



Proposal of the new genus *Gazzaea* (Rhodymeniaceae, Rhodophyta) to accommodate *Botryocladia flookii* C.W.Schneider & C.E.Lane

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Since the onset of genetic sequencing to gain a more accurate understanding of evolutionary relationships in the algae, taxa in the rhodophytan order Rhodymeniales have expanded greatly, resulting in a significantly greater biodiversity of species and genera (e.g., Saunders & al. 1999, 2006, 2007; Dalen & Saunders 2007; Wilkes & al. 2006; Rodríguez-Prieto & al. 2007; Le Gall & al. 2008; Lozada-Troche & al. 2010; Saunders & McDonald 2010; Filloramo & Saunders 2015, 2016; Schmidt & al. 2016, 2017). In the protologue of *Botryocladia flookii* C.W.Schneider & C.E.Lane, Schneider & Lane (2008: 627) noted that *rbcL* sequences of the new species did “not cluster within the other *Botryocladia* sequences, but rather as a sister taxon with only weak support”. Their Bermudian species had striking morphological and anatomical similarities to *B. macaronesica* Afonso-Carrillo, Sobrino, Tittley & Neto from the Canary Islands in the eastern Atlantic (Afonso-Carrillo & al. 2006: 285), yet differences were found to separate these two large-vesicled, short-stalked *Botryocladia* species including the presence of vesicle to vesicle attachments, absence of secretory cells in the stipe, and presence of medullary cell growth under cystocarps (Schneider & Lane 2008: 626, Table 3).

Over the past 12 years, the genetic database available for the Rhodymeniales as cited above, and in particular the family Rhodymeniaceae, has dramatically increased. With a large number of taxa and infrageneric *rbcL* sequences for *Botryocladia*, *Chrysymenia* and related Rhodymeniaceae, many newly generated for their study, Schmidt & al. (2017: 126, fig. 1) demonstrated that *B. flookii* nested in a clade as sister to *Halopeltis* and *Coelarthrum cliftonii* (Harvey) Kylin and did not resolve with other *Botryocladia* species including the generitype, *B. uvaria* (Murray) Harvey [= *B. botryoides* (Wulfen) Feldmann]. The molecular evidence of Schmidt & al. (2017: 134) suggested “the erection of a new elongate-saccate genus within the Rhodymeniaceae”. Therefore, we formally propose the following new genus to accommodate *B. flookii*:

Gazzaea C.W.Schneider & C.E.Lane, *gen. nov.*

Description: Plants composed of one to many, small to large mucilage-filled vesicles on short, simple and solid stipes attached by small discoid holdfasts; vesicles elongate to obovoid and slightly bending during development, producing lateral attachments to adjacent vesicles; vesicle walls multilayered with pigmented cortical layers and hyaline medullary cells, the larger medullary cells ultimately projecting into the inner vesicle cavity and producing one to many pyriform to obovoid secretory cells; outer cortex surface initially incomplete, becoming nearly complete at maturity; gametophytes and tetrasporophytes isomorphic; tetrasporangia formed in

scattered discrete sori in the outer cortex, spherical to subspherical, cruciately arranged; gametophytes monoecious, spermatangia scattered on outer cortical cells and ostiolate cystocarps scattered on vesicles, slightly protruding from the exterior of the vesicle; carposporangia subglobose, obovoid to irregularly angled.

Eponymy: Named for Dr Gary W. Saunders, Professor of Molecular Systematics & Biodiversity at the University of New Brunswick, Canada, for his voluminous and exceptional work pioneering molecular phylogenetics of marine macroalgae, in particular red algae, throughout the world. In that the surname Saunders is already in use for the endemic Brazilian orchid genus *Saundersia* H.G.Reichenbach (1866) and the phaeophyte *Saundersella* Kylin (1940, for De Alton Saunders), we chose to create a generic name using the nickname he acquired during a postdoctoral fellowship in Australia, “Gazza”.

Generitype: *Gazzaea flookii* (C.W.Schneider & C.E.Lane) C.W.Schneider & C.E.Lane, *comb. nov.* [Fig. 1].

Basionym: *Botryocladia flookii* C.W.Schneider & C.E.Lane, *Phycologia* 47(6): 623, figs 24–34, 2008.

Representative DNA barcodes in GenBank: EU977492, EU977493, EU977494 (*rbcL*). Schneider & Lane (2008).

Type locality: Walsingham Pond, Hamilton Parish, Bermuda I., Bermuda, western Atlantic Ocean.



Fig. 1. Type specimen of *Botryocladia flookii* C,W,Schneider & C.E.Lane [= *Gazzaea flookii* (C.W.Schneider & C.E.Lane) C.W.Schneider & C.E.Lane], CWS/CEL 05-8-13, Walsingham Pond, Bermuda [US]. Scale bar = 1 cm.

Notes: *Gazzaea* is genetically distinct from the morphologically similar saccate genus, *Irvinea* Guiry in Saunders & al. (1999: 36) (Schneider & Lane 2008, Schmidt & al. 2017). *Irvinea* develops vesicles from a branched stoloniferous holdfast that coalesces to form a discoidal structure that emits additional axes bearing vesicles, has secretory cells borne exclusively on morphologically smaller specialized medullary cells, and develops dioecious gametophytes (Saunders & al. 1999, Wilkes & al. 2006). Other than *Irvinea* spp. and *Botryocladia macaronesica*, there are also several short-stalked, few- and large-vesicled *Botryocladia* spp.



[e.g., *B. chiajeana* (Meneghini) Kylin, *B. darwinii* C.W.Schneider & C.E.Lane, *B. fernandeziana* Levring, *B. ganesanii* Aponte Díaz, *B. senegalensis* G.Feldmann & Bodard] and *Chrysiomenia brownii* (Harvey) De Toni that have a similar habit to *G. flookii*, and all are distinguished by a suite of anatomical differentiating characteristics.

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- Afonso-Carrillo, J., Rodríguez-Prieto, C., Boisset, F., Sobrino, C., Tittley, I. & Neto, A.I. (2006). *Botryocladia chiajeana* and *Botryocladia macaronesica* sp. nov. (Rhodymeniaceae, Rhodophyta) from the Mediterranean and the eastern Atlantic, with a discussion on the closely related genus *Irvinea*. *Phycologia* 45: 277–292.
- Dalen, J.L. & Saunders, G.W. (2007). A review of the red algal genus *Leptofaucha* (Faucheaceae, Rhodymeniales) including a description of *L. chiloensis* sp. nov. *Phycologia* 46: 198–213.
- Filloramo, G.V. & Saunders, G.W. (2015). A re-examination of the genus *Leptofaucha* (Faucheaceae, Rhodymeniales) with clarification of species in Australia and the northwest Pacific. *Phycologia* 54: 375–384.
- Filloramo, G.V. & Saunders, G.W. (2016). Application of multigene phylogenetics and sitestripping to resolve intraordinal relationships in the Rhodymeniales (Rhodophyta). *Journal of Phycology* 52: 339–355.
- Kylin, H. (1940). Die Phaeophyceenordnung Chordariales. *Acta Universitatis Lundensis* 36(9): 1–67, 30 figs.
- Le Gall, L., Dalen, J.L. & Saunders, G.W. (2008). Phylogenetic analyses of the red algal order Rhodymeniales supports recognition of the Hymenocladaceae fam. nov., Fryellaceae fam. nov., and *Neogastroclonium* gen. nov. *Journal of Phycology* 44: 1556–1571.
- Lozada-Troche, C., Ballantine, D.L. & Ruiz, H. (2010). *Cresia opalescens* gen. et sp. nov. (Rhodymeniaceae, Rhodophyta) from Puerto Rico, Caribbean Sea. *Cryptogamie, Algologie* 31: 293–303.
- Reichenbach, H.G. (1866). On some points connected with the Orchidaceae. The International Horticultural Exhibition, and Botanical Congress, held in London, from May 22nd to May 31st, 1866: *Report of Proceedings. Royal Horticultural Society, London*, pp. 119–123.
- Rodríguez-Prieto, C., Freshwater, D.W. & Sánchez, N. (2007). Vegetative and reproductive morphology of *Gloiocladia repens* (C. Agardh) Sánchez et Rodríguez-Prieto comb. nov. (Rhodymeniales, Rhodophyta), with a taxonomic re-assessment of the genera *Faucha* and *Gloiocladia*. *European Journal of Phycology* 42: 145–162.
- Saunders, G.W., Lane, C.E., Schneider, C.W. & Kraft, G.T. (2006). Unraveling the *Asteromenia peltata* species complex with clarification of the genera *Halichrysis* and *Drouetia* (Rhodymeniaceae, Rhodophyta). *Canadian Journal of Botany* 84: 1581–1607.
- Saunders, G.W. & McDonald, B. (2010). DNA barcoding reveals multiple overlooked Australian species of the red algal order Rhodymeniales (Florideophyceae), with resurrection of *Halopeltis* J. Agardh and description of *Pseudohalopeltis* gen. nov. *Botany* 88: 639–667.
- Saunders, G.W., Strachan, I.M. & Kraft, G.T. (1999). The families of the order Rhodymeniales (Rhodophyta): a molecular-systematic investigation with a description of Faucheaceae fam. nov. *Phycologia* 38: 23–40.
- Saunders, G.W., Wilkes, R.J. & Guiry, M.D. (2007). A nuclear small-subunit ribosomal perspective on the taxonomic affinities of *Maripelta* (Rhodymeniales, Rhodophyta). *Cryptogamie, Algologie* 28: 191–194.



- Schmidt, W.E., Gurgel, C.F.D. & Fredericq, S. (2016). Taxonomic transfer of the red algal genus *Gloiosaccion* to *Chrysymenia* (Rhodymeniaceae, Rhodymeniales), including the description of a new species, *Chrysymenia pseudoventricosa*, for the Gulf of Mexico. *Phytotaxa* 243(1): 54–70.
- Schmidt, W.E., Lozada-Troche, C., Ballantine, D.L., Arakaki, N., Gabriel, D., Norris, J.N. & Fredericq, S. (2017). Taxonomic transfer of the red algae *Chrysymenia enteromorpha* and *C. wrightii* to the genus *Botryocladia* (Rhodymeniaceae, Rhodymeniales). *Phytotaxa* 324(2): 122–138.
- Schneider, C.W. & Lane, C.W. (2008). Notes on the marine algae of the Bermudas. 9. The genus *Botryocladia* (Rhodophyta, Rhodymeniaceae), including *B. bermudana*, *B. exquisita* and *B. flookii* spp. nov. *Phycologia* 47: 614–629.
- Wilkes, R.J., McIvor, L. & Guiry, M.D. (2006). Vegetative morphology and *rbcL* phylogeny of some members of the genera *Botryocladia* and *Irvinea* (Rhodymeniaceae, Rhodophyta). *Phycologia* 45: 481–494.