



Phylogenetics, character evolution and a subgeneric revision of the genus *Pelargonium* (Geraniaceae)

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Abstract

Previous molecular phylogenetic studies of *Pelargonium* have remained inconclusive with respect to branching patterns of major infrageneric lineages, with the exception of a basalmost generic split that reflects chromosome length differences. Because of this and the lack of clearly distinguishing morphological characters, no subgeneric classification has been undertaken so far. Here, we present increased phylogenetic signal using chloroplast *atpB-rbcL* spacer and *trnL-F* sequences including additional taxa (110 taxa in total) and character sampling. All analyses confirmed the previously recognised first split into two clades characterised by chromosome size, and also converged on four major clades (two within each chromosome size group). The four major clades are further supported by synapomorphic length mutations from both intergenic spacers. The evolution of characters from flower morphology and phenolic constituents was examined for usefulness for clade delimitation. Although character state distributions did not generally reveal clear synapomorphies for the respective lineages, differences in state distributions of floral characters and leaf phenols support the circumscription of these major clades. In particular, nectar guides and petal-ratios indicate character state shifts among clades. The leaf flavonoids, myricetin and prodelphinidin, exhibit differing evolutionary trends in *Pelargonium* species with small chromosomes. In summary, all results favour the recognition of four, morphologically diagnosable, lineages as subgenera and support a revised subgeneric classification of *Pelargonium*. In addition, a new section (*stat. nov.*) including two subsections (*comb. nov.*) is segregated from an otherwise paraphyletic section *Polyactium*.

Key words: *atpB-rbcL*, flavonoids, floral traits, indels, *trnL-F*

Introduction

Pelargonium L'Héritier in Aiton (1789: 417) is an important genus of the horticulturally valuable Geranium family, which consists of about 800 mostly herbaceous species with a worldwide, predominantly temperate to subtropical distribution (Albers & van der Walt 2007, Fiz *et al.* 2008). Within Geraniaceae, the genus *Pelargonium* is sister to the remaining genera of the family in its strict sense (Price & Palmer 1993), *Erodium* L'Héritier in Aiton (1789: 414), *Geranium* Linnaeus (1737: 204) and *Monsonia* Linnaeus (1767: 508) incl. *Sarcocaulon* (De Candolle) Sweet (1826: 73). *Pelargonium* represents the second largest genus (about 280 taxa) of Geraniaceae and is morphologically distinct from the remainder of the family in having a hypanthium, consisting of an adnate nectar spur with one nectary, as well as a generally zygomorphic floral symmetry (Albers & van der Walt 2007).

The main distribution of nearly 90% of the genus is in southern Africa, including the Republic of South Africa and adjacent parts of Namibia. The highest species diversity is found in the south-western part of South Africa (van der Walt & Vorster 1983). This centre of *Pelargonium* diversity receives rainfall exclusively in winter or, in a small transition zone, throughout the year. This is in contrast to the central and eastern parts of South Africa, where rainfall is concentrated in the summer months. Outside southern Africa, the genus *Pelargonium* is represented by

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