Taxonomy of *Basicladia* (Cladophorales, Chlorophyta) with Two New Combinations

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Abstract. The green algal genus *Basicladia* W. E. Hoffman & Tilden suggested for synonymy in *Cladophora* Kütz. by van den Hoek is reconfirmed as a genus based on the distinct basal system and the primarily epizoic habit associated with freshwater turtles. Previously assigned to *Cladophora* sect. *Basicladia* (W. E. Hoffmann & Tilden) C. Hoek, *C. kosterae* C. Hoek (type: France) and *C. okamurae* (S. Ueda) C. Hoek (type: Japan) transfer to *Basicladia*, based on morphology and molecular evidence. The two new combinations *B. kosterae* (C. Hoek) Garbary and *B. okamurae* (S. Ueda) Garbary bring the number of species in *Basicladia* to seven.

Key words: *Basicladia*, *Cladophora*, Cladophorales, turtle algae.

The cladophoroid genus *Basicladia* W. E. Hoffmann & Tilden (Hoffmann & Tilden, 1930) was initially described for two species of epizoic algae on the shells of freshwater turtles. Further species were added, all of which were either epizoic on turtles or occurred on a freshwater snail. Five species have now been assigned to the genus: *B. crassa* W. E. Hoffmann & Tilden (generitype), *B. chelonum* (Collins) W. E. Hoffmann & Tilden, *B. ramulosa* Ducker (Ducker, 1958), *B. sinensis* (N. L. Gardner) G. M. Sm. (Smith, 1950), and *B. vivipara* Normandin & Taft (Normandin & Taft, 1959). The genus *Basicladia* is widely distributed in freshwater habitats where turtles are present (e.g., Yoneda, 1952; Ducker, 1958; Prasad & Jain, 1973; Ernst & Norris, 1978; Garbary et al., 2007).

In his monograph of European *Cladophora* Kütz., van den Hoek (1963) considered *Basicladia* as a synonym of *Cladophora* and reduced *Basicladia* to sectional status within the genus. However, he incorrectly designated *B. chelonum* as the type, and none of the five existing species of *Basicladia* were formally transferred into *Cladophora*. A new species of *Cladophora*, *C. kosterae* C. Hoek, was described, and *Chaetomorpha okamurae* S. Ueda was formally transferred to *Cladophora* as *C. okamurae* (S. Ueda) C. Hoek. Van den Hoek (1963) left us with several taxonomic and nomenclatural issues. First, the type of *Cladophora* sect. *Basicladia* was not assigned to *Cladophora*. Furthermore, if *Basicladia* was distinct from *Cladophora* at generic rank, should *C. kosterae* and *C. okamurae* continue to be considered as members of *Cladophora*, or should they be recognized as species of *Basicladia*? These issues can now be resolved.

Molecular evidence shows *Cladophora* to be extremely diverse, forming an ancient assemblage from which several green algal lineages are derived. Even within a limited clade (e.g., the *Cladophora albida* (Nees) Kütz.–*C. sericea* (Hudson) Kütz. series), there were six distinct ITS sequence types (Bakker et al., 1995). More recent molecular studies involving a diverse assemblage of Cladophorales and Siphonocladales showed that various siphonoclad lineages were associated with different clusters of *Cladophora* species (Leliaert et al., 2003, 2007). Thus, if numerous traditional genera of siphonoclads belonging to multiple families continue to be recognized, *Cladophora* can no longer be considered a natural genus.

A similar conclusion regarding the monophyly of *Cladophora* was inherent in the results of Yoshii et al. (2004) and Yoshii (2006), in which a wide range of species of Cladophorales was examined for pigment composition and 18S ribosomal DNA (rDNA) sequences. *Cladophora* species were sister to species in other genera of Cladophorales and Siphonocladales, e.g., *Chaetomorpha* Kütz., *Cladophoropsis* Børgesen, *Valonia* C. Agardh, and *Pithophora* Wittr. Hence, the cladophoroid morphology is plesiomorphic or possibly homoplasious within the assemblage, and *Cladophora* needs to be broken down into monophyletic units that can be recognized at generic level. Some of these units may already have been characterized in the various sections of *Cladophora* (van den Hoek, 1963).

One such segregate from *Cladophora* characterized by Yoshii et al. (2004) is *Basicladia*. While virtually all authors continue to recognize *Basicladia* (e.g., Ernst & Norris, 1978; Colt et al., 1995; John, 2003; Garbary et al., 2007), AlgaeBase follows van den Hoek (1963) and states that *Basicladia* is a synonym of *Cladophora* (Guiry & Guiry, 2007).

While the erect system of *Basicladia* with its branched, uniseriate filaments is similar to *Cladophora*, the poorly branched to unbranched, erect axes of *Basicladia* with very long initial cells in erect axes are characteristic. *Basicladia* species form a distinct basal layer of flattened, tightly packed cells, unlike the rhizoidal attachment of other *Cladophora* species. The association with turtles is diagnostic, even if not all species occur on turtles, and some species have been found on other substrata (Proctor, 1958; Normandin & Taft, 1959; van den Hoek, 1963). It is this heterotrichous basal layer that provides the basis for the association with turtles in that new erect filaments can be produced from a longer-lived basal system.

When van den Hoek (1963) reduced *Basicladia* to a section of *Cladophora* in his monograph of European *Cladophora*, none of the five species previously assigned to *Basicladia* were formally transferred. Furthermore, only two species were included in the section—the new species *C. kosterae* and *C. okamurae* (the latter transferred from *Chaetomorpha*; see Ueda, 1932). Neither species was found on turtles. Belusz and Reed (1969) later reported *C. kosterae* from North America as epizoic algae on turtles. The association of *C. kosterae* with *Basicladia* was later confirmed when Yoshii et al. (2004) used sequence data from type material of *C. kosterae* to show a sister group relationship between *C. kosterae* and two isolates of unidentified *Basicladia* from the United States in the UTEX culture collection (<http://www.utex.org/>).

Since *Basicladia* is a viable genus independent of *Cladophora*, and *C. kosterae* is part of the *Basicladia* clade, *C. kosterae* is hereby transferred to *Basicladia*. The morphology of *C. okamurae* is also definitive for *Basicladia* and that species is also transferred.

1. **Basicladia kosterae** (C. Hoek) Garbary, comb. nov. Basionym: *Cladophora kosterae* C. Hoek, Revision of the European Species of *Cladophora* 1963: 37. TYPE: France. Paris: Jardin des Plantes, alpine garden, on stones in artificial freshwater stream, 25 Apr. 1961, *C. van den Hoek n.61/9* (holotype, L not seen).

2. **Basicladia okamurae** (S. Ueda) Garbary, comb. nov. Basionym: *Chaetomorpha okamurae* S. Ueda, J. Imp. Fish. Inst., Tokyo 27: 23. 1932. *Cladophora okamurae* (S. Ueda) C. Hoek, Revision of the European Species of *Cladophora* 1963: 39. TYPE: Japan. Tokyo: Shirahama (Bôshû), s.d., *S. Ueda s.n.* (holotype, Tokyo University of Marine Science and Technology not seen).

The genus *Basicladia* now comprises seven species: *B. crassa*, *B. chelonum*, *B. kosterae*, *B. okamurae*, *B. ramulosa*, *B. sinensis*, and *B. vivipara*. Guiry and Guiry (2007) list *B. sinensis* and *B. vivipara* as having provisional status. Neither of these species has been redescribed since their first descriptions. *Basicladia sinensis* is particularly ambiguous, as it was described from a turtle many months after it had been brought to California from China (Gardner, 1937). *Basicladia sinensis* is also morphologically similar to *B. okamurae*. If these are conspecific, the latter has priority. *Basicladia vivipara* is known only from the freshwater snail *Viviparus malleatus* (Reeve). This apparent host specificity is analogous to that of the green alga *Sporocladopsis jackii* Garbary, C. J. Bird & K. Y. Kim (Garbary et al., 2005), which is known only from the marine snail *Ilyanassa obsoleta* (Say). Regardless, further studies are required on the status and relationships of *B. sinensis*, *B. okamurae*, and *B. vivipara*.

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