertidal; epilithic	Intertidal to subtidal; epilithic when young, sometimes epiphytic	Mid-intertidal to lower sub-tidal; epilithic
Geographical distribution	Tropical to subtropical	Tropical to subtropical	Tropical to warm temperate	Subtropical to temperate	Okinawa, Japan	Tropical to warm temperate	Tropical to warm temperate
Prostrate thallus morphology	Discoid	Discoid; produce both uni- and plurilocular zooidangia	Discoid; produce both uni- and plurilocular zooidangia	Discoid	-	Discoid; produce both uni- and plurilocular zooidangia	Discoid; produce both uni- and plurilocular zooidangia

*Modified from Santiañez et al. (2018) with additional information from Saunders (1898), Clayton (1975), Wynne and Norris (1976), Parsons (1982), Ramírez and Rojas (1991), Yoshida (1998), Kogame (2001) and Boo et al. (2011).

becoming larger centrally. Plurangia covered with cuticle, coherent, cylindrical to clavate, uniseriate to partially to completely biseriate, paraphyses absent. Prostrate sporophyte produces both uni- and plurilocular zooidangia.

Type species

Pseudochnoospora implexa (J. Agardh) Santiañez, G.Y. Cho et Kogame comb. nov.

Etymology

Pseudochnoospora, or the “false *Chnoospora*”, is in reference to the previous erroneous assignment of the taxon to the genus *Chnoospora*.

Pseudochnoospora implexa (J. Agardh) Santiañez, G.Y. Cho et Kogame comb. nov.

Basionym

Chnoospora implexa J. Agardh 1848: *Species genera et ordines algarum, seu descriptiones succinctae specierum, generum et ordinum, quibus algarum regnum constituitur. Volumen primum: Algas fucoidaeas complectens*: 172.

Synonyms

Dictyota obtusangula Kützinger 1859: 13, *Chnoospora obtusangula* (Kützinger) Sonder 1871: 45 fide Grunow 1874: 25.

Chnoospora pannosa J. Agardh 1848: 172 fide Kraft 2009: 108.

Holotype

BM000569565, Tor, Sinai Peninsula, W. Schimper; deposited in BM.

Distribution

Tropical to subtropical waters (M.D. Guiry in Guiry and Guiry 2017).

Remarks

When J. Agardh (1848) formally described *Sphaerococcus implexus* Hering nom. nud. as a new species, he placed it in *Chnoospora* under the heading “*Species inquirenda*”. Its original disposition has since been followed despite the absence of studies to confirm its generic assignment. Descriptions of “*Ch. implexa*” from various localities has been consistent, with Kraft (2009) providing detailed morphological work on the species based on Australian and Hawaiian samples. Morpho-anatomical observations

on “*Ch. implexa*” clearly indicate that it is different from the generic type *Ch. minima* (Table 2). That is, “*Ch. implexa*” can be differentiated from *Ch. minima* in possessing solid, decumbent and inter-adhesive thalli that are attached to various points on the substratum (vs. erect, freely branching, and partially hollow thalli that were densely growing from a consolidated holdfast) and in having thin-walled cortical and medullary cells (vs. thick-walled cells; Table 2). In addition, previous molecular phylogenetic studies (e.g. Cho et al. 2006, Santiañez et al. 2018) pointed to the polyphyly of the genus *Chnoospora*. *Pseudochnoospora implexa* (as *Ch. implexa*) in culture was shown to have a prostrate sporophyte that produces both uni- and plurilocular zoidangia (Kogame 2001).

***Dactylosiphon* Santiañez, K.M. Lee, S.M. Boo et Kogame gen. nov.**

Description

Thalli composed of hollow, elongate (finger-like) tubes, each tapering to an attenuate to cuneate basal portion and arising from a saccate base. Interiors hollow, bounded by several layers of large, clear, thick-walled medullary cells; outer layer composed of small pigmented cortical cells. Plurangia occurring extensively throughout the surface, always associated with short to slightly longer paraphyses, the plurangia mostly uniseriate, some partially to completely biseriate.

Type species

Dactylosiphon bullosus (D.A. Saunders) Santiañez, K.M. Lee, S.M. Boo et Kogame comb. nov.

Etymology

Named after the finger-like (Greek: *dactylo-*) and siphonous thalli of the species belonging to this genus.

***Dactylosiphon bullosus* (D.A. Saunders) Santiañez, K.M. Lee, S.M. Boo et Kogame comb. nov.**

Basionym

Scytosiphon bullosus D.A. Saunders 1898: *Proceedings of the California Academy of Science, Series 3, Botany 1*: 163, pl. XXXI: figs 1–7.

Synonym

Colpomenia bullosa (D.A. Saunders) Yamada in Yamada et Kinoshita 1948: 6, pl. 4.

Type locality

Pacific Grove, California, USA.

Distribution

Temperate waters of the Pacific (Lee et al. 2012).

Remarks

In culture, *Dactylosiphon bullosus* (as *Colpomenia bullosa*) was shown to have a prostrate sporophyte that produces only unilocular zoidangia, similar to the other species reported within the “*Scytosiphon* group” (Kogame 1994, Kogame and Masuda 2001, Kogame et al. 1999). This character may be used for generic delineation, but life history studies on the other species included in *Dactylosiphon* are yet to be conducted. *Dactylosiphon bullosus* (as *C. bullosa*) has been placed in either *Scytosiphon* or *Colpomenia* by various authors (Parsons 1982), primarily in the latter based on the opinion of Yamada (1948), with Hollenberg and Abbott (1966) providing some details for segregating it from *Scytosiphon*. The confused taxonomy of the species is understandable, considering the wide generic circumscription of both *Colpomenia* and *Scytosiphon*.

***Dactylosiphon durvillei* (Bory de Saint-Vincent) Santiañez, K.M. Lee, S.M. Boo et Kogame comb. nov.**

Basionym

Aspercoccus durvillei Bory de Saint-Vincent 1828: *Botanique, Cryptogamie*. In (Duperrey, L.I. Eds): *Voyage autour du monde, exécuté par ordre du Roi, sur la corvette de Sa Majesté, la Coquille, pendant les années 1822, 1823, 1824 et 1825*: 200, pl. 11: fig. 3 (as “*durvillaei*”).

Synonyms

Colpomenia durvillei (Bory de Saint-Vincent) M.E. Ramírez in Ramírez et Rojas 1991: 17.

Colpomenia phaeodactyla M.J. Wynne et J.N. Norris 1976 *vide* Lee et al. 2014a: 485.

Type locality

Concepcion, Chile.

Distribution

Temperate waters of the Pacific (Lee et al. 2012).

Remarks

The taxonomy and molecular phylogeny of *Dactylosiphon durvillei* (= *Colpomenia durvillei*) relative to other

elongate species of *Colpomenia* (= *Dactylosiphon*) has been reviewed in detail by Lee et al. (2012), where it is suggested that *C. phaeodactyla* may be conspecific with *C. durvillei*. Based on morphological and phylogenetic analyses on an elongate *Colpomenia* from Las Cuevas, Sonora, Mexico (near the type locality of *C. phaeodactyla*) and Chile, Lee et al. (2014a: 485) synonymized *C. phaeodactyla* with *C. durvillei* based on nomenclatural priority.

***Dactylosiphon wynnei* (K.M. Lee, R. Riosmena-Rodriguez, Kogame et S.M. Boo) Santiañez, K.M. Lee, S.M. Boo et Kogame comb. nov.**

Basionym

Colpomenia wynnei K.M. Lee, R. Riosmena-Rodriguez, Kogame et S.M. Boo 2014: *Phycologia* 53 (5): 481, figs. 1–7.

Type locality

Hoedong, Jindo, Korea.

Distribution

Southern Korea and Japan (Lee et al. 2014a).

Remarks

Dactylosiphon wynnei is a recently described species (as *C. wynnei*) from Korea and Japan. It is unique among its congeners in possessing adventitious branchlets along the length of its contorted, mature elongate sacs.

Acknowledgements: WJES is funded by the Ministry of Education, Japan (MEXT) under the Monbukagakusho Scholarship Grant. ECM is funded by the Chilean Millennium Initiative (NC120030) grant. We are indebted to Carolina Sandoval for her assistance in collecting and preparing voucher specimens of the *Hydroclathrus* and *Chnoospora* from Easter Island used in this study. We thank S. Kawaguchi, A. Kato, A. Kurihara, A.D.R. N'Yeurt for the *Chnoospora* samples and P.J.L. Geraldino for the *Rosenvingea orientalis* sample. We also thank our reviewers for their insightful comments and suggestions that have considerably improved this manuscript. The scans of the type specimen of *Chnoospora minima* and *Chnoospora implexa* we examined in this study were courtesy of the Herbarium Hamburgense, University of Hamburg, Germany (HBG) and the Trustees of the Natural History Museum, London (BM), respectively.

References

- Abbott, I.A. and J.M. Huisman. 2004. *Marine green and brown algae of the Hawaiian Islands*. Bishop Museum Press, Honolulu. pp. 259.
- Agardh, J.G. 1847. Nya alger från Mexico. *Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, Stockholm* 4: 5–17.
- Agardh, J.G. 1848. *Species genera et ordines algarum, seu descriptiones succinctae specierum, generum et ordinum, quibus algarum regnum constituitur*. Volumen primum: Algas fucoideas complectens. C.W.K. Gleerup, Lund. pp. 363.
- Anderson, R.J., H. Stegenga and J.J. Bolton. 2016. Seaweeds of the South African South Coast. World Wide Web electronic publication, University of Cape Town, <http://southafrseaweeds.uct.ac.za>; Accessed on 17 August 2017.
- Barton, S.E. 1898. On the fruit of *Chnoospora fastigiata*. *J. Linn. Soc., Bot.* 33: 507–508.
- Boo, S.M., K.M. Lee, G.Y. Cho and W. Nelson. 2011. *Colpomenia claytonii* sp. nov. (Scytosiphonaceae, Phaeophyceae) based on morphology and mitochondrial *cox3* sequences. *Bot. Mar.* 54: 159–167.
- Børgesen, F. 1924. Marine Algae from Easter Island. In: (Skottsberg, C., ed) *The Natural History of Juan Fernandez and Easter Island Vol. 2*. Almqvist & Wiksells, Uppsala. pp. 247–309.
- Bory de Saint-Vincent, J.B.M. 1828. Botanique, Cryptogamie. In: (Duperrey, L.I., ed): *Voyage autour du monde, exécuté par ordre du Roi, sur la corvette de Sa Majesté, la Coquille, pendant les années 1822, 1823, 1824 et 1825*. Paris: Bertrand. pp. 97–200.
- Cho, G.Y., K. Kogame and S.M. Boo. 2006. Molecular phylogeny of the family Scytosiphonaceae (Phaeophyceae). *Algae* 21: 175–183.
- Clayton, M.N. 1975. A study of variation in Australian species of *Colpomenia* (Phaeophyta, Scytosiphonales). *Phycologia* 14: 187–195.
- Etcheverry, D.H. 1986. Algas marinas bentónicas de Chile. UNESCO (Regional office of Science and Technology for Latin America and the Caribbean), Montevideo, Uruguay. pp. 1–379.
- Fernández, M., P. Pappalardo, M.C. Rodríguez-Ruiz and J.C. Castilla. 2014. Synthesis of the state of knowledge about species richness of macroalgae, macroinvertebrates and fishes in coastal and oceanic waters of Easter and Salas y Gómez islands. *Lat. Am. J. Aquat. Res.* 42: 760–802.
- Fotos, S.F. 1981. Observations on *Chnoospora minima* (Hering) Papenfuss (Phaeophyta, Scytosiphonales) in the field and in culture. *Jap. J. Phycol.* 29: 101–108.
- Gabriel, D., S.G.A. Draisma, T. Sauvage, W.E. Schmidt, T. Schils, P.-E. Lim, J. Harris and S. Fredericq. (2016). Multilocus phylogeny reveals *Gibsmithia hawaiiensis* (Dumontiaceae, Rhodophyta) to be a species complex from the Indo-Pacific, with the proposal of *G. eilatensis* sp. nov. *Phytotaxa* 277: 1–20.
- Grunow, A. 1874. Algen der Fidschi-, Tonga- und Samoa-Inseln, gesammelt von Dr. E. Graeffe. *Journal des Museum Godeffroy* 3: 23–50.
- Guiry, M.D. and G.M. Guiry. 2017. *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway. <http://www.algaebase.org>; Accessed on 29 June 2017.
- Hering, C. 1841. Diagnoses algarum novarum a cl. Dre. Ferdinand Krauss in Africa Australi lectarum, auctore Dno. *Ann. Mag. Nat. Hist.* 8: 90–92.

- Hollenberg, G.J. and I.A. Abbott. 1966. *Supplement to Smith's marine algae of the Monterey Peninsula*. Stanford University Press, Stanford, California. pp. 130.
- Huelsenbeck, J.P. and F.R. Ronquist. 2001. MrBayes: Bayesian inference of phylogeny. *Biometrics* 17: 754–755.
- Kogame, K. 1994. A taxonomic study of the family Scytosiphonaceae (Scytosiphonales, Phaeophyceae) in Japan. Ph.D. dissertation, Hokkaido University, Sapporo. pp. 158.
- Kogame, K. 2001. Life history of *Chnoospora implexa* (Chnoosporaceae, Phaeophyceae) in culture. *Phycol. Res.* 49: 123–128.
- Kogame, K. and M. Masuda. 2001. Crustose sporophytes of *Colpomenia bulbosa* (Scytosiphonaceae, Phaeophyceae) in nature. *Cryptogamie Algol.* 22: 201–208.
- Kogame, K., T. Horiguchi and M. Masuda. 1999. Phylogeny of the order Scytosiphonales (Phaeophyceae) based on DNA sequences of *rbcl*, partial *rbcS*, and partial LSU nrDNA. *Phycologia* 38: 496–502.
- Kogame, K., A. Kurihara, G.Y. Cho, K.M. Lee, A.R. Sherwood and S.M. Boo. 2011. *Petalonia tatewakii* sp. nov. (Scytosiphonaceae, Phaeophyceae) from the Hawaiian Islands. *Phycologia* 50: 563–573.
- Kraft, G.T. 2009. *Algae of Australia. Marine benthic algae of Lord Howe Island and the southern Great Barrier Reef, 2. Brown algae*. Australian Biological Resources Study and CSIRO Publishing, Canberra and Melbourne. pp. 364.
- Kraft, G.T. and I.A. Abbott. 2003. *Hydroclathrus* (Scytosiphonaceae, Phaeophyceae): conspectus of the genus and proposal of new species from Australia and Hawaii. *Phycol. Res.* 51: 244–258.
- Lee, K.M., A. Mansilla, W.A. Nelson and S.M. Boo. 2012. *Colpomenia durvillei* (Scytosiphonaceae, Phaeophyceae): its distribution and relationships with other elongate species of the genus. *Bot. Mar.* 55: 367–375.
- Lee, K.M., R. Riosmena-Rodríguez, K. Kogame and S.M. Boo. 2014a. *Colpomenia wynnei* sp. nov. (Scytosiphonaceae, Phaeophyceae): a new species of marine algae from Northeast Asia. *Phycologia* 53: 480–487.
- Lee, K.M., D.D. Hong, and S.M. Boo. 2014b. Phylogenetic relationships of *Rosenvingea* (Scytosiphonaceae, Phaeophyceae) from Vietnam based on *cox3* and *psaA* sequences. *Algae* 29: 289–297.
- Matsumoto, K., K. Ichihara and S. Shimada. 2014. Taxonomic reinvestigation of *Petalonia* (Phaeophyceae, Ectocarpales) in southeast of Honshu, Japan, with a description of *Petalonia tenuis* sp. nov. *Phycologia* 53: 127–136.
- McDevit, D.M. and G.W. Saunders. 2017. A molecular investigation of Canadian Scytosiphonaceae (Phaeophyceae) including descriptions of *Planosiphon* gen. nov. and *Scytosiphon promiscuus* sp. nov. *Botany* 95: 653–671.
- Miller, M.A., W. Pfeiffer W. and T. Schwartz. 2010. Creating the CIPRES Science Gateway for inference of large phylogenetic trees. In: Proceedings of the Gateway Computing Environments Workshop (GCE). Orleans, LA, pp. 1–8.
- Nelson, W.A. and C.A.J. Duffy. 1991. *Chnoospora minima* (Phaeophyta) in Port Underwood, Marlborough – a curious new algal record for New Zealand. *New Zeal. J. Bot.* 29: 341–344.
- N'Yeurt, A.D.R. and C.E. Payri. 2006. Marine algal flora of French Polynesia I. Phaeophyceae (Ochrophyta, brown algae). *Cryptogamie Algol.* 27: 111–152.
- Papenfuss, G.F. 1956. Notes on South African marine algae. IV. *J. S. Afr. Bot.* 22: 65–77.
- Nylander, J.A.A. 2004. *MrModeltest v2*. Program distributed by the author. Evolutionary Biology Centre, Uppsala University.
- Parsons, M.J. 1982. *Colpomenia* (Endlicher) Derbès et Solier (Phaeophyta) in New Zealand. *New Zeal. J. Bot.* 20: 289–301.
- Payo, D.A., F. Leliaert, H. Verbruggen, S. D'hondt, H.P. Calumpong, and O. De Clerck. 2013. Extensive cryptic species diversity and fine-scale endemism in the marine red alga *Portieria* in the Philippines. *Proc. R. Soc. London, B* 280: 20122660.
- Ramírez, J.J. and D.G. Müller. 1991. New records of benthic marine algae from Easter Island. *Bot. Mar.* 34: 133–137.
- Ramírez, M.E. and V.G. Rojas. 1991. El genero *Colpomenia* (F.C. Mertens ex Roth) Derbes et Solier (Phaeophyceae), en Chile. *Bol. Mus. Nac. Hist. Nat.* 42: 11–24.
- Santelices, B. and I.A. Abbott. 1987. Geographic and marine isolation: an assessment of the marine algae of Easter Island. *Pac. Sci.* 41: 1–20.
- Santelices, B. and I. Meneses. 2000. A reassessment of the phytogeographic characterization of temperate Pacific South America. *Rev. Chil. Hist. Nat.* 73: 605–614.
- Santiañez, W.J.E. and K. Kogame. 2017. Transfer of *Petalonia filiformis* (Batters) Kuntze to the genus *Planosiphon* McDevit & G.W.Saunders (Scytosiphonaceae, Phaeophyceae). *Notulae algarum No.* 40: 1–3.
- Santiañez, W.J.E., K.M. Lee, S. Uwai, A. Kurihara, P.J.L. Geraldino, E.T. Ganzon-Fortes, S.M. Boo and K. Kogame. 2018. Untangling nets: Elucidating the diversity and phylogeny of the clathrate brown algal genus *Hydroclathrus*, with the description of a new genus *Tronoella* (Scytosiphonaceae, Phaeophyceae). *Phycologia* 57: 61–78.
- Saunders, D.A. 1898. Phycological memoirs. *Proc. Calif. Acad. Sci. Ser. 3, Bot.* 1: 147–168.
- Schneider, C.W., E.N. Cianciola, T.R. Popolizio, D.S. Sagnuolo, and C.E. Lane. 2015. A molecular assisted alpha taxonomic study of the genus *Centroceras* (Ceramiaceae, Rhodophyta) in Bermuda reveals two novel species. *Algae* 30: 15–33.
- Schultz, N.E., C.E. Lane, L. Le Gall, D. Gey, A.R. Bigney, B. De Reviers, F. Rousseau, and C.W. Schneider. 2015. A barcode analysis of the genus *Lobophora* (Dictyotales, Phaeophyceae) in the western Atlantic Ocean with four novel species and the epitypification of *L. variegata* (J.V. Lamouroux) E.C. Oliveira. *Eur. J. Phycol.* 50: 481–500.
- Silva, P.C., P.W. Basson and R.L. Moe. 1996. Catalogue of the benthic marine algae of the Indian Ocean. *U. Calif. Publ. Bot.* 79: 1–1259.
- Stamatakis, A. 2014. RAxML version 8: a tool for phylogenetic analysis and post-analysis of large phylogenies. *Bioinformatics* 30: 1312–1313.
- Tamura, K., G. Stecher, D. Peterson, A. Filipski and S. Kumar. 2013. MEGA6: Molecular Evolutionary Genetics Analysis version 6.0. *Mol. Biol. Evol.* 30: 2725–2729.
- Trono, G.C. Jr. 1997. *Field guide and atlas of the seaweed resources of the Philippines*. Bookmark, Makati City. pp. 306.
- Tseng, C.K. and B.R. Lu. 1983. Two new brown algae from the Xisha Islands, South China Sea. *Chin. J. Oceanol. Limn.* 1: 185–189.
- Vieira, C., S. D'Hondt, O. De Clerck, and C.E. Payri. 2014. Toward an inordinate fondness for stars, beetles and *Lobophora*? species diversity of the genus *Lobophora* (Dictyotales, Phaeophyceae) in New Caledonia. *J. Phycol.* 50: 1101–1119.

- Vieira, C., O. Camacho, M.J. Wynne, L. Mattio, R.J. Anderson, J.J. Bolton, M. Sansón, S. D'Hondt, F. Leliaert, S. Fredericq, C.E. Payri, and O. De Clerck. 2016. Shedding new light on old algae: Matching names and sequences in the brown algal genus *Lobophora* (Dictyotales, Phaeophyceae). *Taxon* 65: 689–707.
- West, J.A., G.C. Zuccarello, F.F. Pedroche and S. Loiseaux de Goër. 2010. *Rosenvingea orientalis* (Scytosiphonaceae, Phaeophyceae) from Chiapas, Mexico: life history in culture and molecular phylogeny. *Algae* 25: 187–195.
- West, J.A., G.C. Zuccarello, E.K. Ganesan and S. Loiseaux de Goër. 2015. Investigations into *Iyengaria*, a poorly known genus of the Scytosiphonaceae (Phaeophyceae) and description of a new species *Iyengaria quadriseriata*. *Phykos* 45: 43–50.
- Wynne, M.J. and J.N. Norris. 1976. The genus *Colpomenia* Derbès et Solier (Phaeophyta) in the Gulf of California. *Smithson. Contrib. Bot.* 35: 1–18.
- Yaegashi, K., Y. Yamagishi, S. Uwai, T. Abe, W.J.E. Santiañez, and K. Kogame. 2015. Two species of the genus *Acinetospora* (Ectocarpales, Phaeophyceae) from Japan: *A. filamentosa* comb. nov. and *A. asiatica* sp. nov. *Bot. Mar.* 58: 331–343.
- Yamada, Y. 1948. Marine algae. In: (Yamada, Y. and S. Kinoshita, eds.) *Icons of the marine animals and plants of Hokkaido*. No. 1. Hokkaido Fisheries Scientific Institution. Yoichi, Hokkaido, Japan.
- Yoshida, T. 1998. *Marine algae of Japan*. Uchida Rokakuho Publishing Co., Ltd., Tokyo. pp. 1222.

Supplemental Material: The online version of this article offers supplementary material (<https://doi.org/10.1515/bot-2017-0089>).

Bionotes

Wilfred John E. Santiañez
Department of Natural History Sciences,
Graduate School of Science, Hokkaido
University, Sapporo 060-0810, Japan,
wjesantianez@gmail.com

Wilfred John E. Santiañez was formerly a research associate at the Marine Science Institute of the University of the Philippines where he worked on various aspects of seaweed biology, particularly seaweed diversity, ecology, and mariculture. He has a Master's degree in environment and natural resource management from the University of the Philippines Open University and is now pursuing his PhD in Hokkaido University, Sapporo, Japan. His PhD research is focused on the taxonomy and molecular phylogeny of the brown algal family Scytosiphonaceae.

Erasmo C. Macaya
Laboratorio de Estudios Algales (ALGALAB),
Departamento de Oceanografía, Casilla 160-
C, Universidad de Concepción, Concepción,
Chile; and Millennium Nucleus: Ecology and
Sustainable Management of Oceanic Island
(ESMOI), Coquimbo, Chile

Erasmo C. Macaya has been an assistant professor at Concepción University, Chile since 2010. He received a primary degree in marine biology and a Master's in marine sciences from Universidad Católica del Norte, Coquimbo, Chile. He obtained a PhD in marine biology from Victoria University, Wellington, New Zealand studying the dispersal patterns, connectivity, taxonomy and genetic diversity of the giant kelp, *Macrocystis pyrifera*. His research focuses on the different aspects of macroalgae, such as ecology, taxonomy and phylogeography.

Kyung Min Lee
Department of Ecology and Genetics,
University of Oulu, Oulu 90014, Finland

Kyung Min Lee earned a doctor of science in biology from Chungnam National University, Korea. Her PhD thesis focused on molecular systematics and biogeography of the brown algal family Scytosiphonaceae. In 2014, she moved to Ghent University, Belgium to study SNP discovery of *Sargassum* using RAD-sequencing as a postdoc for 1 year before she joined the Mutanen's lab in University of Oulu, Finland as a postdoctoral researcher in February 2015. Her current work focuses on molecular species delimitation at genomic level and clarifying issues caused by DNA barcode-sharing between species, deep intraspecific splits in DNA barcodes, and introgression on DNA-based taxonomy.

Ga Youn Cho
National Institute of Biological Resources,
Incheon 22689, South Korea

Ga Youn Cho is a senior researcher in the National Institute of Biological Resources, Korea. Her research interests are biodiversity, phylogeography, taxonomy, and phylogeny of seaweeds.

Sung Min Boo

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

Sung Min Boo is a professor emeritus at Chungnam National University. He was awarded a PhD by Seoul National University for the taxonomy of the family Ceramiaceae. His research includes the diversity and distribution of brown and red algae.

Kazuhiro Kogame

Department of Biological Sciences, Faculty of Science, Hokkaido University, Sapporo 060-0810, Japan

Kazuhiro Kogame is a Professor in the Faculty of Science, Hokkaido University, Japan. His research interests include taxonomy, phylogeny and life history of seaweeds.

Graphical abstract

Wilfred John E. Santiañez, Erasmo C. Macaya, Kyung Min Lee, Ga Youn Cho, Sung Min Boo and Kazuhiro Kogame
Taxonomic reassessment of the Indo-Pacific Scytosiphonaceae (Phaeophyceae): *Hydroclathrus rapanuii* sp. nov. and *Chnoospora minima* from Easter Island, with proposal of *Dactylosiphon* gen. nov. and *Pseudochnoospora* gen. nov.

<https://doi.org/10.1515/bot-2017-0089>
Botanica Marina 2018; x(x): xxx–xxx

Research article: A new *Hydroclathrus* species, *H. rapanuii*, is described from Easter Island; although not found in the island, we additionally proposed the recognition of two new genera, *Dactylosiphon* and *Pseudochnoospora*, based on three-gene phylogeny and known morphologies/anatomies.

Keywords: *Dactylosiphon* gen. nov.; Easter Island; Indo-Pacific Ocean; *Pseudochnoospora* gen. nov.; Scytosiphonaceae.