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Structures and functions of adventitious roots in species of the genus *Philodendron* Schott (Araceae) ☆

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Abstract

We discuss here the anatomical variations of the arrangements and compositions of stele types observed in different roots types in four populations of the three species of Philodendron as probable adaptations to their habitats. Terrestrial individuals of *P. corcovadense* have cylindrical steles while rupicolous individuals have lobate steles with dispersed internal cortical parenchyma. The *Philodendron* species sampled showed polyarch structures. The crampon roots of *P. oblongum* and anchor roots of *P. cordatum* show medullated protosteles, with the former species having a reduced pith with sclerified parenchyma cells while the latter has a wide pith and parenchyma cells with only slightly thickened walls. The feeder roots of *P. cordatum* also show a medullated protostele—although a central vessel is present until approximately 60cm from the apex that later disappears, forming a parenchymatous pith. We conclude that the different root types reflect adaptations of the subgenera *Philodendron* and *Meconostigma* to their different habits and habitats, such as in *P. corcovadense*, where the roots of rupicolous individuals have lobate steles while the roots of the terrestrial plants have cylindrical steles.

Introduction

Philodendron is the second largest genus of the family Araceae, with nearly 400 species (Govaerts and Frodin, 2002) although future investigations may expand this number to approximately 700 species (Croat, 1997). It is a morphologically and ecologically diverse neotropical genus occurring from northern Mexico to southern Uruguay (Mayo et al., 1997), being very abundant in tropical rain forest habitats (Sakuragui, 2001). One hundred and fifty-six species of *Philodendron* have been described from Brazil (Sakuragui and Soares, 2010) that predominantly grow in humid tropical forests, but are also found on rock outcrops and in swamps, riparian forests, and semiarid regions.

According to Benzing (1987), 20–25,000 species of vascular epiphytes occur in the tropics, with 80% of all epiphyte species being monocots. Epiphytes are largely encountered in tropical rain forests (Kress, 1989) and are partially responsible for the great diversities found in those complex terrestrial ecosystems (Gentry and Dodson, 1987). Rupicolous species develop in environments with high solar radiation and wide temperature variations and can be exposed to strong winds and to water stress (Burke, 2002).

Philodendron taxa grow in a wide variety of habitats as terrestrial, epiphytic, rupicolous, or hemiepiphytic plants. Hemiepiphytic individuals have epiphytic and terrestrial stages in their life cycles, with, prior to living as hemiepiphytes, germinating and initially growing as epiphytes. After germination and initial development on host trees these plants later develop aerial roots that grow toward the ground. But Aroids are usually classified as secondary hemiepiphytes, as they germinate as terrestrials and then develop aerial roots that attach them to the host tree (Patiño et al., 1999). According to Zotz (2013), however, the use of the term “secondary hemiepiphyte” should be discontinued in favor of using term “nomadic vine” (for details see Zotz, 2013).

Due to the wide variety of adventitious root types in the Araceae family, a dimorphism related to their function as feeder roots (which absorb water and nutrients from the substrate) and anchor roots (which attach the plants to their hosts) can be observed. Feeder and anchor roots show morphological and physiological differences (French, 1997), and Mayo (1991) illustrated root dimorphism in *Meconostigma*.

Two subgenera were recognized in the revision of the genus by Krause (1913): *Euphilodendron* (=*Philodendron*) and *Meconostigma*. Subsequent analysis of anatomical characters led Mayo (1989) to elevate the section *Pteromischum* (subgenera *Philodendron)* to the subgenus rank, so that three subgenera (*Pteromischum* with 75 species, *Meconostigma*

with 20 species, and *Philodendron* with over 250 species) are now currently accepted (Mayo et al., 1997).

The root vascular plexus represents the connections between adventitious roots and the vascular system of the stem (French and Tomlinson, 1984). The subgenera *Philodendron* and *Meconostigma* have a vascular plexus formed by branched vascular bundles while the vascular plexus of *Pteromischum* species is composed of simple vascular bundles. This feature is related to the diversification of the habits and habitats of the subgenera, and a branched vascular plexus is a synapomorphy of the monophyletic clade comprising the subgenera *Philodendron* and *Meconostigma* (Tenorio et al., 2012)—and the presence of this branched vascular plexus possibly led to the occurrence of root dimorphism in these subgenera. Assuming that variations in *Philodendron* root types occurred due to the vascular plexus, the objective of this work was to anatomically describe the different root types and identify adaptations to their habitats and their links to anatomical variations among the different root types.

Section snippets

Materials and methods

Three individuals from four populations each (representing three different species) were examined in the anatomical analyses: population A (terrestrial) and population B (rupicolous) of *Philodendron corcovadense*, population C (hemiepiphyte) of *P. cordatum*, and population D (nomadic vines) of *P. oblongum*, all from areas of Atlantic Forest in Rio de Janeiro State, Brazil (Table 1). Voucher specimens were deposited in the Herbarium of the Federal University of Rio de Janeiro (RFA). The samples…

Results

The adventitious roots of the species analyzed all emerge from the aerial nodal regions of the stems. *Philodendron corcovadense* was represented by a population of terrestrial individuals with adventitious roots—classified here as feeder roots—(Fig. 1A) and by another population of rupicolous individuals with adventitious anchor–feeder roots which initially support the individuals on rocks and then detach, growing toward the substratum and assuming the role of feeders (Fig. 1B). The roots of the …

Discussion

In a study of the anatomy of the adventitious roots of the Araceae family, French, 1987a, French, 1987b emphasized the occurrence of a sclerified hypodermis and resiniferous channels as well as the systematic implications of those structures. Vianna et al. (2001) studied the anchor roots of *Philodendron bipinnatifidum* (which have lobate steles) while Hinchee (1981) conducted studies on the different types of roots of *Monstera deliciosa*, classifying them as aerial, aerial–subterranean, or…

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