

## CHAPTER 6

### C O N C L U S I O N

A : External and Internal Morphology in relation to Taxonomy.

I : Significance of some Morphological Characters

Although conventional taxonomical characters have not been dealt with in detail in the present work, some of the non-conventional characters have been found phylogenetically quite significant in some cases which may be summarised below. Some of these characters, however, have been duly considered by King and Pantling (1898) and Shushan (1959).

(a) Number of scale-leaf/normal green leaf/total number of leaves

In Oberonia Lindl. the number of green (when young) scale-leaves including the transitional forms has been found to be 2-3 in all of the three taxa investigated. Uniformity is also noticeable to some extent for the number of green normal leaves which ranges from 4-5 to 5-6 between them. Similarly in Microstylis Nutt. the number of normal leaf is 3-4. In Dendrobium Swartz the number of typical scale-leaves varies from 3 to 4; there are some transitional forms in all of them and the total number of leaves varies from 17 to 25 depending upon growth habit. In Bulbophyllum Thou. except B. odoratissimum (Smith) Lindl. ex wall and B. reptans (Lindl.) Lindl. ex wall. the number of scale-leaves is between

3-4. In B. bicolor Hook. fil. and B. paleaceum Benth., (as enumerated by Hook. fil.), however, the number is five, but these have already been transferred to Sunipia Lindl. On the other hand, the three species of Cirrhonetium Lindl., namely, C. guttulatum Hook. fil., C. ornatissimum Rchb. fil. and C. cornutum Lindl., have 5, 7 (as in B. odoratissimum and B. repens) and 11 scale-leaves although these are now considered as species of Bulbophyllum. It is interesting to note that in all these species there is a single photosynthetic leaf.

Present investigation does not include any species of Trias and Drymoda but the next genus as enumerated by Hooker fil., viz. Monomeria Lindl. also has  $5 + 1 = 6$  leaves indicating relationship with Bulbophyllum, particularly Sunipia Lindl.

In Phaius Lour., again, the number of scale-leaf is eight and the total number of leaf is 12-14. P. albus Lindl. having a total number of 24-32 leaves has already been transferred to Thunia Rehb. f. In case of Nerhelaphyllum Blume numbers are 4-5 and 5-6. The next genus Tainia Blume has consistency like  $5 + 1$  and in both of these related genera there is a single photosynthetic leaf.

The number of scale-leaf is 6-7 in Cryptochilus Wall., 8-13 in Coelogyne Lindl., 7 in Otochilus Lindl. and 6-7 in Pholidota Lindl. Coelogyne praecox Lindl. having only 4 scale-leaves has already been transferred to Pleione D. Don and the present investigation questions (please see Chapter 6, A II, g(11)) the systematic position of Coelogyne uniflora Lindl. having 6-7 scale-leaves. The number of photosynthetic leaf, however, is uniform and happens to be only two in all of these taxa under the related genera Cryptochilus, Coelogyne, Otochilus and Pholidota. The aberrant type P. imbricata Hook. shows only one photosynthetic leaf and this has been discussed under A II (h) hereafter.

The total number of leaf in Calanthe Brown, varies from 8-11 except in C. densiflora Lindl. where it is 12-13. The number of typical photosynthetic leaves seems to be between 3-5 although the number of scale-leaves including transitional forms is more variable but exceptionally higher in C. densiflora which appears to be an aberrant form within the genus and discussed under A II(1).

The number of scale-leaves in Arundina Blume appears to have a close range (3-4).

(b) Position of Inflorescence/Flower and number of Flower(s).

It appears that the related genera of Hooker fil., namely, Oberonia Lindl., Microstylis Nutt. and Liparis

Rich. are characterised by the presence of terminal raceme originated from the apical bud. Dendrobium Swartz seems to be characterised by axillary lateral inflorescence having about 3-4 flowers which sometimes may be reduced even unto one. D. fimbriatum Hook., however, shows the presence of many-flowered inflorescence. D. amplum Lindl. and D. rotundatum Benth. with single apical flower have already been shifted to Epigeneium Gagnep. The position of D. anceps Swartz with a solitary flower, on the other hand, has been questioned in this work in consideration of other aberrant characters.

Bulbophyllum Thou., Monomeria Lindl. and Panisea Lindl. show axillary lateral racemose inflorescence but the members of Cirrhonetium Lindl. which has now been merged with Bulbophyllum have solitary inflorescence or small umbels.

The taxa of Eria Lindl. including Trichosma suavis Lindl. as in Hooker fil. (1830) show both axillary and apical inflorescences. These two groups also show other dissimilarities and are discussed in the next sub-chapter. Similarly Phaius albus Lindl. with terminal inflorescence, in contrast to axillary in the other species, also appears to aberrant in other characters and is discussed in the next sub-chapter.

The related genera of Hooker fil. coming next in the series, namely, Nephelaphyllum Blume, Tainia Blume and Anthogonium Lindl. show axillary raceme. Agrotophyllum Blume and Cryptochilus Wall. also have racemose inflorescence but in apical position.

Coelogyne Lindl. appears to be a heterogeneous assemblage in respect of position of the racemose inflorescence which may be either axillary or apical. C. praecox Lindl. with an axillary solitary inflorescence has already been removed to Pleione D. Don as P. praecox (Smith) D. Don. Coelogyne uniflora Lindl., a debated taxon, on the other hand, has solitary apical flower not fitting with either Coelogyne Lindl. or Panisea Lindl. This taxon has been discussed further in the next sub-chapter.

Otochilus Lindl. and Pholidota Lindl. are characterised by apical raceme and Calanthe Brown by axillary raceme. C. densiflora Lindl., however, exhibits an umbel-like structure and its systematic position has been discussed in the next sub-chapter.

## II. : Consideration on Taxonomical Problems :

As consideration of the morphological criteria significant for classification and nomenclature has not been the objective of the present work, the conventional details of

morphological characters were not included under the first sub-chapter of observation of this study. Therefore, consideration of such details which are conventional for the taxonomists are not being discussed herewith although some morphological informations usually not considered to be very important have been mentioned whenever and wherever relevant. As a natural consequence citations of these morphological characteristics should be considered as additions for conventional taxonomic considerations. Moreover, significant anatomical characteristics, if any, have also been discussed as corroborative factors.

(a) Nomenclatural status of Linaris longipes Lindl. var. spathulata Ridley :

*Altogether*  
Although six species of Linaris Rich., two terrestrial and four epiphytic, have been worked out in the present investigation. The two groups, terrestrial and epiphytic, show some anatomical distinction supposedly caused by ecological diversity; and L. resuninata Ridley - an epiphytic taxon - represents an intermediate form between the two as regards the adaptive characteristics.

L. longipes var. spathulata has been included within the taxon L. longipes Lindl. by Ridley (1896), although Lindley (1842) considered it as a distinct species, namely L. spathulata Lindl.

The present investigation supports Lindley particularly in consideration of the following distinctions as tabulated below.

Characters	<u>L. longipes</u>	<u>L. spatulata</u>
Roots:	Pith-cells thick-walled	Thin-walled parenchymatous
Scale-leaves:	7	4
Leaf:	(a) 0.47 mm. thick	0.70 mm. thick
	(b) Several mesophyll cells adaxial to mid-vein are significantly large and somewhat dorsoventrally elongated.	No such specialised cells are present.
	(c) Larger veins elliptical in shape in cross-section.	Larger veins clearly dumb-bell shaped with a distinctly constricted region between the xylem and phloem strands.
	(d) Xylem fibre absent in the mid-vein.	Xylem fibre present in mid-vein.
Stomatal frequency:	49.02 per sq.mm.	63.72 per sq. mm.
Leaf-bearing axis:	Long and semi-fleshy pseudo-stem.	Short, fleshy and typical pseudo-bulb.

Lastly, a quite notable factor, that is, dissimilarity in chromosome number  $n=15$  (Arora, 1968) and  $2n=26$  (Kliphuis, 1963) in L. spathulata in contrast to  $2n=38$  (Biswas, 1980) and 42 (Mitsukuri and Kozuka, 1967) in L. longipes decisively warrants separation of the former from the latter and confers it a status of independent species.

(b) Validity of removal of Dendrobium amplum Lindl. and D. rotundatum Benth. from the genus and taxonomic revaluation of D. anceps Swartz.

(1) Altogether seven species of Dendrobium Swartz out of the list of species enumerated by Hooker fil. have been worked out and these taxa show considerable variation as regards their morphological and anatomical features.

D. amplum Lindl. and D. rotundatum Benth. have been removed by Summerhayes (1957) from the genus and placed under Epigeneium Gagnepain (1932) as E. amplum (Lindl.) Summerh. (1957) and E. rotundatum (Lindl.) Summerh. (1957). This transfer seems to be well justified in consideration of the following observations as revealed in the present investigation. From the morphological point of view the said taxa show distinction from the other species of Dendrobium by the following characters - (1) presence of a creeping, long rhizome with many more (8-10) scale leaves and bearing a typical pseudo-bulb at the terminal end; (2) normal leaves are only two instead of



many; and (3) the flower is truly terminal and solitary. In addition, taking into account the anatomical characteristics, distinction is apparent by the presence of slender and radially much elongated cells with a layer of suberin on the inner walls in the innermost velamen layer; presence of 1 or 2 triangular cover cells outside the passage cells of root-exodermis; the stele in the root is very large with about 35 xylem strands in D. amplum and 27 in D. rotundatum in contrast to 11-12, 13, 15, 16 and 18 in the other species of Dendrobium investigated; a continuous band of about 8 layers of very thick-walled sclerenchyma forming the middle zone of ground tissue in the rhizomeous stem. The chromosome number in Dendrobium is variable and as such  $n=20$  in D. amplum and D. rotundatum (Mehra and Vij, 1970 and Malla et al. 1978) is not helpful for the present problem.

- (11) Dendrobium anceps Swartz seems to be unique within the genus in having ensiform leaf. Moreover, the flowers are always solitary unlike in the other species of Dendrobium and also borne exclusively near the middle part of the axis although in others these are on the upper limit. In addition this taxon also shows distinction on the following anatomical characters some of which are quite important -

(1) the endodermal cells of the root are exceptionally thick-walled; (2) presence of a hypodermis consisting of 1-3 layers of very thick-walled lignified cells with very narrow lumen in the rhizomaceous base of the axis; (3) presence of numerous small spherical patches of thick-walled sclerenchymatous cells in the sub-epidermal (abaxial) zone of leaf-blade; (4) stomatal frequency significantly low. Although the chromosome number  $n = 19 + (0-2B)$  (Mehra and Vij, 1970) is in conformity with the other species of Dendrobium, the cumulative value of the aforesaid distinctive characteristics is sufficient to warrant in favour of the removal of the taxon from the genus and to establish a new genus, but before that we need to examine, particularly, D. terminale Par. and Rchb. fil. (1874) which also shows ensiform leaf.

(c) Re-establishment of Bulbophyllum bicolor (Lindl.) Hook. fil. and B. paleaceum (Lindl.) Benth. to Sunipia Lindl.; taxonomic reevaluation of B. cylindraceum Lindl. and B. rigidum King and Pantling and incorporation of Cirrhonetium ornatissimum Reichb. fil., C. guttulatum Hook. fil. and C. cornutum Lindl. into Bulbophyllum Thouars.

All of the ten species under Bulbophyllum Thou. and Cirrhonetium Lindl. investigated presently are characterised by epiphytic habit and only a single layer of epidermal cells consisting the velamen. Moreover, these velamen cells are

universally radially elongated with suberised inner walls, but from anatomical standpoint they also show much variability between themselves and the subjects under consideration may be dealt with separately.

- (1) Bulbophyllum bicolor (Lindl.) Hook. fil. was originally described and nomenclatured by Lindley as Sunipia bicolor (1833) and renamed as Ione bicolor (1853). Similarly, Bulbophyllum paleaceum was originally published by Lindley as Ione paleacea (1853) but Munt (1971) recombined it as Sunipia paleacea (Lindl.) P.F. Hunt. Hook. fil. (1890), however, treated both species under the genus Bulbophyllum (in a separate section Ione) as B. bicolor Hook. fil. and B. paleaceum Benth. But Hara et al. (1978) called the latter as B. paleaceum (Lindl.) Hook. fil. as a synonym. It appears that in accordance with the rules of I. C. B. N. the corrected name for the taxa should be B. paleaceum (Lindl.) Benth. and in case it is considered under Sunipia Lindl., as has been treated by Hara et al. (1978) themselves, the valid nomenclature as S. paleacea (Lindl.) P.F. Hunt remains noncontroversial.

Hara et al. (1978) have, however, treated both of these species under Sunipia Lindl. The absence of any middle sclerenchymatous zone of ground tissue in

the rhizome in contrast to its presence in the other taxa gives some support for their removal from Bulbophyllum. Presence of five scale leaves in these two species (also Cirrhopetalum guttulatum) seems to be uniform in contrast to 3-4 or 7 for the other taxa. But the chromosome number  $n=20$  (Mehra and Sehgal, 1974) for I. bicolor (= S. bicolor Lindl.) is in conformity with the chromosome numbers in Cirrhopetalum -  $2n=38$  (Chardard, 1963; Daker, 1970) and 38-40 (Chardard, 1963) and 40 (Pancho, Cn. III, 1965) which has now been transferred and incorporated in Bulbophyllum. More critical examination and re-evaluation of characters seem to be essential to determine the systematic position and nomenclature of these two taxa.

- (ii) Bulbophyllum cylindraceum Lindl. and B. rigidum K. & P., on the other hand, appear to be aberrant in consideration that in addition to the absence of pseudo-bulb and presence of only 3-4 scale leaves [also found in B. leopardinum (Wall) Lindl. ex Wall.], the sclerenchymatous middle zone of the ground tissue in rhizome is absent. Moreover, in these two species the velamen cells are only very slightly elongated. This group is also distinguished by the presence of a continuous 1-2 layered exodermis in the outer part of the ground tissue of rhizome and in this respect B. reptans (Lindl.)

Lindl. ex Wall. may be considered as an intermediate form although there are seven scale leaves in the latter. These facts warrant for more critical taxonomic evaluation for these two species.

- (iii) Of the three species of Cirrhopetalum Lindl. investigated, C. ornatissimum Reichb. fil. has been redesignated as Bulbophyllum ornatissimum (Reichb. fil.) J.J. Smith (1912), C. guttulatum Hook. fil. as B. guttulatum Wall. ex. Hook. fil. by Seidenfaden (1973) and C. cornutum Lindl. as B. helenae (Kunze) Smith (1912) and these shiftments have been accented by Tuyama (1966, 1971) and Hara et al. (1978). However, these species are distinct from Bulbophyllum in having either solitary flower or umbel inflorescence and in addition, C. cornutum has many more (eleven) scale leaves in contrast to 3-7 in the species of Bulbophyllum. It is interesting that the latter two species (i.e. C. guttulatum and C. cornutum) are similar to B. reptans in showing an incipient exodermis in the rhizome although the number of scale leaves varies between the three. C. guttulatum also shows the presence of a continuous ring of sclerenchymatous middle zone typical for species of Bulbophyllum. A similar middle zone has also been found in C. ornatissimum. Thus, although the anatomical characters support inclusion of these species of Cirrhopetalum into

Bulbophyllum it appears that C. cornutum is more related to B. cylindraceum Lindl. and B. rigidum K. & P. but it is very distinct in having eleven scale leaves in contrast to 3-4 in the latter two. The chromosome number  $n=19$  (Mehra and Sehgal, 1980 and Biswas, 1980) and  $n=20$  (Mehra and Vij, 1970) in B. cylindraceum;  $n=19$  (Arora, 1971),  $2n=38$  (Chardard, 1963) and 40 (Pancho Cn. III, 1965) in C. cornutum is also corroborative. C. guttulatum, on the other hand, from anatomical view point and also in consideration of the number of scale leaves stands intermediate between the latter group and the rest of Bulbophyllum. C. ornatissimum showing closeness to B. odoratissimum (Smith) Lindl. ex Wall. and B. leopardinum (Wall.) Lindl. ex Wall. by the presence of sclerenchymatous middle zone in rhizome. It is also similar to B. odoratissimum and B. reptans in having seven scale leaves but is unique with a solitary flower. The chromosome number  $2n=ca.38$  (Daker, 1970) and 38-40 (Chardard, 1963) in C. ornatissimum in contrast to  $2n=20$  (Malla et al., 1978) and 38 (Chardard, 1963) in B. odoratissimum is indicative that the former might be a tetraploid.

Although for B. cylindraceum the chromosome number  $n=19$  (Mehra and Sehgal, 1980; and Biswas, 1980) and 20 (Mehra and Vij, 1970) is indicative of a cytological

conformity but the cumulative significance of morphological and anatomical distinctions necessitates a critical re-investigation for determination of systematic position of these two taxa.

(d) Validity of inclusion of Trichosma suavis Lindl. (1842) into Eria Lindl. and composition of the latter genus.

Trichosma suavis has been enumerated by Hook. fil. (1890) but its accepted present nomenclature is E. coronaria (Lindl.) Reichb. fil. (1861). On comparing this taxon with the three species of Eria, namely, E. stricta Lindl., E. convallarioides Lindl. ex Wall. and E. flava Lindl. ex Wall. it has been noted that the former fits well as a species closely related with E. stricta in having only two photosynthetic leaves, a terminal inflorescence and more or less identical stomatal frequency and also in the absence of a typical pseudo-bulb. Moreover, unlike the other two species of Eria these two taxa show uniseriate lower epidermis in leaf.

Thus, these four species of Eria seem to conform to two distinct morphological groups. One group consisting of E. convallarioides and E. flava exhibits the presence of a typical pseudo-bulb with about four leaves at the top and axillary inflorescence borne laterally. These two species are also characterised by the presence of two layers of cells in the lower epidermis of leaf and the chromosome

number  $n=18$  (Chatterji, 1965);  $n=19$  (Chardard, 1963) and 20 (Mehra and Vij, 1970) or  $2n=36$  (Chatterji, 1965) and 40 (Vij and Gard, 1976 and Vij, Gupta and Gard, 1976). The other group consisting of E. stricta and E. coronaria lacks the typical pseudo-bulb and the axis with two photosynthetic leaves bears a terminal inflorescence, and the lower epidermis of leaf is uniseriated. Unfortunately, there is no record of chromosome number for E. stricta but  $n=18$  has been reported for E. coronaria (i.e. Trichosma suavis) by Mehra and Vij, 1970. These factors are quite suggestive that the taxa of Eria should be re-examined to evaluate inter-relationship and taxonomic position.

- (e) Transference of Phaius albus Lindl. to Thunia Reichb. fil. as T. alba (Lindl.) Reichb. fil. (1852).

In the present investigation the genus Thunia has not been taken under consideration as it is not included in the classification and enumeration of Hooker fil. which conforms the base of this work.

The taxon under consideration, that is, Thunia alba has, however, been casually compared with other species of Thunia and found to be quite fitting. This taxon differs from other species of Phaius Lour. not only by its epiphytic habitat but also by the following morphological characters -



(i) total number of leaves (scale leaf and green leaf) in a branch is 24-32 (compared to about 14 in others) although the number of typical scale leaves is less in contrast to an extraordinarily high number of photosynthetic leaves; (ii) presence of narrow leaves; (iii) inflorescence is terminal in contrast to lateral axillary in the others.

From anatomical point of view thinness of leaf and very high stomatal frequency are also significant. Although the endodermis of root, unlike the species of Phaius, shows U-type cells the analysis of Table IV diminishes its significance. Similarly increase in number and density of veins, presence of broader metaxylem cells, thicker pith cells in the root and some other minor distinctions might have resulted through epiphytic habit. Cytological information is also not helpful as the recorded chromosome numbers in Phaius (P. wallichii  $n=21$ , Mehra and Vij, 1970 and  $2n=48$ , Roy and Sharma, 1972; P. maculata  $2n=48$ , Chatterji, 1981; P. mishmensis  $n=31$ , Roy and Sharma, 1972 and P. tankervilliae Bl.  $n=23$ , Mehra and Sehgal, 1975) and in Thunia alba ( $n=20$ , Mehra and Vij, 1970, and Mehra and Kashyap, 1978;  $n=c.40$ , Mehra and Sehgal, 1978 and  $2n=36$ , Chatterji, 1981;  $2n=42$ , Tanaka, 1964a, and Vij, Shekhar and Kuthiala, 1981; and  $2n=44$ , Roy and Sharma, 1972) are variable.

(f) Separation of Agrostophyllum brevipes King and Pantling from A. callosum Reichb. fil. complex.

King and Pantling (1898) splitted type specimen of A. callosum of Hooker fil. and established a new species on the basis of conventional morphology and named it as A. brevipes. The present investigation provides a significant amount of evidence in favour of the said separation. The contrasting characters are tabulated below.

Characters	<u>A. callosum</u> ( <u>sensu stricto</u> )	<u>A. brevipes</u>
Root :	Epidermis has three layers of cells.	It has five layers of cells.
Axis :	Pseudo-stem somewhat slender throughout.	Pseudo-stem semi-fleshy gradually broadening upwards.
Leaf :		
(a) Total no. of leaves	33-36	21-23
(b) No. of photosynthetic leaves	18-20	6-8
(c) Thickness	0.30 mm.	0.35 mm.
(d) Stomatal frequency of lower epidermis	110.80 per sq.mm.	80.39 per sq.mm.
(e) Internal structure	Absence of lysigenous cavities in mesophyll.	Large lysigenous cavities present in mesophyll between the veins.

The chromosome number  $n=20$  (Mehra and Vij, 1970) for A. brevipes and  $n=20$  (Mehra and Vij, 1970) and  $2n=38$  (Chatterji, 1965; and Mehra and Sehgal, 1978) for A. callosum are indicative of close relationship.

- (g) Nomenclatural validity of Coelogyne praecox Lindl. re-unification of C. uniflora Lindl. to Coelogyne Lindl. and non-uniformity in the genus Coelogyne Lindl.
- (i) Coelogyne praecox (Smith) Lindl., enumerated by Hook. fil. as C. praecox Lindl., was previously named as Pleione praecox (Smith) D. Don (1825) and the latter is now being supported in recent literature (Tuyama, 1966, 1971, 1975 and Hara et al., 1978). The presence of solitary inflorescence and single layer of epidermis in the leaf are indicative of heterogeneity. Reduction in the number of scale-leaves to four only, comparatively higher stomatal frequency and reduction of the velamen into two layers are additional factors. The chromosome number  $n=20$  (Mehra and Vij, 1970) and  $2n=40$  (Chatterji, 1965; Hunt and Vosa, 1971; and Roy and Sharma, 1972) is indicative of close relationship between Coelogyne Lindl. and Pleione D. Don.
- (ii) Coelogyne uniflora Lindl. ex Wall. was transferred to Panisea Lindl. as P. uniflora Lindley (1830) but was considered as Coelogyne by Hooker fil. (1890) and King and Pantling (1898). It is interesting that C. uniflora exhibits some important character-

istics common with Panisea parviflora Lindl. (investigated in this work) in having, unlike other species of Coelogyne, unilayered epidermis on both surfaces of leaf, identical stomatal frequency, equally thinner leaf and a reduced number of (only six) scale-leaves. The number of flowers borne terminally, however, is extremely reduced to one in comparison to the presence of 4-6 flowers in axillary inflorescence in P. parviflora. The chromosome number  $n=20$  (Mehra and Vij, 1970; and Arora, 1971) in C. uniflora and other species of Coelogyne being identical is, however, indicative of close relationship but unfortunately report on other species of Panisea is lacking.

- (111) The other four species of Coelogyne, namely, C. ochracea Lindl., C. flaccida Lindl. ex Wall., C. elata Lindl. ex Wall. and C. cristata Lindl., show aberrant character. C. ochracea is unusual in having a much higher stomatal frequency and absence of elongation and suberization of cells of the innermost layer of velamen. C. flaccida, on the other hand, unlike other members show the presence of thickening on the cell-walls of sub-epidermal layer on both surfaces of leaf resembling hypodermis and

two layers of well differentiated palisade cells in addition to the unusually thick leaf. C. elata and C. cristata, however, show more or less identical characteristics.

(h) Similarities and dissimilarities of characters between Otochilus Lindl. and Pholidota Lindl.

Two species of Otochilus, viz., O. porrecta Lindl. ex Wall. and O. fusca Lindl. and three species of Pholidota, e.g., P. griffithii Hook. fil., P. recurva Lindl. and P. imbricata Hook., have been worked out. Externally the four former species show similarity in the nature and disposition of annual pseudo-stem segments and the total number of scale-leaves and normal leaves, and also chromosome numbers. These factors, in addition to other identical morphological and anatomical characteristics, are indicative of close relationship between themselves. However, these two species of Pholidota differ from those of Otochilus by one major character in having a uniseriate epidermis on either surface of leaf. It is confusing that while P. recurva also differs from Otochilus by the absence of any elongation and suberization of velamen cells, P. griffithii is similar to the latter in this respect. It appears that these taxa should be critically re-examined to determine validity of their separation in generic level,

particularly in view that chromosome number  $n=20$  (Mehra and Vij, 1970; Vij and Gupta, 1976; and Mehra and Sehgal, 1980) and  $2n=40$  (Mehra and Kashyap, 1981) is common for all.

2. imbricata, on the other hand, although showing the same chromosome number,  $n=20$  (Mehra and Vij, 1970) and  $2n=40$  (Pancho, 1965a,b; Arora, 1968; Singh, 1981; and Mehra and Kashyap, 1981) and also the identical number of velamen cell-layers, seems to be aberrant differing from the above group in having only one photosynthetic leaf and 2-3 layered upper epidermis of leaf. Moreover, the annual growth of the axis is a typical pseudo-bulb with rhizomaceous base and the main axillary bud, destined to develop into the axis for next year, appears directly laterally near the base of the pseudo-bulb and not placed laterally near the terminus of the pseudo-bulb (which results into the group of bud traces piercing through the fleshy pseudo-stem from basal to terminal regions in the other taxa).

These factors are quite significant to warrant a thorough re-examination and re-assessment of its taxonomic position.

- (1) Significance of morphological dissimilarity in Calanthe densiflora Lindl.

Out of the four species of Calanthe Brown investigated in the present work C. densiflora differs from the others in having a rhizome-like elongated axis with a slightly swollen head in contrast to a typical bulb in others and also possessing 8-9 scale leaves in contrast to 4-5 in others. In C. densiflora the inflorescence is borne by axillary bud of the last scale leaf situated just below the swollen head, but in other three species it is borne by the axillary bud of a normal green leaf and disposed at the terminus of the bulb along with the cluster of leaves.

Interestingly except these three points of variation, the present investigation failed to show any other major distinction except that the leaf is thinner. Unfortunately no cytological record for C. densiflora is available. However, a re-evaluation of conventional taxonomic features may be suggested in consideration of the facts revealed in this study.

**B: Consideration on Morphological Nature of stem and leaf.**

**I : Morphology of Pseudo-stem/Pseudo-bulb**

The basal part of the axis of orchids bearing scale-leaves is thinner and conventionally it is described as a rhizome. The significance of the characteristics related to this organ has been discussed and is suggested that this part of the axis better be called as a sucker although in

the present work it has been referred to as rhizome following the convention adopted in texts.

This rhizome and the leafy axis is a continuous structure and in many cases also show transitional stages and in all cases the whole body of the axis is a single unit.

The upper or terminal part of this unit of the axis bears normal photosynthetic leaves and this part of the axis may remain more or less slender but normally thicker in comparison to the basal rhizomaceous part and is described as a reed. In other cases it may become quite fleshy at least regionally or it may be converted into a pseudo-bulb. The pseudo-bulb, on the other hand, may have a single or few or a number of internodes. Variations and intermediate structures are also noticeable.

The rhizomaceous part of the axis internally shows a typical cortex demarcated internally by a more or less defined ring of vascular bundles surrounding some scattered vascular bundles at the centre. In some cases even a small pith-like area is recognizable. Such an organisation could also be encountered not only in the thicker region of the rhizome bearing scale-leaves but also in the region of the leafy axis bearing larger scale-leaves or transitional leaves.

Although the leafy axis exhibits scattered vascular



bundles without any recognizable cortex or a ring in the vascular system but in some cases where nodal region of the leafy axis is recognizable reversion to a typical rhizomaceous construction could be noticed above the nodal region. In other cases a similar organisation of the vascular bundles could be encountered just above the departure of each leaf in succession in the leafy axis.

Irrespective of whether it is <sup>a</sup> typical bulb or a reed, when inflorescence is borne terminally by the apical meristem, it has been found that after contribution of vascular traces to the leaves the centrally disposed remaining bundles become aggregated and organised so that the inflorescence axis also shows a typical rhizomaceous construction.

The disintegration of this rhizomaceous construction has been found associated principally with three factors - (i) comparative length of the internode, (ii) increase in girth of the axis and (iii) vascular supply to the normal photosynthetic leaf.

The comparatively longer rhizome of Calanthe densiflora internally shows a typical rhizomaceous construction but three other species of the same genus with shorter rhizome and internodes do not show similar ring arrangement of the outer vascular bundles although the cortical area is still recognizable.

Increase in the girth tends to disperse the vascular bundles in a wider circumference and the impact makes disturbance in the ring arrangement of the outwardly disposed vascular bundles which now becomes scattered. Quite naturally in the pseudo-bulb the dispersal would be maximum.

The third factor, that is, vascular supply to the larger normal photosynthetic leaf, seems to be much more effective for scattering of the vascular bundles. The unusually high number of vascular bundles participating in a leaf supply and also some other important factors associated with it as has already been discussed make the disturbance and scattering total. And in this respect there is no distinction between a reed and pseudo-bulb. It has also been noted that the nature of organization and orientation of vascular supply to a leaf-base is more or less uniform although irrespective of thickness of the axis. Such observations are indicative that basically the leaf-bearing axis is morphologically identical in all cases and as such the reed and pseudo-bulb have no basic distinction except their size and shape.

In consideration of the above facts in the present work it has been suggested that if pseudo-bulb remains to be a valid term to describe an orchid, its counterpart where the leafy axis is not typically bulbous should be called as pseudo-stem.

In some cases nodes and internodes in the pseudo-stem and even in the pseudo-bulb are externally recognizable but in a majority it is not so. Internally from anatomical point of view there is no distinction indicative of the position of the node except in some cases where the vascular organisation is reversed to a typical rhizomaceous condition. In a few other cases the disposition of the axillary bud, although microscopic, gives indication of the presence of a node in serial sections of the leafy shoot. In case of the bulb such disposition has always been found near the top of the structure. But in other cases although the external appearance of the bud is much higher up, the origin of bud-traces could be encountered near the base of the bulb deep inside just laterally to the central axial core. Such a bud-trace complex remains encircled by extensive tissue of the pseudo-bulb containing scattered vascular bundles of its own which indicates that not only the leaf base of the leaf/leaves of upper node(s) are extended below but also the vascular supply of the said leaves starts organising in the lower internode(s). All these factors make the vascular organisation of the leafy axis utmostly complicated. Esau (1965) also reports of such a complex arrangement in the grasses on the basis of observations made by Percival (1921), Kumazawa (1961) and Inosaka (1962).

It is quite evident from the above statements that

in the pseudo-stem or pseudo-bulb of the orchids irrespective of its thickness the true axial system is centrally disposed and it always remains masked by differentiating leaf-base(s) and the  $\frac{2}{2}$  systems remain completely integrated so that apparently either externally or internally the morphological identity is not at all recognizable. The situation reminds us of old conceptions regarding the morphology of the stem which lead to the hypothesis of leaf-skin theory by Saunders (1922).

Esau (1965) states "that the presence or absence of an anatomic delimitation of cortex, endodermis, pericycle, medullary rays, leaf gaps, and pith constitutes a variation in the relative distribution of the vascular and ground tissues. On the one hand are the plant axes with an almost diagrammatic division into cortex, vascular cylinder, and pith (if present), and with distinctly differentiated endodermis and pericycle; on the other, are the axes having no sharp boundary between the vascular and fundamental tissues, and lacking a pericycle. In the extreme condition, the vascular system is dispersed to such an extent that no cortex or pith can be delimited (stems of many monocotyledons)".

It is interesting that the internal construction of the rhizomaceous part of the axis in the orchids under

investigation without any exception and probably in families of other monocotyledons showing identical structures is to some extent comparable with the construction of a dicotyledonous stem with the sole major exceptions of the absence of cambium and presence of bundle-sheaths. It is interesting that these two factors of exception may be interrelated and one of them be a corollary of the other. It is more noteworthy that the scattered vascular bundles at the central part of the rhizomaceous axis is comparable to the medullary bundles particularly found in some primitive families of dicotyledons. The absence of the pericycle and endodermis is possibly caused by scattering of the vascular bundles in the stem related with leaf supply but even then in some taxa like Bulbophyllum rentans and B. odoratissimum structurally some tissues could be encountered which are comparable to endodermis or pericycle or both indicating parallelism with the typical dicotyledonous stem. Thus, accepting the conception that the monocotyledon is an off-shoot from some primitive dicotyledonous stalk or a precursor, from anatomical point of view the distinction lies in the points of (i) loss of cambium and development of bundle-sheath, (ii) permanent retention of the medullary bundles and (iii) total disturbances in the axial vascular organisation and consequent loss of endodermis and pericycle caused by the complexity of leaf supply organisation. It may

be mentioned that anatomical construction of the root in both groups is almost identical except the presence of exodermis which is found in a few families of monocotyledons with significant number of epiphytic representatives.

## II : Morphology of Ensiform leaf

The ensiform leaf in Oberonia myriantha Lindl., O. iridifolia Lindl., O. falcata King and Pantling and Dendrobium anceps Swartz is comparable to that of Iris where it is considered to be a modification of the petiole and according to Esau (1965) this blade is a product of simulation of the petiole. Eames and MacDaniels (1947) state that the inversion of bundles in the Iris leaf may have come about by longitudinal folding and fusion of the leaf halves. In the material under investigation a similar condition has been encountered. De Candolle (1827) conceived that the linear leaf outline and parallel venation in monocotyledons might be due to their phyllode nature. Arber (1925) on the basis of an extensive work concluded that the monocotyledonous leaf is basically of phyllode nature. She thought that the isobilateral pseudo-ensiform leaf of Phormium and Dianella is equivalent to that of Acacia for the phyllode is petiolar. Boker (1940) on the basis of an extensive work on Acacia concluded that the phyllode is actually the modified rachis (petiole) where the abaxial

bundle represents the middle bundle of the rachis and the pairs of bundles placed laterally in the body of the flattened phyllode are representing the lateral bundles.

In the present investigation not only a parallel condition could be encountered but it is more interesting to note that the intermediate region between the typical blade and typical sheathing leaf-base is flattened having vascular organisation typical for the leaf blade in other species under investigation. It is more interesting to note that this flattened structure gradually becomes folded above and ultimately fused by its upper surface to give rise to the ensiform leaf which serves as a direct evidence of its parallelism with the phyllode of Acacia.