European Journal of Phycology

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| Journal: | *European Journal of Phycology* |
| Manuscript ID | TEJP-2016-0091.R1 |
| Manuscript Type: | Original Article |
| Date Submitted by the Author: | n/a |
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| Keywords: | Biogeography, Evolution, Molecular systematics, morphology, phylogeny, Polysiphonia, Red algae, Time calibration |
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# The genera *Melanothamnus* Bornet & Falkenberg and *Vertebrata* S.F. Gray constitute well-defined clades of the red algal tribe Polysiphonieae (Rhodomelaceae, Ceramiales)

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Running title: The genera *Melanothamnus* and *Vertebrata* (Rhodophyta)

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## ABSTRACT

*Polysiphonia* is the largest genus of red algae, and several schemes subdividing it into smaller taxa have been proposed since its original description. Most of these proposals were not generally accepted, and currently the tribe Polysiphonieae consists of the large genus *Polysiphonia* (190 species), the segregate genus *Neosiphonia* (43 species), and 13 smaller genera (< 10 species each). In this paper, phylogenetic relationships of the tribe Polysiphonieae are analysed, with particular emphasis on the genera *Carradoriella*, *Fernandosiphonia*, *Melanothamnus*, *Neosiphonia*, *Polysiphonia sensu stricto, Streblocladia* and *Vertebrata*. We evaluated the consistency of 14 selected morphological characters in the identified clades. Based on molecular phylogenetic (*rbc*L and 18S genes) and morphological evidence, two speciose genera are recognized: *Vertebrata* (including the type species of the genera *Ctenosiphonia*, *Enelittosiphonia*, *Boergeseniella* and *Brongniartella*) and *Melanothamnus* (including the type species of the genera *Fernandosiphonia* and *Neosiphonia*). Both genera are distinguished from other members of the Polysiphonieae by synapomorphic characters, the emergence of which could have provided evolutionarily selective advantages for these two lineages. In *Vertebrata* trichoblast cells are multinucleate, possibly associated with the development of extraordinarily long, photoprotective, trichoblasts. *Melanothamnus* has 3-celled carpogonial branches and plastids lying exclusively on radial walls of the pericentral cells, which similarly may improve resistance to damage caused by excessive light. Other relevant characters that are constant in each genus are also shared with other clades. The evolutionary origin of the genera *Melanothamnus* and *Vertebrata* is estimated as 75.7-95.78 and 90.7-138.66 Ma, respectively. Despite arising in the Cretaceous, before the closure of the Tethys Seaway, *Melanothamnus* is a predominantly Indo-Pacific genus and its near-absence from the northeastern Atlantic is enigmatic. The nomenclatural implications of this work are that 46 species are here transferred to *Melanothamnus*, six species are transferred to *Vertebrata* and 13 names are resurrected for *Vertebrata*.

**Key words:** biogeography, evolution, molecular systematics, morphology, phylogeny, *Polysiphonia*, red algae, time calibration

## INTRODUCTION

The Rhodomelaceae Areschoug is the largest family of red algae, currently including more than 1,000 species (Guiry & Guiry, 2016). It consists of the tribes Amansieae Schmitz (1889), Bostrychieae Falkenberg (1901), Chondrieae Schmitz & Falkenberg (1897), Herposiphonieae Schmitz & Falkenberg (1897), Heterocladieae Falkenberg (1901), Laurencieae Schmitz (1889), Lophothalieae Schmitz & Falkenberg (1897), Neotenophyceae Kraft & I.A.Abbott (2002), Pleurostichidieae (Hommersand, 1963), Polysiphonieae Schmitz (1889), Polyzonieae Schmitz & Falkenberg (1897), Pterosiphonieae Falkenberg (1901), Rhodomeleae Schmitz & Falkenberg (1897), Sonderelleae L.E.Phillips (2001) and Streblocladieae nom. nud. (Hommersand, 1963; Kraft & Abbott, 2002; Womersley, 2003), of which the most speciose is the Polysiphonieae with over 300 species in 15 currently recognized genera (Guiry & Guiry, 2016).

Within the Polysiphonieae the genus *Polysiphonia* Greville (1824), nom. cons., has representatives throughout the world, in the majority of photic marine benthic habitats including brackish ones (e.g. Womersley, 1979; Hollenberg, 1942, 1944, 1968*a*, 1968*b*; Maggs & Hommersand, 1993; Lam *et al.,* 2013). *Polysiphonia* is poorly circumscribed, and has remained in a state of taxonomic flux since its original description. Numerous schemes for subdividing this large and morphologically diverse genus into smaller and more manageable groups have been proposed (e.g. Segi, 1951; Hollenberg, 1968*a*, 1968*b*), based mostly on the number of periaxial cells, either four (subgenus *Oligosiphonia*) or more than four (subgenus *Polysiphonia*). These schemes have generally been rejected and several generic names [e.g. *Orcasia* Kylin (1941), based on *Polysiphonia senticulosa* Harvey] are currently regarded as synonyms of *Polysiphonia.* However, despite having been subsumed within *Polysiphonia* in most classification schemes, *Vertebrata* S.F.Gray (1821) is currently recognized as a monospecific genus containing only the type species, *V. lanosa* ~~(Linnaeus) T.A.Christensen~~.

The segregate genus *Neosiphonia* M.-S.Kim & I.K.Lee (Kim & Lee, 1999) has been widely accepted and is now the second largest in the Polysiphonieae (Guiry & Guiry, 2016). *Neosiphonia* (type species: *N. flavimarina* ~~M. S.Kim & I.K.Lee~~ from Korea) is characterized by the following features: (1) thalli erect with a main axis bearing branches; (2) branches or trichoblasts formed on every segment; (3) rhizoids cut off from pericentral cells; (4) carpogonial branches 3-celled; (5) spermatangial branches formed on a branch of modified trichoblasts; (6) tetrasporangia in ~~a~~ spiral arrangement (Kim & Lee, 1999). These features contrast markedly with the key characters of *Polysiphonia sensu stricto*, exemplified by the type species *P. stricta* ~~(Dillwyn) Greville~~: prostrate axes with rhizoids in open connection with pericentral cells; carpogonial branches 4-celled; spermatangial branches borne directly on axes; tetrasporangia in straight rows (Kim *et al*., 2000). In addition to describing the new species *N. flavimarina*, Kim & Lee (1999) also transferred eleven species of *Polysiphonia* to *Neosiphonia*, all based on material from Korea, and there are 43 currently recognized species (Guiry & Guiry, 2016), not all of which exhibit the six key characters of *Neosiphonia* listed above.

Kim & Lee (1999) considered *Neosiphonia* (also referred to as the "*Polysiphonia japonica* complex" *sensu* Yoon (1986)) to be related to *Fernandosiphonia* Levring, which was erected for *F. unilateralis* ~~Levring~~ from the Juan Fernández Islands off Chile on the basis of its unilateral development of ultimate branches (Levring, 1941) and which currently consists of three species. They reported that *Neosiphonia* differed from *Fernandosiphonia* principally in its branching pattern, the origin of spermatangial branches, and the 3-celled carpogonial branches. Kim & Lee (1999) did not comment, however, on the possible relationship between *Fernandosiphonia* and *Streblocladia* F. Schmitz (in Schmitz & Falkenberg, 1897). Hommersand (1963) and Norris (1994) compared *Fernandosiphonia* (trichoblasts formed spirally) with *Streblocladia* (trichoblasts borne only adaxially). Choi *et al.* (2001) drew attention to the relationship in their 18S tree between *N. japonica* ~~(Harvey) M. S.Kim & I.K.Lee~~ and *Polysiphonia virgata* ~~(C.Agardh) Sprengel~~, the type species of *Carradoriella* P.C.Silva (Kylin, 1956, as *Carradoria*; Silva *et al*., 1996), and suggested that *Neosiphonia* might either be subsumed into *Carradoriella* or be resolved as a sister to it. Recent searches of DNA sequence databases unexpectedly showed a possible relationship between

*Neosiphonia* species and *Melanothamnus somalensis* ~~Bornet & Falkenberg~~, the type species of the genus *Melanothamnus* Bornet & Falkenberg ~~(in Falkenberg, 1901)~~, which was regarded as *incertae sedis* ~~by Bornet & Falkenberg in (~~Falkenberg, ~~(~~1901).

Given the taxonomic and nomenclatural complexity within the Polysiphonieae, our aims were to re-evaluate the morphological features of *Neosiphonia* and *Vertebrata* in relation to those of *Fernandosiphonia*, *Streblocladia*, *Carradoriella*, *Melanothamnus* and *Polysiphonia sensu stricto* within a phylogenetic analysis of the Polysiphonieae using sequences of the plastid-encoded *rbc*L gene and the ribosomal DNA 18S gene (SSU). We surveyed within the Polysiphonieae the distribution of a striking characteristic of the "*Polysiphonia japonica* complex", the position of plastids on radial walls of the periaxial cells and their absence from the outer walls such that nuclei are clearly visible after staining (Maggs & Hommersand, 1993; McIvor *et al*., 2001). Likewise, we analysed the multinucleate *vs.* uninucleate character of trichoblast cells, which seems to be taxonomically significant (Maggs & Hommersand, 1993).

## MATERIALS AND METHODS

### Field collections, morphological studies and literature review

Samples of Polysiphonieae (Table S1) were collected from European Atlantic coasts, New Zealand, Australia, Taiwan, Japan, Chile, USA, South Africa and Oman and processed fresh, desiccated in silica gel or preserved in ethanol.

Type material of *Fernandosiphonia unilateralis* ~~Levring~~ was obtained from the Herbarium, Botanical Museum, Göteborg, Sweden (GB) by correspondence with the curator. It consisted ~~in~~ of four permanent slides, a herbarium sheet and ~~formalin~~liquid--preserved material. Furthermore, we studied recent collections from Juan Fernández Islands, the type locality. We also studied the type material in US and TCD of several species currently assigned to *Neosiphonia* (Table S2; herbarium abbreviations as in Thiers, 2016) for which the key morphological characteristics (Table 1) could not be clearly ascertained from published literature, in order to determine their correct generic assignment. For this purpose, we exclusively considered the descriptions provided for material from type localities or near them. To ensure the accuracy of our interpretation of the genera, our concept of them is based on material of their type species obtained from their type localities. For *Streblocladia,* we used material of, and sequences from, the type species *S. glomerulata* ~~(Montagne) Papenfuss~~ from New Zealand. *Carradoriella* (i.e. *Polysiphonia virgata*) was obtained from the type locality in South Africa, and the type species of *Vertebrata* and *Melanothamnus* came from Ireland and Oman respectively.

Fresh material and herbarium samples were prepared as squashes, either unstained or stained with aqueous aniline blue, post-fixed in 1% HCl, and mounted in 80% Karo corn syrup (Bestfoods Inc, NJ, USA). Permanent slide mounts were prepared as vouchers and deposited in: BM, MICH, SANT, WNC and MEL.

A systematic review was carried out to identify relevant phycological literature from around the world from which to assess for each species of Polysiphonieae the 14 vegetative and reproductive features relevant to *Neosiphonia* and *Vertebrata*.

Nomenclatural authorities for the species mentioned in the manuscript are provided in Tables 2-5 and S1-S2.

DNA extraction, PCR amplification and sequencing

This was carried out in four different laboratories using different protocols as described below.

At Queen's University Belfast, DNA was extracted from fresh, silica gel-dried or ethanol-preserved material using the Qiagen DNeasy Plant Mini Kit (Qiagen GmbH, Hilden, Germany), according to the manufacturer's instructions, or by a CTAB method, modified after Doyle & Doyle

(1987). For PCR amplification, a PTC-200 DNA Engine (MJ Research Inc.) was used. Except for material of *Fernandosiphonia unilateralis*, all PCR amplifications were carried out using rbcLFC as the forward primer, and rbcLRD as the reverse primer (Nam *et al*., 2000; McIvor *et al*., 2001). All reactions contained 200 µM each of dATP, dCTP, dGTP and dTTP, 0.3 µM of each primer, 2.5 mM $MgCl_2$, and 1.6 units of Biotaq$^{TM}$ DNA ~~Taq~~ polymerase (Bioline, UK). The PCR amplification followed Nam *et al.* (2000) and McIvor *et al.* (2001). About 1250 base pairs (bp) of the *rbc*L gene were amplified ~~using rbcLFC and rbcLRD~~and t~~. T~~he PCR fragments for sequencing were purified using the High Pure PCR Product Purification Kit (Roche Diagnostics Ltd., Lewes, UK), according to the manufacturer's instructions. The PCR products were directly sequenced commercially by MWG-Biotech, Ebersberg, Germany.

Type material of *Fernandosiphonia unilateralis* had been preserved in F~~f~~ormalin by Levring (1941) prior to long-term storage in ethanol (A. Athanasiados, personal communication). At the Leiden herbarium, various protocols for retrieving DNA from formalin-preserved specimens were attempted (Kirby & Reid, 2001); the most successful was to soak and wash the material repeatedly in clean sterile water, prior to DNA extraction using using a Chelex-100 (Biorad, Hercules, California) protocol (Goff & Moon, 1993; Zuccarello *et al*., 1999). Applying a strategy for amplifying degraded "ancient" DNA (Provan *et al.*, 2008), primers were designed from an alignment of *Neosiphonia harveyi* ~~(Bailey) M. S.Kim, H. G.Choi, Guiry & G.W.Saunders~~ and related species in order to amplify 100-bp fragments. We used the primers F183 (5' TGCAGGTGAATCTTCTACAGCT 3') and R383 (5' ACGTTACCAATAATTGAAGCTGTT 3').

At the University of Melbourne, DNA was extracted from silica gel-dried material following Saunders & McDevit (2012). PCR amplification was carried out for *rbc*L using the primers F7/RrbcStart or F57/rbcLrevNEW (Freshwater & Rueness, 1994; Saunders & Moore, 2013) and for 18S using the primers F47 (5' AGCCATGCAAGTGCCTGTAT 3') and R1867 (5'CGCAGGTTCACCTACGGAAA 3'). Reactions were performed in a total volume of 25 µl, consisting of 5 µl 5× MyTaq$^{TM}$ reaction buffer, 0.7 µl 10 µM of forward and reverse primers, 0.125 µl 1U ~~/~~µl$^{-1}$ My Taq$^{TM}$ DNA Polymerase (Bioline), 17.475 µl MilliQ® water and 1 µl template DNA. The PCR profile consisted of initial denaturation (93ºC for 3 min); 35 cycles of denaturation (94ºC for 30 s), primer annealing (45ºC for 30 s), and extension (74ºC for 90 s); and final extension (74ºC for 5 min). The PCR products were purified and sequenced commercially by Macrogen.

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At A Coruña, *Melanothamnus* from Oman was extracted using the CTAB protocol (Doyle & Doyle, 1987) and *rbc*L was amplified using the primers F7-R753 and F57-rbcLrevNEW (Freshwater & Rueness, 1994; Saunders & Moore, 2013). The PCR products were purified and sequenced commercially by the sequencing service of the University of A Coruña.

DNA extraction, amplification and sequencing at UNCW were as described by Stuercke & Freshwater (2008).

## Sequence alignment and phylogenetic analysis

A total of 65 *rbc*L and 48 18S sequences were downloaded from GenBank and 25 new *rbc*L and ten new 18S sequences were generated in this study. The sequences and their corresponding GenBank accession numbers are listed in Table S1.

Sequences were aligned using Muscle in Geneious 6.1.8 (Kearse *et al.,* 2012). Identical sequences and those that diverged by less than 1.1% were removed from the *rbc*L analysis, except for *Neosiphonia flavimarina* and *N. harveyi* (0.4% divergence), the two selected representatives of the "*N. japonica* complex" (Kim & Lee, 1999), which also includes *N. decumbens*, *N. harlandii* and *P. akkeshiensis* Segi (McIvor *et al.*, 2001; Kim & Yang, 2006; Savoie & Saunders, 2015; Bárbara *et al.*, 2013). Identical sequences were also removed from the 18S analysis. The sequences included in the final alignment were selected after considering their quality in terms of both length and the presence of ambiguous bases. Phylogenetic trees for *rbc*L and 18S were estimated with

Maximum Likelihood (ML) using RAxML 8.1.6 (Stamatakis, 2014). GTR-Gamma was selected as the best nucleotide model; branch support was estimated with 100 bootstrap replicates. Three species of *Symphyocladia* Falkenberg (in Schmitz & Falkenberg, 1897) were selected as the outgroup in the *rbc*L phylogeny and one species each of *Symphyocladia*, *Xiphosiphonia* Savoie & Saunders (2016) ~~*Pterosiphonia*~~ ~~Falkenberg (in Schmitz & Falkenberg, 1897)~~ and *Herposiphonia* Nägeli (1846) were selected as outgroups for the 18S analysis. This outgroup selection was based on our phylogenomic analyses of the major lineages of the Rhodomelaceae which resolve a clade formed by the Herposiphonieae and Pterosiphonieae as sister to the Polysiphonieae (Díaz-Tapia *et al.*, 2015).

We used MrBayes v.3.2.2 for Bayesian phylogenetic inference (Ronquist *et al.*, 2011). The *rbc*L alignment was analysed using a single (unpartitioned) GTR+Γ+I as well as completely unlinked GTR+Γ+I for each codon position. We used a single GTR+Γ+I model for 18S. All analyses were run for 5~~M~~ million~~s of~~ generations, sampling every 1,000th generation and using two independent runs each consisting of four incrementally heated Metropolis-coupled (MCMC) chains. Convergence and stationarity of runs were evaluated with Tracer v.1.6.0 (Rambaut *et al.*, 2013), resulting in the use of a burnin of 500k generations for all analyses. Post-burnin trees were summarized with the sump~~t~~ command in MrBayes, using the all-compatible-groups consensus type.

Trees were calibrated in geological time using relaxed molecular clock analyses. The calibration was derived from node ages inferred by Yang *et al.* (2016), which estimated the earliest split in Ceramiales (between *Spyridia* Harvey (1833) and the remaining Ceramiales) to be 292 Ma old (stdev ≈ 24.6 Ma). After adding the *rbc*L sequences of Ceramiales from the Yang *et al.* (2016) study to our alignment and setting *Spyridia* as the outgroup, node ages were inferred with two Bayesian methods. The first analysis used an autocorrelated model of molecular evolutionary rate change (Thorne & Kishino, 2002) as implemented in PhyloBayes v.3.3f (Lartillot *et al.*, 2009). The MCMC chain was run for 50k cycles, stationarity was assessed with Tracer, and the node ages summarized with the readdiv command, discarding the first 25k cycles as burnin. The second analysis used uncorrelated rates of evolution sampled from a lognormal distribution (Drummond *et al*., 2006) as implemented in BEAST v.1.8.2. The MCMC chain was run for 10 ~~M~~ million generations, used a Yule tree prior, and an unpartitioned GTR+Γ+I model of sequence evolution. Stationarity was assessed with Tracer. A maximum clade credibility tree and median node heights were inferred with TreeAnnotator, discarding the first ~~1M~~ 1 million generations as burnin and using a posterior probability limit of zero.

## RESULTS

### DNA sequences and alignments

DNA extraction and PCR amplification of type material of *Fernandosiphonia unilateralis* that had been initially ~~formalin~~Formalin/seawater fixed and then stored in ethanol for several decades yielded a 95 bp partial *rbc*L sequence with seven ambiguous nucleotides. The sequence was unique by comparison with other taxa sequenced either at QUB or in Leiden, confirming that there had been no contamination.

25 new *rbc*L sequences and ten 18S sequences were obtained from members of the Polysiphoniae (Table S1), including an *rbc*L sequence from *Melanothamus somalensis*, and four *rbc*L and two 18S sequences from new collections of *F. unilateralis* from the type locality. Alignments for the *rbc*L were unambiguous, with no insertions or deletions.

### Phylogenetic analyses

The ML *rbc*L tree (Fig. 1) has three strongly supported major clades within the Polysiphonieae: *Polysiphonia sensu stricto* 1 (including *P. stricta*, the type of the genus), *Polysiphonia sensu stricto* 2 (with morphological features corresponding to those defining *Polysiphonia sensu stricto*:

Kim *et al*., 2000) and a third clade grouping all the other taxa. The third clade comprised a large number of lineages, many with low or intermediate support. The two most speciose lineages, here named *Vertebrata* and *Melanothamnus*, however, are both robustly supported (Fig. 1). The *Vertebrata* clade includes *V. lanosa*, the current name for the type species of *Vertebrata*, *V. fastigiata* S.F.Gray (1821), as well as the type species of several other genera: *Brongniartella* Bory (1822), *Boergeseniella* Kylin (1956), *Enelittosiphonia* Segi (1949) and *Ctenosiphonia* Falkenberg (in Schmitz & Falkenberg, 1897). The *Melanothamnus* clade includes *Fernandosiphonia unilateralis*, *Neosiphonia flavimarina*, and *M. somalensis*, the type species of their corresponding genera. In addition to these two large clades, six other lineages containing 3-4 species are highly supported (BP/PP > 94/0.95); among these are the *Carradoriella* clade including *Polysiphonia virgata*, the type species of *Caradoriella*, and the *Streblocladia* clade, which includes the type species *S. glomerulata*. Our phylogenetic tree also resolved five individual species as sisters to the other clades with low support.

The *Melanothamnus* clade receives support of 100/1.00 (Fig. 1). In addition to *F. unilateralis*, *N. flavimarina* and *M. somalensis*, this clade includes 27 other species currently assigned to *Neosiphonia* and *Polysiphonia.* The 95 bp sequence obtained from the type material of *F. unilateralis* analysed separately showed that this sequence was positioned unequivocally within the *Melanothamnus* clade, but sequence ambiguities due to the quality of the DNA made it impossible to determine its precise position.

The phylogenetic relationships among species within the *Melanothamnus* clade are generally poorly resolved, with a few exceptions. Although the lineage formed by "*Polysiphonia*" *schneideri*, "*P.*" *amplacapilli*, "*P.*" *pentamera* and "*P.*" *morroides* is very weakly positioned as sister to the *Melanothamnus* clade in the *rbc*L tree, in 18S analyses this position is robustly supported (see below).

The RAxML 18S tree (Fig. 2) has a similar topology to the *rbc*L phylogeny, with three strongly supported major clades: *Polysiphonia sensu stricto* 1 and 2 and a third clade with all the other taxa. *Polysiphonia sensu stricto* clades 1 and 2 are placed robustly together (99/1.00). Within the third clade, the *Vertebrata* clade receives full support, while support is lower for *Melanothamnus* (82/1.00). The sister relationship between the *Melanothamnus* and "*P.*" *schneideri* clades is strongly supported in the 18S phylogeny. In addition, the *Carradoriella* and *Streblocladia* clades are highly supported.

The time-calibrated phylogenies (Figs S1, S2) estimated the divergence in *Vertebrata* to be more ancient than in *Melanothamnus* (90.7-138.66 *vs* 75.7-95.78 Ma). Furthermore, the radiation of major lineages in *Vertebrata* and *Melanothamnus* was gradual and took place over periods of ca. 20 and 12 Ma, respectively.

## Morphological observations

An overview of the distribution of selected morphological characters within clades of the Polysiphonieae is shown in Table 1.

*Habit*: There is considerable variation within and among clades (Table 1), with the exception of the *Carradoriella* clade, in which both species are erect. True prostrate axes giving rise to erect axes, as opposed to decumbent axes that themselves become erect, are confined to *Polysiphonia sensu stricto* and *Vertebrata*. Most species of the *Melanothamnus* clade are completely erect or have a very short prostrate system. However, some taxa are decumbent (e.g. *Polysiphonia blandii, P. simplex*), forming extensive prostrate systems with rhizoids in the basal parts of the erect axes. Members of the Polysiphonieae are typically smaller than 10 cm. As an exception, *M. afaqhusainii* can exceed 1 m in length.

*Rhizoids*: The connection between the rhizoids and the pericentral cells from which they originate is a uniform character within each clade, so far as it can be observed (Table 1). Rhizoids are in open connection with pericentral cells in *Polysiphonia sensu stricto* (Fig. 19), while they are cut off from pericentral cells in the other clades (Figs 20-24). Observations on rhizoids cannot be made in mature specimens of some species, such as *Vertebrata lanosa* which is an obligate hemi-parasite that lacks rhizoids, and *Fernandosiphonia unilateralis, Streblocladia glomerulata* and *Melanothamnus somalensis*, which all have compact basal discs without individual rhizoids.

*Pericentral cells and cortication*: The number of pericentral cells and the presence of cortication are variable in most of the clades (Table 1). All species in the *Vertebrata* clade have six or more pericentral cells, while members of the *Polysiphonia sensu stricto* clades have four pericentral cells, with the exception of *Bryocladia cuspidata* (6-8 pericentrals). Cortication is uniformly absent in the *Polysiphonia sensu stricto* and "*P.*" *schneideri* clades. Cortication is variable within the other clades, absent or slight in small species of *Fernandosiphonia* but very heavy in *Melanothamnus*, and absent or slight in most species of *Vertebrata* with the exception of *Boergeseniella*, in which cortication is elaborate.

*Plastid arrangement*: The arrangement of plastids in the cells is a synapomorphy for the *Melanothamnus* clade. The species in this clade have the plastids lying exclusively on radial walls of pericentral cells so the outer walls appear transparent (Table 1, Figs 8, 13, 34-39). This particular arrangement of the plastids can be easily observed under the microscope as the cells show a dark flank when observed in detail (Figs 14, 35, 37), as well as a transparent halo when the pericentral cells are observed in a suitable position (Fig. 38). All the other taxa of the Polysiphonieae have plastids against all the cell walls including the outer wall (Table 1, Figs 25-33). The revision of the type materials listed in Table S2, currently assigned to *Neosiphonia*, allowed us to verify the plastid character in the species *Polysiphonia concinna*, *P. eastwoodiae*, *P. gorgoniae*, *P. harlandii* and *P. johnstonii*. Conversely, the species *Lophosiphonia mexicana*, *P.*

*beaudettei, P. confusa*, *P. poko*, *P. profunda* and *P. rubrorhiza* have the plastids scattered within the cells, including against the outer wall cells.

*Branch/trichoblast arrangement*: Whether trichoblasts and/or branches are formed on every segment or are separated by naked segments is variable in three clades, *Melanothamnus, Carradoriella* and *Vertebrata.* Most species of the *Melanothamnus* clade have branches or trichoblasts on every segment, which is a key feature of *Neosiphonia*. However, there are exceptions in this clade such as *Neosiphonia collabens*, *Polysiphonia nuda* and *P. pseudovillum* from Panama, in which there are interspersed naked segments. Conversely, the formation of trichoblasts/branches with naked segments between them is a uniform character in the *Streblocladia*, "*Polysiphonia*" *schneideri* and *Polysiphonia sensu stricto* clades (Table 1). Within all clades except *Melanothamnus*, branches may form in a position axillary to trichoblasts, but although constant at the species level, this character is variable within clades. In the *Melanothamnus* clade this character is absent, and branches are never axillary.

*Trichoblast nuclei*: The proximal cells of trichoblasts are multinucleate in the *Vertebrata* clade (Table 1, Figs 41-43), with up to 8 or more nuclei in the basal cell and decreasing in number towards the apices, which can be uninucleate. The nuclei are uniformly distributed inside the cells, each appearing to have a domain within the cell. Conversely, all the cells of trichoblasts are uninucleate in other clades of the Polysiphonieae (Figs 40, 44-46). The only known exception is *Leptosiphonia schousboei*, which sometimes has two nuclei in the trichoblast cells.

*Branching pattern*: Despite the great significance previously placed on dorsiventral *vs.* radial branching in the Rhodomelaceae, this character varies within all our clades. A primary dorsiventral branching pattern characterizes some species of the clades *Melanothamnus* (*F. unilateralis* and *N. collabens*; Figs 10, 11), *Streblocladia* (*S. glomerulata*) and *Vertebrata* (*Ctenosiphonia hypnoides*)

(Table 1). However, this characteristic is not significant in delineating these three genera, as our phylogenetic tree reveals that each of these four species is closely related to others that have spirally or pseudodichotomously arranged branches. For example, the branching pattern of members of the *Streblocladia* clade varies from dorsiventral in *S. glomerulata*, the type species, to spiral or pseudodichotomous in *Polysiphonia muelleriana* and *Polysiphonia* sp. Likewise, the dorsiventral *Neosiphonia collabens* is related to species with spiral or pseudodichotomous branching patterns.

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*Spermatangial branches*: Whether spermatangial branches replace trichoblasts completely or replace only one branch of a dichotomously branched trichoblast is a constant character in all clades (Table 1). In the two *Polysiphonia sensu stricto* and *Streblocladia* clades, spermatangial branches almost uniformly replace trichoblasts (Fig. 47). In the other clades, they are formed on the first dichotomy of modified trichoblasts (Figs 15, 49-52), with the exception of *Vertebrata* (Fig. 48) as *V. lanosa* has no trichoblasts in male thalli - they can only be observed occasionally in females. The presence or absence of apical sterile cells on spermatangial branches is variable within clades, except for *Carradoriella* in which they are present (Figs 47-52, Table 1).

*Carpogonial branches:* The *Melanothamnus* clade is characterized by having 3–celled carpogonial branches (Table 1). In our study, we observed this character in *N. harveyi*, *N. collabens*, *P. blandi* and *P. forfex* (Figs 57, 58). By contrast, the other Polysiphonieae uniformly have 4-celled carpogonial branches like the majority of the Rhodomelaceae (Table 1, Figs 53-56).

*Cystocarps*: The outline morphology of cystocarps varies from globose to ovoid in all the clades analysed here (Table 1, Figs 60-64). Urceolate cystocarps are exclusive to the *Polysiphonia sensu stricto* clades (Table 1, Fig. 59). Cells around the ostiole are conspicuously larger than (more than twice the size of) the cells of the pericarp immediately below in most species of the

*Melanothamnus* clade (Fig 70). However, *Neosiphonia harveyi* is an exception, and the cells of the ostiole in this species are only slightly larger than the other cells of the pericarp. This character is also seen in *Streblocladia glomerulata* (Fig. 68). Conversely, the cells of the ostiole in the other four clades are uniformily similar to the cells below (Figs 65-67, 69).

*Tetrasporangia*: The formation of tetrasporangia in straight or spiral rows is variable in all clades (Table 1, Figs 71-76). It must be noted that very long straight series of tetrasporangia are typically observed only in members of the *Polysiphonia sensu stricto* clade (Fig. 71). However, straight series can also form in other clades, for example in *Neosiphonia collabens* and *Polysiphonia nuda* within the *Melanothamnus* clade whereas tetrasporangia in *Fernandosiphonia unilateralis* form short and markedly spiral series (Fig. 18). The third tetrasporangial cover cell is exclusive to the *Polysiphonia sensu stricto* clade, but this character has not been examined in all the species.

## DISCUSSION

### Phylogenetic analysis

Amongst the Polysiphonieae studied here, the early-branching clade/clades *Polysiphonia sensu stricto* 1 and 2 were resolved as separate lineages in *rbc*L analyses (Fig. 1) but together formed a robust clade in 18S analyses (Fig. 2). The marked discordance between *rbc*L and 18S trees regarding the monophyly/paraphyly of the *Polysiphonia sensu stricto* lineages requires additional research for a more accurate assessment of relationships and character evolution. Because the *Polysiphonia sensu stricto* lineages occur near the base of the tree, it is possible that the outgroups (which are relatively distant taxa compared to the ingroup) could have attached to the ingroup in the wrong position in one of the analyses (Shavit *et al.*, 2007). Future work should focus on including a wider range of taxa from across the Rhodomelaceae as well as using larger, multi-gene datasets to infer the correct branching order of the two *Polysiphonia sensu stricto* lineages.

The *Vertebrata* and *Melanothamnus* clades were resolved as large, speciose clades with strong support using *rbc*L. The 18S phylogeny also resolves the *Vertebrata* clade with robust support, while *Melanothamnus* is moderately well supported. Both clades are clearly distinguished from *Polysiphonia sensu stricto* by the rhizoid anatomy (cut off from pericentral cells). Both clades are identified by distinct morphological synapomorphies. The *Vertebrata* clade is characterized by the multinucleate cells of trichoblasts; the other key feature of *Vertebrata*, that all species have six or more pericentral cells, is shared with members of some other clades. The *Melanothamnus* clade is unequivocally distinguished from other Polysiphonieae by two synapomorphic characteristics: the plastid arrangement and the 3-celled carpogonial branches. Furthermore, branch origin is independent from trichoblasts in all the species of this clade, and the majority of species have enlarged ostiolar cells.

In addition to the above-mentioned clades, the *rbc*L phylogeny resolved six small (3-4 species) but highly supported clades, as well as indicating five species that are uncertainly positioned. The generic assignment of these lineages requires further taxon and gene sampling in order to better understand their phylogenetic relationships and establish a natural classification – it would be premature to speculate on the outcomes of these investigations at present. One of the major shortcomings in Polysiphonieae sequence databases is the uneven geographical sampling, as the majority of sequenced taxa come from Atlantic Europe and northwestern America. The generation of molecular data from additional regions could contribute to acquiring a more realistic perspective of the magnitude of unplaced lineages and to delineating their corresponding genera. Also, the resolution of the commonly employed molecular markers in the Polysiphonieae is not sufficient to resolve the phylogenetic relationships among numerous lineages, which could be improved using larger gene datasets (Díaz-Tapia *et al.*, 2015).

## Taxonomic position of *Vertebrata*

*Vertebrata lanosa* is placed in a strongly supported clade that also includes *Brongniartella byssoides*, *Boergeseniella fruticulosa, Ctenosiphonia hypnoides* and *Enelittosiphonia stimpsonii*, the type species of their corresponding genera, and *Lophosiphonia reptabunda* (which is not the type species). All members of this clade have a synapomorphic characteristic that was previously overlooked in relation to systematics (but see Maggs & Hommersand, 1993): multinucleate trichoblast cells. We conclude from molecular and morphological evidence that members of this clade represent a single genus. *Vertebrata* is the oldest name among those available for this clade, as noted before (Choi *et al*., 2001), and the new combinations proposed in Table 2 are required. Furthermore, the *Vertebrata* binomials previously established by Kuntze (1891) should be reinstated for the other 13 species included in this clade (Table 3).

Interestingly, *Brongniartella* is not monophyletic despite its distinctive persistent and pigmented trichoblasts that led to its classification in the tribes Lophothalieae (Falkenberg, 1901; Womersley, 2003) or Brongniartelleae Parsons (Parsons, 1975; Maggs & Hommersand, 1993). Although trichoblasts are typically considered unpigmented in the Polysiphonieae, they are commonly pigmented when young before they enlarge and become colourless (Delivopoulos, 2002). The two currently recognized species of *Brongniartella*, *B. byssoides* and *B. australis*, were separated within the *Vertebrata* clade, respectively placed with *V. lanosa* and *Polysiphonia nigra*.

*Ctenosiphonia* is a monotypic genus segregated from *Polysiphonia* due to its very peculiar morphological characteristics, including a dorsiventral thallus and two tetrasporangia per segment (Falkenberg, 1901; Díaz-Tapia & Bárbara, 2013). This genus, together with *Lophosiphonia* Falkenberg (1987), is currently positioned within the “Lophosiphonia group” (Falkenberg, 1901). *Boergeseniella* and *Enelittosiphonia* were distinguished from other Polysiphonieae by their particular branching patterns (Kylin, 1956; Segi, 1949), but our molecular evidence (Fig. 1) does not support their recognition as independent genera.

The diversity of currently recognized genera included in this clade reflects the high variability among *Vertebrata* species in trichoblast characteristics (pigmented/unpigmented; persistent/deciduous; spirally/dorsiventrally arranged) and branching patterns (spiral/dorsiventral; presence or absence of alternating branches of determinate and indeterminate growth), which classical authors considered important at levels of genus and tribe (Falkenberg, 1901; Kylin, 1956; Hommersand, 1963).

The main morphological character delineating the *Vertebrata* group is that trichoblast cells are multinucleate. In the Polysiphonieae and some other Ceramiales, the apical cell is uninucleate, whereas the cells cut off from it undergo nuclear divisions during elongation, becoming multinucleate, with the number of nuclei being proportional to the volume of the cell (Goff & Coleman, 1986; McIvor *et al.*, 2002). The trichoblasts of the Rhodomelaceae are usually uninucleate, whereas the polysiphonous parts of the thalli are multinucleate (Coomans & Hommersand, 1990; Garbary & Clarke, 2001; Delivopoulos, 2002). A plausible advantage of having multinucleate trichoblasts in *Vertebrata* is that their cells can reach larger sizes. In fact, trichoblasts in this genus are sometimes extremely well developed, exceeding 10 mm in length in species such as *Vertebrata* (*Lophosiphonia*) *reptabunda* and *V.* (*Ctenosiphonia*) *hypnoides*. In the red algae, cell streaming is slow compared with other algae (Pueschel, 1990), and multinuclearity of large cells may facilitate the regulation of cellular activities. Several potential functions have been attributed to the vegetative hairs of the red algae or trichoblasts of the Rhodomelaceae including dessication resistance, nutrient uptake, metabolite secretion, shading, trapping of spermatia, mucilage stabilization and monitoring of phosphorus status (Delivopoulos, 2002, and references therein). Physically, trichoblasts can form a dense network around the apices that could potentially restrict access to the cells by small grazers, such as amphipods and copepods.

### Taxonomic position of *Neosiphonia*, *Fernandosiphonia* and *Melanothamnus*

The presence of the type species of the genus *Melanothamnus* (*M. somalensis*) in a strongly supported clade with the type species of the genus *Neosiphonia* (*N. flavimarina*) and *Fernandosiphonia* (*F. unilateralis*) indicates that *Neosiphonia*, *Fernandosiphonia* and *Melanothamnus* are not distinct monophyletic genera. *Neosiphonia* is a later heterotypic synonym of *Fernandosiphonia.* However, the name *Melanothamnus* is older than both *Fernandosiphonia* and *Neosiphonia*, and the new combinations proposed in Tables 4 and 5 are required. These new combinations include 31 species that were previously assigned to *Neosiphonia*; two species known to be closely related to *Neosiphonia* but that had been retained in *Polysiphonia* because their morphology conflicted with Kim & Lee (1999); six species for which molecular data are presented here for the first time; and three species that are transferred to *Melanothamnus* on the basis of their morphology.

On the other hand, ten species that are currently placed in *Neosiphonia* should be replaced in *Polysiphonia* for formal purposes pending clarification of their phylogenetic affinities and generic assingment. *Polysiphonia beaudettei, P. confusa, P. echinata, P. elongella, P. poko*, *P. rubrorhiza* and *P. profunda* were assigned to *Neosiphonia* based on morphological characteristics (Kim & Lee, 1999; Abbott *et al.*, 2002; Kim & Abbott, 2006; Mamoozadeh & Freshwater, 2011; Norris, 2014). However, they lack the plastid character, and furthermore molecular data for *P. echinata* and *P. elongella* show that they do not belong to the *Melanothamnus* clade (Fig. 1). Likewise, *Polysiphonia sertularioides* was transferred to *Neosiphonia* based on the morphology of Korean material attributed to this species (Nam & Kang, 2012). However, its type locality is in the Mediterranean, and Atlantic sequences for this species are not in the *Fernandosiphonia* clade (Fig. 1; Mamoozadeh & Freshwater, 2012). *Polysiphonia paniculata* was transferred to *Neosiphonia* (Norris, 2014), but again it is not in the *Melanothamnus* clade (Figs 1, 2). Finally, our study of the type material of *Lophosiphonia mexicana,* also transferred to *Neosiphonia* (Norris, 2014; Table S2), ~~leads us to conclude~~ indicates that this species is probably not a member of the Polysiphonieae. As noted by Norris (2014), further studies are needed to clarify the generic placement of this unusual species, and meanwhile we propose to leave it in *Lophosiphonia* until more information is available.

Specimens of *Melanothamnus* collected in Oman and housed in MICH were initially assigned to *M. somalensis* (Wynne & Banaimoon, 1990), before the description of *M. afaqhusainii* ~~M.Shameel~~ from Pakistan (1999). Revision of the Omani materials leads us to conclude that both *M. somalensis* and *M. afaqhusainii* are represented in Oman, and their morphology agrees with the criteria proposed by Shameel (1999, 2000) for distinguishing them. Their *rbc*L sequences diverged by 1.4% (18 bp).

The *Melanothamnus* clade is morphologically distinguished from other members of the tribe Polysiphonieae by an unequivocal synapomorphic character: plastids lie exclusively on the radial walls of the pericentral cells and are absent from outer walls. The plastid character was previously noted by Hollenberg (1961, 1968*a*), who described "hyaline cell walls" for several species (e.g. *P. pseudovillum*, *P. bajacali*), and by Maggs & Hommersand (1993). However, its significance at higher taxonomic levels has not previously been highlighted. We observed this character in a total of 35 species, and we conclude that it is uniform in the *Melanothamnus* clade. Conversely, other Polysiphonieae and most of the Rhodomelaceae have plastids distributed within the cytoplasm, some lying against outer cell walls. In the family, the only other exception is some species of *Herposiphonia* in which the plastids form transverse bands (Hollenberg, 1968*c*; Womersley, 2003; Díaz-Tapia & Bárbara, 2013).

Carpogonial branches are typically 4-celled throughout the family Rhodomelaceae. 3-celled carpogonial branches were described for the first time in *Polysiphonia platycarpa* (Iyengar & Balakrishnan, 1950), and later this was one of the features proposed to delineate the genus *Neosiphonia* (Kim & Lee, 1999). 3-celled carpogonial branches have been reported in 17 species (four of them in the "*japonica*-complex"), all of which are placed here in *Melanothamnus*. Alternative interpretations of the carpogonial branch configuration were found in the literature for *F. unilateralis*, as Leving (1941) described and illustrated a 4-celled structure, while Morrill (1976, plate 37, figs E and H) illustrated 3-celled carpogonial branches in the same species, also from the type locality. This character can be easily misinterpreted if the carpogonial branches are not observed at the right developmental stage. In our study of the type material, a single procarp was observed in a permanent slide (Fig. 16), most probably the same one illustrated by Levring. It is unclear how this procarp should be interpreted because it is too mature, and so it is difficult to determine with certainty which cell corresponds to the sterile basal cell and which to the basal cell of the carpogonial branch. From the evidence of the presence of both the plastid character and 3-celled carpogonial branches, *Kintarosiphonia fibrillosa* Uwai & Masuda (1999), based on *Pterosiphonia fibrillosa*, and *Polysiphonia platycarpa* are also here transferred to *Melanothamnus* (Table 1).

The other morphological characters proposed by Kim & Lee (1999) to delineate the genus *Neosiphonia* vary among closely related species, except for the rhizoid anatomy. Rhizoids are cut off from the pericentral cells in all Polysiphonieae except for *Polysiphonia sensu stricto* in which they are in open connection with the pericentral cells. After the establishment of *Neosiphonia*, numerous species were transferred to the new genus based on morphology, but commonly overlooking the number of cells in carpogonial branches. Excluding this trait, several species have all five characteristics proposed by Kim & Lee (1999) to delineate *Neosiphonia* but nevertheless are not in the *Melanothamnus* clade (e.g. *P. brodiei*, *P. echinata*, *P. elongella*), while several species are clearly in the clade (e.g. *M. collabens, M. nuda*, *M. pseudovillum*) but lack this combination of traits.

The key morphological feature of *Melanothamnus* is the restriction of plastids to the radial walls of the pericentral cells and their absence from the outer walls. Algae demonstrate a notable decline in photosynthesis at higher light levels possibly due to damage to the photosynthetic apparatus caused by excessive light delivery to photosystem II (Lüning, 1990; Hurd *et al*., 2014). Many green and brown algal plastids have phototropic reactions to blue and UV light in order to protect them from irradiation damage (Lüning, 1990). Plastid movement, however, has never been demonstrated for the vast majority of red algae (Pueschel, 1990), and it appears that red algae have evolved other types of protection against UV damage. Red algae including *Polysiphonia* species have high concentrations of various mycosporine-like amino acids that respond rapidly to environmental change and act as defences against the photooxidative effects of sunlight (Karsten *et al.*, 1998; Navarro *et al.*, 2014). The movement of the plastids onto the radial walls of the periaxial cells, in combination with MAAs, may have given the *Melanothamnus* ancestor a selective advantage over other Polysiphonieae, allowing it to exploit new ecological niches. The prevalence of *Melanothamnus* species in habitats with exposure to high light levels, such as in Hawaii or turfs on coral reefs (Price & Scott, 1992~~,~~; Kim & Abbott, 2006), supports this speculation.

**Biogeography of *Vertebrata* and *Melanothamnus***

The genus *Vertebrata* is distributed worldwide and representatives have been described from all regions where there has been a detailed study of the tribe Polysiphonieae. The majority of our sequences are from Europe, but our systematic review and unpublished data suggest that this genus is widespread. BEAST and PhyloBayes calibrations indicate radiation of the major lineages of the *Vertebrata* clade over a 20 MA period starting about 140 or 90 Ma (estimates from different methods; see Figs S1, S2). Further conclusions as to its origins and centres of diversity would be premature, pending more comprehensive sampling.

In contrast, *Melanothamnus* is predominantly Indo-Pacific (Fig. 77). Although few molecular data are available from Indian coasts, some species occur in South Africa (*M. incompta*), Oman (*M. somalensis* and *M. afaqhusainii*), India (*M. platycarpa*) and Thailand (*M. thailandica*). Among the regions for which there is a comprehensive study of the Polysiphonieae, the diversity of *Melanothamnus* is particularly high in Korea, Japan and Hawaii (14, 11 and 14 species, respectively). This genus is also well represented on North American Atlantic coasts (4-5 species), but it is almost completely absent from Atlantic and Mediterranean Europe, where only two species have been reported, which are both most probably examples of old human-mediated introductions. *Melanothamnus harveyi* is native to southeastern Asia and has been introduced by multiple events onto northern Atlantic coasts (McIvor *et al.*, 2001; Savoie & Saunders, 2016). Similarly, *M. collabens* is likely to be an old introduction into the Atlantic, where it extends from the Bay of Biscay to Cape Verde, including the western Mediterranean (Díaz-Tapia & Bárbara, 2013). The finding of *M. collabens* in California (as *P. johnstonii*, see Table 4) supports this hypothesis, but although *Polysiphonia johnstonii* was first collected from the Gulf of California in 1921 (Setchell & Gardner, 1924), California was probably not the original source of the introduction. ~~*Polysiphonia johnstonii* was first collected from the Gulf of California in 1921 (Setchell & Gardner, 1924). However an~~ An investigation of *Polysiphonia* species from the Northern Gulf of California (Hollenberg & Norris, 1977) suggested that since its initial collection and description, *P. johnstonii* has extended its range along the Pacific coast of North America, fulfilling one of the criteria for an invasive species (Chapman & Carlton, 1991; Ribera & Boudouresque, 1995). How far this species has spread along the Pacific coast of America and along North Atlantic coastlines remains to be determined, and further sampling is needed to establish its origin.

The absence of naturally occurring *Melanothamnus* species in the Mediterranean and northeastern Atlantic might suggest that *Melanothamnus* is of recent origin, having evolved in the Pacific Ocean after the closure of the Tethys Seaway, between 60 and 20 million years ago, particularly as the sister "*P.*" *schneideri* clade is also primarily Pacific in distribution. In our *rbc*L phylogeny (Fig. 1), the "*P.*" *schneideri* clade includes two Korean species and two species distributed in the Pacific and North America with one of them introduced in Europe (Díaz-Tapia *et al.*, 2013). Furthermore, our surveys in Australia revealed five other Indo-Pacific species belonging to this clade (unpublished data). However, BEAST and PhyloBayes calibrations indicate radiation of the major lineages of the *Melanothamnus* clade over a 12 Ma period starting about 95 or 75 Ma (the two methods providing different estimates), with divergence from the "*P.*"

*schneideri* clade 140 or 95 Ma (Figs S1, S2). The distribution resembles a Tethyan one that originated during the Cretaceous 125-75 Ma (Lüning, 1990; Hommersand, 2007) when the Tethys Ocean formed a tropical girdle around the earth. Unlike typical Tethyan distributions, in addition to its wide occurrence throughout the tropics, *Melanothamnus* occupies more temperate regions in the North Pacific (e.g. Japan, Korea) and the South Pacific/Oceania (e.g. South Australia, New Zealand). The question of whether *Melanothamnus* failed to colonize the northeastern Atlantic as it opened up during the Cretaceous, or whether northeastern Atlantic lineages evolved but became extinct, perhaps during Pleistocene glaciations, cannot be answered at present.

## ACKNOWLEDGEMENTS

We are pleased to recognize here that Dr Max H. Hommersand (UNC Chapel Hill) independently discovered the key morphological character of the position of plastids in the *Melanothamnus* clade. We thank Joana Costa for providing us samples of *Polysiphonia* spp. from South Africa, and Erasmo Macaya for supplying material from his recent collections of *Fernandosiphonia unilateralis* from the type locality. Prof. Gary Saunders is thanked warmly for generously sharing sequences for *Melanothamnus afaqhusainii* from Oman. We acknowledge the curators of the herbaria TFC, US and TCD; Dr Joe Zuccarello provided host support for Lynne McIvor during her Marie Curie fellowship at Leiden Herbarium. PDT acknowledges support by the postdoctoral programmes Axudas de apoio á etapa inicial de formación posdoutoral do Plan I2C (Xunta de Galicia). Funding for the aspects of the work carried out in the Melbourne lab was provided by the Australian Biological Resources Study (RFL213-08) and the Australian Research Council (FT110100585).

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Table 1. Comparison of selected morphological characteristics among the *Polysiphonia sensu stricto* 1 and 2, *Vertebrata*, *Carradoriella*, *Streblocladia, Polysiphonia schneideri* and *Melanothamnus* clades.

| Feature | *Polysiphonia sensu stricto* 1 and 2 | *Vertebrata* | *Carradoriella* clade | *Streblocladia* clade | *"Polysiphonia" schneideri* clade | *Melanothamnus* |
|---|---|---|---|---|---|---|
| Thallus habit | Erect; decumbent; prostrate | Erect; decumbent; prostrate | Erect | Erect | Erect; decumbent | Erect; decumbent |
| Rhizoid connection | Open | Cut off | Cut off | Cut off | Cut off | Cut off |
| Pericentral cells | 4 (6-8 in *Bryocladia cuspidata*, clade 2) | 6-24 | 5-16 | 4-12 | 4-7 | 4-9 |
| Cortication | Absent | Absent / Present | Present | Present | Absent | Absent / Present |
| Plastid arrangement | Scattered | Scattered | Scattered | Scattered | Scattered | Radial walls |
| Branch/trichoblast arrangement | With naked segments | On every segment or with naked segments | On every segment or with naked segments | With naked segments | With naked segments | On every segment or with naked segments |
| Branches in trichoblast axils | No | Yes / No | Yes / No | No | Yes / No | No |

| | | | | | | |
|---|---|---|---|---|---|---|
| Trichoblast cell nuclei and pigmentation | Uninucleate; Pigmentation absent | Multinucleate; Pigmentation absent (Present) | Uninucleate; Pigmentation absent | Trichoblasts absent | Uninucleate; Pigmentation absent | Uninucleate; Pigmentation absent |
| Branching pattern | Spiral, pseudodichotomous | Spiral, pseudodichotomous, dorsiventral | Pseudodichotomous | Dorsiventral, spiral, pseudodichotomous | Spiral, pseudodichotomous | Dorsiventral, spiral, pseudodichotomous |
| Spermatangial branches | Replacing trichoblasts (or on a trichoblast branch in *P. devoniensis* and *P. kapraunii*), with or without sterile apical cells | On a branch of trichoblasts (replacing them in *V. lanosa*), with/without sterile apical cells | On a branch of trichoblasts, with sterile apical cells | Replacing trichoblasts, without sterile apical cells | On a branch of trichoblasts, with/without sterile apical cells | On a branch of trichoblasts, with/without sterile apical cells |
| Carpogonial branch | 4-celled | 4-celled | 4-celled | Unknown | 4-celled | 3-celled |
| Cystocarp morphology | Globular; ovoid; urceolate | Globular; ovoid | Ovoid | Ovoid | Globular | Globular; ovoid |
| Cells of the ostiole | Similar to the cells | Similar to the cells | Similar to the cells | Larger than cells | Similar to the cells | (Similar to) Larger |

| | | | | | | |
|---|---|---|---|---|---|---|
| | below | below | below | below | below | than cells below |
| Tetrasporangial rows | Straight (slightly spiral) | Straight or spiral (two per segment in *Ctenosiphonia*) | Straight or spiral | Straight or spiral | Straight or spiral | (Straight) Spiral |
| References | This work, 5, 6, 9, 15, 16, 18, 22. | This work, 1, 2, 3, 6, 7, 8; 16, 18, 20, 21, 24. | This work, 16, 21. | This work, 2, 3. | This work, 7, 13, 18, 22. | This work, 2, 3, 4, 6, 9, 10, 11, 12, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25. |

References: [1]Abbott & Hollenberg (1976); [2]Adams (1991); [3]Adams (1994); [4]Bustamante *et al.* (2013 *b*); [5]Dawes & Mathieson (2008); [6]Díaz-Tapia & Bárbara (2013); [7]Díaz-Tapia *et al.* (2013*a*); [8]Díaz-Tapia *et al.* (2013*b*); [9]Hollenberg (1942); [10]Hollenberg (1968*a*); [11]Hollenberg & Norris (1977); [12]Kim & Lee (1999); [13]Kim & Kim (2014); [14]Kim & Kim (2016); [15]Kim *et al.* (1994); [16]Maggs & Hommersand (1993); [17]Mamoozadeh & Freshwater (2011); [18]Mamoozadeh & Freshwater (2012); [19]Muangmai *et al.* (2014); [20]Segi (1949); [21]Stegenga *et al.* (1997); [22]Stuercke & Freshwater (2010); [23]Uwai & Masuda (1999); [24]Womersley (2003); [25]Yoon (1986).

Table 2. Genus *Vertebrata* with new combinations resulting from the present study

| Binomial in *Vertebrata*<br>Basionym<br>Synonyms | Type material<br>Type locality |
|---|---|
| *Vertebrata constricta* (Womersley) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia constricta* Womersley (1979, 497-498; Southern Australian species of *Polysiphonia* Greville (Rhodophyta). *Australian Journal of Botany*, **27**: 459-528) | Holotype: AD A32927<br>Kangaroo I., South Australia; 21.xi.1968 |
| *Vertebrata foetidissima* (Cocks ex Bornet) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia foetidissima* Cocks ex Bornet (1892, pp. 314-315; Les algues de P. K. A. Schousboe….. *Mémoires de la Société Nationale des Sciences naturelles et Mathématiques de Cherbourg*, **28**: 165-376.) | Lectotype (Maggs & Hommersand, 1993): PC 0146017<br>Plymouth, England; undated |
| *Vertebrata isogona* (Harvey) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia isogona* Harvey (in Hooker 1855, p. 231; *The botany of the Antarctic voyage*…. Reeve, London.) | Lectotype (Womersley, 1979): BM 1082304<br>Blind Bay, Cook´s Straits, New Zealand; viii.1849 |

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| *Vertebrata lobophoralis* (N.R.Mamoozadeh & D.W.Freshwater) D.W.Freshwater<br>*Polysiphonia lobophoralis* N.R.Mamoozadeh & D.W.Freshwater (2012, pp. 331-333; *Polysiphonia sensu lato* (Ceramiales, Florideophyceae) species of Caribbean Panama including *Polysiphonia lobophoralis* sp. nov. and *Polysiphonia nuda* sp. nov. *Botanica Marina*, **55**: 317–347.) | Holotype: US 217938<br>Bocas del Toro, Panama;<br>6.viii.2010 |
| *Vertebrata nigra* (Hudson) Díaz-Tapia & Maggs, comb. nov.<br>*Conferva nigra* Hudson (1762, p. 481; *Flora anglica*.... Prostant venales apud J. Nourse in the Strand & C. Moran in Covent-Garden, London.)<br>*Polysiphonia nigra* (Hudson) Batters | Neotype (Maggs & Hommersand, 1993): BM 1067621<br>Marsden, Durham, England;<br>12.vi.1971 |
| *Vertebrata reptabunda* (Suhr) Díaz-Tapia & Maggs, comb. nov.<br>*Hutchinsia reptabunda* Suhr (1831, p. 684; Beschreibung einiger neuen Algen. *Flora* 14: 673-687, 709-716, 725-731)<br>*Lophosiphonia reptabunda* (Suhr) Kylin | Holotype: L 955.62.97<br>Biarritz, Pyrénées-Atlantiques, France |

Table 3. Genus *Vertebrata* with resurrected names resulting from the present study.

| Binomial in *Vertebrata*<br>Basionym<br>Synonyms | Type material<br>Type locality |
|---|---|
| *Vertebrata aterrima* (J.D.Hooker & Harvey) Kuntze<br>*Polysiphonia aterrima* J.D.Hooker & Harvey | Probable syntypes: TCD 12786-8, BM 1067593-6 and BM 1067598<br>New Zealand |
| *Vertebrata australis* (C.Agardh) Kuntze<br>*Cladostephus australe* C.Agardh<br>*Brongniartella australis* (C.Agardh) F.Schmitz | Lectotype (Parsons, 1980): PC<br>Western Australia |
| *Vertebrata byssoides* (Goodenough & Woodward) Kuntze<br>*Fucus byssoides* Goodenough & Woodward<br>*Brongniartella byssoides* (Goodenough & Woodward) F.Schmitz | Lectotype (Maggs & Hommersand, 1993): BM<br>Christchurch, England; 1794 |
| *Vertebrata fruticulosa* (Wulfen) Kuntze<br>*Fucus fruticulosus* Wulfen | Lectotype (Maggs & Hommersand, 1993): Wulfen (1789), pl. 16, fig. 1 |

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| *Boergeseniella fruticulosa* (Wulfen) Kylin | Trieste [Tergestum], Adriatic |
| *Vertebrata fucoides* (Hudson) Kuntze<br>*Conferva fucoides* Hudson<br>*Polysiphonia fucoides* (Hudson) Greville | Neotype (Maggs & Hommersand, 1993): BM 807101<br>Unlocalized, undated |
| *Vertebrata furcellata* (C.Agardh) Kuntze<br>*Hutchinsia furcellata* C.Agardh<br>*Polysiphonia furcellata* (C.Agardh) Harvey | Lectotype (Maggs & Hommersand, 1993): LD 40907<br>Brittany, France; undated |
| *Vertebrata hypnoides* (Welwitsch) Kuntze<br>*Polysiphonia hypnoides* Welwitsch ex J.Agardh<br>*Ctenosiphonia hypnoides* (Welwitsch ex J.Agardh) Falkenberg | Holotype: LD Agardh´s herbarium no. 39346<br>Lisbon, Portugal |
| *Vertebrata lanosa* (Linnaeus) T.A.Christensen<br>*Fucus lanosus* Linnaeus<br>*Polysiphonia lanosa* (Linnaeus) Tandy | Holotype: LINN 1274.23<br>Iceland, undated |
| *Vertebrata simulans* (Harvey) Kuntze<br>*Polysiphonia simulans* Harvey | Lectotype (Maggs & Hommersand, 1993): BM-K<br>Devon, England; 20.v.1831 |
| *Vertebrata stimpsonii* (Harvey) Kuntze | Holotype: TCD 11956 |

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| *Polysiphonia stimpsonii* Harvey<br>*Enelittosiphonia stimpsonii* (Harvey) Kudo & Masuda | Hakodate Bay, Japan |
| *Vertebrata subulifera* (C.Agardh) Kuntze<br>*Hutchinsia subulifera* C.Agardh<br>*Polysiphonia subulifera* (C.Agardh) Harvey | Lectotype (Maggs & Hommersand, 1993): LD 41607<br>Venice, Italy; undated |
| *Vertebrata thuyoides* (Harvey) Kuntze<br>*Polysiphonia thuyoides* Harvey<br>*Boergeseniella thuyoides* (Harvey) Kylin | Lectotype (Maggs & Hommersand, 1993): TCD<br>Milltown Malbay, Ireland; 1831 |
| *Vertebrata tripinnata* (J.Agardh) O.Kuntze<br>*Polysiphonia tripinnata* J.Agardh (1842, p. 142; *Algae maris Mediterranei et Adriatici*, observationes in diagnosin specierum et dispositionem generum. Apud Fortin, Masson et Cie, Paris.)<br>[Kuntze transferred “*Polysiphonia tripinnata* Harvey” to *Vertebrata*, presumably a typographical error as the basionym is *P. tripinnata* J.Agardh (1842)] | Lectotype (Díaz-Tapia *et al.,* 2013*b*): LD J. Agardh´s Herbarium 40938<br>Trieste, Italy |
| *Vertebrata urbana* (Harvey) Kuntze<br>*Polysiphonia urbana* Harvey | Probable Holotype: TCD 186<br>Table Bay, Cape Province, South Africa |

**Note**: The positions of *Polysiphonia paniculata* in the *rbc*L and 18S trees are not congruent. This suggests that these two sequences, generated from samples from Chile and California, respectively (Table S1), were obtained from different species. The assignment of this species to the genus *Vertebrata* therefore requires further study to clarify the identity of the two published sequences. The type locality is Peru.

Table 4. Genus *Melanothamnus* with new combinations resulting from the present study.

| New combination (if any)<br>Basionym<br>Synonyms | Type material<br>Type locality, collection date | Notes |
|---|---|---|
| *Melanothamnus somalensis* Bornet & Falkenberg | Probable syntypes: PC 584990-2<br>Somalia | Figs 3-8 |
| *Melanothamnus afaqhusainii* M.Shameel | Holotype: KUH-SW SAH-127<br>Pakistan | |
| *Melanothamnus unilateralis* (Levring) Díaz-Tapia & Maggs, comb. nov.<br>*Fernandosiphonia unilateralis* Levring (1941, pp. 660-662; Die Meeresalgen der Juan Fernandez-Inseln. Die Corallinaceen der Juan Fernandez-Inseln. In: *The natural history of Juan Fernandez and Easter Island* (Skottsberg, C., editor) Vol. 2, 601-670; 753-757. Almqvist & Wiksells Boktryckeri, | Holotype: GB<br>Juan Fernández Islands, Chile | Figs 9-18 |

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| Uppsala) | | |
| *Melanothamnus apiculatus* (Hollenberg) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia apiculata* Hollenberg (1968a, p. 61; An account of the species of *Polysiphonia* of the central and western tropical Pacific ocean. II *Oligosiphonia*. *Pacific Science*, 22: 56-98)<br>*Neosiphonia apiculata* (Hollenberg) Masuda & Kogame | Holotype: US 48522<br>O'ahu Island, Hawai'i; 30.vii.1959 | 3-celled carpogonial branches (Kim & Abbott, 2006); plastid character (Hollenberg 1968*a*; Fig. 9) |
| *Melanothamnus bajacali* (Hollenberg) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia bajacali* Hollenberg (1961, pp. 347-348; Marine red algae of Pacific Mexico, Part 5: The genus *Polysiphonia*. *Pacific Naturalist*, 2: 345-375)<br>*Neosiphonia bajacali* (Hollenberg) N.R.Mamoozadeh & D.W. Freshwater | Holotype: AHFH<br>Isla Guadalupe, Baja California, Mexico; 18.xii. 1949 | "Cell walls hyaline" (Hollenberg, 1961).<br>Molecular data available from Yucatan, Mexico (Mamoozadeh & Freshwater, 2011) |
| *Melanothamnus balianus* (D.E.Bustamante, B.Y.Won & T.O.Cho) Díaz-Tapia & Maggs, com. nov.<br>*Neosiphonia baliana* D.E.Bustamante, B.Y.Won & T.O.Cho | Holotype: CUK 7937<br>Blue Lagoon beach, Padang Bai, Karangasem, Bali, Indonesia; 27.iv. | Molecular data from the type locality (Bustamante *et al*., 2013*b*) |

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| (2013 *b*, pp. 516-518; *Neosiphonia baliana* sp. nov. and *N. silvae* sp. nov. (Rhodomelaceae, Rhodophyta) from Bali, Indonesia. *Botanica Marina*, **56**: 515-524) | 2012. | |
| *Melanothamnus blandii* (Harvey) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia blandii* Harvey (1862, pl. 184; *Phycologia australica…. Vol. 4*. Lovell Reeve & Co, London) | Lectotype (Womersley, 1979): TCD Brighton, Port Phillip, Victoria, Australia | 3-celled carpogonial branches; plastid character. Molecular data available from the type locality (this work) |
| *Melanothamnus cheloniae* (Hollenberg & J.N.Norris) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia sphaerocarpa* var. *cheloniae* Hollenberg & J.N.Norris (1977, p. 16-17; The red alga *Polysiphonia* (Rhodomelaceae) in the Northern Gulf of California. *Smithsonian Contributions to the Marine Sciences*, 1: 1-21.)<br>*Neosiphonia cheloniae* (Hollenberg & J.N.Norris) J.N.Norris | Holotype: US 160602<br>Sonora, Gulf of California, Mexico; 21.i.1974 | Plastid character (Hollenberg & Norris, 1977; fig. 4B) |
| *Melanothamnus collabens* (C.Agardh) Díaz-Tapia & Maggs, comb. nov.<br>*Hutchinsia collabens* C.Agardh (1824, p. 153; *Systema algarum.* | Syntypes: LD Agardh herbarium 40885-40887 and 40890-40898; Cádiz, Spain | 3-celled carpogonial branches; plastid character; molecular data available from the type locality (Díaz-Tapia & Bárbara, |

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| Berlinginiana, Lundae)<br>*Polysiphonia collabens* (C.Agardh) Kützing<br>*Streblocladia collabens* (C.Agardh) Falkenberg<br>*Neosiphonia collabens* (C.Agardh) Díaz-Tapia & Bárbara | | 2013) |
| *Melanothamnus concinnus* (Hollenberg) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia concinna* Hollenberg (1944, pp. 474-475; An account of the species of *Polysiphonia* on the Pacific coast of North America. II. *Polysiphonia*. *American Journal of Botany*, 31: 474-483)<br>*Polysiphonia johnstonii* var. *concinna* (Hollenberg) Hollenberg<br>*Neosiphonia concinna* (Hollenberg) J.N.Norris | Holotype: US 61210;<br>La Jolla, California, USA;<br>26.xii.1936. | Plastid character observed in our study of the type material |
| *Melanothamnus decumbens* (T.Segi) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia decumbens* T.Segi (1951, p. 218; Systematic study of the genus *Polysiphonia* from Japan and its vicinity. *Journal of the Faculty of Fisheries, Prefectual University of Mie*, 1: | Holotype: SAP 25880;<br>Mihonoseki, Shimane Prefecture, Japan; vi.1948. | 3-celled carpogonial branches; plastid character (Kim, 2003, fig. 5F). Molecular data available from Korea (Kim & Yang, 2006) |

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| 169-272)<br>*Neosiphonia decumbens* (T.Segi) M.-S.Kim & I.K.Lee | | |
| *Melanothamnus ecorticatus* (R.E.Norris) Díaz-Tapia & Maggs, comb. nov.<br>*Fernandosiphonia ecorticata* R.E.Norris (1994, p. 434; Some cumophytic Rhodomelaceae (Rhodophyta) occuring in Hawaiian surf. *Phycologia* 33: 434-443) | Holotype: BISH 630042<br>Keokea Bay, Hawai´i; v.1990 | Plastid character; ostiolar cells larger than other pericarpial cells (Abbott, 1999) |
| *Melanothamnus eastwoodiae* (Setchell & N.L.Gardner) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia eastwoodiae* Setchell & N.L.Gardner (1930, p. 161, as *P. eastwoodae*; Marine algae of the Revillagigedo Islands expedition in 1925. *Proceedings of the California Academy of Sciences*, 4: 109-215)<br>*Neosiphonia eastwoodae* (Setchell & N.L.Gardner) Xiang Si-duan | Holotype: CAS 173674<br>Islas Revillagigedo | Plastid character observed in type material |
| *Melanothamnus ferulaceus* (Suhr ex J.Agardh) Díaz-Tapia & | Type materials are in LD, J.Agardh´s | Plastid character in Panama and Brazil. |

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| Maggs, comb. nov.<br>*Polysiphonia ferulacea* Suhr *ex* J.Agardh (1863, p. 980; *Species Genera et Ordines Algarum*..... C.W.K. Gleerup, Lundae)<br>*Neosiphonia ferulacea* (Suhr ex J.Agardh) S.M.Guimarães & M.T.Fujii | Herbarium (not seen)<br>Atlantic Mexico; North America; Guadeloupe; Hawaiian Islands; Marquesas Islands; Australia | Molecular data from Panama (Mamoozadeh & Freshwater, 2012; Guimarâes *et al.*, 2004) |
| *Melanothamnus fibrillosus* (Okamura) Díaz-Tapia & Maggs, comb. nov.<br>*Pterosiphonia fibrillosa* Okamura (1912, p. 172; *Icones of Japanese Algae. Vol. II (10)*. Privately published, Tokyo)<br>*Kintarosiphonia fibrillosa* (Okamura) S. Uwai & Masuda | Lectotype (Uwai & Masuda, 1999): SAP<br>Shirahama, Chiba Prefecture, Japan; undated | 3-celled carpogonial branches, plastid character, cells surrounding the ostiole much larger than the cells below (Uwai & Masuda, 1999, figs. 18, 19). |
| *Melanothamnus flavimarinus* (M.-S.Kim & I.K.Lee) Díaz-Tapia & Maggs, comb. nov.<br>*Neosiphonia flavimarina* M.-S.Kim & I.K.Lee (1999, p. 272; *Neosiphonia flavimarina* gen. et sp. nov. with a taxonomic reassessment of the genus *Polysiphonia* (Rhodomelaceae, Rhodophyta). *Phycological Research*, 47: 271-281) | Holotype: SNU IBA001<br>Bangpo, Anmyondo, Korea; 17.vii.1988. | 3-celled carpogonial branches; plastid character (Kim & Lee, 1999, fig. 5). Molecular data available from the type locality (Kim & Yang, 2006) |
| *Melanothamnus forfex* (Harvey) Díaz-Tapia & Maggs, comb. | Lectotype (Womersley, 1979): TCD | 3-celled carpogonial branches; plastid |

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| nov.<br>*Polysiphonia forfex* Harvey (1859, pl. XCVI; *Phycologia Australica…. Vol. 2.* Lovell Reeve & Co, London) | 15353-4<br>Rottnest Island, Western Australia | character, molecular data available from the type locality (this work) |
| *Melanothamnus gorgoniae* (Harvey) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia gorgoniae* Harvey (1853, p. 39; Nereis boreali-americana…. *Smithsonian Contributions to Knowledge*, 5: [i-ii], [1]-258, pls XIII-XXXVI)<br>*Neosiphonia gorgoniae* (Harvey) S.M.Guimarães & M.T.Fujii | Syntypes: TCD 12801-4, NY 900637-8<br>Key West, Florida, U.S.A | 3-celled carpogonial branches observed in Brazil (Guimaraes, *et al*., 2004); plastid character observed in type material (this work) |
| *Melanothamnus harlandii* (Harvey) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia harlandii* Harvey (1860, p. 330; Characters of new algae…. *Proceedings of the American Academy of Arts and Sciences*, 4: 327-335)<br>*Neosiphonia harlandii* (Harvey) M.S.Kim & I.K.Lee | Probable syntypes: TCD 11955, US 56848<br>Hong Kong | 3-celled carpogonial branches. Molecular data available from Korea (Kim, 2003; Kim & Yang, 2006) |
| *Melanothamnus harveyi* (Bailey) Díaz-Tapia & Maggs, comb. nov. | Lectotype (Maggs & Hommersand, 1993): TCD 12810 | 3-celled carpogonial branches (this work); plastid character. Molecular data |

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| *Polysiphonia harveyi* Bailey (1848, p. 38; Continuation of the list of localities of algae in the United States. *Proceedings of the American Academy of Arts and Sciences*, 4: 327-335)<br>*Neosiphonia harveyi* (Bailey) M.-S.Kim, H.-G.Choi, Guiry & G.W.Saunders | Bailey; Stonington, Connecticut, USA; vii.1847 | available from the type locality (McIvor *et al.*, 2001) |
| *Melanothamnus hawaiiensis* (Hollenberg) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia hawaiiensis* Hollenberg (1968 *a*, pp. 66-67; An account of the species of *Polysiphonia* of the central and western tropical Pacific ocean. II *Oligosiphonia*. *Pacific Science*, 22: 56-98.)<br>*Neosiphonia hawaiiensis* (Hollenberg) M.-S.Kim & I.A.Abbott | Holotype: US 48524<br>Waikiki beach, O´ahu Island, Hawai´i; 21.i.1963 | 3-celled carpogonial branches (Kim & Abbott, 2006). Plastid character (Abbott, 1999, fig. 122C) |
| *Melanothamnus incomptus* (Harvey) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia incompta* Harvey (1847, p. 44; *Nereis australis*…. Reeve Brothers, London) | Probable holotype: TCD 192<br>False Bay, Cape Province, South Africa | Plastid character. Molecular data available from the type locality (this work) |
| *Melanothamnus japonicus* (Harvey) Díaz-Tapia & Maggs, | Lectotype (Masuda *et al.*, 1995): | Plastid character (this work); 3-celled |

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| comb. nov.<br>*Polysiphonia japonica* Harvey (in M.C. Perry 1857, p. 331; *Account of the Botanical specimens.* (Gray, A., editor) *Narrative of the expedition of an American squadron to the China Seas and Japan….* Senate of the Thirty-third Congress, Second Session, Executive Document. House of Representatives, Washington)<br>*Neosiphonia japonica* (Harvey) M.S.Kim & I.K.Lee | TCD 11905<br>Hakodate, Japan; v.1854 | carpogonial branches. Molecular data available from the type locality (Kim & Yang, 2006) |
| *Melanothamnus johnstonii* (Setchell & Gardner) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia johnstonii* Setchell & Gardner (1924, p. 767; XXIX Expedition of the California Academy of Sciences to the Gulf of California in 1921. The Marine Algae. *Proceeding of the California Academy of Science, Series 4* 12: 695-949)<br>*Neosiphonia johnstonii* (Setchell & N.L.Gardner) J.N.Norris | Holotype: CAS1361<br>San Esteban Island, Gulf of California; iv.1921 | Plastid character. Molecular data available from the type locality (this work).<br>The sequence from California (KX756670) is only 0.1-0.2 % divergent in its *rbc*L sequence from *M. collabens* from Spain. Further studies are needed to clarify the possible synonymy between these two species that share the unusual |

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| | | character of having (5-) 6 pericentral cells. |
| *Melanothamnus nudus* (N.R.Mamoozadeh & D.W.Freshwater) D.W.Freshwater<br>*Polysiphonia nuda* N.R.Mamoozadeh & D.W.Freshwater (2012, p. 335; *Polysiphonia sensu lato* (Ceramiales, Florideophyceae) species of Caribbean Panama including *Polysiphonia lobophoralis* sp. nov. and *Polysiphonia nuda* sp. nov. *Botanica Marina*, 55: 317–347) | Holotype: US 211334<br>Parque de Juventud, Calle Primero, Colon, Caribbean coast of Panama; 20.v.2009 | Molecular data available from the type locality (Mamoozadeh & Freshwater, 2012) |
| *Melanothamnus peruviensis* (D.E.Bustamante, B.Y.Won, M.E.Ramirez & T.O.Cho) Díaz-Tapia & Maggs, comb. nov.<br>*Neosiphonia peruviensis* D.E.Bustamante, B.Y.Won, M.E.Ramirez & T.O.Cho (2012, p. 360; *Neosiphonia peruviensis* sp. nov. (Rhodomelacea, Rhodophyta) from the Pacific coast of South America. *Botanica Marina*, 55: 359-366) | Holotype: CUK 7976<br>Lagunillas, Pisco, Ica, southern coast of Lima, Peru; 21.viii.2008 | Plastid character. Molecular data available from the type locality (Bustamante *et al*., 2012, fig. 10) |
| *Melanothamnus platycarpus* (Børgesen) Díaz-Tapia & Maggs, comb. nov. | Probable syntypes: BM 1067681 and 106760 | 3-celled carpogonial branches; plastid character (Iyengar & Balakrishnan, 1949, |

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| *Polysiphonia platycarpa* Børgesen (1934, p. 23; Some Indian Rhodophyceae especially from the shores of the Presidency of Bombay-IV. *Bulletin of Miscellaneous Information, Royal Botanic Gardens, Kew*, 1934: 1-30) | Bombay, India; 19.xii.1927 | fig. 1) |
| *Melanothamnus pseudovillum* (Hollenberg) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia pseudovillum* Hollenberg (1968 *a*, p. 73; An account of the species of *Polysiphonia* of the central and western tropical Pacific ocean. II *Oligosiphonia*. *Pacific Science*, 22: 56-98) | Holotype: US 61232;<br>North Island, Johnston Islands; 22.vi.1965 | Cell walls “hyaline” (Hollenberg, 1968 *a*). Molecular data available from Panama (Mamoozadeh & Freshwater, 2011) |
| *Melanothamnus ramireziae* (D.E.Bustamante, B.Y.Won & T.O.Cho) Díaz-Tapia & Maggs, comb. nov.<br>*Neosiphonia ramirezii* D.E.Bustamante, B.Y.Won & T.O.Cho (2013*a*, *Neosiphonia ramirezii* sp. nov. (Rhodomelaceae, Rhodophyta) from Peru. *Algae*, 28: 73-82.) | Holotype: CUK 6511<br>Lagunillas, Pisco, Ica, Peru; 21.viii.2008. | Plastid character, 3-celled carpogonial branches. Molecular data available from the type locality (Bustamante *et al.*, 2013*a*, fig. 1f) |
| *Melanothamnus silvae* (D.E.Bustamante, B.Y.Won & T.O.Cho) Díaz-Tapia & Maggs, comb. nov. | Holotype: CUK 7976<br>Geger, Nusadua, Bali, Indonesia; | Plastid character. Molecular data available from the type locality |

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| *Neosiphonia silvae* D.E.Bustamante, B.Y.Won & T.O.Cho (2013*b*, pp. 518-520; *Neosiphonia baliana* sp. nov. and *N. silvae* sp. nov. (Rhodomelaceae, Rhodophyta) from Bali, Indonesia. *Botanica Marina*, 56: 515-524) | 26.iv.2012 | (Bustamante *et al*., 2013*b*, figs 22-23) |
| *Melanothamnus simplex* (Hollenberg) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia simplex* Hollenberg, (1942, p. 782; An account of the species of *Polysiphonia* on the Pacific coast of North America. I. Oligosiphonia. *American Journal of Botany,* 29: 772-785)<br>*Neosiphonia simplex* (Hollenberg) Y.-P.Lee | Holotype: US 61238<br>Laguna Beach, Orange County, California, U.S.A; 14.v.1937 | Plastid character. Molecular data available from the type locality (this work).<br>*Rbc*L sequence not incuded in our phylogeny because it is only 1% divergent from *N. ramirezii*. |
| *Melanothamnus sphaerocarpus* (Børgesen) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia sphaerocarpa* Børgesen (1918, p. 271; The marine algae of the Danish West Indies. Part 3. Rhodophyceae (4). *Dansk Botanisk Arkiv*, 3: 241-304.)<br>*Neosiphonia sphaerocarpa* (Børgesen) M.-S.Kim & I.K.Lee | Isotypes: US , C<br>Store Nordsidebugt, St. Thomas, Virgin Islands | Plastid character. Molecular data available from Florida (Mamoozadeh & Freshwater, 2011, fig. 18) |

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| *Melanothamnus strictissimus* (J.D.Hooker & Harvey) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia strictissima* J.D.Hooker & Harvey (1845, p. 538; Algae Novae Zelandiae…. *London Journal of Botany*, 4: 521-551.) | Probable syntype: BM 561312<br>New Zealand | Plastid character (this work). Molecular data available from the type locality (Stuercke & Freshwater, 2010) |
| *Melanothamnus thailandicus* (N.Muangmai & C.Kaewsuralikhit) Díaz-Tapia & Maggs, comb. nov.<br>*Neosiphonia thailandica* N.Muangmai & C.Kaewsuralikhit (2014, pp. 460-461; The new species *Neosiphonia thailandica* sp. nov. (Rhodomelaceae, Rhodophyta) from the Gulf of Thailand. *Botanica Marina*, 57: 459-467) | Holotype: KUMF-SRC 03-011-1<br>Sri Racha Harbor, Chon Buri, Thailand; 11.iii.2011 | 3-celled carpogonial branches. Molecular data available from the type locality (Muangmai *et al.*, 2014) |
| *Melanothamnus yongpilii* (B.Kim & M.-S.Kim) Díaz-Tapia & Maggs, comb. nov.<br>*Neosiphonia yongpilii* B.Kim & M.-S.Kim (2016, pp. 324-325; *Neosiphonia yongpilii* sp. nov. (Rhodomelaceae, Rhodophyta), known as *Neosiphonia simplex* from Korea, with an emphasis on cystocarp development. *Phycologia*, 55: 323-332) | Holotype: JNUB 140704-101<br>Jongdal, Jeju Island, Korea; 04.iv.2014 | 3-celled carpogonial branches; plastid character. Molecular data available from the type locality (Kim & Kim, 2016, fig. 14) |

Note: Here we include only species that we can confidently assign to this genus (i.e., we have examined type material or suitable pictures of the type material showing the plastid character and/or sequences are available from the type locality or nearby).

Table 5. New combinations in *Melanothamnus* made for formal reasons (because the current genus is here placed in synonymy with *Melanothamnus*) although type material has not been examined

| Binomial in *Melanothamnus* (if any)<br>Basionym<br>Synonyms | Type material<br>Type locality | Notes |
|---|---|---|
| *Melanothamnus hancockii* (Dawson) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia hancockii* E.Y.Dawson (1944, pp. 331-332; The marine algae of the Gulf of California. Allan Hancock Pacific Expeditions 3: 189-432)<br>*Fernandosiphonia hancockii* (Dawson) R.E.Norris | Holotype: LAM EYD629c<br>Baja California, Mexico; 16.ii.1940 | Plastid character. Molecular data from Japan (this work) |
| *Melanothamnus masonii* (Setchell & N.L.Gardner) Díaz-Tapia & Maggs, comb. nov. | Holotype: CAS 173618<br>Isla Guadalupe, México; iv.1925 | |

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| *Polysiphonia masonii* Setchell & Gardner (1930, p. 160; Marine algae of the Revillagigedo Islands expedition in 1925. *Proceedings of the California Academy of Sciences*, 4: 109-215)<br>*Neosiphonia masonii* (Setchell & N.L.Gardner) J.N.Norris | | |
| *Melanothamnus minutissimus* (Hollenberg) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia minutissima* Hollenberg (1942, p. 781, An account of the species of *Polysiphonia* on the Pacific coast of North America. I. Oligosiphonia. *American Journal of Botany,* 29: 772-785) | Holotype: US 66797<br>Punta Banda, Baja California, Mexico; 17.xii.1938 | Plastid character. Molecular data from Japan (this work) |
| *Melanothamnus nanus* (A.J.K.Millar) Díaz-Tapia & Maggs, comb. nov<br>*Fernandosiphonia nana* A.J.K.Millar (1990, p. 439; Marine red algae of the Coffs Harbour region, northern New South Wales. *Australian Systematic Botany*, **3**: 293-593) | Holotype: MELU AM752<br>Coffs Harbour, New South Wales; 27.viii.1980 | |
| *Melanothamnus notoensis* (Segi) Díaz-Tapia & Maggs, comb. | Holotype: SAP 025894 | Plastid character in Korea (Nam & Kang, |

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| nov.<br>*Polysiphonia notoensis* Segi (1951, p. 266; Systematic study of the genus *Polysiphonia* from Japan and its vicinity. *Journal of the Faculty of Fisheries, Prefectual University of Mie*, 1: 169-272)<br>*Neosiphonia notoensis* (Segi) M.S.Kim & I.K.Lee | Shibagaki, Ishikawa Prefecture, Japan; 9.vii.1947 | 2012; fig. 47E) |
| *Melanothamnus polyphysus* (Kützing) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia polyphysa* Kützing (1863, p. 20; *Tabulae phycologicae; oder, Abbildungen der Tange. Vol. XIII*. Gedruckt auf kosten des Verfassers (in commission bei W. Köhne), Nordhausen)<br>*Neosiphonia polyphysa* (Kützing) Skelton & G.R.South | Holotype: L 4082747<br>Vieillard; New Caledonia; undated | |
| *Melanothamnus porrectus* (T.Segi) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia porrecta* Segi (1951, p. 260; Systematic study of the genus *Polysiphonia* from Japan and its vicinity. *Journal of the* | Holotype: SAP 025867<br>Henashi, Nishitsugaru-gun, Aomori Prefecture, Japan; 19.vi.1948. | Plastid character in Korea (Lee, 2008; p. 314, fig. C) |

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| *Faculty of Fisheries, Prefectual University of Mie*, 1: 169-272)<br>*Neosiphonia porrecta* (Segi) Y.-P. Lee | | |
| *Melanothamnus savatieri* (Hariot) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia savatieri* Hariot (1891, p. 226; Liste des algues marines rapportés de Yokoska (Japon) par M. le Dr Savatier. *Mémoires de la Société nationale des sciences naturelles de Cherbourg*, 27: 211-230)<br>*Neosiphonia savatieri* (Hariot) M.S.Kim & I.K.Lee | Lectotype (Kim, 2005): PC 0011879<br>Yokosuka, Kanagawa Prefecture, Japan | 3-celled carpogonial branches in Malaysia (Masuda *et al.*, 2001).<br>Molecular data available from Korea (Phillips *et al.*, 2000) |
| *Melanothamnus sparsus* (Setchell) Díaz-Tapia & Maggs, comb. nov.<br>*Lophosiphonia sparsa* Setchell (1926, p. 103; Tahitian algae collected by W.A. Setchell, C.B. Setchell and H.E. Parks. *University of California Publications in Botany*, 12: 61-142)<br>*Polysiphonia sparsa* (Setchell) Hollenberg<br>*Neosiphonia sparsa* (Setchell) I.A.Abbott | Holotype: UC 261144;<br>Arue Reef, Tahiti; 27.vi.1922 | Plastid character in Vietnam (Abbott *et al.*, 2002; fig. 27) |
| *Melanothamnus teradomariensis* (M.Noda) Díaz-Tapia & Maggs, | Holotype: Herbarium Niigata | Molecular data available from Korea |

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| comb. nov.<br>*Polysiphonia teradomariensis* M.Noda (in Noda, M. & Kitami, T. 1971, 47; Some species of marine algae from Echigo Province facing the Japan Sea. *Scientific Reports Niigata University, Ser. D. (Biology)*, 8: 35-52)<br>*Polysiphonia japonica* var. *teradomariensis* (M.Noda) H.Y.Yoon<br>*Neosiphonia teradomariensis* (M.Noda) M.-S.Kim & I.K.Lee | University<br>Echigo Province, Japan; 28.xi.1968 | (Bárbara *et al.*, 2013) |
| *Melanothamnus tongatensis* (Harvey ex Kützing) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia tongatensis* Harvey ex Kützing, (1864, p. 14; *Tabulae phycologicae; oder, Abbildungen der Tange. Vol. XIV*. Gedruckt auf kosten des Verfassers (in commission bei W. Köhne), Nordhausen)<br>*Neosiphonia tongatensis* (Harvey ex Kützing) M.-S.Kim & I.K.Lee | Holotype: L 4083619<br>Tonga, Friendly Islands; undated | Molecular data available from Panama (Mamoozadeh & Freshwater, 2011) |
| *Melanothamnus upolensis* (Grunow) Díaz-Tapia & Maggs, comb. nov. | Syntypes: W<br>Upolu, Western Samoa | Molecular data available from Hawaii (Sherwood *et al.*, 2010) |

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| *Polysiphonia upolensis* Grunow (1874, p. 49; Algen der Fidschi-, Tonga- und Samoa-Inseln, gesammelt von Dr. E. Graeffe. *Journal des Museum Godeffroy*, 3: 23-50)<br>*Neosiphonia upolensis* (Grunow) M.S.Kim & Boo | | |
| *Melanothamnus yendoi* (T.Segi) Díaz-Tapia & Maggs, comb. nov.<br>*Polysiphonia yendoi* Segi (1951, p. 211; Systematic study of the genus *Polysiphonia* from Japan and its vicinity. *Journal of the Faculty of Fisheries, Prefectual University of Mie*, 1: 169-272)<br>*Neosiphonia yendoi* (Segi) M.-S.Kim & I.K.Lee | Holotype: SAP 0258883 Muroran, Hokkaido, Japan; 30.iv.1935 | Molecular data available from Korea (Bárbara *et al.*, 2013) |
| *Neosiphonia saccorhiza* (F.S.Collins & Hervey) J.M.C.Nunes & S.M.Guimarães, nom. inval.<br>*Lophosiphonia saccorhiza* F.S.Collins & Hervey<br>*Polysiphonia saccorhiza* (F.S.Collins & Hervey) Hollenberg | Isotypes: NY, Collins Herbarium Gibbet Island, Bermuda | Transfer to *Melanothamnus* is not made here as *N. saccorhiza* is an invalid combination (the basionym was not cited), and the phylogenetic affinities of *Lophosiphonia saccorhiza* are unknown. |

Figure legends

**Fig. 1**. Phylogenetic tree estimated with ML analysis of *rbc*L sequences. Values at nodes indicate bootstrap support (BP)/posterior probability (PP) (only shown if > 60/0.6). Branches marked with an asterisk received 100% (BP)/1.00 (PP) support. Species names printed in bold correspond to type species of genera.

**Fig. 2**. Phylogenetic tree estimated with ML analysis of 18S sequences. Values at nodes indicate bootstrap support/posterior probability (only shown if > 60%/0.6 PP). Branches marked with an asterisk received 100%/1.00 PP support. Species names printed in bold correspond to type species of genera.

**Figs 3-8**. *Melanothamnus somalensis*, the type species of *Melanothamnus.* **Fig. 3**. Herbarium specimen MICH 662774. **Fig. 4.** Apical part of a specimen with alternately arranged branches. **Figs 5-6**. Apices of branches with (Fig. 5) or without (Fig. 6) abundant trichoblasts. **Fig. 7**. Apex of a lateral branch with trichoblasts. **Fig. 8**. Surface view of cells with the plastids lying exclusively on radial walls while the outer walls appear transparent (arrows). Scale bars: Fig. 3, 6 cm; Fig. 4, 1 mm; Figs 5 and 6, 350 µm; Fig. 7, 200 µm; Fig. 8, 100 µm.

**Figs 9-18.** *Fernandosiphonia unilateralis* type material, the type species of *Fernandosiphonia.* **Fig. 9**. Herbarium specimen. **Figs 10-11**. Branches unilaterally arranged. **Fig. 12**. Axis with scar cells of trichoblasts (arrows). **Figs 13-14**. Surface view of pericentral cells with plastids lying only on the radial walls, so that the outer walls appear transparent (Fig. 13, arrows) and cells have a dark flank (Fig. 14). **Fig. 15**.

Young spermatangial branch formed on the first dichotomy of a trichoblast, remaining the other vegetative branch (arrow). **Fig. 16**. Procarp (su = supporting cell; cp = carpogonium). **Fig. 17**. Cystocarp. **Fig. 18**. Tetrasporangia arranged in short spiral series. Scale bars: Fig. 9, 3 cm; Fig. 10, 2 mm; Fig. 11, 450 µm; Figs 12, 14, 17 and 18, 100 µm; Figs 13 and 15, 40 µm; Fig. 16, 20 µm.

**Figs 19-24**. Rhizoid anatomy in the Polysiphonieae. In open connection with pericentral cells in *Polysiphonia stricta* (**Fig. 19**, *Polysiphonia sensu stricto* clade 1). Cut off from pericentral cells in *P. foetidissima* (**Fig. 20**, *Vertebrata* clade), *P. denudata* (**Fig. 21**, *Carradoriella* clade), *Polysiphonia* sp. (**Fig. 22**, *Streblocladia* clade), *P. schneideri* (**Fig. 23**, *P. schneideri* clade) and *P. incompta* (**Fig. 24,** *Melanothamnus* clade). Scale bars: Figs 19-23, 100 µm; Fig. 24, 500 µm.

**Figs 25-39**. Plastid arrangement in the Polysiphonieae. Scattered against all cell walls of the pericentral cells in *Polysiphonia stricta* (**Figs 25-26**, *Polysiphonia sensu stricto* clade 1), *Vertebrata lanosa* (**Figs 27-28**, *Vertebrata* clade), *P. virgata* (**Figs 29-30**, *Carradoriella* clade), *Polysiphonia* sp. (**Fig. 31**, *Streblocladia* clade) and *P. schneideri* (**Figs 32-33**, *P. schneideri* clade). Lying exclusively on the radial walls of the pericentral cells in species of the *Melanothamnus* clade: *Neosiphonia collabens* (**Figs 34-35**), *N. harveyi* (**Figs 36-38**) and *P. forfex* (**Fig. 39**). Scale bars: Figs 25, 27, 29, 38 and 39, 500 µm; Figs 26, 28 and 30, 800 µm; Figs 31, 32, 34, 35 and 37, 100 µm; Fig. 33, 300 µm; Fig, 36, 50 µm.

**Figs 40-46**. Trichoblast nuclei (arrows) in the Polysiphonieae. Uninucleate trichoblast cells in *Polysiphonia scopulorum* (**Fig. 40,** *Polysiphonia sensu stricto* clade 1), *P.*

*denudata* (**Fig. 44**, *Carradoriella* clade), *P. schneideri* (**Fig. 45**, *P. schneideri* clade) and *P. blandii* (**Fig. 46**, *Melanothamnus* clade). Multinucleate trichoblast cells in species of the *Vertebrata* clade: *P. nigra* (**Fig. 41**), *Boergeseniella fruticulosa* (**Fig. 42**) and *P. foetidissima* (**Fig. 43**). Scale bars: Figs 40-43, 60 µm, Fig. 44, 30 µm; Fig. 45, 20 µm; Fig. 46, 100 µm.

**Figs 47-52**. Spermatangial branches in the Polysiphonieae. Replacing trichoblasts and with sterile apical filaments in *Polysiphonia stricta* (**Fig. 47**, *Polysiphonia sensu stricto* clade 1). Replacing trichoblasts and lacking sterile apical cells in *Vertebrata lanosa* (**Fig. 48**, *Vertebrata* clade). On a branch of a trichoblast and with sterile apical cells in *P. fucoides* (**Fig. 49**, *Vertebrata* clade), *P. denudata* (**Fig. 50**, *Carradoriella* clade), *P. schneideri* (**Fig. 51**, *P. schneideri* clade) and *Neosiphonia harveyi* (**Fig. 52**, *Melanothamnus* clade). Scale bars: 100 µm. Arrows show the apical sterile cells and arrowheads the sterile branch of fertile trichoblasts.

**Figs 53-58**. Carpogonial branches in the Polysiphonieae. Four-celled in *Polysiphonia stricta* (**Fig. 53**, *Polysiphonia sensu stricto* clade 1), *P. nigra* (**Fig. 54**, *Vertebrata* clade), *P. denudata* (**Fig. 55**, *Carradoriella* clade) and *P. schneideri* (**Fig. 56**, *P. schneideri* clade). Three-celled in species of the *Melanothamnus* clade: *Neosiphonia harveyi* (**Fig. 57**) and *P. blandii* (**Fig. 58**). Su = supporting cell; st = sterile basal cell; 1-4 cells of carpogonial branches. Scale bars: Fig. 53, 30 µm; Figs 54-58, 20 µm.

**Figs 59-64**. Cystocarps in the Polysiphonieae. Urceolate in *Polysiphonia stricta* (**Fig. 59**, *Polysiphonia sensu stricto* clade 1). Ovoid in *Vertebrata lanosa* (**Fig. 60**, *Vertebrata* clade), *P. denudata* (**Fig. 61**, *Carradoriella* clade), *Streblocladia glomerulata* (**Fig. 62**, *Streblocladia* clade). Globose in *Polysiphonia schneideri* (**Fig. 63**, *P. schneideri* clade) and *Neosiphonia collabens* (**Fig. 64**, *Melanothamnus* clade). Scale bars: Figs 59-62 and 64, 200 µm; Fig. 63, 100 µm.

**Figs 65-70**. Cells surrounding the ostiole in the Polysiphonieae. Similar or slightly larger than the cells of the pericarp inmediately below in *Polysiphonia stricta* (**Fig. 65**, *Polysiphonia sensu stricto* clade 1), *Vertebrata lanosa* (**Fig. 66**, *Vertebrata* clade), *P. denudata* (**Fig. 67**, *Carradoriella* clade), and *P. schneideri* (**Fig. 69**, *P. schneideri* clade). They are much larger in *Streblocladia glomerulata* (**Fig. 68**, *Streblocladia* clade) and *Neosiphonia collabens* (**Fig. 70**, *Melanothamnus* clade). Scale bars: Figs 65-68 and 70, 100 µm; Fig. 69, 60 µm.

**Figs 71-76**. Tetrasporangia in the Polysiphonieae. Forming long straight series in *Polysiphonia stricta* (**Fig. 71**, *Polysiphonia sensu stricto* clade 1). Forming spiral series in *Vetebrata lanosa* (**Fig. 72**, *Vertebrata* clade), *Polysiphonia* sp. (**Fig. 74**, *Streblocladia* clade) and *Neosiphonia harveyi* (**Fig. 76**, *Melanothamnus* clade). Forming short straight series in *P. denudata* (**Fig. 73**, *Carradoriella* clade), and *P. schneideri* (**Fig. 75**, *P. schneideri* clade). Scale bars: Figs 71, 74 and 76, 200 µm; Figs 72, 73 and 75, 400 µm.

**Fig. 77**. World map representing the proportion of *Fernandosiphonia* (black) and other Polysiphonieae (grey) species in selected regions where the Polysiphonieae were studied in detail. Data were obtained from the following references after updating the species names: Alaska: Lindstrom (http://www.seaweedsofalaska.com); Brazil (Espírito Santo-São Paulo): Guimâraes *et al.* (2004); Hawaii: Abbott (1999); Japan: Yoshida

(1998); Korea: Nam & Kang (2012); Panama: Mamoozadeh & Freshwater (2012); Spain (Galicia): Bárbara *et al.* (2005); British Isles: Maggs & Hommersand (1993).

**Fig. S1**. Chronogram resulting from the Bayesian relaxed molecular clock analysis performed with BEAST.

**Fig. S2**. Chronogram resulting from the autocorrelated molecular clock analysis performed with PhyloBayes.

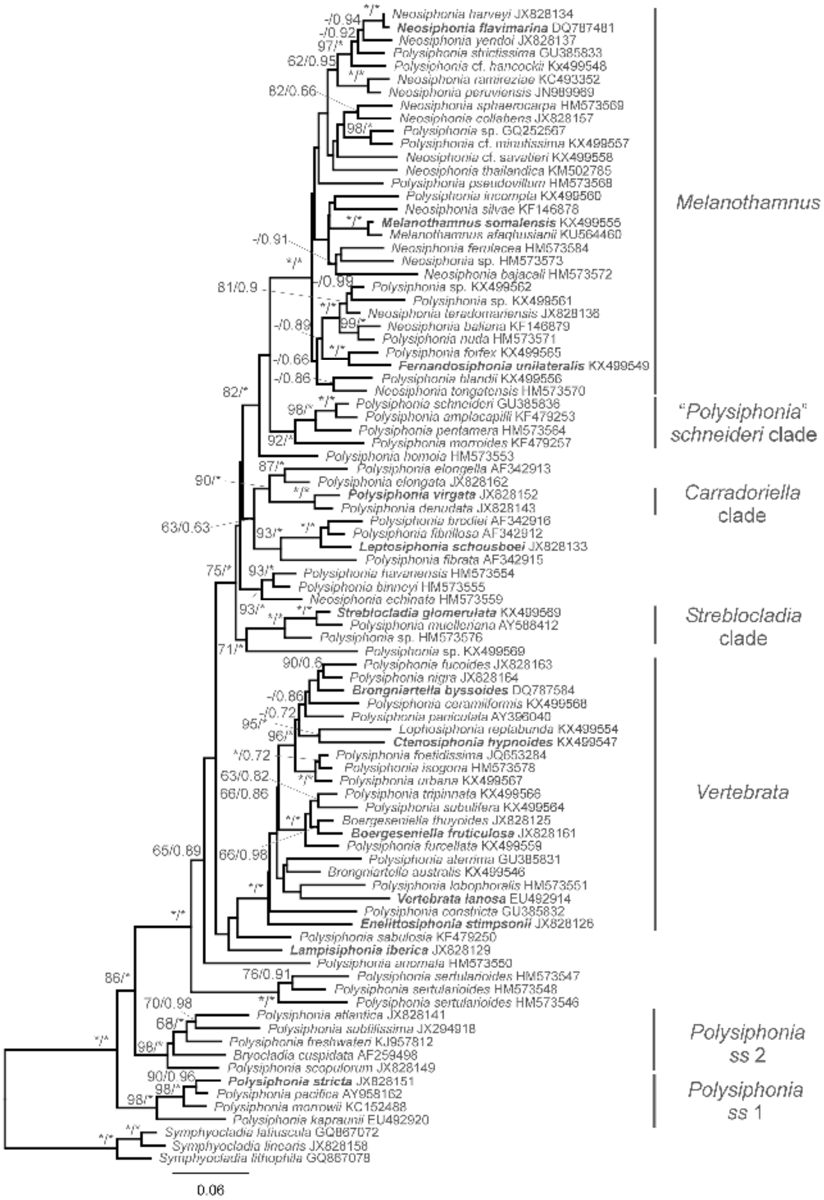


Fig. 1. Phylogenetic tree estimated with ML analysis of rbcL sequences. Values at nodes indicate bootstrap support (BP)/posterior probability (PP) (only shown if > 60/0.6). Branches marked with an asterisk received 100% (BP)/1.00 (PP) support. Species names printed in bold correspond to type species of genera.

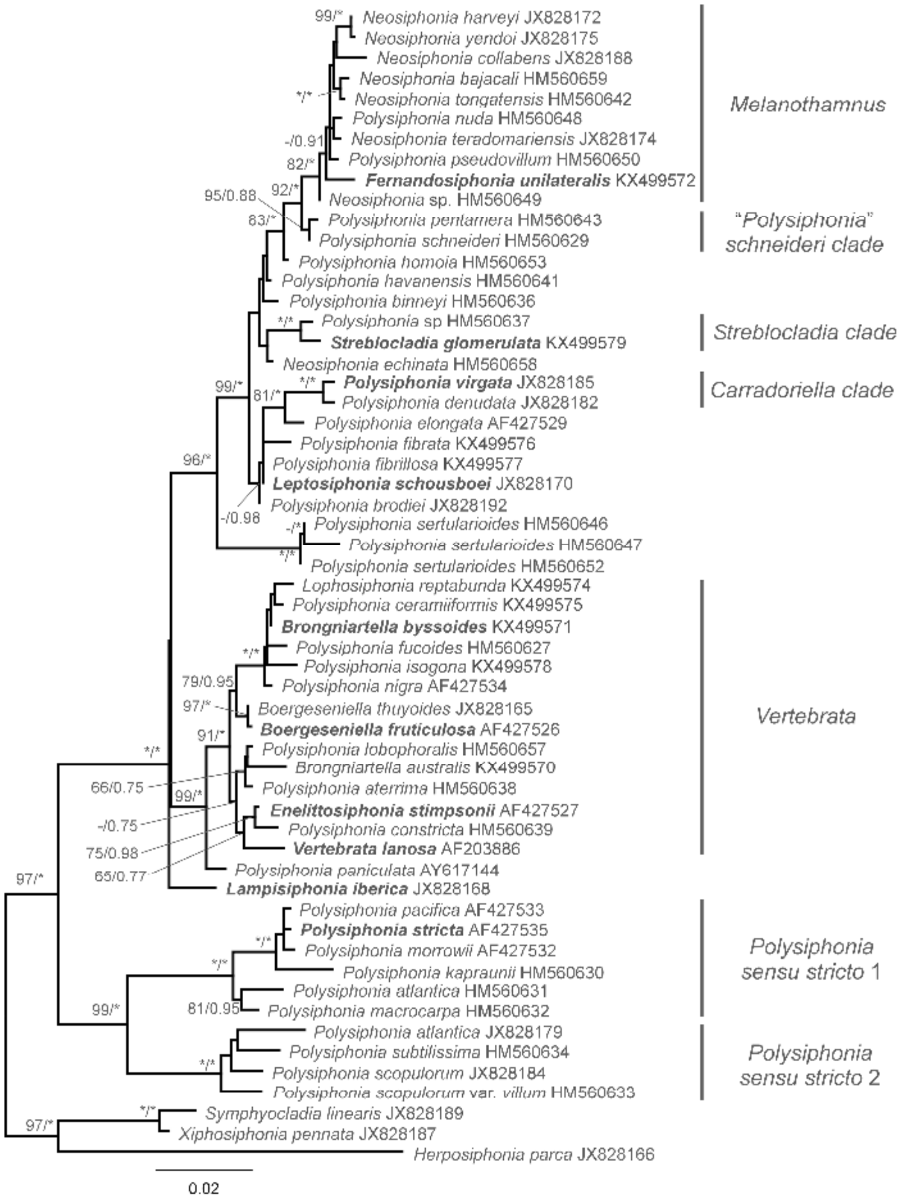
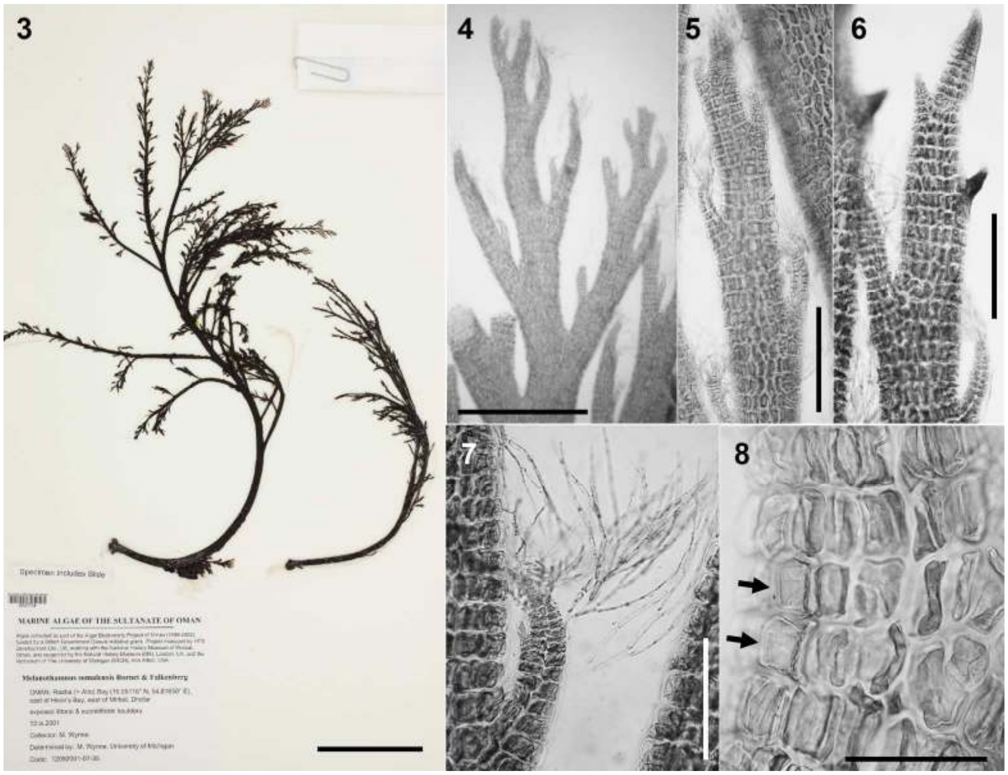
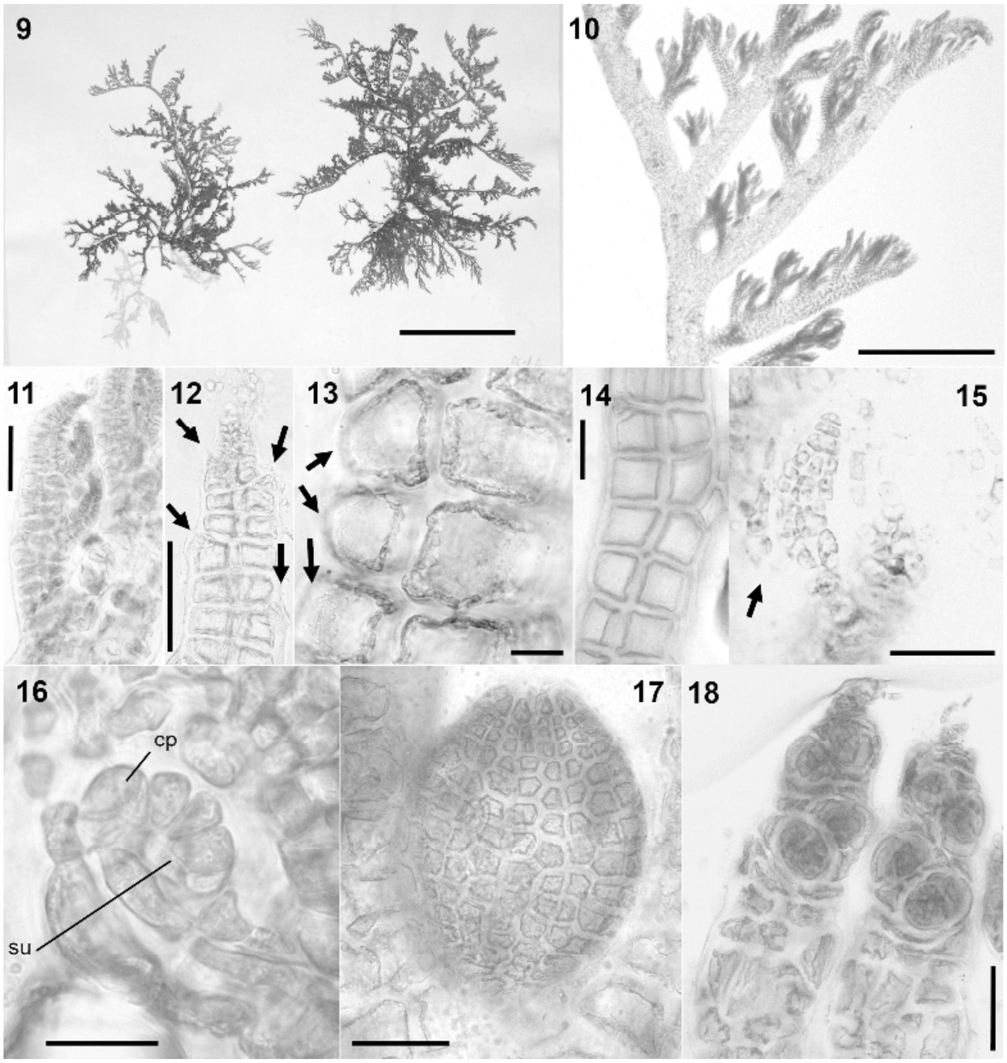


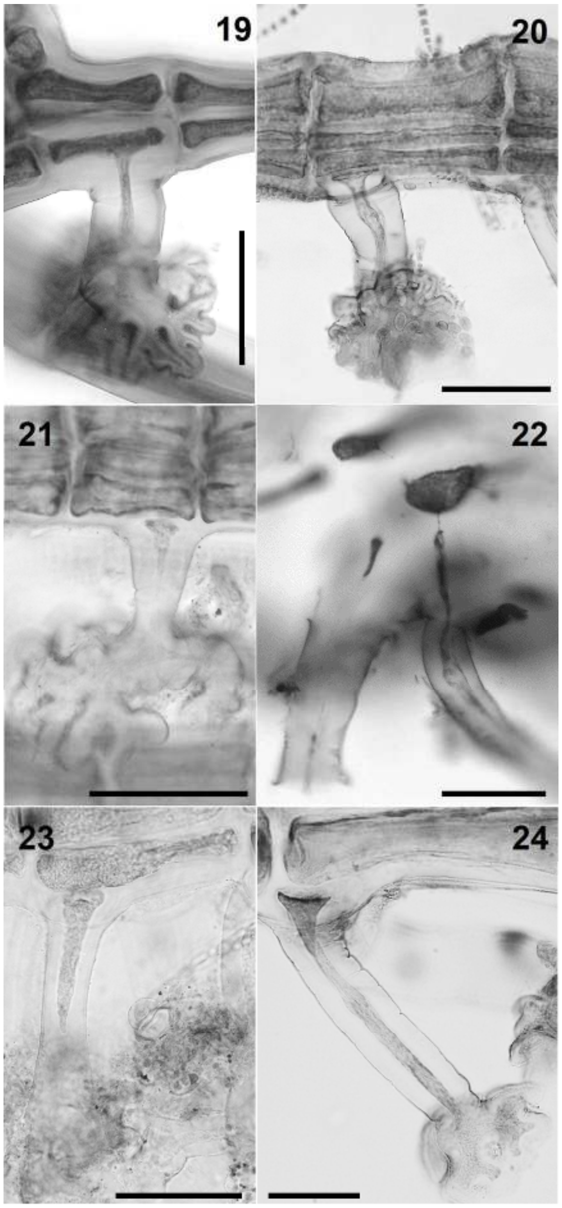
Fig. 2. Phylogenetic tree estimated with ML analysis of 18S sequences. Values at nodes indicate bootstrap support/posterior probability (only shown if > 60%/0.6 PP). Branches marked with an asterisk received 100%/1.00 PP support. Species names printed in bold correspond to type species of genera.



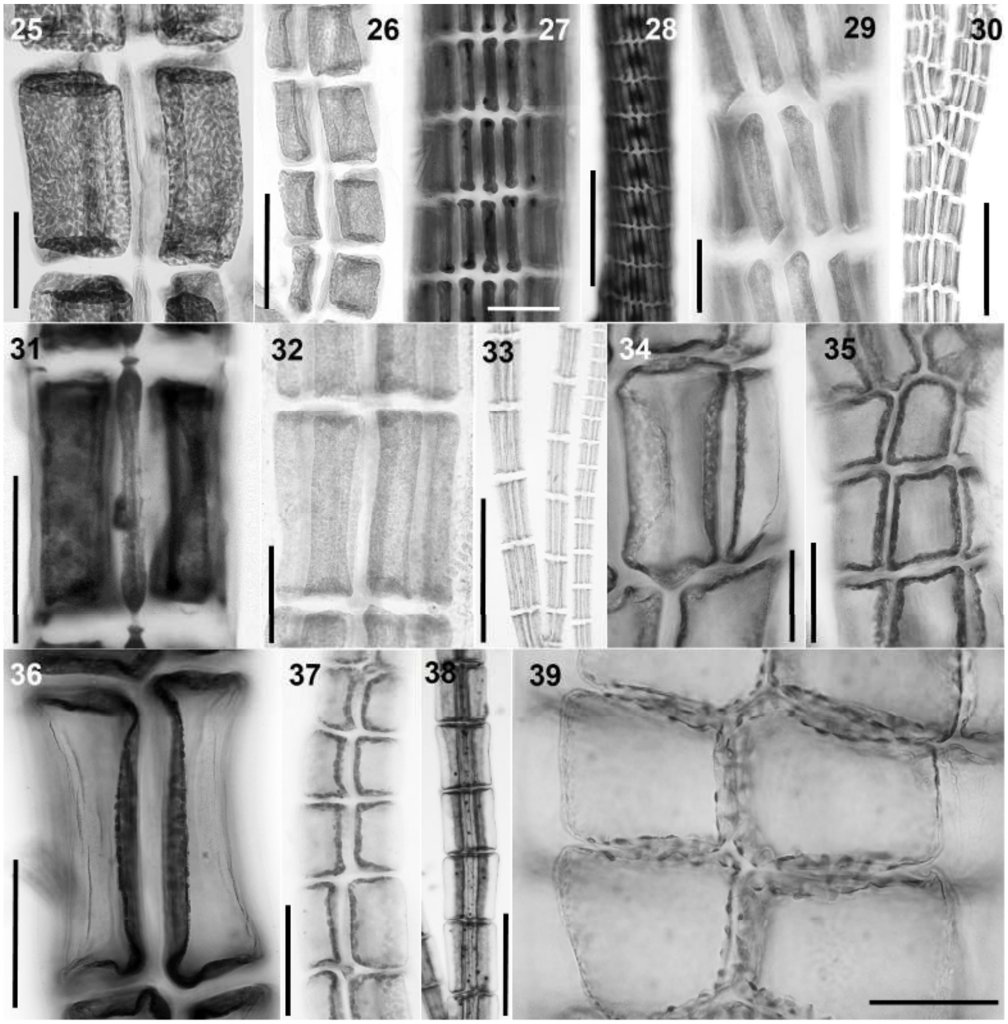
Figs 3-8. Melanothamnus somalensis, the type species of Melanothamnus. Fig. 3. Herbarium specimen MICH 662774. Fig. 4. Apical part of a specimen with alternately arranged branches. Figs 5-6. Apices of branches with (Fig. 5) or without (Fig. 6) abundant trichoblasts. Fig. 7. Apex of a lateral branch with trichoblasts. Fig. 8. Surface view of cells with the plastids lying exclusively on radial walls while the outer walls appear transparent (arrows). Scale bars: Fig. 3, 6 cm; Fig. 4, 1 mm; Figs 5 and 6, 350 μm; Fig. 7, 200 μm; Fig. 8, 100 μm.



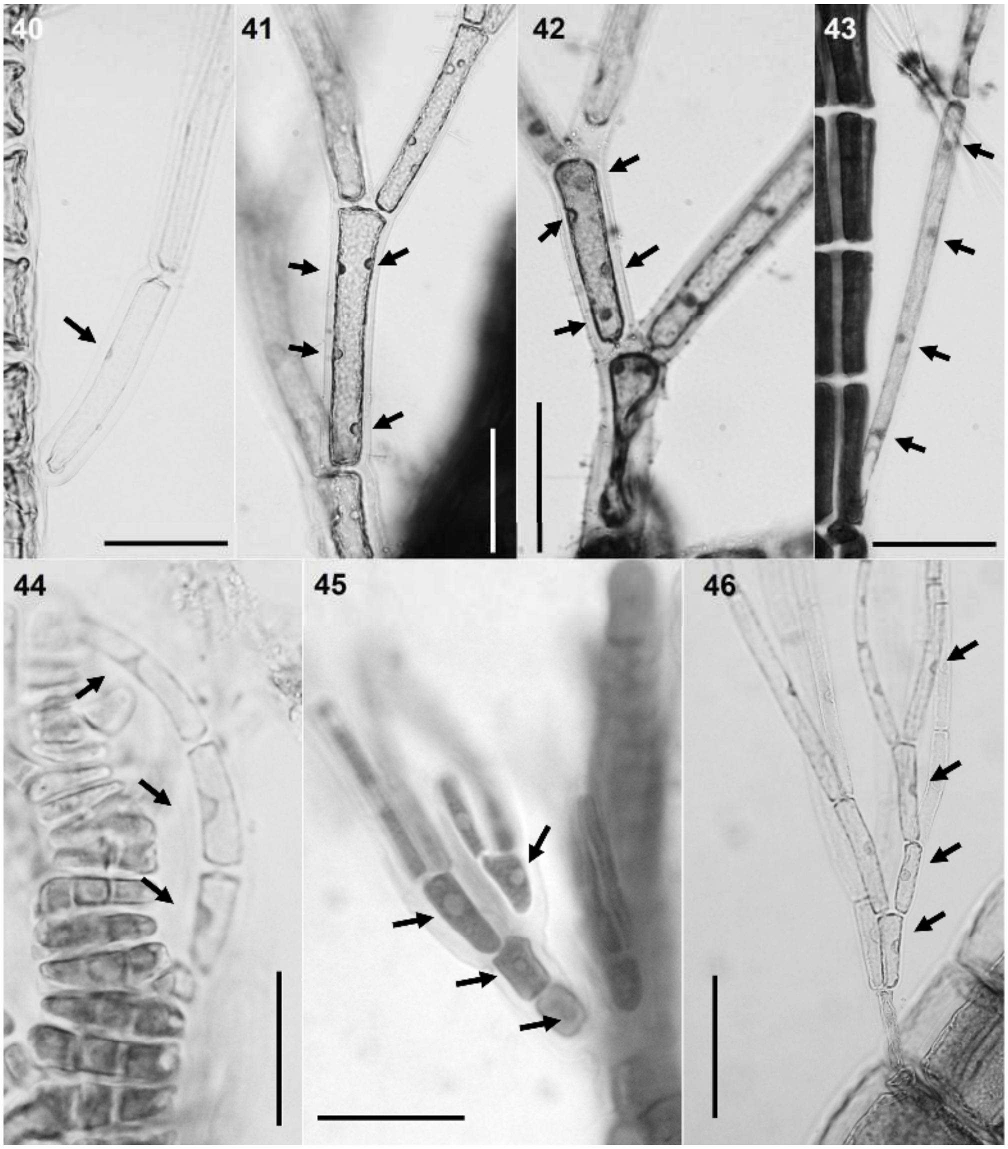
Figs 9-18. Fernandosiphonia unilateralis type material, the type species of Fernandosiphonia. Fig. 9. Herbarium specimen. Figs 10-11. Branches unilaterally arranged. Fig. 12. Axis with scar cells of trichoblasts (arrows). Figs 13-14. Surface view of pericentral cells with plastids lying only on the radial walls, so that the outer walls appear transparent (Fig. 13, arrows) and cells have a dark flank (Fig. 14). Fig. 15. Young spermatangial branch formed on the first dichotomy of a trichoblast, remaining the other vegetative branch (arrow). Fig. 16. Procarp (su = supporting cell; cp = carpogonium). Fig. 17. Cystocarp. Fig. 18. Tetrasporangia arranged in short spiral series. Scale bars: Fig. 9, 3 cm; Fig. 10, 2 mm; Fig. 11, 450 μm; Figs 12, 14, 17 and 18, 100 μm; Figs 13 and 15, 40 μm; Fig. 16, 20 μm.



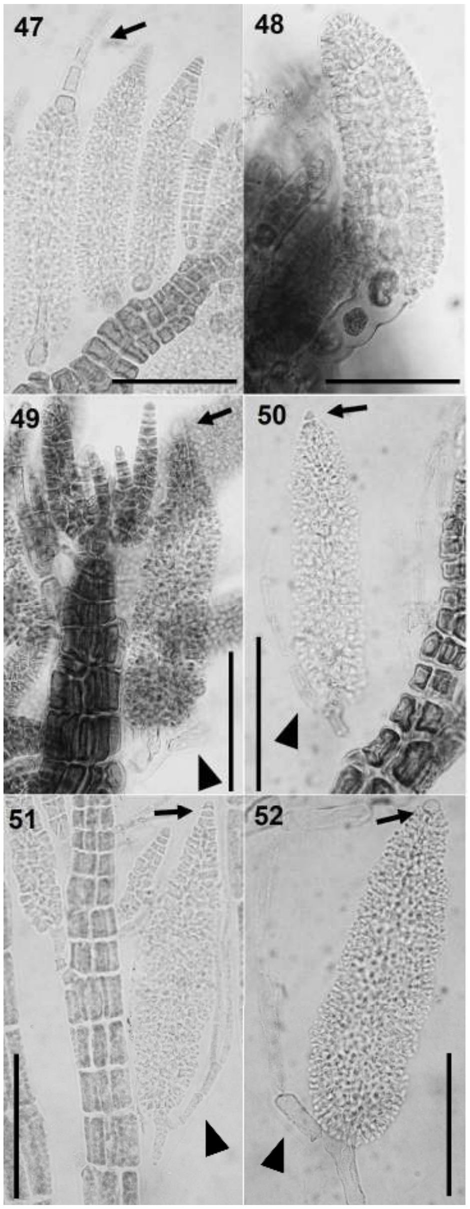
Figs 19-24. Rhizoid anatomy in the Polysiphonieae. In open connection with pericentral cells in Polysiphonia stricta (Fig. 19, Polysiphonia sensu stricto clade 1). Cut off from pericentral cells in P. foetidissima (Fig. 20, Vertebrata clade), P. denudata (Fig. 21, Carradoriella clade), Polysiphonia sp. (Fig. 22, Streblocladia clade), P. schneideri (Fig. 23, P. schneideri clade) and P. incompta (Fig. 24, Melanothamnus clade). Scale bars: Figs 19-23, 100 μm; Fig. 24, 500 μm.



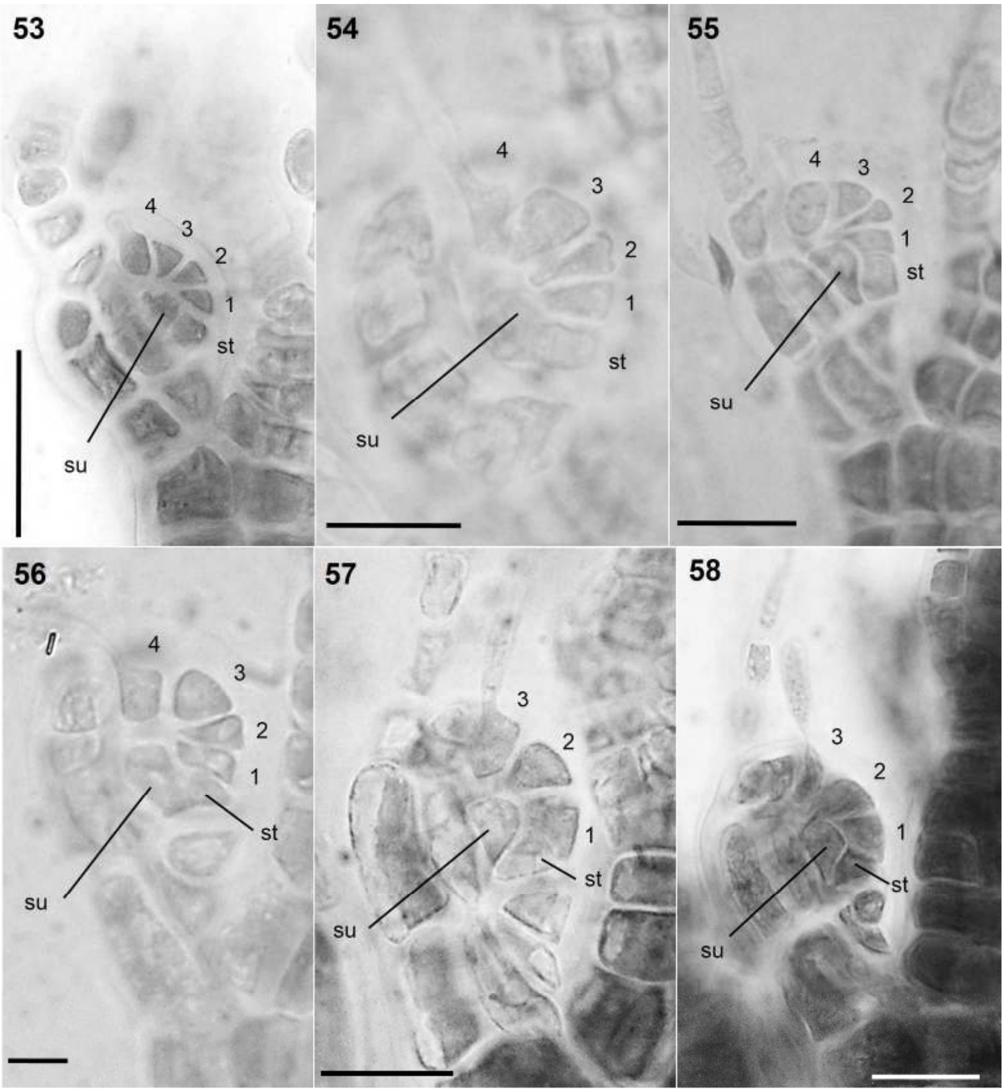
Figs 25-39. Plastid arrangement in the Polysiphonieae. Scattered against all cell walls of the pericentral cells in Polysiphonia stricta (Figs 25-26, Polysiphonia sensu stricto clade 1), Vertebrata lanosa (Figs 27-28, Vertebrata clade), P. virgata (Figs 29-30, Carradoriella clade), Polysiphonia sp. (Fig. 31, Streblocladia clade) and P. schneideri (Figs 32-33, P. schneideri clade). Lying exclusively on the radial walls of the pericentral cells in species of the Melanothamnus clade: Neosiphonia collabens (Figs 34-35), N. harveyi (Figs 36-38) and P. forfex (Fig. 39). Scale bars: Figs 25, 27, 29, 38 and 39, 500 μm; Figs 26, 28 and 30, 800 μm; Figs 31, 32, 34, 35 and 37, 100 μm; Fig. 33, 300 μm; Fig, 36, 50 μm.



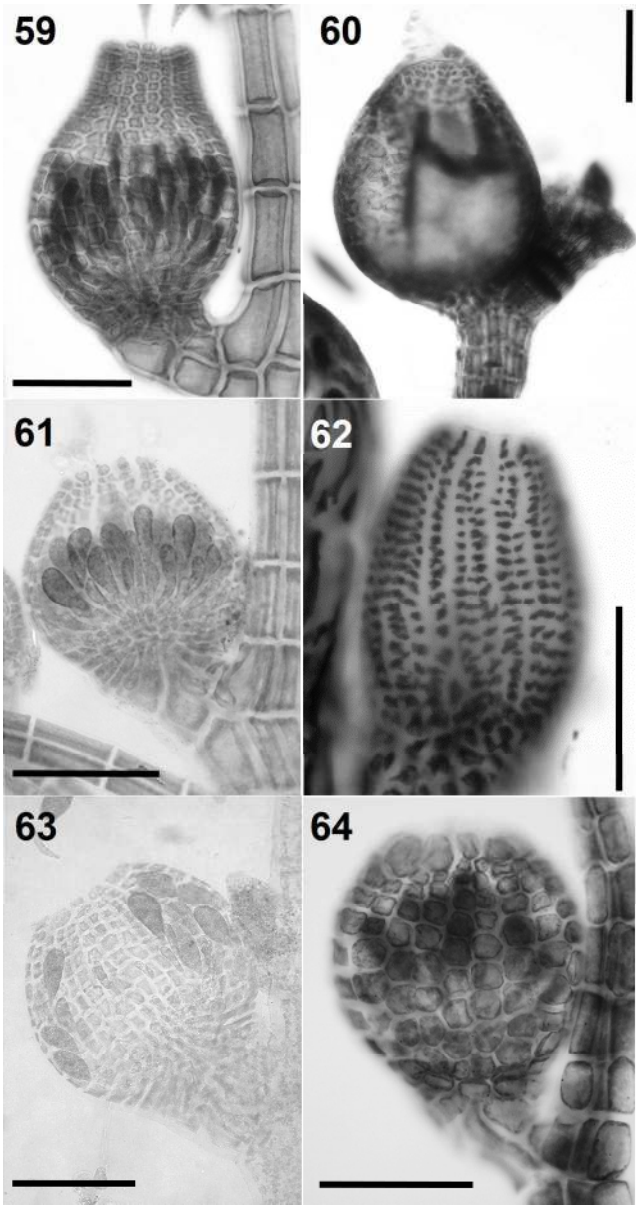
Figs 40-46. Trichoblast nuclei (arrows) in the Polysiphonieae. Uninucleate trichoblast cells in Polysiphonia scopulorum (Fig. 40, Polysiphonia sensu stricto clade 1), P. denudata (Fig. 44, Carradoriella clade), P. schneideri (Fig. 45, P. schneideri clade) and P. blandii (Fig. 46, Melanothamnus clade). Multinucleate trichoblast cells in species of the Vertebrata clade: P. nigra (Fig. 41), Boergeseniella fruticulosa (Fig. 42) and P. foetidissima (Fig. 43). Scale bars: Figs 40-43, 60 µm, Fig. 44, 30 µm; Fig. 45, 20 µm; Fig. 46, 100 µm.



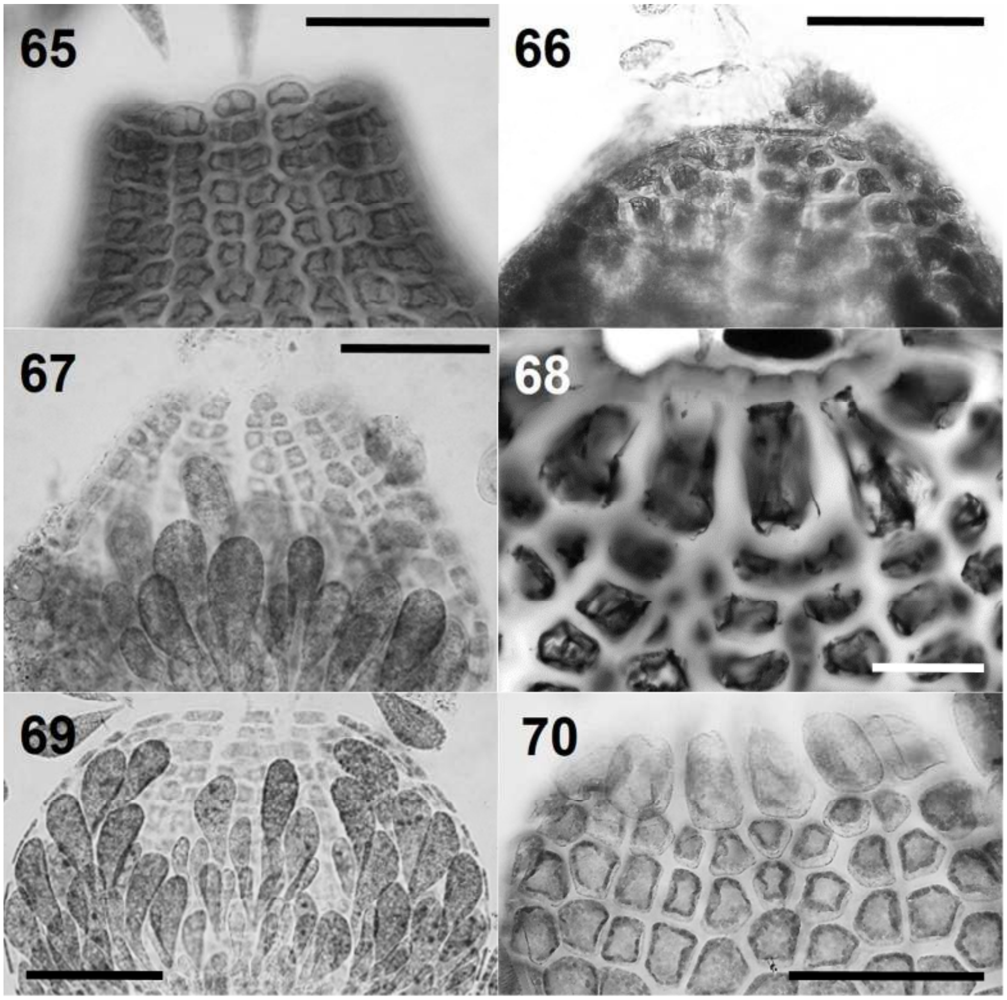
Figs 47-52. Spermatangial branches in the Polysiphonieae. Replacing trichoblasts and with sterile apical filaments in Polysiphonia stricta (Fig. 47, Polysiphonia sensu stricto clade 1). Replacing trichoblasts and lacking sterile apical cells in Vertebrata lanosa (Fig. 48, Vertebrata clade). On a branch of a trichoblast and with sterile apical cells in P. fucoides (Fig. 49, Vertebrata clade), P. denudata (Fig. 50, Carradoriella clade), P. schneideri (Fig. 51, P. schneideri clade) and Neosiphonia harveyi (Fig. 52, Melanothamnus clade). Scale bars: 100 µm. Arrows show the apical sterile cells and arrowheads the sterile branch of fertile trichoblasts.



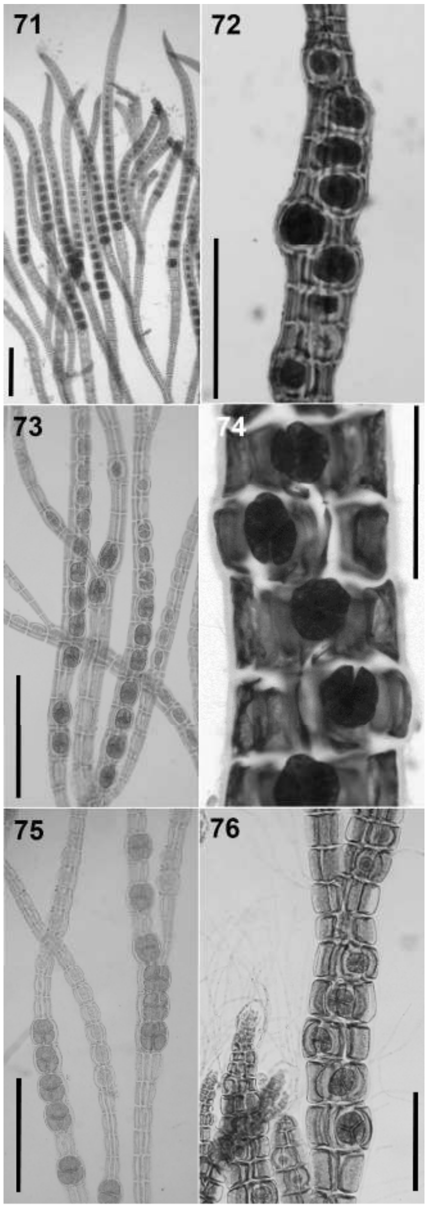
Figs 53-58. Carpogonial branches in the Polysiphonieae. Four-celled in Polysiphonia stricta (Fig. 53, Polysiphonia sensu stricto clade 1), P. nigra (Fig. 54, Vertebrata clade), P. denudata (Fig. 55, Carradoriella clade) and P. schneideri (Fig. 56, P. schneideri clade). Three-celled in species of the Melanothamnus clade: Neosiphonia harveyi (Fig. 57) and P. blandii (Fig. 58). Su = supporting cell; st = sterile basal cell; 1-4 cells of carpogonial branches. Scale bars: Fig. 53, 30 μm; Figs 54-58, 20 μm.



Figs 59-64. Cystocarps in the Polysiphonieae. Urceolate in Polysiphonia stricta (Fig. 59, Polysiphonia sensu stricto clade 1). Ovoid in Vertebrata lanosa (Fig. 60, Vertebrata clade), P. denudata (Fig. 61, Carradoriella clade), Streblocladia glomerulata (Fig. 62, Streblocladia clade). Globose in Polysiphonia schneideri (Fig. 63, P. schneideri clade) and Neosiphonia collabens (Fig. 64, Melanothamnus clade). Scale bars: Figs 59-62 and 64, 200 µm; Fig. 63, 100 µm.



Figs 65-70. Cells surrounding the ostiole in the Polysiphonieae. Similar or slightly larger than the cells of the pericarp inmediately below in Polysiphonia stricta (Fig. 65, Polysiphonia sensu stricto clade 1), Vertebrata lanosa (Fig. 66, Vertebrata clade), P. denudata (Fig. 67, Carradoriella clade), and P. schneideri (Fig. 69, P. schneideri clade). They are much larger in Streblocladia glomerulata (Fig. 68, Streblocladia clade) and Neosiphonia collabens (Fig. 70, Melanothamnus clade). Scale bars: Figs 65-68 and 70, 100 µm; Fig. 69, 60 µm.



Figs 71-76. Tetrasporangia in the Polysiphonieae. Forming long straight series in Polysiphonia stricta (Fig. 71, Polysiphonia sensu stricto clade 1). Forming spiral series in Vetebrata lanosa (Fig. 72, Vertebrata clade), Polysiphonia sp. (Fig. 74, Streblocladia clade) and Neosiphonia harveyi (Fig. 76, Melanothamnus clade). Forming short straight series in P. denudata (Fig. 73, Carradoriella clade), and P. schneideri (Fig. 75, P. schneideri clade). Scale bars: Figs 71, 74 and 76, 200 µm; Figs 72, 73 and 75, 400 µm.

Fig. 77. World map representing the proportion of Fernandosiphonia (black) and other Polysiphonieae (grey) species in selected regions where the Polysiphonieae were studied in detail. Data were obtained from the following references after updating the species names: Alaska: Lindstrom (http://www.seaweedsofalaska.com); Brazil (Espírito Santo-São Paulo): Guimâraes et al. (2004); Hawaii: Abbott (1999); Japan: Yoshida (1998); Korea: Nam & Kang (2012); Panama: Mamoozadeh & Freshwater (2012); Spain (Galicia): Bárbara et al. (2005); British Isles: Maggs & Hommersand (1993).

Table S1. Sample information for the species included in the phylogenetic analysis.

| Species (current name) | Publication or collection data and herbarium voucher for new sequences | GenBank accession number | |
|---|---|---|---|
| | | *rbc*L | SSU |
| *Boergeseniella fruticulosa* (Wulfen) Kylin | Bárbara *et al.* (2013) / Choi *et al.* (2001) | JX828161 | AF427526 |
| *Boergeseniella thuyoides* (Harvey) Kylin | Bárbara *et al.* (2013) | JX828125 | JX828165 |
| *Brongniartella australis* (C.Agardh) F.Schmitz | Pope´s Eye, Port Phillip Bay, Victoria Australia, 1.xii.2014, P. Díaz-Tapia & V. Marcelino; MEL | KX499546 | KX499570 |
| *Brongniartella byssoides* (Goodenough & Woodward) F.Schmitz | Yang *et al.* (2016) / Fanan Head, Donegal, Ireland, 15.vi.2015, P. Díaz-Tapia & C. Maggs; SANT 31111 | DQ787584 | KX499571 |
| *Bryocladia cuspidata* (J.Agardh) De Toni | Lin *et al.* (2001) | AF259498 | - |

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|---|---|---|---|
| *Ctenosiphonia hypnoides* (Welwitsch ex J.Agardh) Falkenberg | Ensenada Cegoñas, Lugo, Spain, 15.vii.2010, P. Díaz-Tapia & I. Bárbara; SANT 24410 | KX499547 | - |
| *Enelittosiphonia stimpsonii* (Harvey) Kudo & Masuda | Bárbara *et al.* (2013) / Choi *et al.* (2001) | JX828126 | AF427527 |
| *Fernandosiphonia unilateralis* Levring | Juan Fernández, Chile, E. Macayo; SANT 31104-6 | KX499549-52 | KX499572-3 |
| *Fernandosiphonia unilateralis* Levring | Type material, GB | KX499553 | - |
| *Herposiphonia parca* Setchell | Bárbara *et al.* (2013) | - | JX828166 |
| *Lampisiphonia iberica* Bárbara, Secilla, Díaz & H.-G. Choi | Bárbara *et al.* (2013) | JX828129 | JX828168 |
| *Leptosiphonia schousboei* (Thuret) Kylin | Bárbara *et al.* (2013) | JX828133 | JX828170 |
| *Lophosiphonia reptabunda* (Suhr) Kylin | Zumaia, Basque Country, Spain, 18.iii.2011, P. Díaz-Tapia & I. Bárbara; | KX499554 | KX499574 |

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|---|---|---|---|
| | SANT 25139 | | |
| *Melanothamnus somalensis* Bornet & Falkenberg | Raaha Bay, Oman, 12.ix.2001, M. Wynne; MICH 662274 | KX499555 | - |
| *Melanothamnus afaqhusainii* Bornet & Falkenberg | Savoie & Saunders (2016, as *M. somalensis*) | KU564460 | - |
| *N. teradomariensis* (M. Noda) M.S. Kim & I.K. Lee | Bárbara *et al.* (2013) | JX828136 | JX828174 |
| *Neosiphonia bajacali* (Hollenberg) N.R.Mamoozadeh & D.W.Freshwater | Mamoozadeh & Freshwater (2011) | HM573572 | HM560659 |
| *Neosiphonia baliana* D.E.Bustamante, B.Y.Won & T.O.Cho | Bustamante *et al.* (2013) | KF146879 | - |
| *Neosiphonia collabens* (C. Agardh) Díaz-Tapia & Bárbara | Bárbara *et al.* (2013, as *Streblocladia collabens*) | JX828157 | JX828188 |
| *Neosiphonia echinata* (Harvey) N.Mamoozadeh & D.W.Freshwater | Mamoozadeh & Freshwater (2011) | HM573559 | HM560658 |

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|---|---|---|---|
| *Neosiphonia ferulacea* (Suhr *ex* J.Agardh) S.M.Guimarães & M.T.Fujii | Mamoozadeh & Freshwater (2011) | HM573584 | - |
| *Neosiphonia flavimarina* M.-S.Kim & I.K.Lee | Kim & Yang (2006) | DQ787481 | - |
| *Neosiphonia harveyi* (J. Bailey) M.-S. Kim, H.-G. Choi, M.D. Guiry & G.W. Saunders | Bárbara *et al.* (2013) | JX828134 | JX828172 |
| *Neosiphonia peruviensis* D.E.Bustamante, B.Y.Won, M.E.Ramirez & T.O.Cho | Bustamante *et al.* (2012b) | JN989969 | - |
| *Neosiphonia* cf. *savatieri* (Hariot) M.S.Kim & I.K.Lee | Onno, Okinawa, Japan, 10.xi.2003, C. Trowbridge; BM | KX499558 | |
| *Neosiphonia silvae* D.E.Bustamante, B.Y.Won & T.O.Cho | Bustamante *et al.* (2013) | KF146878 | - |
| *Neosiphonia ramireziae* D.E.Bustamante, B.Y.Won & T.O.Cho | Bustamante *et al.* (2012a) | KC493352 | - |
| *Neosiphonia* sp. | Mamoozadeh & Freshwater (2011) | HM573573 | HM560649 |

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|---|---|---|---|
| *Neosiphonia sphaerocarpa* (Børgesen) M.-S.Kim & I.K.Lee | Mamoozadeh & Freshwater (2011) | HM573569 | - |
| *Neosiphonia thailandica* N.Muangmai & C.Kaewsuralikhit | Muangmai *et al.* (2014) | KM502785 | - |
| *Neosiphonia tongatensis* (Harvey ex Kützing) M.-S.Kim & I.K.Lee | Mamoozadeh & Freshwater (2011) | HM573570 | HM560642 |
| *Neosiphonia yendoi* (Segi) M.S. Kim & I.K. Lee | Bárbara *et al.* (2013) | JX828137 | JX828175 |
| *Polysiphonia amplacapilli* B.Kim & M.S.Kim | Kim & Kim (2014) | KF479253 | - |
| *Polysiphonia anomala* Hollenberg | Mamoozadeh & Freshwater (2011) | HM573550 | - |
| *Polysiphonia aterrima* J.D.Hooker & Harvey | Stuercke & Freshwater (2010) /<br>Mamoozadeh & Freshwater (2011) | GU385831 | HM560638 |
| *Polysiphonia atlantica* Kapraun & J.N. Norris | Bárbara *et al.* (2013) | JX828141 | JX828179 |
| *Polysiphonia atlantica* Kapraun & J.N. Norris | Stuercke & Freshwater (2008) /<br>Mamoozadeh & Freshwater (2011) | - | HM560631 |
| *Polysiphonia binneyi* Harvey | Mamoozadeh & Freshwater (2011) | HM573555 | HM560636 |

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|---|---|---|---|
| *Polysiphonia blandii* Harvey | Sandrigham, Port Phillip Bay, Victoria Australia, 8.i.2015, P. Díaz-Tapia & M.Brookes; SANT 31107 | KX499556 | - |
| *Polysiphonia brodiei* (Dillwyn) Sprengel | McIvor *et al.* (2001) / Bárbara *et al.* (2013) | AF342916 | JX828192 |
| *Polysiphonia ceramiiformis* P.Crouan & H.Crouan | Wembury Point, Exeter, England, UK, 23.iii.2016, P. Díaz-Tapia & C. Maggs; SANT 31108 | KX499568 | KX499575 |
| *Polysiphonia constricta* Womersley | Stuercke & Freshwater (2010) / Mamoozadeh & Freshwater (2011) | GU385832 | HM560639 |
| *Polysiphonia denudata* (Dillwyn) Grevill ex Harvey | Bárbara *et al.* (2013) | JX828143 | JX828182 |
| *Polysiphonia elongata* (Hudson) Sprengel | Bárbara *et al.* (2013) / Choi *et al.* (2001) | JX828162 | AF427529 |
| *Polysiphonia elongella* Harvey | McIvor *et al.* (2001) | AF342913 | - |

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| *Polysiphonia fibrata* (Dillwyn) Harvey | McIvor *et al.* (2001) / Kimmeridge, Dorset, England, UK, 6.vi.2015, P. Díaz-Tapia & C. Maggs; SANT 31110 | AF342915 | KX499576 |
| *Polysiphonia fibrillosa* (Dillwyn) Sprengel | McIvor *et al.* (2001) / Swangea, Dorset, England, UK, 7.vi.2015, P. Díaz-Tapia & C. Maggs; SANT 31110 | AF342912 | KX499577 |
| *Polysiphonia foetidissima* Cocks *ex* Bornet | Díaz-Tapia *et al.* (2013) | JQ653284 | - |
| *Polysiphonia forfex* Harvey | Rottnest Island, Western Australia, 15.iii.2015, P. Díaz-Tapia & J. Costa; MEL | KX499565 | - |
| *Polysiphonia freshwateri* D.Bustamante, B.Y.Won & T.O.Cho | Bustamante *et al.* (2015) | KJ957812 | - |
| *Polysiphonia fucoides* (Hudson) Sprengel | Bárbara *et al.* (2013) / Mamoozadeh & Freshwater (2011) | JX828163 | HM560627 |

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|---|---|---|---|
| *Polysiphonia furcellata* (C.Agardh) Harvey | Pwllheli, Wales, UK, 20.viii.1998, C. Maggs; BM | KX499559 | - |
| *Polysiphonia* cf. *hancockii* (Dawson) R.E.Norris | Makung, Taiwan, v.2002, M. Hommersand & S.-M. Lin; BM | KX499548 | - |
| *Polysiphonia havanensis* Montagne | Mamoozadeh & Freshwater (2011) | HM573554 | HM560641 |
| *Polysiphonia homoia* Setchell & N.L.Gardner | Mamoozadeh & Freshwater (2011) | HM573553 | HM560653 |
| *Polysiphonia incompta* Harvey | Preekstoel, Western Cape, South Africa, 25.xi.2014, K. Dixon & J. Ferreira; MEL | KX499560 | - |
| *Polysiphonia isogona* Harvey | Mamoozadeh & Freshwater (2011) / Frankston, Dave´s Bay, Port Phillip Bay, Victoria, Australia, 19.xi.2014, H. Verbruggen, MEL | HM573578 | KX499578 |
| *Polysiphonia kapraunii* B.Sturcke & D.W.Freshwater | Stuercke & Freshwater (2008) / | EU492920 | HM560630 |

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|---|---|---|---|
| | Mamoozadeh & Freshwater (2011) | | |
| *Polysiphonia lobophoralis* N.R.Mamoozadeh & D.W.Freshwater | Mamoozadeh & Freshwater (2011) | HM573551 | HM560657 |
| *Polysiphonia macrocarpa* (C.Agardh) Sprengel | Mamoozadeh & Freshwater (2011) | - | HM560632 |
| *Polysiphonia* cf. *minutissima* Hollenberg | Sunabe, Okinawa, Japan, 6.xi.2003, C. Towbridge; BM | KX499557 | - |
| *Polysiphonia morroides* B.Kim & M.S.Kim | Kim & Kim (2014) | KF479257 | - |
| *Polysiphonia morrowii* Harvey | D' Archino *et al.* (2013) / Choi *et al.* (2001) | KC152488 | AF427532 |
| *Polysiphonia muelleriana* J.Agardh | Fujii *et al.* (2006) | AY588412 | - |
| *Polysiphonia nigra* (Hudson) Batters | Bárbara *et al.* (2013) / Choi *et al.* (2001) | JX828164 | AF427534 |
| *Polysiphonia nuda* N.R.Mamoozadeh & D.W.Freshwater | Mamoozadeh & Freshwater (2011) | HM573571 | HM560648 |
| *Polysiphonia pacifica* Hollenberg | Kim *et al.* (2004) / Choi *et al.* (2001) | AY958162 | AF427533 |

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|---|---|---|---|
| *Polysiphonia paniculata* Montagne | Kim *et al.* (2004) from Chile | AY396040 | - |
| *Polysiphonia paniculata* Montagne | Zuccarello *et al.* (2004) from California | - | AY617144 |
| *Polysiphonia pentamera* Hollenberg | Mamoozadeh & Freshwater (2011) | HM573564 | HM560643 |
| *Polysiphonia pseudovillum* Hollenberg | Mamoozadeh & Freshwater (2011) | HM573568 | HM560650 |
| *Polysiphonia sabulosia* B.Kim & M.S.Kim | Kim & Kim (2014) | KF479250 | - |
| *Polysiphonia schneideri* B.Stuercke & D.W.Freshwater | Stuercke & Freshwater (2010) /<br>Mamoozadeh & Freshwater (2011) | GU385836 | HM560629 |
| *Polysiphonia scopulorum* Harvey | Bárbara *et al.* (2013) | JX828149 | JX828184 |
| *Polysiphonia scopulorum* var. *villum* (J.Agardh) Hollenberg | Mamoozadeh & Freshwater (2011) | - | HM560633 |
| *Polysiphonia sertularioides* (Grateloup) J.Agardh FL1 | Mamoozadeh & Freshwater (2011) | HM573548 | HM560646 |
| *Polysiphonia sertularioides* (Grateloup) J.Agardh FL2 | Mamoozadeh & Freshwater (2011) | HM573547 | HM560652 |
| *Polysiphonia sertularioides* (Grateloup) J.Agardh FL3 | Mamoozadeh & Freshwater (2011) | HM573546 | HM560647 |

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|---|---|---|---|
| *Polysiphonia* sp. | Carlile (2009) | GQ252567 | - |
| *Polysiphonia* sp. | Sunabe, Okinawa, Japan, 9.iii.2003, C. Trowbridge; BM | KX499561 | - |
| *Polysiphonia* sp. | Sail Rock, Taiwan, v.2002, M.H. Hommersand; BM | KX499562 | - |
| *Polysiphonia* sp. Womersley | Mamoozadeh & Freshwater (2011, as *P. pernacola*) | HM573576 | HM560637 |
| *Polysiphonia* sp. | New Zealand, W. Freshwater, WNC 34062 | KX499569 | - |
| *Polysiphonia stricta* (Dillwyn) Greville | Bárbara *et al.* (2013) / Choi *et al.* (2001) | JX828151 | AF427535 |
| *Polysiphonia strictissima* J.D.Hooker & Harvey | Stuercke & Freshwater (2010) / Mamoozadeh & Freshwater (2011) | GU385833 | - |
| *Polysiphonia subtilissima* Montagne | Lam et al. (2013) / Mamoozadeh & | JX294918 | HM560634 |

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|---|---|---|---|
| | Freshwater (2011) | | |
| *Polysiphonia subulifera* (C.Agardh) Harvey | Kingstown Bay, Co. Galway, Ireland, 22.ix.1999, C. Maggs; BM | KX499564 | - |
| *Polysiphonia tripinnata* J.Agardh | Peinzás, Lugo, Spain, 18.ix.2008, P. Díaz-Tapia & I. Bárbara; SANT 22246 | KX499566 | - |
| *Polysiphonia urbana* Harvey | Shelley Beach, Eastern Cape, South Africa, 8.xii.2014, K. Dixon & J. Ferreira; MEL | KX499567 | - |
| *Polysiphonia virgata* (C. Agardh) Sprengel | Bárbara *et al.* (2013) | JX828152 | JX828185 |
| *Xiphosiphonia pennata* (C. Agardh) Savoie & Saunders | Bárbara *et al.* (2013) | - | JX828187 |
| *Streblocladia glomerulata* (Montagne) Papenfuss | New Zealand, W. Freshwater; WNC 34061 | KX499569 | KX499579 |

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|---|---|---|---|
| *Symphyocladia latiuscula* (Harvey) Yamada | Kim *et al.* (2010) | GQ867072 | - |
| *Symphyocladia linearis* (Okamura) Falkenberg | Bárbara *et al.* (2013) | JX828158 | JX828189 |
| *Symphyocladia lithophila* M.-S.Kim | Kim *et al.* (2010) | GQ867078 | - |
| *Vertebrata lanosa* (Linneaeus) T. Christensen | Stuercke & Freshwater (2008) / Phillips *et al.* (2000) | EU492914 | AF203886 |

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Table S2. List of herbarium specimens examined for comparison with *Melanothamnus* species

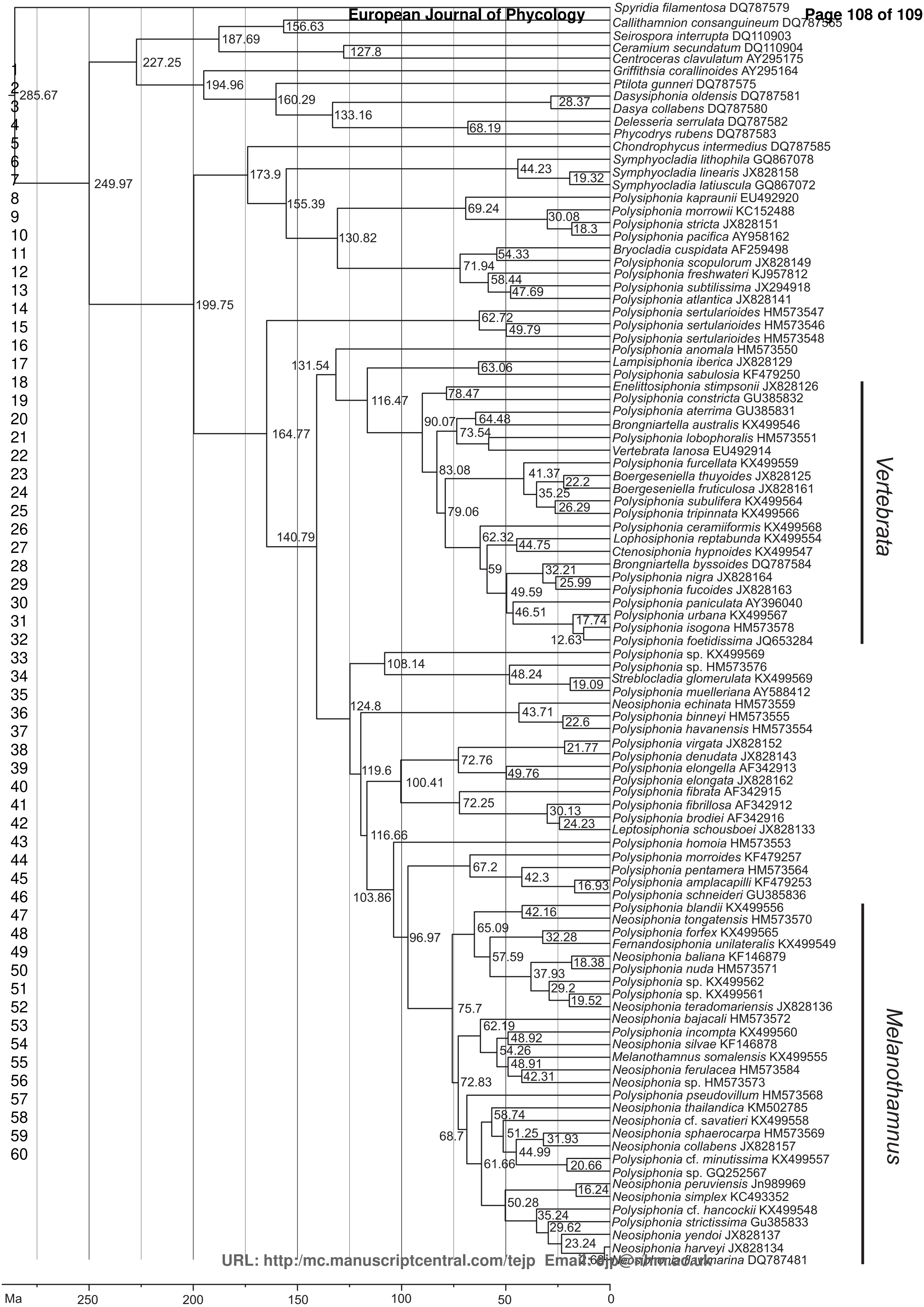
| Species | Herbarium | Code |
|---|---|---|
| *Lophosiphonia mexicana* E.Y.Dawson | US | EYD430 (66781) |
| *Polysiphonia beaudettei* Hollenberg | US | EYD21379 (5219) |
| *Polysiphonia concinna* Hollenberg | US | GJH2015 (61210) |
| *Polysiphonia eastwoodae* Setchell & N.L.Gardner | US | 55 (66788) |
| *Polysiphonia gorgoniae* Harvey | TCD | TCD0012804 |
| *Polysiphonia harlandii* Harvey | TCD | TCD0011955 |
| *Polysiphonia inconspicua* (*P. confusa* Hollenberg) | US | GJH3285 (61222) |
| *Polysiphonia johnstonii* Setchell & N.L.Gardner | US | 110 (66795) |
| *Polysiphonia poko* Hollenberg Hollenberg | US | GJH.65-82.6 (61243) |
| *Polysiphonia poko var longii* | US | 2709.1 (61230) |
| *Polysiphonia profunda* Hollenberg | US | MSD19116AI1 (61231) |
| *Polysiphonia rubrorhiza* Hollenberg | US | 18740D (48527) |

Table S3. Percentage of bases that differ (down) and are identical (above) for the species sequences of the *Melanothamnus* clade included in our *rbc*L alignment.

| | *Neosiphonia bajacali* | *Polysiphonia pseudovillum* | *Polysiphonia savatieri* | *Neosiphonia thailandica* | *Neosiphonia* sp. | *Neosiphonia silvae* | *Neosiphonia ferulacea* | *Polysiphonia* sp. | *Polysiphonia* cf. *minutissima* | *Polysiphonia blandii* | *Neosiphonia flavimarina* | *Neosiphonia harveyi* | *Neosiphonia tongatensis* | *Neosiphonia sphaerocarpa* | *Neosiphonia collabens* | *Neosiphonia peruviensis* | *Neosiphonia simplex* (as *ramirezii*) | *Neosiphonia simplex* | *Polysiphonia forfex* | *Fernandosiphonia unilateralis* | *Melanothamnus afaqhusainii* | *Melanothamnus somalensis* | *Fernandosiphonia* cf. *hancockii* | *Polysiphonia strictissima* | *Neosiphonia yendoi* | *Polysiphonia* sp. | *Neosiphonia baliana* | *Polysiphonia* sp. | *Polysiphonia nuda* | *Polysiphonia incompta* | *Neosiphonia teradomariensis* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Neosiphonia bajacali* | | 90.7 | 90.9 | 90.2 | 92.3 | 90.9 | 92.6 | 90.4 | 90.4 | 91.7 | 90.6 | 90.9 | 91.6 | 91.2 | 90.6 | 91.2 | 91.5 | 90.6 | 91 | 91.2 | 91.8 | 91.9 | 90.9 | 91.2 | 91.3 | 91.1 | 92 | 91.8 | 92.6 | 91.2 | 92.1 |
| *Polysiphonia pseudovillum* | 9.3 | | 91.9 | 92.8 | 92 | 92.4 | 92.8 | 92.4 | 92.1 | 93.1 | 92.2 | 92.4 | 92.4 | 92.2 | 92.4 | 93 | 93 | 91.7 | 92.8 | 92.4 | 93.1 | 93.3 | 92.1 | 93.2 | 92.3 | 91.4 | 92.3 | 92.6 | 92.8 | 91.8 | 92.8 |
| *Polysiphonia savatieri* | 9.1 | 8.1 | | 91.7 | 91.5 | 91.7 | 92.7 | 93.3 | 93.4 | 91.4 | 93 | 93.1 | 91.7 | 93.6 | 92.9 | 92.5 | 92 | 91.4 | 91.8 | 92.2 | 91.4 | 92.1 | 92.4 | 92.2 | 93.2 | 91.7 | 91.6 | 91.9 | 92.7 | 90.6 | 92.5 |
| *Neosiphonia thailandica* | 9.8 | 7.2 | 8.3 | | 92.4 | 92.6 | 92.5 | 93.1 | 92.5 | 93 | 92.4 | 92.9 | 91.7 | 92.7 | 93.3 | 93.2 | 92.7 | 90.5 | 92.3 | 92 | 92.1 | 92 | 91.8 | 92.8 | 93.5 | 91.7 | 91.8 | 92.9 | 92.9 | 91 | 93.1 |
| *Neosiphonia* sp. | 7.7 | 8 | 8.5 | 7.6 | | 92.8 | 93.6 | 91.8 | 91.3 | 92.6 | 92 | 92.2 | 92.7 | 92.5 | 92.6 | 92.4 | 92.2 | 91.4 | 92.2 | 91.4 | 93.3 | 93.5 | 92 | 92.5 | 92.3 | 91.5 | 91.4 | 92.8 | 92.9 | 92.4 | 92.9 |
| *Neosiphonia silvae* | 9.1 | 7.6 | 8.3 | 7.4 | 7.2 | | 92.8 | 92.7 | 92 | 92.8 | 91.9 | 92.2 | 92.4 | 92.1 | 91.8 | 93.1 | 92.9 | 92.2 | 91.8 | 91.2 | 93.6 | 93.7 | 91.4 | 91.9 | 92.4 | 90.7 | 91.7 | 91.7 | 91.9 | 92.5 | 92.1 |
| *Neosiphonia ferulacea* | 7.4 | 7.2 | 7.3 | 7.5 | 6.4 | 7.2 | | 92 | 91.8 | 93.8 | 92.9 | 92.9 | 93.3 | 92.6 | 92.3 | 93.3 | 93.2 | 90.9 | 93.2 | 93.1 | 94 | 94.1 | 92.6 | 92.8 | 93.1 | 92 | 92.6 | 93.3 | 93.5 | 93 | 93.7 |
| *Polysiphonia sp.* | 9.6 | 7.6 | 6.7 | 6.9 | 8.2 | 7.3 | 8 | | 96.5 | 92 | 92.7 | 93.5 | 92.2 | 94 | 94.3 | 94 | 93.5 | 91.5 | 92.6 | 92.3 | 91.6 | 92.5 | 92.7 | 92.6 | 93.3 | 92 | 93.1 | 92.9 | 92.5 | 91.8 | 93.8 |
| *Polysiphonia* cf. *minutissima* | 9.6 | 7.9 | 6.6 | 7.5 | 8.7 | 8 | 8.2 | 3.5 | | 91.7 | 91.9 | 92.3 | 92 | 93.5 | 93.2 | 92.7 | 91.9 | 91.4 | 91.5 | 91.8 | 91.4 | 91.7 | 91.9 | 91.3 | 92.6 | 91 | 91.1 | 91.4 | 92.2 | 90.2 | 92.1 |
| *Polysiphonia blandii* | 8.3 | 6.9 | 8.6 | 7 | 7.4 | 7.2 | 6.2 | 8 | 8.3 | | 91.8 | 92.3 | 95.8 | 92.1 | 91.9 | 93 | 92.6 | 90.9 | 94 | 92.1 | 92.8 | 92.6 | 92.2 | 92.8 | 93.3 | 92.3 | 91.7 | 93.4 | 93.3 | 93.3 | 93.4 |
| *Neosiphonia flavimarina* | 9.4 | 7.8 | 7 | 7.6 | 8 | 8.1 | 7.1 | 7.3 | 8.1 | 8.2 | | 99.6 | 93.7 | 92.8 | 93.4 | 93.7 | 93.7 | 92.5 | 92.9 | 93.4 | 92.4 | 92.9 | 95.7 | 96.1 | 95.8 | 91.6 | 92.4 | 92.7 | 93.2 | 91.6 | 93.7 |
| *Neosiphonia harveyi* | 9.1 | 7.6 | 6.9 | 7.1 | 7.8 | 7.8 | 7.1 | 6.5 | 7.7 | 7.7 | 0.4 | | 93.9 | 93 | 94.3 | 94.2 | 94 | 92.8 | 93.3 | 93.3 | 92.5 | 93.3 | 95.8 | 96.7 | 96.7 | 91.9 | 93.5 | 92.9 | 93.1 | 92 | 94.3 |
| *Neosiphonia tongatensis* | 8.4 | 7.6 | 8.3 | 8.3 | 7.3 | 7.6 | 6.7 | 7.8 | 8 | 4.2 | 6.3 | 6.1 | | 92.1 | 92.4 | 93.5 | 93.3 | 91.9 | 93 | 92.7 | 93.2 | 93.3 | 93.1 | 93.6 | 93.4 | 92.9 | 93.7 | 94.2 | 94.1 | 91.9 | 94.3 |
| *Neosiphonia sphaerocarpa* | 8.8 | 7.8 | 6.4 | 7.3 | 7.5 | 7.9 | 7.4 | 6 | 6.5 | 7.9 | 7.2 | 7 | 7.9 | | 95.5 | 93.7 | 93.6 | 92.7 | 93.2 | 92.5 | 92.3 | 93 | 93.4 | 93 | 93.7 | 92.6 | 91.8 | 93.2 | 93 | 91.8 | 93.6 |
| *Neosiphonia collabens* | 9.4 | 7.6 | 7.1 | 6.7 | 7.4 | 8.2 | 7.7 | 5.7 | 6.8 | 8.1 | 6.6 | 5.7 | 7.6 | 4.5 | | 94.1 | 93.5 | 92.5 | 93.1 | 91.8 | 92 | 92.5 | 93.4 | 93.4 | 94.5 | 92 | 92.5 | 93 | 92.7 | 92.3 | 94.1 |
| *Neosiphonia peruviensis* | 8.8 | 7 | 7.5 | 6.8 | 7.6 | 6.9 | 6.7 | 6 | 7.3 | 7 | 6.3 | 5.8 | 6.5 | 6.3 | 5.9 | | 97.8 | 96.6 | 93.5 | 93.1 | 92.7 | 93.4 | 94.3 | 95 | 94.2 | 91.9 | 93.3 | 93.7 | 93.4 | 92.2 | 94.5 |
| *Neosiphonia simplex* (as *ramirezii*) | 8.5 | 7 | 8 | 7.3 | 7.8 | 7.1 | 6.8 | 6.5 | 8.1 | 7.4 | 6.3 | 6 | 6.7 | 6.4 | 6.5 | 2.2 | | 99 | 93.5 | 93.7 | 92.7 | 93.4 | 93.8 | 95 | 93.5 | 91.4 | 93 | 93.6 | 92.7 | 92.4 | 93.7 |
| *Neosiphonia simplex* | 9.4 | 8.3 | 8.6 | 9.5 | 8.6 | 7.8 | 8.1 | 8.5 | 8.6 | 9.1 | 7.5 | 7.2 | 8.1 | 7.3 | 7.5 | 3.4 | 1 | | 92.2 | 92.7 | 91.7 | 92.5 | 92.2 | 93.7 | 92.1 | 89.9 | 91.1 | 91.8 | 91.7 | 92.1 | 91.7 |
| *Polysiphonia forfex* | 9 | 7.2 | 8.2 | 7.7 | 7.8 | 8.2 | 6.8 | 7.4 | 8.5 | 6 | 7.1 | 6.7 | 7 | 6.8 | 6.9 | 6.5 | 6.5 | 7.8 | | 95.3 | 92.6 | 93.1 | 92.8 | 93.4 | 93.8 | 92.3 | 93.5 | 94.2 | 93.3 | 91.8 | 94.8 |
| *Fernandosiphonia unilateralis* | 8.8 | 7.6 | 7.8 | 8 | 8.6 | 8.8 | 6.9 | 7.7 | 8.2 | 7.9 | 6.6 | 6.7 | 7.3 | 7.5 | 8.2 | 6.9 | 6.3 | 7.3 | 4.7 | | 91.3 | 91.9 | 92.8 | 93.2 | 93.4 | 91.4 | 93.5 | 93 | 92.9 | 91.2 | 93.4 |
| *Melanothamnus afaqhusainii* | 8.2 | 6.9 | 8.6 | 7.9 | 6.7 | 6.4 | 6 | 8.4 | 8.6 | 7.2 | 7.6 | 7.5 | 6.8 | 7.7 | 8 | 7.3 | 7.3 | 8.3 | 7.4 | 8.7 | | 98.6 | 91.9 | 92.7 | 92.4 | 91.6 | 92.9 | 93.7 | 93.2 | 93.1 | 93.3 |
| *Melanothamnus somalensis* | 8.1 | 6.7 | 7.9 | 8 | 6.5 | 6.3 | 5.9 | 7.5 | 8.3 | 7.4 | 7.1 | 6.7 | 6.7 | 7 | 7.5 | 6.6 | 6.6 | 7.5 | 6.9 | 8.1 | 1.4 | | 92.7 | 93.5 | 93 | 92 | 93.2 | 94.1 | 93.5 | 93.5 | 94.1 |
| *Fernandosiphonia* cf. *hancockii* | 9.1 | 7.9 | 7.6 | 8.2 | 8 | 8.6 | 7.4 | 7.3 | 8.1 | 7.8 | 4.3 | 4.2 | 6.9 | 6.6 | 6.6 | 5.7 | 6.2 | 7.8 | 7.2 | 7.2 | 8.1 | 7.3 | | 95.5 | 95.3 | 91.7 | 92.5 | 93 | 93 | 91.2 | 93.4 |
| *Polysiphonia strictissima* | 8.8 | 6.8 | 7.8 | 7.2 | 7.5 | 8.1 | 7.2 | 7.4 | 8.7 | 7.2 | 3.9 | 3.3 | 6.4 | 7 | 6.6 | 5 | 5 | 6.3 | 6.6 | 6.8 | 7.3 | 6.5 | 4.5 | | 96.1 | 91.3 | 93.8 | 93.3 | 93.2 | 92.2 | 93.9 |
| *Neosiphonia yendoi* | 8.7 | 7.7 | 6.8 | 6.5 | 7.7 | 7.6 | 6.9 | 6.7 | 7.4 | 6.7 | 4.2 | 3.3 | 6.6 | 6.3 | 5.5 | 5.8 | 6.5 | 7.9 | 6.2 | 6.6 | 7.6 | 7 | 4.7 | 3.9 | | 91.5 | 93.3 | 92.7 | 93.2 | 92.5 | 94.1 |
| *Polysiphonia* sp. | 8.9 | 8.6 | 8.3 | 8.3 | 8.5 | 9.3 | 8 | 8 | 9 | 7.7 | 8.4 | 8.1 | 7.1 | 7.4 | 8 | 8.1 | 8.6 | 10.1 | 7.7 | 8.6 | 8.4 | 8 | 8.3 | 8.7 | 8.5 | | 93.8 | 95.8 | 94.5 | 90.3 | 95.3 |
| *Neosiphonia baliana* | 8 | 7.7 | 8.4 | 8.2 | 8.6 | 8.3 | 7.4 | 6.9 | 8.9 | 8.3 | 7.6 | 6.5 | 6.3 | 8.2 | 7.5 | 6.7 | 7 | 8.9 | 6.5 | 6.5 | 7.1 | 6.8 | 7.5 | 6.2 | 6.7 | 6.2 | | 95.6 | 97.4 | 91.4 | 96 |
| *Polysiphonia* sp. | 8.2 | 7.4 | 8.1 | 7.1 | 7.2 | 8.3 | 6.7 | 7.1 | 8.6 | 6.6 | 7.3 | 7.1 | 5.8 | 6.8 | 7 | 6.3 | 6.4 | 8.2 | 5.8 | 7 | 6.3 | 5.9 | 7 | 6.7 | 7.3 | 4.2 | 4.4 | | 96 | 92 | 97.9 |
| *Polysiphonia nuda* | 7.4 | 7.2 | 7.3 | 7.1 | 7.1 | 8.1 | 6.5 | 7.5 | 7.8 | 6.7 | 6.8 | 6.9 | 5.9 | 7 | 7.3 | 6.6 | 7.3 | 8.3 | 6.7 | 7.1 | 6.8 | 6.5 | 7 | 6.8 | 6.8 | 5.5 | 2.6 | 4 | | 92.4 | 96 |
| *Polysiphonia incompta* | 8.8 | 8.2 | 9.4 | 9 | 7.6 | 7.5 | 7 | 8.2 | 9.8 | 6.7 | 8.4 | 8 | 8.1 | 8.2 | 7.7 | 7.8 | 7.6 | 7.9 | 8.2 | 8.8 | 6.9 | 6.5 | 8.8 | 7.8 | 7.5 | 9.7 | 8.6 | 8 | 7.6 | | 92.5 |
| *Neosiphonia teradomariensis* | 7.9 | 7.2 | 7.5 | 6.9 | 7.1 | 7.9 | 6.3 | 6.2 | 7.9 | 6.6 | 6.3 | 5.7 | 5.7 | 6.4 | 5.9 | 5.5 | 6.3 | 8.3 | 5.2 | 6.6 | 6.7 | 5.9 | 6.6 | 6.1 | 5.9 | 4.7 | 4 | 2.1 | 4 | 7.5 | |

Table S4. Percentage of bases that differ (down) and are identical (above) for the species sequences of the *Vertebrata* clade included in our *rbc*L alignment.

| | *Vertebrata lanosa* | *Enelittosiphonia stimpsonii* | *Polysiphonia constricta* | *Polysiphonia aterrima* | *Polysiphonia lobophoralis* | *Boergeseniella fruticulosa* | *Boergeseniella thuyoides* | *Polysiphonia tripinnata* | *Polysiphonia furcellata* | *Polysiphonia subulifera* | *Brongniartella australis* | *Ctenosiphonia hypnoides* | *Lophosiphonia reptabunda* | *Polysphonia simulans* | *Polysiphonia urbana* | *Polysiphonia foetidissima* | *Polysiphonia isogona* | *Polysiphonia paniculata* | *Polysiphonia fucoides* | *Brongniartella byssoides* | *Polysiphonia nigra* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Vertebrata lanosa* | | 89.8 | 90.3 | 91.4 | 91.7 | 90.8 | 91.2 | 91.5 | 90.5 | 90 | 91.9 | 90.2 | 89.8 | 90.9 | 91.6 | 91.9 | 91.6 | 91.4 | 91 | 91.3 | 91.2 |
| *Enelittosiphonia stimpsonii* | 10.2 | | 91.1 | 90.9 | 91.3 | 91.5 | 91.3 | 92.3 | 91.4 | 90.7 | 93.1 | 91.5 | 90.7 | 90.1 | 92.2 | 91.6 | 91.7 | 92.2 | 90.7 | 92.3 | 91.2 |
| *Polysiphonia constricta* | 9.7 | 8.9 | | 91 | 91.2 | 91.6 | 91.8 | 91.7 | 91 | 90.7 | 92.2 | 91.1 | 90.4 | 91.3 | 92.7 | 92.5 | 92 | 91.5 | 91.1 | 91.6 | 91.4 |
| *Polysiphonia aterrima* | 8.6 | 9.1 | 9 | | 92.4 | 91.6 | 92.2 | 91.7 | 92.2 | 91.4 | 93.2 | 90.9 | 90.8 | 91.6 | 92.6 | 92.2 | 92.8 | 92.1 | 91.7 | 91.7 | 91.6 |
| *Polysiphonia lobophoralis* | 8.3 | 8.7 | 8.8 | 7.6 | | 91.7 | 92.7 | 90.5 | 90.9 | 90.8 | 93.4 | 90.5 | 91 | 91.6 | 91.7 | 91.5 | 91.3 | 90.7 | 90.3 | 91 | 91.1 |
| *Boergeseniella fruticulosa* | 9.2 | 8.5 | 8.4 | 8.4 | 8.3 | | 97.4 | 96.6 | 95.3 | 95.4 | 93.6 | 91.9 | 91.4 | 92 | 92.9 | 92.4 | 92.1 | 92.2 | 92 | 92.8 | 92.5 |
| *Boergeseniella thuyoides* | 8.8 | 8.7 | 8.2 | 7.8 | 7.3 | 2.6 | | 96.4 | 96.1 | 95.5 | 94.6 | 92.2 | 91.5 | 92.9 | 94 | 93.5 | 93 | 92.8 | 92.4 | 93.1 | 93.3 |
| *Polysiphonia tripinnata* | 8.5 | 7.7 | 8.3 | 8.3 | 9.5 | 3.4 | 3.6 | | 95.7 | 96.3 | 93.8 | 92.3 | 90.5 | 93.6 | 94.5 | 94.1 | 94.5 | 93.3 | 93.8 | 94.1 | 94.1 |
| *Polysiphonia furcellata* | 9.5 | 8.6 | 9 | 7.8 | 9.1 | 4.7 | 3.9 | 4.3 | | 94.7 | 93.4 | 91.7 | 90.5 | 92 | 93.5 | 92.9 | 92.4 | 92 | 91.5 | 92.4 | 92.2 |
| *Polysiphonia subulifera* | 10 | 9.3 | 9.3 | 8.6 | 9.2 | 4.6 | 4.5 | 3.7 | 5.3 | | 92.9 | 91.6 | 90 | 91.4 | 92.8 | 91.9 | 91.5 | 90.9 | 91.2 | 91.7 | 91.6 |
| *Brongniartella australis* | 8.1 | 6.9 | 7.8 | 6.8 | 6.6 | 6.4 | 5.4 | 6.2 | 6.6 | 7.1 | | 92.6 | 92.1 | 92.4 | 94.6 | 94 | 94 | 93.3 | 92.5 | 93.5 | 93.5 |
| *Ctenosiphonia hypnoides* | 9.8 | 8.5 | 8.9 | 9.1 | 9.5 | 8.1 | 7.8 | 7.7 | 8.3 | 8.4 | 7.4 | | 92.3 | 92.4 | 93.4 | 93.1 | 92.8 | 92.5 | 92.2 | 92.8 | 92.5 |
| *Lophosiphonia reptabunda* | 10.2 | 9.3 | 9.6 | 9.2 | 9 | 8.6 | 8.5 | 9.5 | 9.5 | 10 | 7.9 | 7.7 | | 92 | 92.8 | 92.2 | 92.4 | 92.2 | 91.4 | 92.1 | 92.3 |
| *Polysphonia simulans* | 9.1 | 9.9 | 8.7 | 8.4 | 8.4 | 8 | 7.1 | 6.4 | 8 | 8.6 | 7.6 | 7.6 | 8 | | 94.2 | 93.8 | 93.5 | 93.9 | 94.2 | 94.8 | 94.8 |
| *Polysiphonia urbana* | 8.4 | 7.8 | 7.3 | 7.4 | 8.3 | 7.1 | 6 | 5.5 | 6.5 | 7.2 | 5.4 | 6.6 | 7.2 | 5.8 | | 97.9 | 97.4 | 94.7 | 94.5 | 95.3 | 95.2 |
| *Polysiphonia foetidissima* | 8.1 | 8.4 | 7.5 | 7.8 | 8.5 | 7.6 | 6.5 | 5.9 | 7.1 | 8.1 | 6 | 6.9 | 7.8 | 6.2 | 2.1 | | 98.1 | 94.9 | 94.3 | 95.2 | 95.4 |
| *Polysiphonia isogona* | 8.4 | 8.3 | 8 | 7.2 | 8.7 | 7.9 | 7 | 5.5 | 7.6 | 8.5 | 6 | 7.2 | 7.6 | 6.5 | 2.6 | 1.9 | | 95.1 | 94.2 | 94.8 | 95.2 |
| *Polysiphonia paniculata* | 8.6 | 7.8 | 8.5 | 7.9 | 9.3 | 7.8 | 7.2 | 6.7 | 8 | 9.1 | 6.7 | 7.5 | 7.8 | 6.1 | 5.3 | 5.1 | 4.9 | | 94.3 | 95 | 95.5 |
| *Polysiphonia fucoides* | 9 | 9.3 | 8.9 | 8.3 | 9.7 | 8 | 7.6 | 6.2 | 8.5 | 8.8 | 7.5 | 7.8 | 8.6 | 5.8 | 5.5 | 5.7 | 5.8 | 5.7 | | 95.7 | 96.4 |
| *Brongniartella byssoides* | 8.7 | 7.7 | 8.4 | 8.3 | 9 | 7.2 | 6.9 | 5.9 | 7.6 | 8.3 | 6.5 | 7.2 | 7.9 | 5.2 | 4.7 | 4.8 | 5.2 | 5 | 4.3 | | 96.5 |
| *Polysiphonia nigra* | 8.8 | 8.8 | 8.6 | 8.4 | 8.9 | 7.5 | 6.7 | 5.9 | 7.8 | 8.4 | 6.5 | 7.5 | 7.7 | 5.2 | 4.8 | 4.6 | 4.8 | 4.5 | 3.6 | 3.5 | |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Callithamnion consanguineum DQ787565
Seirospora interrupta DQ110903
Ceramium secundatum DQ110904
Centroceras clavulatum AY295175
Griffithsia corallinoides AY295164
Ptilota gunneri DQ787575
Dasysiphonia oldensis DQ787581
Dasya collabens DQ787580
Delesseria serrulata DQ787582
Phycodrys rubens DQ787583
Chondrophycus intermedius DQ787585
Symphyocladia lithophila GQ867078
Symphyocladia linearis JX828158
Symphyocladia latiuscula GQ867072
Polysiphonia kapraunii EU492920
Polysiphonia morrowii KC152488
Polysiphonia stricta JX828151
Polysiphonia pacifica AY958162
Bryocladia cuspidata AF259498
Polysiphonia scopulorum JX828149
Polysiphonia freshwateri KJ957812
Polysiphonia subtilissima JX294918
Polysiphonia atlantica JX828141
Polysiphonia sertularioides HM573547
Polysiphonia sertularioides HM573546
Polysiphonia sertularioides HM573548
Polysiphonia anomala HM573550
Lampisiphonia iberica JX828129
Polysiphonia sabulosa KF479250
Enelittosiphonia stimpsonii JX828126
Polysiphonia constricta GU385832
Polysiphonia aterrima GU385831
Brongniartella australis KX499546
Polysiphonia lobophoralis HM573551
Vertebrata lanosa EU492914
Polysiphonia furcellata KX499559
Boergeseniella thuyoides JX828125
Boergeseniella fruticulosa JX828161
Polysiphonia subulifera KX499564
Polysiphonia tripinnata KX499566
Polysiphonia ceramiiformis KX499568
Lophosiphonia reptabunda KX499554
Ctenosiphonia hypnoides KX499547
Brongniartella byssoides DQ787584
Polysiphonia nigra JX828164
Polysiphonia fucoides JX828163
Polysiphonia paniculata AY396040
Polysiphonia urbana KX499567
Polysiphonia isogona HM573578
Polysiphonia foetidissima JQ653284
Polysiphonia sp. KX499569
Polysiphonia sp. HM573576
Streblocladia glomerulata KX499569
Polysiphonia muelleriana AY588412
Neosiphonia echinata HM573559
Polysiphonia binneyi HM573555
Polysiphonia havanensis HM573554
Polysiphonia virgata JX828152
Polysiphonia denudata JX828143
Polysiphonia elongella AF342913
Polysiphonia elongata JX828162
Polysiphonia fibrata AF342915
Polysiphonia fibrillosa AF342912
Polysiphonia brodiei AF342916
Leptosiphonia schousboei JX828133
Polysiphonia homoia HM573553
Polysiphonia morroides KF479257
Polysiphonia pentamera HM573564
Polysiphonia amplacapilli KF479253
Polysiphonia schneideri GU385836
Polysiphonia blandii KX499556
Neosiphonia tongatensis HM573570
Polysiphonia forfex KX499565
Fernandosiphonia unilateralis KX499549
Neosiphonia baliana KF146879
Polysiphonia nuda HM573571
Polysiphonia sp. KX499562
Polysiphonia sp. KX499561
Neosiphonia teradomariensis JX828136
Neosiphonia bajacali HM573572
Polysiphonia incompta KX499560
Neosiphonia silvae KF146878
Melanothamnus somalensis KX499555
Neosiphonia ferulacea HM573584
Neosiphonia sp. HM573573
Polysiphonia pseudovillum HM573568
Neosiphonia thailandica KM502785
Neosiphonia cf. savatieri KX499558
Neosiphonia sphaerocarpa HM573569
Neosiphonia collabens JX828157
Polysiphonia cf. minutissima KX499557
Polysiphonia sp. GQ252567
Neosiphonia peruviensis Jn989969
Neosiphonia simplex KC493352
Polysiphonia cf. hancockii KX499548
Polysiphonia strictissima Gu385833
Neosiphonia yendoi JX828137
Neosiphonia harveyi JX828134
Neosiphonia flavimarina DQ787481
Vertebrata
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187.69
156.63
127.8
194.96
160.29
28.37
133.16
68.19
199.75
173.9
44.23
19.32
155.39
69.24
30.08
18.3
130.82
54.33
71.94
58.44
47.69
164.77
62.72
49.79
131.54
63.06
116.47
78.47
90.07
64.48
73.54
83.08
41.37
22.2
35.25
26.29
79.06
140.79
62.32
44.75
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32.21
25.99
49.59
46.51
17.74
12.63
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19.09
124.8
43.71
22.6
119.6
72.76
21.77
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30.13
24.23
116.66
103.86
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16.93
96.97
42.16
65.09
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57.59
18.38
37.93
29.2
19.52
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62.19
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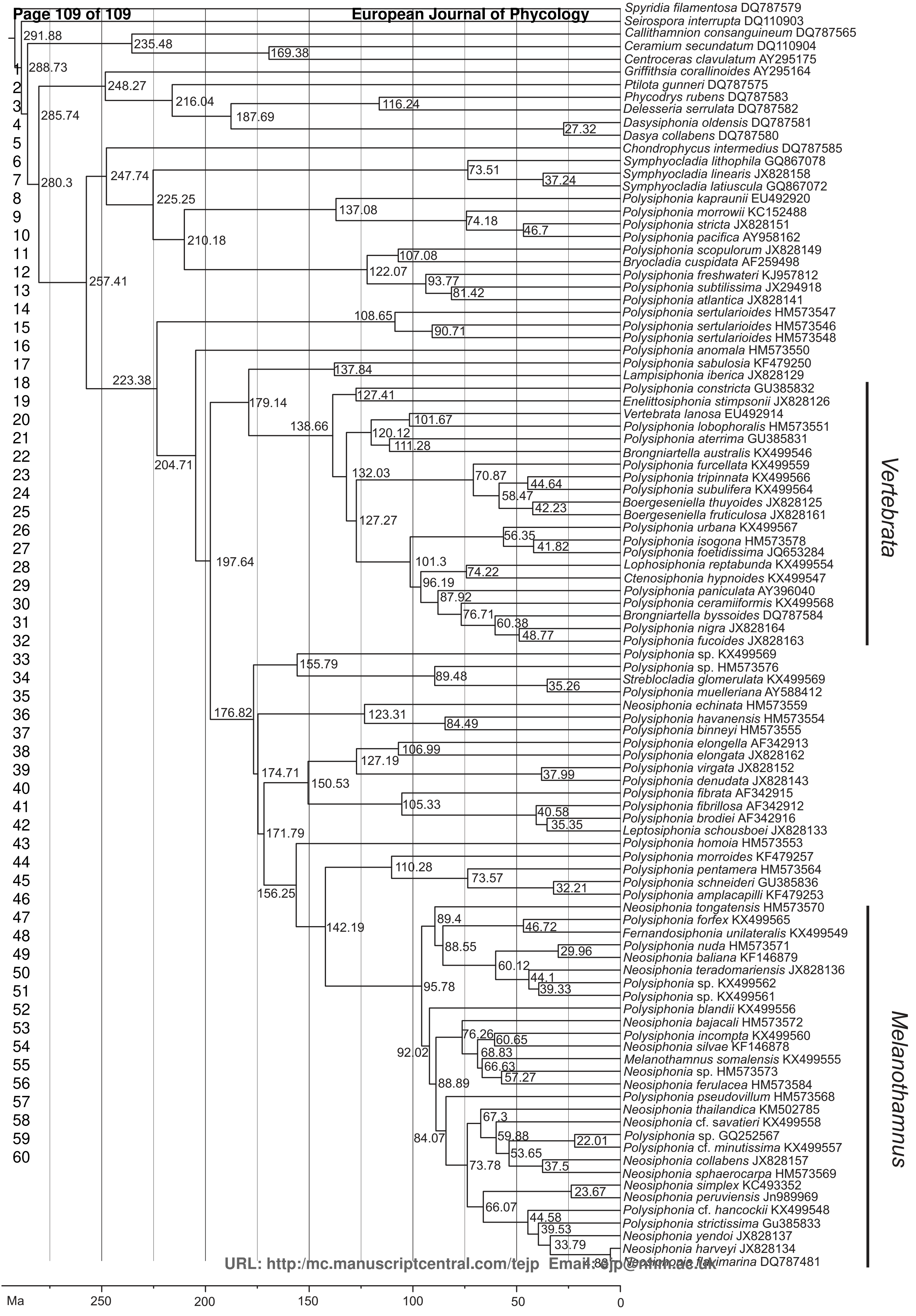
Spyridia filamentosa DQ787579
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Vertebrata
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