SABUJEEMA
An International Multidisciplinary e-Magazine
Volume 3 - Issue 8– August,2023

Taxonomy and morphology of Orchids

[Article ID: SIMM0284]

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Abstract

The orchids belong to the kingdom Plantae, order Asparagales and family Orchidaceae. There are 5 subfamilies, 22 tribes, 70 subtribes and 850 genera. They are herbaceous perennial monocot plants and epiphytic, terrestrial and lithophytic in nature. Orchids are distributed almost all over the world. They are unique for diversity in morphological characters especially in pseudobulb shape, leaf shape, inflorescence variation, flower shape, sepal, petal and lip shape, colour pattern, curvatures and other descriptors of reproductive parts. One of the best-known plant groups in the global horticultural and cut flower trades, orchids are also harvested, grown, and traded for a variety of purposes, including as ornamental plants, medicinal products, and food.

Key words: Orchidaceae, epiphytic, terrestrial, pseudobulbs, monopodial, sympodial

Introduction

The orchids belong to the kingdom Plantae, order Asparagales and family Orchidaceae. The family is subdivided into five subfamilies, and then into tribes and subtribes. The subtribes are formally divided into genera. Some of the genera are divided into subgenera, and some of the subgenera are divided into sections. All the genera contain at least one species. A special nomenclature is used to name hybrids between different species.

There are 5 subfamilies, 22 tribes, 70 subtribes and 850 genera. Orchids account for c. 8% of angiosperm species diversity. Till date, 29,199 species have been identified and accepted (Govaerts et al., 2017), although several hundred new species are added each year. By the end of 2017, the IUCN Global Red List included assessments for 948 orchid species, of which 56.5% are reported to be threatened. In addition to their geographical and taxonomic diversity, orchids are also widely used for a variety of reasons, both legally and illegally, sustainably, and unsustainably. One of the best-known plant groups in the global horticultural and cut flower trades, orchids are also harvested, grown, and traded for a variety of purposes, including as ornamental plants, medicinal products and food.

Subfamilies

A distinction between monandrous flowers and others is especially important in the classification of orchids. A monandrous flower contains only a single stamen. The flowers are monandrous in the subfamilies Vanilloideae, Orchidoideae, and Epidendroideae. The monandrous orchids form a monophyletic group. It is now known that monandry arose twice in the orchids, once in Vanilloideae, and again in the common ancestor of Orchidoideae and Epidendroideae. The other subfamilies, Apostasioideae and Cypripedioideae, have either three stamens or two stamens and a staminode.

The following subfamilies are recognized:

- Subfamily Apostasioideae: monophyletic - the most basal of the orchids: three fertile anthers, or two

fertile anthers and a filamentous staminode.

- Subfamily Cypripedioideae: monophyletic - two fertile diandrous anthers, a shield-shaped staminode and a saccate lip.
- Subfamily Orchidoideae: monophyletic - one fertile, monandrous, basitonic anther.
    - (Subfamily Spiranthoideae): now accepted as nested within a more broadly defined Orchidoideae as the sub-tribe Spiranthinae of the tribe Cranichideae.
- Subfamily Epidendroideae: monophyletic - includes almost 80% of the orchid species; orchids with an incumbent to suberect anther.
    - (Subfamily higher Epidendroideae (formerly Vandoideae): specialised clade within a more broadly defined Epidendroideae
- Subfamily Vanilloideae: monophyletic - an ancient clade now recognized as a distinct subfamily. Their phylogenetic position had long been controversial.

Cladistically, the interrelationships of these subfamilies can be shown in a phylogenetic tree as follows:

- Asparagales
    - Other families in the Asparagales
    - Orchidaceae
        - Apostasioideae
        - Vanilloideae
        - Cypripedioideae
        - Epidendroideae
        - Orchidoideae

Distribution

Orchids are perennial herbaceous monocot plants. Orchids are found on all continents except Antarctica. The great majority are to be found in the tropics, mostly Asia, South America, and Central America. Some are found above the Arctic Circle, in southern Patagonia, and even on Macquarie Island, close to Antarctica.

The following list gives a rough overview of their distribution:

- Eurasia: 40–60 genera
- North America: 20–30 genera
- tropical America: 300–350 genera
- tropical Africa: 125–150 genera
- tropical Asia: 250–300 genera
- Oceania: 50–70 genera

Classification

About 70% of the world's orchids are epiphytic and/or lithophytic, 25% are terrestrial and 5% of the world's orchids grow in mixed substrates (both lithophytic, epiphytic and terrestrial) (Arditti, 1992).

- A majority of species are perennial *epiphytes* which grow on or attached to another living plant. They are found in tropical moist broadleaf forests or mountains and subtropics. These are anchored on other plants, mostly trees, sometimes shrubs. However, they are not parasites, E.g., Cymbidium, Dendrobium, Vanda, Phalaenopsis, Cattleya, Oncidium
- A few are *lithophytes*, like epiphytes but grow naturally on rocks or on very rocky soil. Epiphytes and lithophytes derive their nutrients from the atmosphere, rainwater, litter, humus, and even their own dead tissue, e.g., Coelogyne, Paphiopedilum, Diplomeris.
- Others are *terrestrial* plants. They grow in the soil and obtain their nutrients from the soil. This group includes nearly all temperate orchids, e.g., Calanthe, Acanthephippium,

Eulophia, Tainia, Phaius , Habenaria, Peristylus.

- Some lack chlorophyll and are *myco-heterotrophs*. These achlorophyllous orchids have an ectomycorrhizal relationship, i.e. they are completely dependent on soil fungi feeding on decaying plant matter to provide them with nutrients. Typical examples include the Bird's-nest Orchid (*Neottia nidus-avis*) and Spotted Coral-root (*Corallorrhiza maculata*).

Morphological features of advanced orchids

- The presence of a column, also called gynostemium.
- The flower is bilaterally symmetric.
- The pollen are glued together into the pollinia, a mass of waxy pollen on filaments.
- The seeds are microscopically small, lacking endosperm (food reserves) in most of the species. There are notable exceptions, such as *Disa cardinalis*, whose seeds may grow to a length of 1.1 millimeters. Seeds of *Vanilla* may weigh 20 times or more that of other orchids.
- The seeds can, under natural conditions, only germinate in symbiosis with specialized fungi. Under artificial circumstances, however, germination is possible "in vitro" on sterile substrates of agar in specialized laboratories. Germinating seeds in agar, usually done in flasks, is an advanced technique, requiring sterility at all costs. It takes anywhere from one up to five to ten years for an orchid seedling to mature. An alternative artificial germination, however, is done by cultivating the fungus and sowing the seeds on them. This is called *in-vitro* symbiotic culture and is used most for terrestrial orchids.

Leaves: Orchids have simple leaves with parallel veins. Their shape is highly variable between species. Lanceolate is common in Dendrobium; linear in *Cymbidium pendulum*, *Coelogyne graminifolia*, *Eria bamboosifolia*; oblong in Paphiopedilum, *Dendrobium nobile*, *Vanda tessellata*, *Renanthera imschootiana*; Elliptic in *Epidendrum* spp., Cattleya hybrids; Oblanceolate in *Zygopetalum maculatum*, *Coelogyne nitida*, *Dendrobium aggregatum*, Oncidium hybrids, narrow obovate in Phalaenopsis, Terete, semi-terete, channelled and strap in Vanda and linear-oblong in Cymbidium hybrids (Table 1 & Fig.1). The leaves can be enormous or minute, or they can even be lacking (as in the Ghost Orchid (*Dendrophylax lindenii*), a mycoheterotrophic species, and *Aphyllorchis* and *Taeniophyllum*, which depend on their roots, which contain chlorophyll, for photosynthesis.

The structure of the leaves corresponds to the specific habitat of the orchid. Species that typically bask in sunlight or grow on sites that can be occasionally very dry, have thick, leathery leaves. The laminas are covered by a waxy cuticle to retain water. Shade species, on the other hand, have tall, thin leaves. They cannot tolerate a drop in atmospheric humidity or exposure to direct sunlight. Epiphytic orchids are characterized by thick and succulent leaves with thick cell walls, cuticles and small substomatal chamber whereas those of terrestrial species are thin (De, 2021). Thick leaves of Phalaenopsis have Crassulacean Acid Metabolism (CAM), a very important adaptation to water stress. All thin orchid leaves show C3 photosynthesis. In monopodial orchids, the number of leaves on stem depends on the age

of the plant while the orchid like Paphiopedilum has 2-6 leaves per flowering shoot, Cattleya has one or two leaf per pseudobulb, Oncidium has 2-4 leaves, Cymbidium and Dendrobium have 5-20 leaves per pseudobulb.

Table 1. Leaf types in orchids

Characters	**Example varieties/ species**
Linear	*Cymbidium pendulum*, *Coelogyne graminifolia*, *Eria bamboosifolia*
Linear - oblong	Cymbidium hybrids
Lanceolate	*Dendrobium moschatum*, *Den. densiflorum*, *Den. aphyllum*, *Den. gibsonii*, *Den. bulboflorum*, *Den. thyrsiflorum*, *Den. farmeri*
Oblong	*Paphiopedilum*, *Dendrobium nobile*, *Vanda tessellata*, *Renanthera imschootiana*
Ob-lanceolate	*Zygopetalum maculatum*, *Coelogyne nitida*
Elliptic	*Epidendrum* spp., Cattleya hybrids
Terete	*Vanda teres*, *V. 'John Clubb'*, *V. 'Miss Joaquim*
Channelled	*Vanda sanderiana*, *Vanda lamellata*
Strap	Vanda hybrids

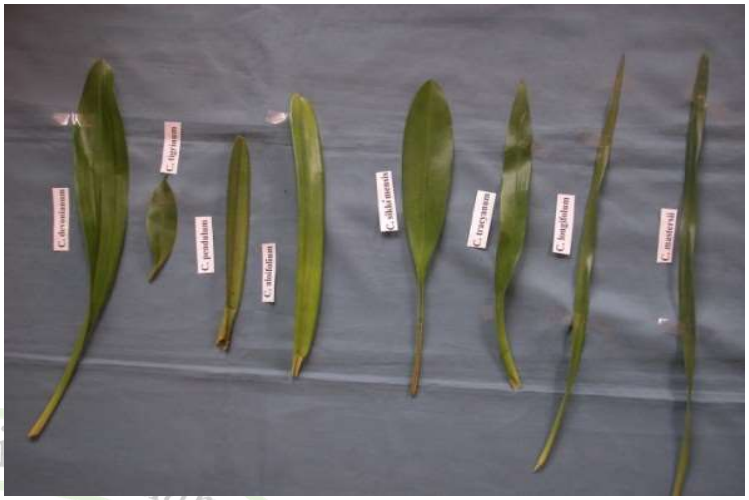

Fig.1 Leaf shape in Cymbidium

The leaves of some species can be most beautiful. The leaves of the *Macodes sanderiana*, a semiterrestrial or lithophyte, show a sparkling silver and gold veining on a light green background. The cordate leaves of *Psychopsiella limminghei* are light brownish green with maroon-puce markings, created by flower pigments. The attractive mottle of the leaves of Lady's Slippers from temperate zones (*Paphiopedilum*) is caused by uneven distribution of chlorophyll. Also, *Phalaenopsis schilleriana* is a lovely pastel pink orchid with leaves spotted dark green and light green. The Jewel Orchid (*Ludisia discolor*) is grown more for its colorful leaves than its inconspicuous white flowers.

Stem: The stem of an orchid determines the habit of the species. Each type of stem can grow in one of these two ways:

- Monopodial (Single stemmed) growth: The new shoots grow upwards from a single stem, originating in the end bud of the old shoots. It then produces leaves and flowers along this stem. The stem of these orchids can reach a length of several meters, as in the genera *Renanthera*, *Vanda* and *Vanilla*.

- Sympodial (Multi-stemmed) growth: Sympodial orchids grow horizontally, form new shoots from the old rhizome. Sympodial orchids include Cymbidium, Cattleya, Oncidium and Dendrobium.

Roots: All orchids are perennial herbs, lacking any permanent woody structure. Some orchids are terrestrial, growing rooted in the soil. Terrestrial orchids may be rhizomatous, forming corms or tubers. These act as storage organs for food and water. The root caps of terrestrials are smooth and white. Epiphytic orchids have modified aerial roots and, in the older parts of the root, an epidermis modified into a spongy, water-absorbing velamen, which can have a silvery-grey, white, or brown appearance. The cells of the root epidermis grow at a right angle to the axis of the root. This allows them to get a firm grasp on their support. These roots can sometimes be a few meters long, to take up as much moisture as possible. Nutrients mainly come from animal droppings on their supporting tree that are washed down when it rains. In terrestrial orchids, in addition to the simple absorbing roots with root hairs, sometimes large root tuber as in *Habenaria* or root tubercles as in *Nervilia* are also present.

Pseudobulbs: The base of the stem of sympodial epiphytes, the entire stem, may be thickened to form what is called a pseudobulb. These contain nutrients and water for drier periods. They typically stay alive for five or six years. They have different sizes and shapes. Pseudobulbs may be cylindric, clavate, globular in Cattleya; narrow cylindric, round, ovoid, conical in Cymbidium; cane woody, cane cylindric fleshy, cane clavate fleshy, bulbous round in Dendrobium and oblong, elliptic, ovate, and grooved in Oncidium. In the Black Orchids (*Bulbophyllum*), the pseudobulbs are no longer than 2 millimeters. The largest orchid in the world, the Giant Orchid (*Grammatophyllum speciosum*), has pseudobulbs with lengths of 2–3 meters. When the orchid has aged and the pseudobulb has shed its leaves, the pseudobulb becomes dormant and is called a backbulb as found in Cymbidium, Zygopetalum and Oncidium which can be used as propagules to regenerate new plants.

Some sympodial terrestrials, such as *Orchis* and *Ophrys*, have two subterranean tubers between the roots. One is used as a food reserve for wintry periods, and provides for the development of the other pseudobulb, from which visible growth develops.

Flowers: There are many types of specializations within the Orchidaceae. Best known are the many structural variations in the flowers that encourage pollination by particular species of insects, bats, or birds. Most African orchids are white, while Asian orchids are often multicolored. Some orchids only grow one flower on each stem, others sometimes more than a hundred together on a single spike.

The typical orchid flower is zygomorphic, i.e., bilaterally symmetric. Notable exceptions are the genera *Mormodes*, *Ludisia*, and *Macodes*.

The flowers grow on racemes or panicles. It is solitary in Paphiopedilum, raceme in Dendrobium, Cymbidium, Vanda and Phalaenopsis hybrids and panicle in Oncidium. These can be basal (i.e., produced from the base of the pseudobulb, as in *Cymbidium*), apical (i.e., produced from the apex of the orchid, as in *Cattleya*) and or axillary (i.e., coming from a node between the leaf axil and the plant axis, as in *Vanda*). Inflorescence is mostly erect in hybrids, and arching or pendulous mostly in species.

The basic orchid flower is composed of three sepals in the outer whorl, and three petals in

the inner whorl. A sepal is an individual unit of the outer part of a flower, with the units usually differentiated into petals and sepals. The term 'tepal' is usually applied when the petals and sepals are not differentiated. However, in a "typical" flower the sepals are green and lie under the more conspicuous petals. When the flower is in bud, the sepals enclose and protect the more delicate floral parts within. The medial petal is usually modified and enlarged (then called the labellum or lip), forming a platform for pollinators near the center of the corolla. Together, except the lip, they are called tepals.

The orchid flowers exhibit mimicry like Spiders, Dancing girls, Bees, Ladies slipper, or Insects. In few cases like Oberonia and Malaxis the flowers are in an upside down position, having twisted through 180° on its pedicel. The inferior ovary or the pedicel usually rotates 180 degrees, so that the labellum, goes on the lower part of the flower, thus becoming suitable to form a platform for pollinators. It is called resupination. Some orchids have secondarily lost this resupination, e.g., *Zygopetalum* and *Epidendrum secundum*. The inflorescence of *Geoderum densiflorum* bends down in 180° and present the flowers in upside down position.

Sepals may mimic petals such as in some phalaenopsis, or be completely distinct. In many orchids, the sepals are mutually different and generally resemble the petals. It is not always easy to distinguish sepals and petals. The normal form can be found in *Cattleya*, with three sepals forming a triangle. But in Venus Slippers (*Paphiopedilum*) the lower two sepals are concrescent (fused together into a synsepal), while the lip has taken the form of a slipper. In *Masdevallia* all the sepals are fused into a calyx. In an example like this, the sepals are very prominent, especially in lycaste orchids, the actual petals become diminished and inconspicuous. Sepal and petal shape varies from linear, lanceolate, elliptic, oblong, obovate, ovate, cordate, round to orbicular. Curvature of sepals and petals ranges from incurved, straight, concave, convex to reflexed.

The reproductive organs in the center (stamens and pistil) have adapted to become a cylindrical structure called the column or gynandrium. On top of the column lies the stigma, the vestiges of stamens and the pollinia, a mass of waxy pollen on filaments. These filaments can be a caudicle (as in *Habenaria*) or a stipe (as in *Vanda*). These filaments hold the pollinia to the viscidium (sticky pad). The pollen is held together by the alkaloid viscine. This viscidium adheres to the body of a visiting insect. The type of pollinia is useful in determining the genus. On top of the pollinia is the anther cap, preventing self-pollination. At the upper edge of the stigma of single-anthered orchids, in front of the anther cap, is the rostellum, a slender beaklike extension.

Fruits and seeds: If pollination is successful, the sepals and petals fade and wilt but they remain attached to the ovary. The ovary typically develops into a capsule with three or six longitudinal slits, remaining closed at both ends. The ripening of a capsule can take 2–18 months. The microscopic seeds are very numerous (over a million per capsule in most species). They blow off after ripening like dust particles or spores, barely visible to the human eye. Since they lack endosperm, they must enter symbiotic relationship with mycorrhizal fungi to germinate. These fungi provide the necessary nutrients to the seeds.

All species rely upon mycorrhizal associations with various fungi, mostly genus *Rhizoctonia* (class Basidiomycetes),

for at least part of their life cycle. Some achlorophyllous species are adapted to be entirely dependent upon these fungi for nutrients. The fungi decompose surrounding matter, freeing up water-soluble nutrients. Because most orchid seeds are extremely tiny with no food reserves (endosperm lacking), they will not germinate without such a symbiont to supply nutrients in the wild. Some fungi continue to live in the roots of the adult orchid. This enables an orchid such as *Neottia nidus-avis* to function without chlorophyll. The chance for a seed to meet a fitting fungus is very small. Of all the seeds released, only a minute fraction grows into new orchids.

Conclusions

A good morphological study is required for conservation and utilization of endangered orchids. Native species can be effectively utilized for development of inter-generic, inter-specific or intra-specific natural hybrids of commercially orchid general like Cattleya, Cymbidium, Dendrobium, Mokara, Oncidium, Paphiopedilum, Phalaenopsis and Vanda and their compatible alliances which would be market driven having export value as well as tolerant to biotic and abiotic stresses. Investigations on morphological diversity could open avenues for identification of new and elite germplasm for pot culture, cut flowers, dry flowers, herbal preparations and exhibits for market displays.

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