Orchidaceae Phylogeny

Introduction

All three species of orchids, Phragmipedium grande, Phalaenopsis schilleriana, and Cymbidium cyperfolium belong to the Phylum Magnoliophyta, which includes angiosperms (flowering plants). Some defining traits of orchids, as monocots, are three-parted flowers and fruits, leaves equipped with usually sheathing bases, and parallel, rather than net-like, venation. As members of Class Liliopsida (the monocots), orchids lack woody tissue and the vascular cambium needed to produce it. Subtle aspects of flowers, vegetative organs, and diagnostic DNA sequences place orchids in Order Asparagales within Class Liliopsida. While not a monophyletic group, all the species are members of the very large family Orchidaceae. Orchidaceae not only exceeds all of the other flowering plant families for species richness, but also has outstanding adaptive variety and novelty.

Synapomorphies

Despite the variation in the family, orchids represent a coherent group among monocots, possessing several defining floral synapomorphies. The most distinctive plesiomorphic feature of Orchidaceae is its flower, specifically the sexual portions of the flower. The male and female portions of flowers (the filaments, anthers, style and stigma) are consolidated into a single structure called the column.
Major Taxonomic Divisions

Despite being intensively studied, Orchid taxonomy remains fluid due to the challenge of fully reconstructing the phylogeny. There are five major taxonomic divisions, or subfamilies, within the group: Apostasioideae, Cypripedioideae, Orchidoideae, Epipendroideae, and Vanoideae.

- **Apostasioideae**: This small group includes the most primitive orchids. Apostasioideae inhabit moist tropical forests as soil-rooted herbs. These flowers release powdery pollen rather than the aggregated form (pollinia) characteristic of the rest of the family. Its current membership of only two genera suggests that modern species are only a remnant of a more diverse collection in earlier times.

- **Vanilloideae**: Vanilla and its relative have only one anther, but otherwise exhibit features consistent with the more basal status of the family. Pollinia are poorly organized, and seeds are larger and harder-coated than other, more specialized species.

- **Cypripedioideae**: These orchids, including Phragmipedium grande, are the popular "lady's slipper" orchids. Molecular data has confirmed that these orchids are more primitive than most of the family, including our other target species. Cypripedioideae are characterized by a unique, shield-like staminode and a pouch-like labellum.
Orchidoideae

Most terrestrial orchids are members of the subfamily Orchidoideae. More advanced features, such as well-defined pollinia and dust-type seeds, occur here, as well as more specialized pollination methods.  

Epidendroideae

This subfamily accounts for about 80% of total orchid species; therefore, it presents the greatest taxonomic challenge. Phalaenopsis schilleriana and Cymbidium cyperfolium are both members of this subspecies, although they reside in different tribes within it. A key synapomorphy that distinguishes the Epidendroideae subfamily is the incumbent anther, which, unlike other species of orchids, is at a right angle to the axis of the column.

Fossil Data

Despite the large number of orchid species, the vast majority of fossil discoveries are poorly preserved or do not indisputably represent Orchidaceae. Furthermore, no findings are more than 55 million years old, which is only about half the age recorded for other plant families. However, one recent fossil has allowed calibration of the molecular phylogeny. Using its Oligocene age, Ramirez et al. calculated that the Orchidaceae family shared its most recent common ancestor during the late Cretaceous Period between 76-84 million years ago. The massive radiations experienced by the subfamilies of Orchidoideae and Epidendroideae began later in the Eocene epoch. Using molecular clocks and cladograms based on DNA structure, Chase et al. were able to place the origins of the Orchidaceae family as a whole between 90 and 100 million years ago.

Focal Traits

Flower Structure

Although the overall composition of orchid flowers is conserved, there is an enormous amount of diversity in the size and structural details. One
aspect of orchid floral structure is a specialized petal called the labellum, or lip. The labellum of Phragmipedium grande, as a "lady's slipper" orchid, is pronounced and pouch-like. This pitcher-like structure arose in Cypripedioideae and is one of the key synapomorphies that distinguishes the group.

Another aspect of floral structure that varies within Orchidaceae is the anther. Although most orchids have a single anther that is part of the fused column, the structure varies within the family. An incumbent anther, which bends at a right angle to the column, is a trait that arose in the Epidendroideae subfamily.

**Leaf Composition**

The leaf composition of orchids is largely conserved between different orchid species. The major variation between the leaves of different orchid species is due to environmental factors. The family Orchidaceae has radiated to cover an extensive range of environments, ranging from wet to dry, and from full shade to full sun. The positioning and amount of chlorophyll and carotenoids within an orchid's leaf allow it to maximize its fitness in its specific environment. Although some orchids have developed specific regulatory traits, they all rely on photosynthesis as their energy source.