CHAPTER 7

SUMMARY

The present investigation deals with the anatomical study of different parts of the sixty seven species under twenty two genera out of the Tribe Epidendreae of Hook.fil. (1890). In addition, the morphological characteristics of the plants, in general, has also been described. The epiphytic orchids, as is characteristic for the terrestrial ones, have been found to possess only one type of root, which is conventionally called as aerial root. These roots are ~~are~~ smooth but on coming in contact with any substratum produce root-hairs on the contact surface, then behave as clinging ones.

The axis consists of two parts - lower creeping typical sucker bearing only scale-leaves although described here as rhizomaceous base following conventional description and upper slender/semi-fleshy elongated pseudo-stem or fleshy pseudo-bulb of one or more internode(s) and bearing normal leaf/leaves.

The number of scale-leaves and normal leaves vary in the orchids but for a species and sometimes also genus it has been found to be more or less constant. In some taxa, particularly those with elongated axis, there exists a gradual

transition from scale-leaves to normal ones. Three types of photosynthetic leaves, namely, plicate, leathery and ensiform, have been encountered. The leaf-base may be distinct and separable or it may be partly or wholly amalgamated with the internode(s) above its node of origin so as to form a complex structure. The 'petiole', when present, may be short or long, cylindrical with a central longitudinal lumen or cylindrical with a vertical groove at the adaxial side or flattened with the adaxial side slightly concaved. The blade in plicate leaf is generally thin and broad with multicostate convergent venation, that in leathery leaf is thick (with a few exceptions) and generally conduplicate while the ensiform leaf with the two halves of the blade fused is fleshy or very thick.

In some cases due to unequal but extensive elongation of the base(s), the leaf/leaves may apparently appear more or less terminal particularly in species with pseudo-bulb but morphologically they have been always found typically lateral.

The internal structure of root, rhizomaceous stem, and leaf and also the morphology of leafy axis for each genus have been described separately and the characters have been compared and tabulated whenever necessary and discussed.

The comparative anatomical study of the root for each genus has been made tissue-zone-wise under the marginal heads -

epidermis, exodermis, cortex, endodermis, stele, pericycle, phloem, xylem, conjunctive tissue and pith. Similar and dissimilar characters have been evaluated.

The epidermis is uniseriate or multiseriate and velaminous being composed of compactly-set dead cells at maturity. The occurrence of unilayered or multilayered epidermis is little correlated with ecological adaptation as both conditions have been encountered in the epiphytic as well as terrestrial orchids. Peculiarly, the comparative frequency of the occurrence of multiple epidermis is higher in the terrestrial forms. In some cases specific layer of velamen tissue may show large or radially elongated cells sometimes accompanied by thickening of the inner walls. In the light of critical study proposal has been made to coin three new terms, namely,"epi-velamen", "epi-endo-velamen" and "endo-velamen" to facilitate better expression in short descriptive terms.

The epidermis is separated from the cortex by the outermost single limiting layer of the latter called exodermis which may have only very slight suberization of the outer wall or in extreme cases all the walls of exodermal cells may be heavily thickened and suberized. In the material under the present investigation occurrence of solitary passage cells here and there between the units of variable number of thick-walled exodermal cells has been found to be universal. In a

few taxa 1-2 specialized cover-cells have been noticed on the outer side of the passage cells.

The cortex is thin or massive, generally composed of a few to several layers of thin-walled, more or less isodiametric, spherical-oval parenchymatous cells with distinct (sometimes large) intercellular spaces except in the species of Eria and Cryptochilus where wall-thickening by lignification has been encountered in the inner layers of cells.

The endodermis is universally uniseriate consisting of compactly arranged cells. The cells may be thin-walled and parenchymatous with typical casparian strips; or the endodermis may have multicellular groups of thick-walled, generally suberized, U-type or O-type cells alternating with 1-more-celled units of thin-walled passage cells. Unlike in exodermis the passage cells occur more or less at regular intervals. In old roots of a few taxa, e.g. Dendrobium, Bulbophyllum and Eria, the walls of the passage cells undergo slight thickening.

The pericycle is also uniseriate and composed of slightly thickened to very thick-walled lignified sclerenchymatous cells with a few passage cells abutting the protoxylem points. In many of the taxa investigated this layer is contiguous with the recognizable phloem patch consisting of thin-walled elements, while in others there are 1-3 layers of thick-walled lignified cells between them, associated with a mass of ligni-

fied cells between xylem and phloem strands.

As usual, the vascular bundle is radial with exarch xylem. The number of vascular strands may vary even in the same root. The number is higher at the basal region where the stele is larger in diameter and is gradually or sharply reduced towards the tip. The reduction in the number of strands, effected by obliteration of any xylem strand here and there followed by lateral fusion of the two neighbouring phloem strands, is not related with root branching.

In majority of the cases, pith is composed of thin-walled, spherical, isodiametric parenchymatous cells. On the contrary, in several taxa it becomes thick-walled and lignified at quite an early stage and in a few cases the peripheral layers only acquire such thickening on maturity.

The rhizome or rhizomaceous basal region of the axis bearing scale leaves exhibits epidermis, ground tissue and vascular bundles in transverse sections.

Commonly, with a few exceptions, the ground tissue could be classified into two types - one showing distinction into two zones and the other into three zones.

The outer zone, corresponding to the cortex of a dicotyledonous stem, is devoid of vascular bundles and consists of a few to several layers of thin-walled isodiametric paren-

chymatous cells with a few idioblasts here and there. The inner or the central zone although having similar type of cells is characterised by the presence of dispersed vascular bundles of which the outer small ones may be arranged in a ring-like line in cross-sections showing some resemblance with the dicotyledonous construction.

In the three-zoned condition an additional middle stratum of sclerenchyma is present between the two parenchymatous zones. This middle sclerenchymatous zone has the peripheral bundles adpressed to it on the inner side or partly embedded in it.

Besides the typical two-zones form is two species and three-zoned form in another two species of Bulbophyllum there are other three species showing 4-5 zones in the ground tissue. In these cases an exodermal-like tissue consisted of 1-2 layers of cells intervened the outer zone of ground tissue separating the latter into two sub-zones and consequently the total number of zones in the rhizome is increased.

In Bulbophyllum reptans there are only two layers in the middle band varying in stainability and indicating similarity to endodermis and pericycle. In B. odoratissimum, on the other hand, out of four layers in the band the outer two show identical conditions.

In a few taxa, like Liparis resupinata, Phaius wallichii,

Agrostophyllum spp. and Calanthe densiflora the middle sclerenchymatous ring has a number of small gaps of variable size all round here and there. On the other hand, in Liparis spp. (except L. resupinata), Dendrobium longicornu, D. draconis, D. chrysanthum, D. fimbriatum and Coelogyne spp. it has been observed that at the point of origin of adventitious root a few peripheral bundles of the rhizome become aggregated resulting in the fusion of sclerenchymatous bundle-sheaths. This gives rise to strips of sclerenchyma with the vascular bundles incorporated in it.

In several terrestrial taxa each vascular bundle is surrounded by a layer of thin-walled parenchymatous cells which distinctly differ from other neighbouring cells of ground tissue; but in other orchids this layer is less or not distinguishable. The xylem and phloem strands are covered by layer(s) of sclerenchyma. Interestingly the vascular bundles in Nephelaphyllum pulchrum var. sikkimensis and N. cordifolium are devoid of sclerenchyma. In majority of the taxa investigated a line of lignified cells separates xylem and phloem strands of the vascular bundles.

Transverse sections of base, petiole and blade of leaf, wherever present, have been described and discussed.

Leaf-base is either circular or semi-circular and either partly or wholely fused with the axis. The petiole is O-, C-

or U-shaped in cross-section.

Out of the 67 species investigated, ensiform leaves are found only in all of the three species of Oberonia and in Dendrobium ancepS as an aberrant characteristic. Anatomically an ensiform leaf-blade shows a clear distinction from the plicate and leathery leaves in having the two lateral halves of the blade fused by adaxial face, the adaxial epidermis obliterated and the lateral veins of the two halves in pairs with their xylem strands facing each other. The characters are analysed and discussed and a parallel has been suggested with the dicotyledonous phyllode in Acacia.

In the plicate and leathery leaves of terrestrial orchids the epidermis in uniseriate while the epiphytic taxa exhibit both uniseriate and multiseriate ones. The uniseriate epidermis and the surface layer of multiple epidermis are more or less identical and possess glandular trichomes and stomata; while the sub-surface layer(s) of the multiple epidermis differ remarkably. In species of Calanthe non-glandular unicelled or multicelled hairs have also been observed. Bulliform cells have been encountered in a limited number of taxa like Spathoglottis sp., Otochilus porrecta and Arundina spp. Hypodermis-like layer having spiral or reticulate thickenings on the walls is present only in Coeloryne flaccida.

The mesophyll is not differentiated into palisade and spongy parenchyma in the plicate and ensiform leaves, but in the leathery leaves the mesophyll ranges from undifferentiated homogeneous to well differentiated ones through the transitory stages possessing incipient palisade. Patches of sclerenchyma forming I-girders have been encountered on the inner side of epidermis in Agrostophyllum spp. and Dendrobium anceps.

Each vascular bundle is encircled by an outer thin-walled parenchymatous and inner thick-walled mestom layers.

The mid-vein as well as the larger lateral veins give out small branches which after emerging through the bundle-sheath run more or less parallel to other veins. The pattern of vein-branching is simple in the majority of cases but in Otochilus and Pholidota it is more complicated.

As has been mentioned earlier, without any exception, the rhizomaceous part of the axis bearing scale-leaves internally exhibits a typical construction where demarcation of a cortical region and a stelar region, more or less parallel to a dicotyledonous construction, is quite evident.

In contrast, from anatomical point of view it has been noted that the photosynthetic leaf-bearing portion of the axis is morphologically not a true stem but a composite structure wherein the medianly placed axis remains encircled by

and amalgamated with the extending leaf-base(s). Such an organisation is universal irrespective of the external diversity and thickness of the pseudo-stem (reed) or pseudo-bulb although the degree of complication may be varied depending upon the number of leaves, length of internodes, disposition of laminar expansion, etc.

The small scale-leaf receives only a few bundles as vascular supply and thereby does not substantially disturb the vascular organisation of the rhizomaceous axis. But it i has been noted, again without any exception, that the vascular supply of a normal photosynthetic leaf, comprising of a large number of anastomosing bundles, needs a long course for differentiation and organisation before the leaf-base becomes properly recognizable. As the leaf-base completely encircles the axis at least in its initiating phase, vascular supply is derived from all round the axial system spreading out centrifugally and this phenomenon makes the pattern of distribution of vascular bundles more complicated. But in all cases these diverging vascular bundles gradually conform a distinctly separate mass and get themselves oriented and arranged in a circular line near the peripheral region when the leaf-base is morphologically differentiated by splitting of the ground tissue inbetween the central and peripheral masses of vascular system and with simultaneous organization of epidermal tissues of the axis and the adaxial face of the leaf. In some cases,

like Bulbophyllum, although the orientation and organisation of the vascular system are variable and complicated its course of differentiation from the axial system is in conformity.

That the leaf-bearing portion of the axis is not a true stem becomes evident from certain observations where in specific cases or under special circumstances the rhizomaceous construction is at least temporarily revived.

In the five species of Dendrobium having long reed-like pseudo-stem, although the later-formed region of the rhizome is somewhat fleshy and bulbous it continues to show the typical rhizomaceous constriction. Similar observations were made with the two species of Arundina. The basal region of the pseudo-stem of Agrostophyllum still bearing scale-leaves, also shows rhizomaceous characters. Microstylis congesta although with a thicker pseudo-stem but bearing a scale-leaf at its lower region exhibits a cortex-like area whereas M. wallichii with a thinner pseudo-stem but bearing a green leaf has no distinct cortex.

In Phaius mishmensis the middle region of the erect pseudo-stem still bearing scale-leaf exhibits typical rhizomaceous construction and in addition, shows a more or less ring-like arrangement of the outer vascular bundles. In Oberonia the leafy axis shows a typical rhizomaceous construction just above

the nodal region. As the leaf-base of the next (ensiform) leaf gradually differentiates, associated with increase in dimension of the compound structure (true stem and leaf-base), the vascular system also gradually becomes more and more dispersed and scattered.

The lower part of the pseudo-bulb with one scale-leaf in Cryptochilus species and Eria convallarioides does not show any appreciable cortical region but in that of Phaius wallichii and four species of Calanthe with multiple scale-leaves a typical cortical region is recognizable. Moreover, in C. densiflora repeated revival of a similar situation could be noticed in the upper regions after departure of vascular supply for successive leaves. In E. stricta, with a fleshy pseudo-stem and two leaves only, a similar condition could be encountered.

In Liparis the vascular bundles after separation of the vascular supply to the last leaf aggregate together into a central group reviving the rhizomaceous constriction and enter into the terminal inflorescence axis. Similar observations were also made in Dendrobium rotundatum, D. amplum, Eria stricta, Cryptochilus sp., Trichosma suavis, Coelogyne ochracea, C. elata and Pholidota species. In Coelogyne praecox although the inflorescence is not terminal a typical rhizomaceous organisation follows upto the base of the shoot apex after the last leaf is borne.

Trichosma suavis has about four scale-leaves where the upper 1-2 nodes show laterally dispersed and exposed axillary buds with the potentiality of giving rise to new shoots in the next growing season. The terminal region of the axis bears two leaves having very long and fused base(s) forming a pseudo-stem. The axillary bud of the lower leaf has been found embedded inside this pseudo-stem near its base.

In Nephelaphyllum species and Tainia latifolia, having a single terminal photosynthetic leaf, the axillary bud of the last scale-leaf remains fused with the lower region of the pseudo-bulb and gradually emerges out to bear a few scale-leaves with axillary buds and a terminal inflorescence.

In Otochilus spp. and Pholidota (2 out of 3 species), on the other hand, with two photosynthetic leaves disposed terminally on the fleshy pseudo-stem, the vascular supply of axillary bud becomes differentiated right near the base of the pseudo-stem inbetween the central axial vascular system and the vascular system of the leaf-base sheath. This differentiated unit of vascular supply of the axillary bud moves upward and outward piercing through the fused leaf-base and passes out to the base of the extra-nodal bud disposed laterally near the top of the fleshy pseudo-stem. This bud gives rise to about seven scale-leaves, two photosynthetic leaves (to be matured at a later stage and survive next growing

season, with the axis enlarging into a fleshy pseudo-stem) and a terminal inflorescence in succession.

All of these above mentioned facts and figures have been analysed and assessed and a thorough discussion has been made concluding that the leafy-axis of the orchids is not a true stem but a compounded fused structure of the axis, leaf-base(s) and in some cases associated structures, and morphologically the construction is similar in all cases irrespective of the external feature exhibited by the leafy-axis.

In the concluding part of this present work significance of some morphological characteristics, as evidenced in course of the study but not very seriously considered beforehand, has been pointed out. Moreover, supportive evidences have been lent in favour of the transfer of certain taxa from one unit to the other and also questions have been raised in some other cases regarding retention of the taxa as a valid member within the group.