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Adaptations to the Epiphytic Lifestyle

by Sue Bottom, sbottom15@gmail.com

True epiphytes spend their entire lives without contacting the forest floor. Epiphytes (epi- means “on top” and -phyte means “plant”), describes plants that grow on tree trunks, branches and even on twigs. In locations where moisture and nutrients are available more or less continuously, such as in wet forests, epiphytes differ little in form and physiology from plants that grow in your garden. Epiphytes are particularly abundant in cloud forests, where the air is always saturated and leaves are dripping from condensing mist. In other tropical habitats many families of plants find it difficult to survive as epiphytes. Orchids are one family of plants that have evolved to the epiphytic lifestyle so thoroughly that they are also found in even the most extreme tropical environments, e.g. dry forests.

There are some orchids that grow in soil or leaf litter, but millions of years of competition led most of the tropical members of the Orchid family into trees where light was plentiful. Leaving the moisture- and nutrient-rich forest floor, however, created many evolutionary challenges for orchids. Once orchids overcame obstacles inherent for life in the trees they evolved quickly into many different genera and species on all continents.

In dry forest environments, water and nutrients are supplied in pulses during unpredictable rain events. There are often extended periods of dryness between storms. Orchids adapted to these dry conditions by obtaining their water and mineral ions through unusual plant forms and major changes in their physiology and/or life history. Two general approaches are avoidance and endurance.



1. *Catasetums* are drought avoiders. They drop their leaves and go into a deep “sleep” when a predictable and prolonged dry season deprives them of the moisture they need.



2. *Cattleyas* are drought endurers. They sustain themselves during shorter periods by consuming energy and moisture stored in their pseudobulbs.

★ *Drought avoiders* are seasonal growers that restrict most of their vegetative growth to wet periods of the year. Orchids in this group often have thin leaves, which do not function as storage reservoirs. The dry season does not support their normal heavy water use,



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so foliage is shed and the plants lapse into dormancy. Carbohydrates and moisture are held in reserve in fat pseudobulbs or tubers. When favorable weather returns, new growths emerge to repeat the cycle. Commonly grown drought avoiders are most of the Catasetinae and certain dendrobiums and lycastes.

- ★ *Drought endurers*, include major horticultural genera, e.g., the Cattleya Alliance. They require quick adjustments to abrupt environmental challenges to maintain a favorable water balance within leaves. Each time these orchids moisture source dries out, which can take only an hour or two, there is the potential for an extended drought to follow. Adaptations to the epiphytic lifestyle revolve around water relations. Acquiring moisture and preventing the loss of water are critical to their success. Epiphytic orchids survive because they obtain and store water efficiently. These drought enduring orchids have succulent leaves and bulbs for storing moisture, velamentous roots for quick water and nutrient absorption as well as the ability to photosynthesize when moisture is scarce.



3. The living filament is surrounded by a nonliving spongy tissue (velamen) once it reaches maturity, that continues to absorb water and mineral nutrients.



4. Catasetums can grow rapidly during the wet season, storing lots of carbohydrates and moisture in their fattened pseudobulbs.

Roots. Epiphytic orchids have roots adapted to life in the tree canopy. Roots anchor the orchid to its host plant, holding tight even when buffeted by winds. The unique root structure consists of a nonliving, thick air filled layer called velamen that surrounds the living cortex of the central conductive filament. This adaptive velamen structure acts like a sponge, becoming engorged quickly after contact with liquids, so moisture and nutrients can move through the cortex and into the vascular system. This velamen becomes almost impermeable during dry periods, which prevents water from being exuded from roots. The velamen has special cells for gas exchange too, absorbing oxygen for respiration, and, where chloroplasts are present, carbon dioxide for photosynthesis. High porosity potting mixes are recommended for epiphytic orchids to help ensure that roots can be bathed with



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air. When organic matter in a potting mix starts to break down, the mix begins to compact and effectively smothers the roots. It is not too much water that kills your orchids, it is the lack of air around roots that orchids cannot tolerate.

Pseudobulbs. Many epiphytic orchids have short, thick bulb shaped stems called pseudobulbs. These structures store water and carbohydrates, similar to humps on a camel. Pseudobulbs swell or shrink as moisture is stored or withdrawn, allowing orchids to sustain themselves in seasonally dry areas where plants may experience months without rainfall. Plant morphology thus serves as a general guide to basic orchid culture. The fat pseudobulbs with thick leaves typical of cattleyas suggest the plant is more drought tolerant than thin leaved plants like many oncidiums. Some epiphytic orchids do not have pseudobulbs, e.g. phalaenopsis, and instead rely on fat roots and leaves for energy and water reserves.

Leaves. Leaves of epiphytic orchids are often thick and succulent and covered by an evaporation retarding waxy cuticle. The more succulent the leaf, the more the leaf interior assumes a water storage role. Less conspicuous features promoting water retention include recessed stomata (pores used for gas exchange), usually on the leaf undersides, and reflective surfaces. Once again plant morphology acts as a general guide to basic orchid culture.



5. Most cattleya leaves are thick allowing some internal water storage. They have a waxy cuticle to prevent excess water loss.



6. Cattleyas are busy absorbing carbon dioxide during the cooler night hours when humidity is higher, storing it for photosynthesis during the daylight hours.

Photosynthetic Pathway. Life in the trees typically results in what is in effect an arid environment. Most garden plants open their stomata during the day to absorb carbon dioxide for photosynthesis, which occurs during daylight hours. Open stomata during the heat of the day also allows water to escape and evaporate in a process called transpiration.



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More than 90% of the water absorbed through the roots of garden plants can be lost through leaves thanks to transpiration. This excessive water loss would result in death of an epiphytic orchid. Because carbon dioxide gain and transpiration water loss both occur through the same stomatal opening, some epiphytic orchids use a specialized adaptation called CAM photosynthesis (Crassulacean Acid Metabolism) to minimize water losses. Carbon dioxide is absorbed during the nighttime hours when the stomata are open, and then stored within the leaf for subsequent photosynthesis during daylight hours when stomata are closed. Keeping stomata closed during the heat of the day, and open at night minimizes transpiration losses. CAM plants have a very high water use efficiency allowing them to live in the windy, arid environment in the trees. Of course, the intermediate storage of carbon dioxide has an energy cost, so CAM plants grow relatively slowly, requiring less fertilizer to provide mineral nutrition. This is the tradeoff epiphytic orchids made for life in the trees. The more succulent the plant, the more likely the plant uses CAM metabolism. Thick leaved cattleyas and phalaenopsis often use CAM metabolism, while thin leaved oncidiums often use the more conventional photosynthetic pathway.

Nutrition. Orchids in the tree canopy also live in a low nutritional environment. Dust settling on leaves, nutrients in the atmosphere and even molecules leached from leaves by dripping rainfall provides most nutrients taken up by epiphytes. While fecal material may occasionally contribute to an epiphytic orchid's nutrient balance, such events are rare. Nutrients must be dissolved in water to be taken up by plants. Orchids develop tremendous root systems enabling them to survive and grow in a low nutrient environment as long as they grow slowly. They are also extremely effective in taking up nutrients, especially micronutrients. The velamen of orchids, which is so efficient at absorbing water, also helps absorb nutrients from rainfall. Poole and Sheehan wrote:

Rainfall is a valuable source of nutrients for epiphytic plants since it washes dust particles out of the air and onto them. The atmosphere is also an excellent source of nitrates, especially during electrical storms. Water flowing over leaf surfaces leaches mineral and organic nutrients from the leaves. Thus the leaf canopy of the host tree becomes a nutrient source that enriches the water before it reaches the orchid plant. The major source of nutrients, however, is probably the slow decomposition of organic matter (both flora and fauna) that accumulates in tree crotches and among the bark, roots, rhizomes and leaves of orchid plants.

Epiphytic orchids have adapted to ecological constraints with unique mechanisms that tap limited resource pools, prolong contact with passing canopy fluids and promote water and nutrient use efficiency. Epiphytic orchids have adapted to the water deprived and nutrient deficient environment by growing more slowly, producing leaves that are thick and hard, and putting more energy into root formation. Air movement is greater in the tree canopy, drying leaves rapidly after storms, which helps prevent bacteria and fungi from penetrating into the



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plant. Orchids require more fertilizer in culture, thanks to the loss of roots each time they are repotted. Thanks to their inherent ability to take up nutrients, they can be pushed to grow more rapidly with lots of fertilizer, but rapidly growing cell walls may be thinner and softer and more easily invaded by pests and diseases. Rather than relying on a chemical arsenal to cure problems, prevent problems from occurring by mimicking nature. Abundant air movement, dappled light, open freely draining potting mixes, dilute fertilizer and careful watering will help you grow healthy plants, which will reward you with lots of blooms.

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Citations and Additional Reading

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