

**Systematic Studies in Schoeneae (Cyperaceae):
Spikelet Morphology, Species and Generic Limits of *Carpha*,
and Phylogenetic Relationships in and around *Carpha***

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Declaration

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.



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Abstract

Within the Schoeneae (Cyperaceae), the relationships and limits of *Carpha* have been unclear. Further, some species limits within *Carpha* appeared to be uncertain. There are conflicting interpretations of spikelet structure in Schoeneae and *Carpha*. This study examines spikelet structure in Schoeneae, determines species and generic limits of *Carpha*, and estimates phylogeny in and around *Carpha*.

Spikelet morphology of 250 specimens of 47 species of Schoeneae was examined using light microscopy and scanning electron microscopy. The study confirmed that spikelet structure in Schoeneae is cymose with a sympodial 'rachilla'. Monopodial spikelets, as described by most of the current literature, were not found in Schoeneae. The definitions of spikelet and rachilla are revised; problems of previous interpretations of spikelet structure in Schoeneae are discussed and clarified. The study highlights the need to reinvestigate spikelet structure in other tribes of Cyperaceae.

Phenetic analyses of morphology were undertaken to identify and test limits of species of *Carpha*: 16 species in *Carpha sensu lato* (i.e. *Carpha sensu stricto* and *Asterochaete*) were identified. Three, *Asterochaete acuminata*, *A. discolor* and *A. ulugurensis*, are new species; the taxonomic ranks of *A. angustissima*, *A. capitellata* var. *bracteosa*, *Carpha nivicola* and *C. schoenoides* are clarified; *C. perrieri* is synonymised with *A. capitellata*; and the definitions of *A. schlechteri* and *A. glomerata* are amended.

Cladistic analyses were undertaken on morphological and molecular (the *trnL* intron and *trnL-trnF* intergenic spacer sequence) data to estimate phylogenetic relationships. On the basis of these analyses, *Carpha sensu stricto* and *Asterochaete* are reinstated. Within *Carpha sensu lato*, phylogenetic relationships of the species are fully resolved, but with variable support. Phylogenetic relationships are suggested for *Carpha* and its relatives. The analyses also indicate some problems with the limits of Schoeneae and the status of *Costularia*, *Schoenus* and *Tricostularia*; support separation of *Capeobolus* from *Costularia* and *Tetraria*; and support the inclusion of *Schoenoides* back in *Oreobolus*. Lack of support for some clades indicates additional sources of data are needed to corroborate these relationships.

Prologue

Format

The format of this thesis follows the Style Guide of the University of New England (<http://www.une.edu.au/tlc/styleguide/>) except that references are cited in the format of *Australian Systematic Botany*.

Thesis Structure

The body of this thesis is composed of six chapters. Systematic methodology, species concepts for practical application, systematic studies of Schoeneae (Cyperaceae), and a detailed taxonomic history of *Carpha* are reviewed; and limitations of systematic methods and species concept, existing problems and knowledge gaps within Schoeneae, and *Carpha* in particular, are identified (Chapter 1). Spikelet morphology of Schoeneae has been examined, the sympodial spikelet structure of Schoeneae is identified, and problems of previous interpretations and concepts of spikelet structure in Schoeneae are discussed and clarified (Chapter 2). Phenetic analyses of morphological data to determine species limits of *Carpha* are presented (Chapter 3), followed by cladistic analyses of *Carpha* and its relatives using morphological data (Chapter 4) and molecular data (Chapter 5) to estimate phylogenetic relationships in and around *Carpha* and determine generic limits of *Carpha*. Finally, Chapter 6 provides the synthesis, which includes a cladistic analysis of combined morphological and molecular data, the major systematic findings of this study, and a review of *Carpha* in light of some of these findings.

Nomenclature

Following Article 29 of the International Code of Botanical Nomenclature, the new names and combinations contained in this thesis are not validly published here.

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The work in this thesis is entirely my own except where specifically indicated to the contrary.

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