



Title	Proposals to recognize <i>Petalonia tenella</i> comb. nov. and to resurrect <i>Hapterophycus canaliculatus</i> (Scytosiphonaceae, Phaeophyceae)
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Short communication

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Proposals to recognize *Petalonia tenella* comb. nov. and to resurrect *Hapterophycus canaliculatus* (Scytosiphonaceae, Phaeophyceae)

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Abstract: The brown algal family Scytosiphonaceae has recently received considerable attention resulting in the description of several new genera and species. However, members of the genus *Scytosiphon* and *Petalonia* remain polyphyletic. By integrating multi-gene phylogenetic data (mitochondrial *cox3* and plastid *psaA* and *rbcL* genes) with their known morpho-anatomies and life histories, we herein resurrect *Hapterophycus canaliculatus*, currently considered a member of genus *Scytosiphon*, and transfer *Scytosiphon tenellus* to the genus *Petalonia*.

Keywords: brown algae; *cox3*; molecular phylogeny; *Scytosiphon*; taxonomy.

The genus *Scytosiphon* C. Agardh (Ectocarpales, Phaeophyceae), consisting of brown seaweeds with simple and tubular thalli arising from a small holdfast, is widely distributed in temperate to cold coastal waters. Despite being relatively well-studied, the genus is among the problematic groups in the family Scytosiphonaceae. The taxonomic problem in *Scytosiphon* is aggravated by high cryptic species diversity, especially in the generitype *Scytosiphon lomentaria* (Lyngbye) Link (Kogame et al. 2015, Hoshino et al. 2018). The recent taxonomic treatment of *Scytosiphon* based on samples from the Atlantic and Pacific coasts of Canada highlighted the difficulty in delineating morpho-species boundaries within the genus (McDevit and Saunders 2017). Nonetheless, McDevit and Saunders (2017) made considerable changes in the taxonomy of some *Scytosiphon* species, including amending

the description of *S. lomentaria* and describing the new species *Scytosiphon promiscuus* McDevit et G.W. Saunders. Despite this progress, the taxonomy and phylogeny of two *Scytosiphon* species, *Scytosiphon canaliculatus* (Setchell et N.L. Gardner) Kogame and *Scytosiphon tenellus* Kogame, remain confused.

The systematics of the family Scytosiphonaceae have recently received closer scrutiny resulting in several taxonomic and nomenclatural revisions (McDevit and Saunders 2017, Santiañez and Kogame 2017, Santiañez et al. 2018). Noting the discrepancy between morphological and molecular phylogenetic data, Kogame et al. (1999) were the first to suggest the utility of the morphology of prostrate sporophytic thalli to resolve the complex classification of the Scytosiphonaceae at least at the genus level. This proposal was supported by Santiañez and Kogame (2017) who, upon reviewing the life histories of species attributed to the newly established genus *Planosiphon* McDevit et Saunders, reported that these have *Compsonea*-like sporophytes (vs. the *Stragularia*-like sporophytic thalli of *Petalonia* Derbès et Solier). Reassessing the taxonomy and phylogeny of the members of the “*Scytosiphon* group” *sensu* Santiañez et al. (2018), which included the genera *Scytosiphon*, *Planosiphon*, and *Petalonia* among others, suggested that the polyphyly of the genus *Scytosiphon* can be resolved when life history characteristics are considered. Herein, we transfer *Scytosiphon tenellus* to *Petalonia* and reinstate *Hapterophycus canaliculatus*.

Neither *Scytosiphon canaliculatus* nor *Scytosiphon tenellus* clustered with other *Scytosiphon* species in our phylogenetic trees (Figures 1, 2). In the *cox3* tree (Figure 1), samples of *S. canaliculatus* collected from Hokkaido, Japan (Supplementary Table S1) formed a clade with *S. canaliculatus* from San Pedro, California, USA, which is about 100 km from San Clemente, California, the type locality of the species. Albeit with very low support, the species appeared to be more closely related to *Planosiphon* species than to other *Scytosiphon*. Meanwhile, samples of *S. tenellus* from Muroran (type locality; Supplementary Table S1) and Nemuro, Hokkaido, clustered with

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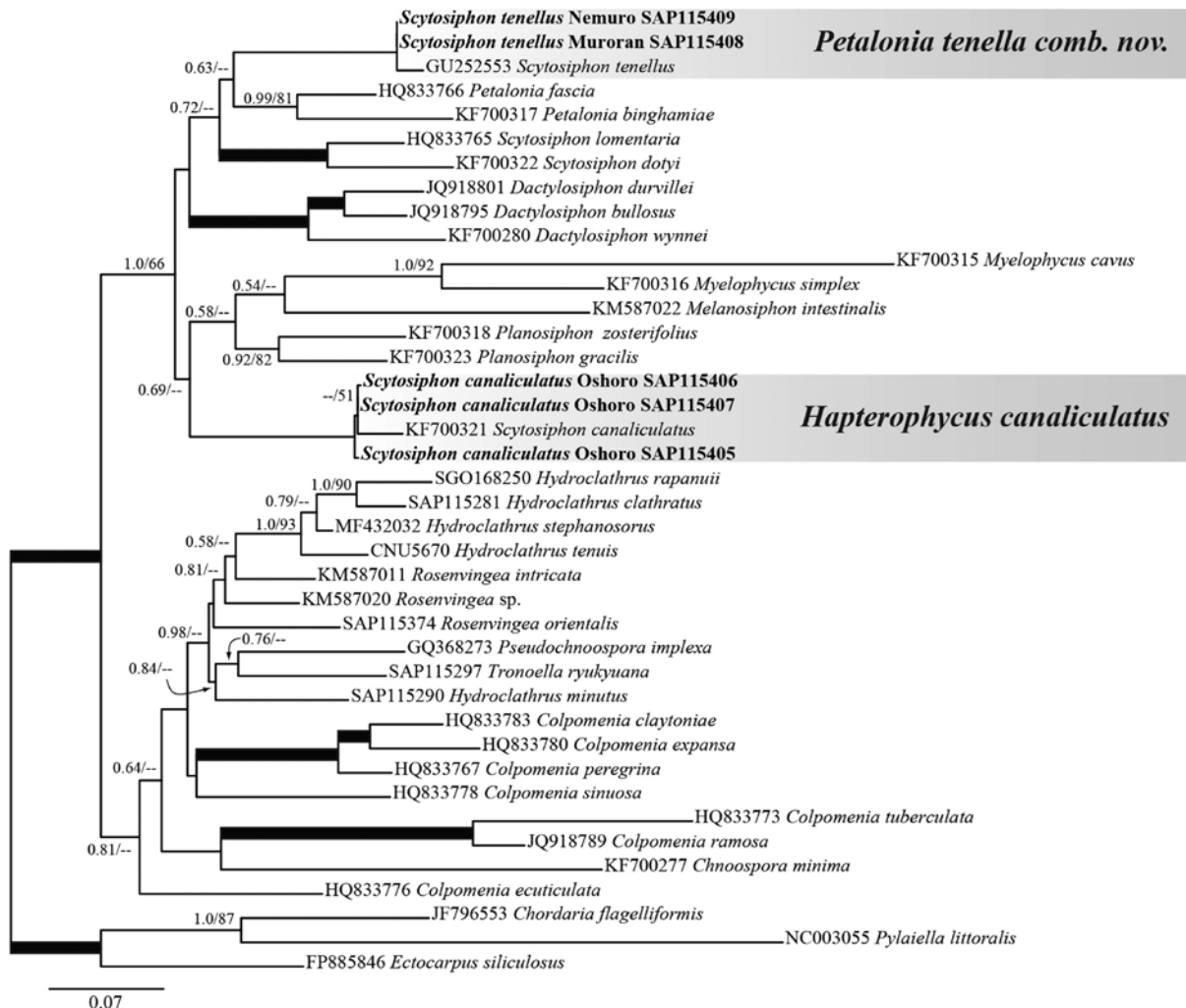


Figure 1: Maximum likelihood (ML) phylogenetic tree for members of the family Scytosiphonaceae based on *cox3* gene sequences. Bayesian posterior probabilities (PP) and ML bootstrap percentages (BP) are shown at each node. Thickened lines indicate highly supported nodes (PP: ≥ 0.98 and BP: $\geq 95\%$). Values $< 50\%$ BP and < 0.50 PP are removed. New taxonomic proposals are indicated by darkened backgrounds. Samples of *Scytosiphon canaliculatus* ($n = 3$) and *S. tenellus* ($n = 2$), which were collected from several localities in Hokkaido, Japan (Supplementary Table S1), were included in this analysis. We amplified partial *cox3* genes for the samples as in Santiañez et al. (2017). Newly generated sequences were aligned with GenBank-available sequences of 32 scytosiphonacean species. ML analysis was conducted through RAXML v.8 (Stamatakis 2014) in the CIPRES Phylogenetic Portal (Miller et al. 2010) using a rapid bootstrap analysis and search for best-scoring ML tree with 1000 bootstrap iterations under the GTR+I+ Γ model. BI analysis was done in MrBayes v.3.2.1 (Ronquist et al. 2012) as follows: Metropolis-coupled Markov-chain Monte Carlo iterations were run for 25 million generations under the GTR+I+ Γ model until the average standard deviations of split frequencies fell below 0.01, indicating convergence of the iterations. Bayesian posterior possibilities were calculated after 25% of the saved trees was removed.

S. tenellus collected from Caleta Palito, Chile. The species formed a clade with *Petalonia* species including the genotype *Petalonia fascia* (O.F. Müller) Kuntze, although with very low support (Figure 1).

Our concatenated *cox3-psaA-rbcL* tree (Figure 2) showed results consistent with our *cox3* tree where *Scytosiphon canaliculatus* and *Scytosiphon tenellus* were not located within the *Scytosiphon* clade. That is, *S. canaliculatus* was found to be more closely related to *Planosiphon* species while *S. tenellus* clustered with *Petalonia* species

with maximum support. Besides the genus *Scytosiphon*, several genera were not shown to be monophyletic including *Colpomenia*, *Hydroclathrus*, and *Rosenvingea*.

Unresolved relationships among the different species in the family Scytosiphonaceae have been attributed to incomplete taxon sampling, the low resolving power of genetic markers currently being used, and the wide and ambiguous morphological delineation of each genus resulting in several incorrect generic assignments (Santiañez et al. 2017, 2018), among others. One of the

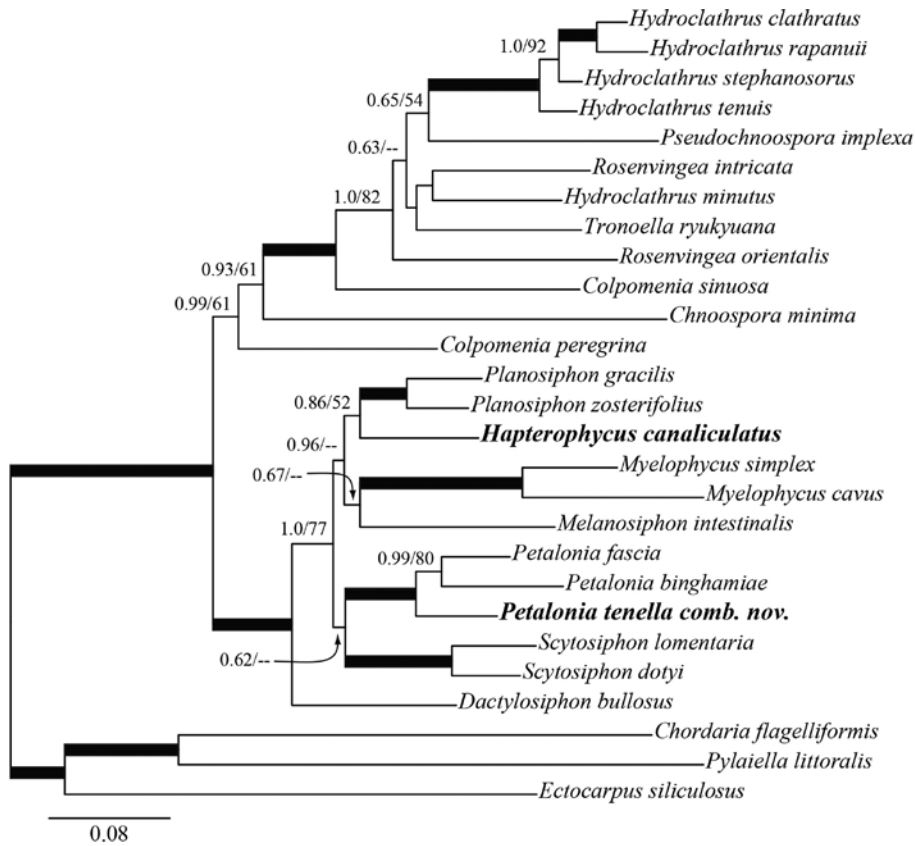


Figure 2: Maximum likelihood (ML) phylogenetic tree for members of the family Scytosiphonaceae based on concatenated sequence data (*cox3*: 610 bp, *psaA*: 740 bp, and *rbcl*: 1383 bp = 2733 bp).

Bayesian posterior probabilities (PP) and ML bootstrap percentages (BP) are shown at each node. Thickened lines indicate highly supported nodes (PP: ≥ 0.98 and BP: $\geq 95\%$). Values $< 50\%$ BP and < 0.50 PP are removed. New taxonomic proposals are written in bold letters. In addition to the *cox3* sequence data, we also amplified both *rbcl* and *psaA* genes for a representative of “*Scytosiphon canaliculatus*” and a *psaA* gene for a representative of “*S. tenellus*”. Concatenated sequence data were then constructed based on these and 22 other scytosiphonacean species that have all three sequence data available in GenBank. Phylogenetic trees were reconstructed based on partitioned concatenated data using ML and BI methods as described in legend of Figure 1.

possible actions to settle the problematic phylogenetic relationships in the family, as suggested by McDevit and Saunders (2017), is to lump several genera into a large genus. However, they also cautioned that this would mean that the genus would have species with widely varied characters. The most pragmatic move would be to adhere to the principle of monophyly, which may require recognizing new taxonomic groups (McDevit and Saunders 2017) and/or revising the classification of several taxa.

Scytosiphon tenellus formed a highly supported clade with *Petalonia* species in our phylogenetic trees based on the concatenated data set, consistent with previous reports (Kogame et al. 2011, Matsumoto et al. 2014, McDevit and Saunders 2017, Santiañez et al. 2017). The species was originally placed in *Scytosiphon* due to its hollow, cylindrical to flattened thallus that was simple or unconstricted, as well as the presence of paraphyses (=ascocysts) among

its plurangia. As for *Petalonia*, its members are distinguished by having complanate, linear to lanceolate thalli that are generally solid in construction and whose medulla possesses rhizoidal filaments. *Scytosiphon tenellus*, as also noted by Matsumoto et al. (2014), is similar to *Petalonia binghamiae* (J. Agardh) V.L. Vinogradova and *Petalonia fascia* in having a *Stragularia*-type prostrate sporophytic thallus (Kogame et al. 1999). The absence of paraphyses in *Petalonia* was previously thought to be an important generic criterion but is now considered of little taxonomic value following the description of *Petalonia tatewakii* Kogame et Kurihara, a species possessing paraphyses (Kogame et al. 2011). Based on the aforementioned morphological, life history, and phylogenetic similarities, we propose that *S. tenellus* be transferred to the genus *Petalonia* and from hereon be recognized as *Petalonia tenella* comb. nov. Consequently, we also expand herein the generic diagnosis of *Petalonia*.

Scytosiphon canaliculatus was first described as *Hapterophycus canaliculatus* Setchell et N.L. Gardner based on hapteron-like thalli (sporophytic thalli) from San Pedro, California, USA (Setchell 1912). Its life history in culture has been reported repeatedly: Hollenberg (1941) and Wynne (1969) showed that the species exhibits a direct-type life history while Nakamura and Nakahara (1977) and Kogame (1996) showed that Japanese populations alternate with macroscopic gametophytic thalli closely resembling *Scytosiphon*. Based on his taxonomic and life history studies on the *H. canaliculatus* of Hokkaido, Japan, Kogame (1996) proposed the transfer of the species to the genus *Scytosiphon* [i.e. *Scytosiphon canaliculatus* (Setchell et N.L. Gardner) Kogame]. However, *S. canaliculatus* differs from other *Scytosiphon* in producing anisogamous gametes (Mine 1990), in having a hapteron-like sporophytic thallus (Kogame 1996), and is phylogenetically segregated from other *Scytosiphon* (Lee et al. 2014, Santiañez et al. 2017, this study). Accordingly, based on its phylogenetic position, anisogamous reproduction, and the morphology of its prostrate sporophytic thallus, we here propose to resurrect the name *Hapterophycus canaliculatus* for the species.

Petalonia Derbès et Solier nom. cons.

Expanded description: Thalli erect, gregarious, leaf-like, compressed, generally flattened, linear to lanceolate or oblanceolate; entire, usually unbranched, old thalli sometimes perforated or torn at the apical portion; hollow, partially hollow to solid. Medulla typically interspersed with rhizoidal filaments. Plurangia occur extensively throughout the thallus, sometimes in sori; generally biseriate, closely packed, covered with cuticle; paraphyses may be present. Sporophytic thalli *Stragularia*-like bear only unangia.

Petalonia tenella (Kogame) Santiañez et Kogame comb. nov.

Basionym: *Scytosiphon tenellus* Kogame 1998: *Phycol. Res.* 46: 44, figs. 29–51.

Holotype: SAP 059746, 2 February 1988, K. Kogame, deposited in SAP.

Type locality: Muroran, Hokkaido, Japan.

Distribution: Hokkaido, Japan (Kogame 1994, 1998); Northern Chile (Camus et al. 2005).

Remarks: The generic name *Petalonia* is considered feminine while the specific epithet “*tenellus*” is masculine; as such, the epithet should take its feminine form and be corrected to “*tenella*”.

Hapterophycus canaliculatus Setchell et N.L. Gardner

Homotypic synonym: *Scytosiphon canaliculatus* (Setchell et N.L. Gardner) Kogame 1996: *Phycol. Res.* 44: 86, figs. 1–30.

Heterotypic synonym: *Hapterophycus echigoensis* Noda 1973: 3 *vide* Kogame (1996).

Holotype: UC 261168, N.L. Gardner, deposited in UC.

Isotype: UC 1883760, N.L. Gardner, deposited in UC.

Type locality: San Pedro, California, U.S.A.

Distribution: California, U.S.A. (Setchell 1912); Baja California, Mexico (Hollenberg 1941); Japan (Nakamura and Nakahara 1977, Kogame 1996).

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References

- Camus, C., A.P. Meynard, S. Faugeron, K. Kogame and J.A. Correa. 2005. Differential life history phase expression in two coexisting species of *Scytosiphon* (Phaeophyceae) in northern Chile. *J. Phycol.* 41: 931–941.
- Hollenberg, G.J. 1941. Culture studies of marine algae. II. *Hapterophycus canaliculatus* S. & G. *Am. J. Bot.* 28: 676–683.
- Hoshino, M., S. Ishikawa and K. Kogame. 2018. Concordance between DNA-based species boundaries and reproductive isolating barriers in the *Scytosiphon lomentaria* species complex (Ectocarpales, Phaeophyceae). *Phycologia* 57: 232–242.
- Kogame, K. 1994. A taxonomic study of the family Scytosiphonaceae (Scytosiphonales, Phaeophyceae) in Japan. Ph.D. dissertation, Hokkaido University, Sapporo. pp. 158.
- Kogame, K. 1996. Morphology and life history of *Scytosiphon canaliculatus* comb. nov. (Scytosiphonales, Phaeophyceae) from Japan. *Phycol. Res.* 44: 85–94.
- Kogame, K. 1998. A taxonomic study of Japanese Scytosiphon (Scytosiphonales, Phaeophyceae), including two new species. *Phycol. Res.* 46: 39–46.
- 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.
- Kogame, K., F. Rindi, A.F. Peters and M.D. Guiry. 2015. Genetic diversity and mitochondrial introgression in *Scytosiphon lomentaria* (Ectocarpales, Phaeophyceae) in the north-eastern Atlantic Ocean. *Phycologia* 54: 367–374.
- Lee, K.M., R. Riosmena-Rodríguez, K. Kogame and S.M. Boo. 2014. *Colpomenia wynnei* sp. nov. (Scytosiphonaceae, Phaeophy-

- ceae): a new species of marine algae from Northeast Asia. *Phycologia* 53: 480–487.
- 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 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.
- Mine, I. 1990. *Marine benthic algal flora from Kikonai to Matsumae, Hokkaido*. M.Sc. thesis, Hokkaido University, Sapporo, 200 pp.
- Nakamura, Y. and H. Nakahara. 1977. The life cycle of *Hapterophycus canaliculatus* (Phaeophyta). *Bull. Jap. Soc. Phycol.* 25 (Suppl.): 203–213.
- Ronquist, F., M. Teslenko, P. van Der Mark, D. Ayres, A. Darling, S. Höhna, B. Larget, L. Liu, M.A. Suchard and J.P. Huelsenbeck. 2012. MrBayes 3.2: efficient Bayesian phylogenetic inference and model choice across a large model space. *Syst. Biol.* 61: 539–542.
- 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* 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. 2017. 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.
- Santiañez, W.J.E., E.C. Macaya, K.M. Lee, G.Y. Cho, S.M. Boo and K. Kogame. 2018. 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. *Bot. Mar.* 61: 47–64.
- Setchell, W.A. 1912. Algae novae et minus cognitae, I. *Univ. Calif. Pub. Bot.* 4: 229–268.
- Stamatakis, A. 2014. RAxML version 8: a tool for phylogenetic analysis and post-analysis of large phylogenies. *Bioinformatics* 30: 1312–1313.
- Wynne, M.J. 1969. Life history and systematic studies of some Pacific North American Phaeophyceae (brown algae). *Univ. Calif. Pub. Bot.* 50: 1–88.

Supplementary Material: The online version of this article offers supplementary material (<https://doi.org/10.1515/bot-2018-0077>).

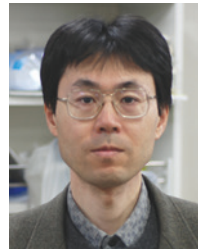
Bionotes



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