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Evolution of cyme architecture in Celastraceae

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Abstract

Celastraceae are characterized by a cymose pattern of inflorescence ramification. Under this basic pattern, many inflorescence forms have been described within the family, e.g., dichasium, monochasium, pleiochasium, botryoid, thyrsoid, fascicle. Thus, the question has arisen—how have these varieties evolved or transformed from one to another? Through morphogenetic observations using paraffin sections, scanning electron microscopy (SEM), and stereomicroscopy, we studied the architecture and developmental processes of the inflorescences of five species of *Celastrus* and *Euonymus*. We found in *C. orbiculatus* that the reduction of subtending leaves of the axillary dichasia on a developing flowering shoot made it become a terminal thyrsoid. A dichasium in the leaf axil as commonly seen in *Euonymus* is the most frequent type of inflorescence in Celastraceae. An analysis of character evolution suggested that a dichasium is the ancestral state for Celastraceae. Therefore, within Celeastaceae, an axillary dichasium may be the basic type or unit of inflorescences. Transitions from dichasium to thrysoid and other types of cymes, and even to solitary flowers might have occurred repeatedly in the family, probably a phenomenon of evolutionary convergence due to changing environmental conditions. The present study provided helpful information for understanding the evolution of the cymose type of inflorescence in flowering plants.

Key words: Cyme, *Celastrus*, *Euonymus*, inflorescence architecture, morphogenesis, transition

Introduction

The inflorescence is one of the most diverse structures produced by angiosperms (Harder & Barrett 2006, Stebbins 1973). Its morphological and structural diversification is intimately linked to the reproductive efficiency of flowering plants, and therefore, must be of adaptive meaning. Inflorescence architecture, or branching pattern, varies enormously among plant groups or species. Convergent or parallel evolution on the one hand and divergence between closely related taxa on the other are commonplace (Tucker & Grimes 1999). Whereas evolution and development of flowers have been in the center of interest in plant science, inflorescences have received much less attention (Endress 2010). Therefore, investigating evolutionary tendencies of inflorescences will improve our knowledge on plant adaptation and evolution, and at the meantime, help botanists in taxonomic practice (Stebbins 1973, Caris *et al*. 2002, Prusinkiewicz *et al*. 2007, Endress 2010).

Plants of Celastraceae are generally distributed in forests from subtropical to tropical areas. They are characterized by a cymose pattern of inflorescence ramification (also commonly termed a determinate inflorescence). Under this basic pattern, many varieties have been described within the family, such as dichasium, thyrsoid, botryoid, monochasium, fascicles or even single flowers (Cheng & Huang 1999). Hardly any of them is diagnostic to any genus but many are repeatedly present in multiple clades. Questions have arisen—how have these forms evolved or transformed from one to another? Do they contain phylogenetic signals? Although Simmons *et al*. (1999, 2001a, 2001b, 2004, 2012) thoroughly studied changes of morphological characters for inferring phylogeny of *Celastraceae* and/or Celastrales, the evolutionary tendency of inflorescence architecture were not specially investigated. In their cladistic analysis using tens of morphological traits (Simmons & Hedin 1999), all multistate characters, including inflorescence, were scored as unordered, and the only trait of which patterns of character evolution was discussed was the aril. Mathews and Endress did numerous comparative studies on floral structures and their systematic implications for taxa of Celastrales

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present analytical result showing the cymose as plesiomorphy is not conclusive. First, the morphological evolution of inflorescences could be more complex associated with the great species diversity of this group; and second, we were not able to access adequate information for the whole group, especially of Malpighiales, the largest order of angiosperms (APG III, 2009; Stevens 2001 onwards). Nevertheless, a cyme is the predominant inflorescence type in Oxalidales and Malpighiales, and apparently at least one of the ancestral states. An in-depth comparative study of inflorescences combined with a comprehensive phylogenetic study would be highly desirable to provide a framework for understanding evolution of inflorescence even if it will be a great challenge.

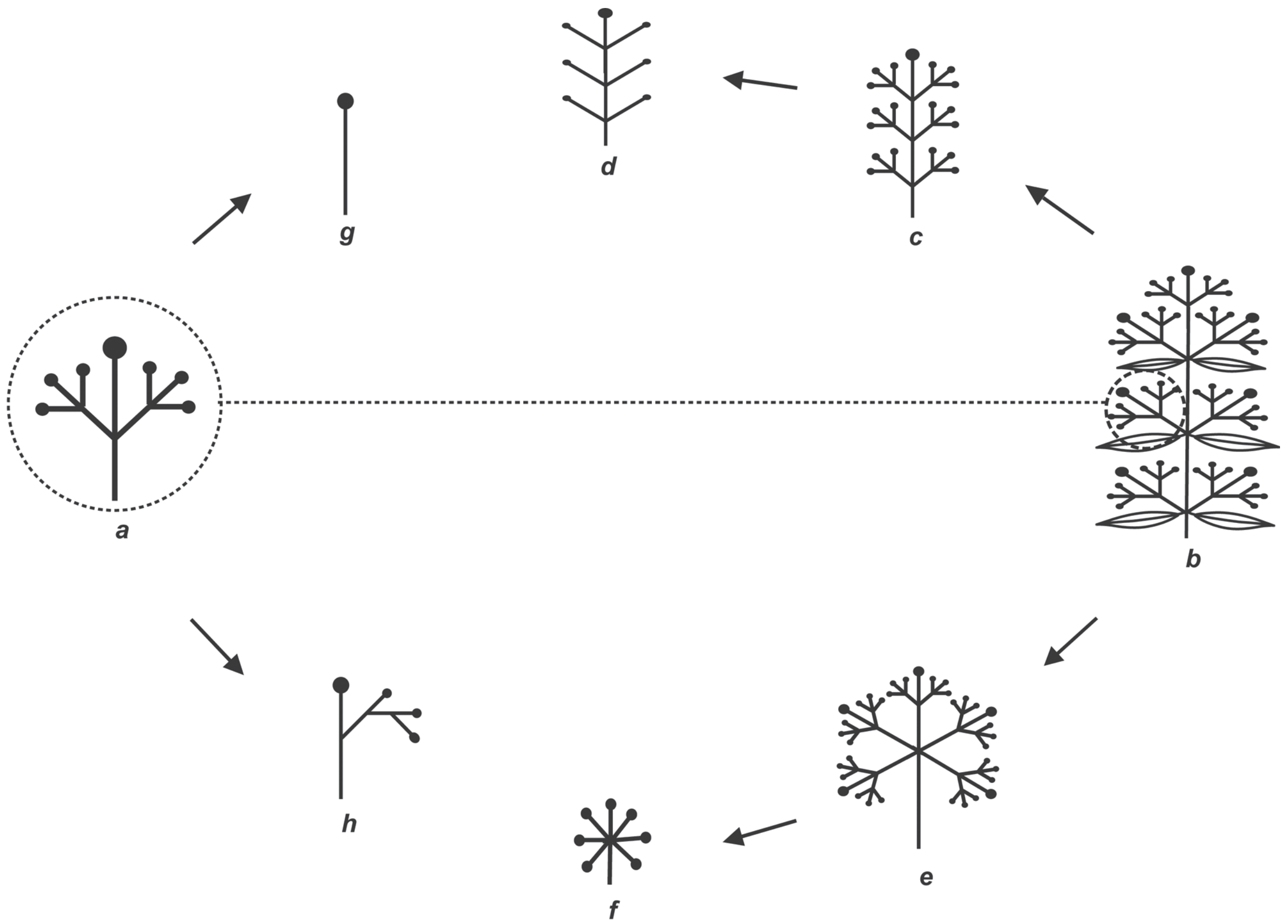

FIGURE 5. The transitional tendencies of cymes in Celastraceae. a. a dichasium unit; b. dichasia in leaf axils; c. thyrsoid; d. botryoid; e. pleiochasium; f. fascicle; g. solitary; h. monochasium.

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