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Studies on the Perimeter : Protoxylem Ratios in Twelve Domesticated Orchid Species

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ABSTRACT

The present study was aimed at ranking twelve domesticated orchid species based on ANOVA of their Perimeter : Protoxylem arch ratios. Two terrestrial orchids, Spathoglottis plicata Blume , Peristeria elata Hook and ten epiphytic orchids, Oncidium flexuosum Sims., Dendrobium crumenatum Sw., Dendrobium var. sonia, Arachnis flosaeris (L.) Rchb. f, Vanda sp., Phalaenopsis equestris (Schauer) Rchb. f., Doritis pulcherrima var. marmorata, Acampe sp., Vanilla sp. and Epidendrum sp. were selected for the present study. The P: Px ratio was observed to correlate with the water adaptive efficiency of the orchids.

Keywords : Orchids, ANOVA, Perimeter : Protoylem Archs Ratio

I. INTRODUCTION

Orchids attract considerable attention largely because of their extraordinary diversity. Orchids are distributed throughout all moist habitats, and a few are found in deserts. Species are found in soil, in litter, on the ground or attached to plant surfaces as epiphytes. All species form very small seeds, and require a fungus to germinate the seed and nourish seedlings in the wild. The Orchidaceae is one of the largest and most diverse families of plants, including somewhere between one tenth and one fourteenth of all flowering plant species (Robert and Dressler, 1927). The radiation of orchid family took place in a very short period as compared to that of most flowering plant families. This suggested that, their speciation rates are exceptionally high (Gill, 1989). The specialised biology of orchids is attributed to an epiphytic ancestry of the family, with evidence from pollination mechanism, seeds and roots. The zygomorphic flower form in orchids can be traced to a pendent form of primitive inflorescence. Repeated reversion of orchids to the terrestrial habit is indicated. Primitive epiphytic plants are believed to follow a general pattern of extinction like that of the primitive forms in other evolutionary successful families such as Asteraceae (Robinson, 1982).

According to the World Conservation Union (IUCN, 1999), two thirds of orchid species are epiphytes and lithophytes, with terrestrial species comprising the remaining third. Yet, they comprise of almost half the extinct species. Based on the comparative anatomy of absorption roots of terrestrial and epiphytic orchids from an ecological view point, it was concluded that anatomical characters should have evolved several adaptations with respect to distinct environments during the evolutionary process (Moreira and Isaias, 2008). Epiphytic orchid-mycorrhizal associations are more conservative and may co-evolve more than terrestrial ones (Martos et al. 2012). However, vascular epiphytes exhibit more drought tolerance characteristics than do terrestrial species even though the water adaptive strategies may differ among epiphytic species. The strategies of epiphytic orchids for maintaining water balance are thick cuticles in leaves, the succulent character of leaves and water storage in pseudo bulbs that can

store enough moisture, so that plants can survive for several months without rainfall. The anatomical characteristics of the absorption roots of orchids are also very interesting that can relate the plants to their habits. The presence of velamen in epiphytic orchids is fundamentally important to facilitate water and nutrients absorption. Lignified exodermis and endodermis offers intensive mechanical protection against water evaporation and control the entrance of mycorrhizae in cortical cells. The presence of velamen, lignified exodermis and endodermis and a higher number of protoxylem arches in relation to root size are observed to be important characteristics for an efficient colonization of the epiphytic environment (Moreira and Isaias, 2008).The terrestrial habit implies less structural adaptations for water deficit. So, in terrestrial orchids transportation may be slower, as the nutrients are nearby. The perimeter: protoxylem arches ratio calls special attention. The higher number of protoxylem arches related to root size observed in epiphytic roots may be a response to the necessity of efficient substances transport to the rest of the plant. This efficient transportation possibly compensates the absence of storage tissues.

The present study of perimeter: proto xylem ratio in orchid roots was therefore taken up to explore the possibility of using P: Px ratio as a measure to quantify the water adaptive efficiency of an orchid. This can help in Orchid conservation studies thereby protecting them from extinction.

II. METHODS AND MATERIAL

Twelve domesticated orchid species including two terrestrial orchids, Spathoglottis plicata.Blume , Peristeria elata Hook and ten epiphytic orchids, Oncidium flexuosum Sims., Dendrobium crumenatum Sw., Dendrobium var.sonia, Arachnis flosaeris(L.)Rchb.f, Vanda sp., Phalaenopsis equestris (Schauer)Rchb.f., Doritis pulcherrima, Acampe sp., Vanilla sp. and Epidendrum sp. (Fig.1) were selected as samples from a common garden in Kottayam, Kerala. Five roots of each species were selected. Transverse sections of each root was taken by hand sectioning , stained in lactophenol cotton blue and mounted with glycerine on a clean glass slide and observed under the light microscope; (LABOMED CX_{RIII}) at 10x, 40x and 100x magnification. Radius of the roots was obtained using a micrometer. Diameter of the root was calculated using formula d=2r. Perimeter was also obtained using the formula $P=2\pi r$. Protoxylem arches were counted in all the root sections and recorded. The Perimeter: Protoxylem ratio (P: Px) was calculated from the upper, middle and the lower parts of five root samples of each species to get an average value and to estimate the relative water and nutrient conduction from the root cortex to the other parts of the plant. The Perimeter: Protoxylem ratio was statistically analyzed using ANOVA (Table 1).

a. *Spathoglottis plicata* Blume

b. *Peristeria elata* Hook.

c. *Oncidium flexuosum* Sims.


d. *Dendrobium crumenatum* Sw.


e. *Dendrobium var.sonia*


f. *Epidendrum sp.*


g. *Arachnis flosaeris* (L.)Rchb.f.


h. *Vanilla sp.*


i. Acampe sp.


j. *Vanda sp.*


k. *Phalanopsis equestris* (Schauer)Rchb.f

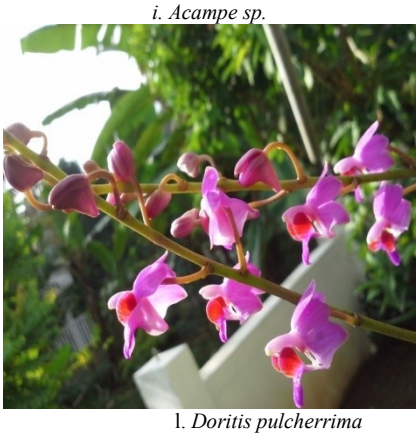

l. *Doritis pulcherrima*

Figure 1 : The twelve orchid species under study

III. RESULTS AND DISCUSSION

Table 1. Rank Order Based on Perimeter: Protoxylem arches ratio using ANOVA

Sl. No.	Name of the orchid	Radius (mm)	Perimeter (mm)	Number of protoxylem archs	P:Px	Rank order
1.	*Spathoglottis plicata* Blume	0.78	4.89	10	0.48	EF
2.	*Peristeria elata* Hook.	1.07	6.71	15	0.44	FG
3.	*Oncidium flexuosum* Sims.	0.59	3.70	12	0.30	GH

4.	*Dendrobium crumenatum* Sw.	0.63	3.95	19	0.20	H
5.	*Dendrobium var-sonia*	0.88	5.52	18	0.30	GH
6.	*Epidendrum sp.*	0.72	4.52	9	0.50	DE
7.	*Arachnis sp.*	1.83	11.49	19	0.60	D
8.	*Vanilla sp.*	0.71	4.45	14	0.31	GH
9.	*Acampe sp.*	2.16	13.56	18	0.75	C
10.	*Vanda sp.*	1.61	10.11	14	0.72	C
11.	*Phalaenopsis equestris* (Schauer) Rchb.f	1.82	11.42	11	1.03	A
12.	*Doritis pulcherrima*	1.57	9.85	12	0.82	B

The Perimeter: Protoxylem ratio (p: px) was calculated to estimate the relative water and nutrient conduction from the root cortex to other parts of the plant. In the present study, highest p: px ratio was observed in the epiphytic orchid *Phalaenopsis equestris* (Schauer) Rchb.f. followed by *Doritis pulcherrima* (Table 1). *Doritis* with a p: px ratio of 0.82 is the peloric form of *Phalaenopsis* with a p: px ratio of 1.03. It is terrestrial and lacks the thick walls in the exodermis and endodermis layers (Fig. 2d) unlike that in *Phalaenopsis* (Fig. 2k). Both *Phalaenopsis* and *Doritis* have a rosette of succulent leaves. Stem and other storage tissues are absent. However, they freely interbreed forming thousands of *Doritaenopsis* hybrids, an adaptive strategy for survivorship in an epiphytic environment. Hence, the high p: px ratio is indicative of the fact that since there are no other adaptations in these orchids other than the absorption roots, the absorptive efficiency of these roots is high. A high p:px ratio also helps in both epiphytic and terrestrial colonization of the orchids.

The epiphytic orchids *Acampe* and *Vanda* with a p: px ratio of 0.75 and 0.72 respectively have long, narrow leaves, and hanging aerial roots. These are better adaptive strategies of the orchids for an epiphytic mode of life. It was observed that *Acampe* has the largest perimeter of absorption roots and a wide cortex for the storage of large amounts of water to withstand dry climate as an epiphyte. The thickening of velamen is also another adaptation of an orchid to the epiphytic habitat. It aids to prevent transpiration i.e. water loss from the root cortex. *Vanda* also resembles *Acampe* in all the characters (Fig. 2 i and j). In addition it has a short stem, tuft of hanging absorption roots with a large perimeter.

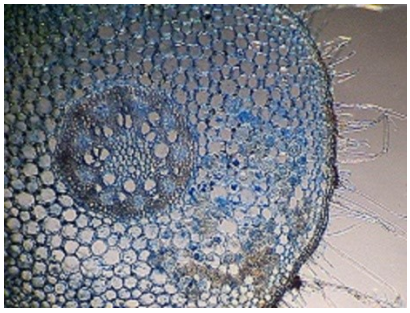
The *Arachnis* and *Epidendrum* sp. with p: px ratios 0.6 and 0.5 respectively have long stems and absorption roots all along the stem (Fig.1g and i). These are also, adaptive strategies of the orchids for an epiphytic and semi epiphytic mode of life.

Spathoglottis and *Peresteria* are terrestrial orchids that show a p: px ratio of 0.48 and 0.44 respectively. Generally, the diameter of absorption roots in the species of terrestrial Orchidaceae is wider than that of the epiphytic ones. This characteristic can be associated with the storage of nutritive substances and water (Zots, 1999). However, *Spathoglottis* and *Peristeria*, the terrestrial species in the present study is observed to have the lowest diameter when compared to other species. The function of storing substances in these species is concentrated in bulbous structures. Root hairs observed in *Spathoglottis sp* (Fig 2a), can be attributed to direct absorption of water and nutrients from soil. *Spathoglottis sp* and

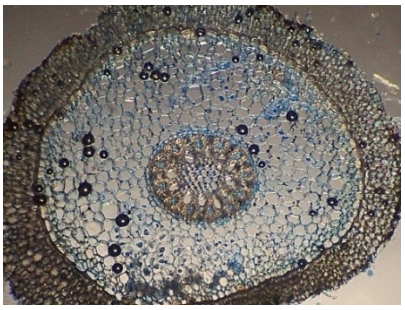
Peristeria sp with bulbous leaf bases (Fig. 1a and b) also show low p: px ratio.

The p: px ratio in *Vanilla sp., Dendrobium var. Sonia* and *Oncidium sp.* is 0.31, 0.3 and 0.3 respectively. In vanilla, aerial roots are produced from branching points of the stem (Fig. 1h). The stem of *Dendrobium var. Sonia* stores water and becomes bulbous (Fig. 1e) whereas *Oncidium sp.* exhibits a bulbous leaf base (Fig. 1c). Storage function of the stem is a recent adaptation when compared to the storage in the leaf bases. For survivorship in an epiphytic environment not only water absorption, but, also its storage is important (Moreira et al. 2013).

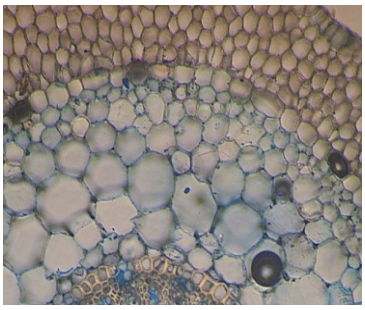
Lowest p: px ratio was observed in *Dendrobium* crumentum Sw. The bulbous stem in this orchid could be an alternate adaptation for storing water and nutrients (Fig. 1d). However, the low p: px ratio can function as an indicative parameter of threat for the survival of an orchid. Measures need to be taken for the conservation of such orchids.



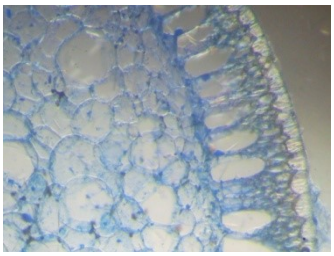
a. *Spathoglottis plicata* Blume

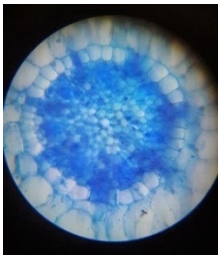


b. *Peristeria elata* Hook.

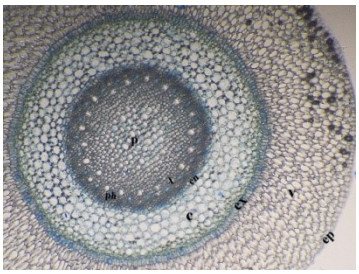


c. *Oncidium flexuosum* Sims.

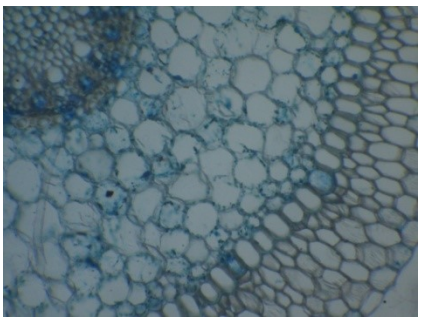




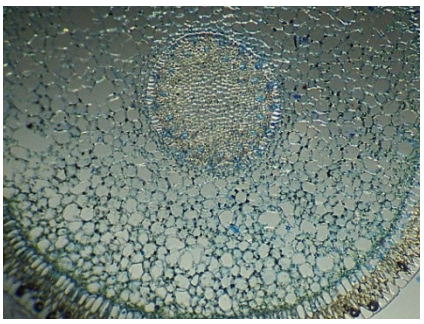
d. *Doritis pulcherrima*



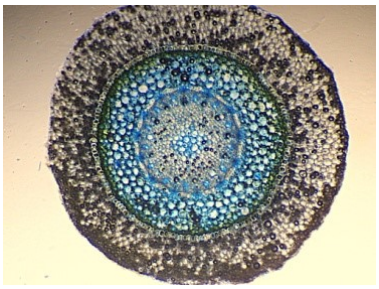
e. *Dendrobium var.sonia*



f. *Epidendrum sp.*

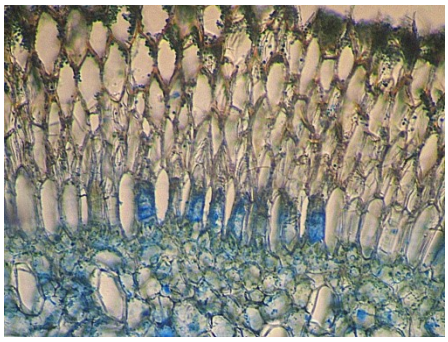


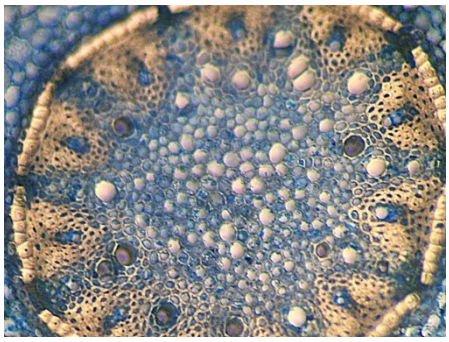
g. Arachnis flosaeris (L.)Rchb.f.



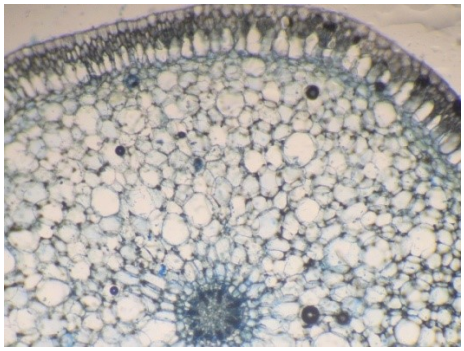
h. *Vanilla sp.*

i. *Acampe sp.*

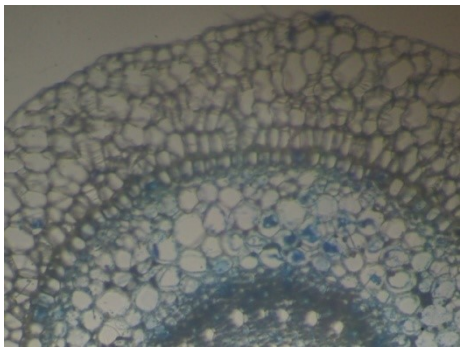




j. *Vanda sp.*



k. *Phalaenopsis equestris* (Schauer) Rchb.f



l. *Dendrobium crumenatum* Sw.

Figure 2 : Transverse sections of the roots of twelve orchid species.

IV. CONCLUSION

The present study was aimed at exploring the possibility of using P: Px ratio as a measure to quantify the water adaptive efficiency of an orchid. This can help in Orchid conservation studies thereby protecting them from extinction.

The major conclusions of the study are as follows.

1. Highest p:px ratio observed in epiphytic orchid *Phalaenopsis* species and the lowest ratio found in *Dendrobium crumenatum* Sw.
2. Highest diameter of absorption roots is observed in the epiphytic orchid species of *Acampe* where the exodermis and endodermis are thick walled, an adaptation to prevent transpiration.
3. Lowest diameter was observed in *Oncidium*. The species with lowest diameter showed bulbous structures for storage. Therefore, bulbous structures can be considered as an alternative adaptation for the storage of water and nutrients.

4. A high p: px ratio is indicative of the fact that the absorptive efficiency of these roots is high. A high p:px ratio also helps in both epiphytic and terrestrial colonization of the orchids. These are also, adaptive strategies of the orchids for an epiphytic and semi epiphytic mode of life.
5. The low p: px ratio can be an indicator of threat, for the survival of an orchid. Measures need to be taken for the conservation of such orchids.

Many orchid species are on the verge of decline. Measures have to be taken for conserving and regrowing them. Conservation of orchids requires an understanding about their adaptations and characteristics. The present work will be helpful for further research, conservation and protection of the diverse species of Orchids.

V. ACKNOWLEDGEMENT

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