



Systematic placement of the necklace-chain genera *Bleakeleya*, *Koernerella* and *Perideraion* (*Koernerellaceae* fam. nov., *Koernerellales* ord. nov., *Bacillariophyta*)

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Bleakeleya Round (in Round & al. 1990: 394), type *Bleakeleya notata* (Grunow) Round (= *Asterionella bleakeleyi* var. *notata* Grunow, 1867) and suggested that *A. bleakeleyi* var. *recticostata* Körner, 1970 "...should be a species and not a variety of *B. notata*". Round & al. (1990: 394) further commented that, "*B. notata* cannot be included in either *Asterionella* or *Asterionellopsis* without over-widening the circumscription of these and making imprecise genera". Lobban & al. (2011) found these two taxa and several similar species in Micronesia and, based upon ultrastructure and gene sequences described two new genera, including *Koernerella* Ashworth, Lobban & E.C.Theriot for *Asterionella notata* var. *recticostata* and *Perideraion* Lobban & R.W.Jordan for three previously undescribed species. A second species of *Koernerella*, *K. grunowii* Lobban & C.O.Pérez, was subsequently discovered in Grunow's Honduras material (Lobban & Pérez 2016) growing on *Sargassum* along with *B. notata*.

When we described *Perideraion* and *Koernerella*, there was insufficient taxon sampling to place them within the *Fragilariophyceae* and sequence analysis showed a clade encompassing *Asterionellopsis*, *Asteroplanus*, *Delphoneis*, *Rhaphoneis* and a separate *Bleakeleya* clade (Lobban & al. 2011: fig. 47). That has changed considerably in the last ten years, particularly because of work on the *Plagiogrammales* (e.g. Sato & al. 2008, Li & al. 2015, 2020). Meanwhile, *Bleakeleya* was placed in the "*Ulnariaceae*" E.J.Cox, *nom. inval.** (*Licmophorales*, *Fragilariophycidae*) by Cox (2015: 87) but was found by Medlin & Desdevises (2016) to pair with *Asterionellopsis* in the *Asterionellopsidaceae* Medlin (*Rhaphoneidales*, *Urneidophycidae*). *Perideraion* and *Koernerella* remained in the *Fragilariaceae* by default, not considered by either Cox (2015) or Medlin & Desdevises (2016). The analysis by Medlin & Desdevises (2016: fig. 1, "clade 7, *Asterionellopaceae* [sic], fam. nov.") showed a clade comprising *Asterionellopsis* and *Asteroplanus* and they added *Bleakeleya* only under "expected/predicted genera to be included in this clade...". (Medlin & Desdevises 2016: 138) citing morphology described in Round & al. (1990). Despite this, they concluded by describing the new family specifically to include *Bleakeleya*.

Our recently published diatom trees (Ashworth & Lam in Lobban & al. 2022) show the *Bleakeleya*–*Perideraion*–*Koernerella* clade in a clade with the *Rhaphoneidales* and *Plagiogrammales*, two well-defined orders. The relationship between these clades and to *Asterionellopsis* shifts somewhat with the analytical method used to construct the tree; Fig. 1 is a strict consensus tree of the three supplemental trees in Lobban & al. (2022). Although there is a general morphological similarity in frustule and colony form between *Asterionellopsis* and *Bleakeleya*, namely tapered cells attached by ocelli or basal pore fields, respectively, the two genera are widely separated in our trees. *Asterionellopsis* was shown to have several species separable on molecular data but with very few morphological differences (Kaczmarek & al. 2014), but is easily distinguished from *Bleakeleya*, *Perideraion* and *Koernerella* by the strongly spathulate valve, with a broad basal part (bearing a small, rimmed basal pore field) tapering abruptly to a narrow, linear apical part. In addition, the basal and apical fields in *Asterionellopsis* and *Asteroplana* are considered ocelli (Round & al. 1990,

* "*Ulnariaceae*" E.J.Cox is an invalid designation (ICN Art. 36.1) as it was introduced as a *nomen provisorium* ("nom. prov.")



Crawford & Gardner 1997, Kaczmarska & al. 2014) and in *Asterionellopsis* has slits rather than pores. By contrast, *Bleakeleya*, *Perideraion* and *Koernerella* have more gradually tapered apices and the basal pore fields are perforated by small pores.

Because the *Bleakeleya*, *Perideraion* and *Koernerella* clade is consistently resolved in the molecular phylogenetic trees, but its relationship to the *Plagiogrammales* and *Rhaphoneidales* is less consistently resolved, we feel it is most appropriate at this time to classify the *Bleakeleya* clade to a level equivalent to these more well-established orders. We therefore propose *Koernerellaceae* fam. nov., and *Koernerellales* ord. nov., which reflect the constituent genera without creating confusion with similar described family names (*Berkeleyaceae* vs. “*Bleakeleyaceae*”) or basing the name on a genus that appears to be paraphyletic in the molecular phylogeny.

Koernerellales Lobban & Ashworth, ord. nov.

Description: Heteropolar cells tapering from a broad base in girdle and valve views, forming necklace-like colonies (Fig. 2). Basal pore fields occupying the entire basal valve face, separated from striae by hyaline bar or ring and not organized as elevated ocelli; apical poles with smaller pores not organized into a distinct field.

Type: *Koernerella* Ashworth, Lobban & E.C. Theriot, 2011

PhycoBank registration: <http://phycobank.org/103381>

Notes: The term “Basal pole” is employed here for the broader, attached end, as in Round & al. (1990), Lobban & al. (2011) and Kaczmarska & al. (2014), not the other way around as claimed by Medlin & Desvignes (2016). Although Lobban & al. (2011) referred to smaller pores at the apices as a pore field, Round & al. (1990) did not classify them as a pore field and, following our consideration of the similar situation in *Hyalosira* (Lobban et al. 2021), we now follow Round & al. (1990).

Koernerellaceae Lobban & Ashworth, fam. nov.

With the characters of the order *Koernerellales*.

Type: *Koernerella* Ashworth, Lobban & E.C. Theriot, 2011

PhycoBank registration: <http://phycobank.org/103382>

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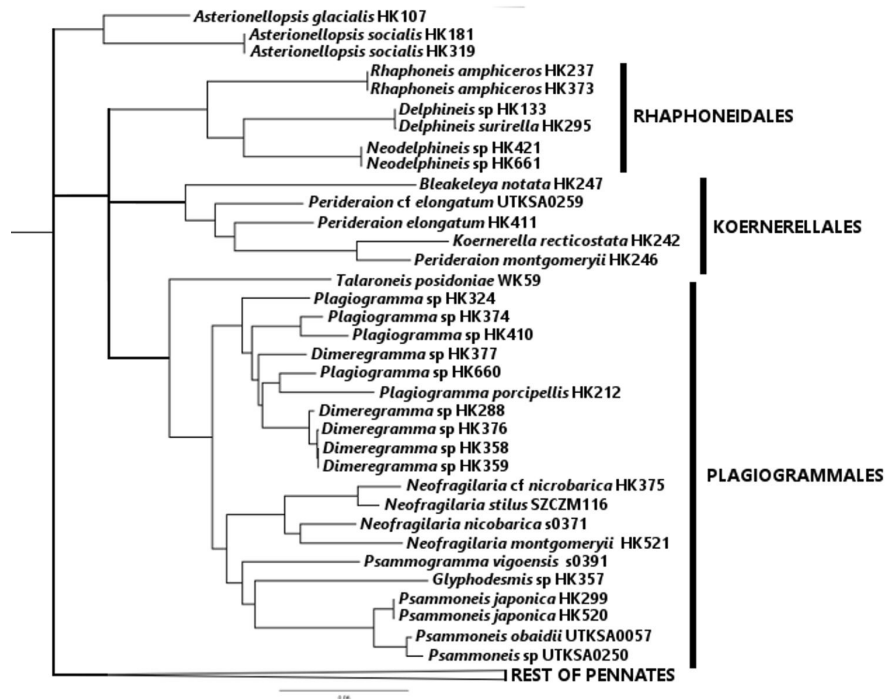


Fig. 1. Strict consensus tree of the results of phylogenetic analyses of a recent DNA sequence dataset, showing the *Bleakeleya*–*Perideraion*–*Koernerella* clade exclusive of the *Asterionellopsis*, *Rhaphoneidales* and *Plagiogrammales* clades. The full trees are available in Ashworth & Lam Supplementary Material 5–7 for Lobban et al. (2022).



Fig. 2. *Perideraion elongatum* R.W.Jordan, Y.Arai & Lobban: “necklace chain” colony from Guam.