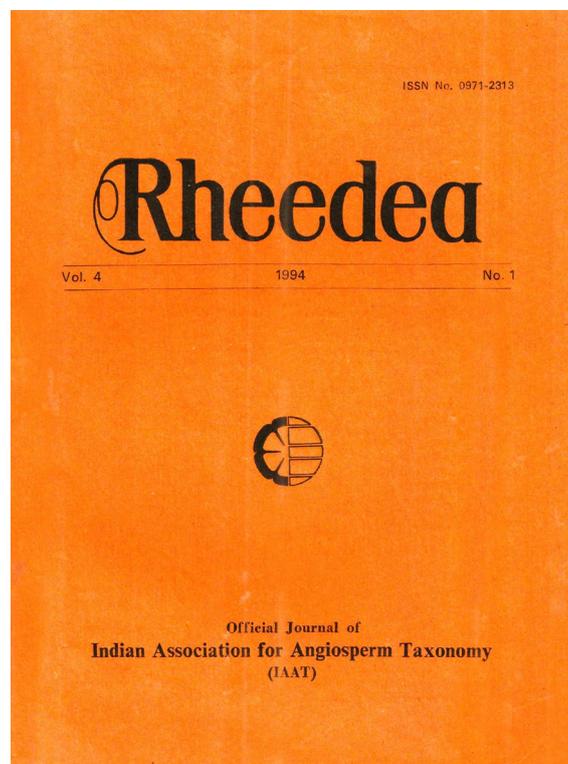




Taxonomic significance of seed surface morphology in Orchidaceae

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How to cite:

Jeeja G. & R. Ansari 1994. Taxonomic significance of seed surface morphology in Orchidaceae. *Rheedea* 4(1): 48–59.

<https://dx.doi.org/10.22244/rheedea.1994.04.01.10>

Published in print: 30.06.1994

Published Online: 01.01.2022

Taxonomic significance of seed surface morphology in Orchidaceae

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Abstract

Seed surface morphology of 82 species of orchids are analysed and illustrated. The value of seed morphology in assessing the relationship of different taxa of Orchidaceae is emphasized. The seeds are broadly classified into eight groups and a dichotomous key is provided for their recognition.

INTRODUCTION

Seed surface and seed anatomical characters have provided valuable information on taxonomy and phylogenetic affinities of several plant taxa, because they are less subject to environmental influence (Corner, 1976; Barthlott, 1984). In orchids, however, these features, still remain little studied. In spite of the fact that Curtiss (1893), after a study of 25 species of Eastern orchids, had emphasized the importance of seed morphology in orchid classification, the publications on this aspect are far too few. The notable contributions are those of Netolitzky (1926), Carlson (1940), Withner (1959), Podzorski (1977) and Manilal and Sathish Kumar (1991). It is in this backdrop, that we thought of undertaking an exhaustive seed morphological study of South Indian orchids in relation to taxonomy, of which this paper forms the first contribution.

Generally, orchid seeds are minute, often elongated structures, with the embryo enclosed in a loose testa. The seed coat is generally a single layered transparent sac, open at the micropylar end and closed at the chalazal end. The cells of seedcoat are dead at maturity and are of varying forms, but usually with some basic patterns. The cells at the chalazal end are smaller than those at the

Seed surface morphology in Orchidaceae

micropylar end. The walls of the cells may remain thin or may develop some lignified thickenings. Embryo is an undifferentiated mass of polyhedral cells filled with dense cytoplasm.

Seeds of different taxa differ not only in their size and shape, but also in the relative size of the embryo and the testa. Eventhough, the seed characters of the taxa investigated here do not correlate well with the existing tribal classification of the family, they would be of use in generic and species delimitation in many, if not all, cases.

MATERIALS AND METHODS

Seeds of 82 species of South Indian Orchids falling under 42 genera have been studied and illustrated in the present work. *Eria spicata* Hand.- Mass. and *Spathoglottis Plicata* Bl. which are under cultivation in South India are also included.

Mature seeds from 5—10 fruits of each taxon collected from widely separated localities have been selected for the study. As much as possible, both herbarium and live specimens have been used for the study. In case of herbarium specimens, those deposited in MH and CAL have been used whereas, the live specimens have been collected from various places by the first author. The voucher specimens of these collections are preserved in the herbarium of S. N. G. College, Alathur.

The seeds collected were fixed in F. A. A. and mounted in euparal after staining with safranin and dehydrating with acetic acid-butanol series. The seeds were studied under a Light Microscope. Diagrams were made with the aid of a camera lucida.

OBSERVATIONS

The present study reveals that the 82 species studied fall under 8 distinct groups, as described below.

Group 1. *Malaxis* type**(Fig. 1. a-f)**

Seeds with obovoid and inflated testa. Cells of testa equilateral at least towards the chalazal end. Cell walls without thickening. Embryo much smaller than the testa.

The testa in this group is of the simplest form with almost equilateral cells, like those of the nucellus. The minute, ovoid or oblong embryo suspended in a large space indicates a primitive form of development. This space between

G. Jeeja and R. Ansari

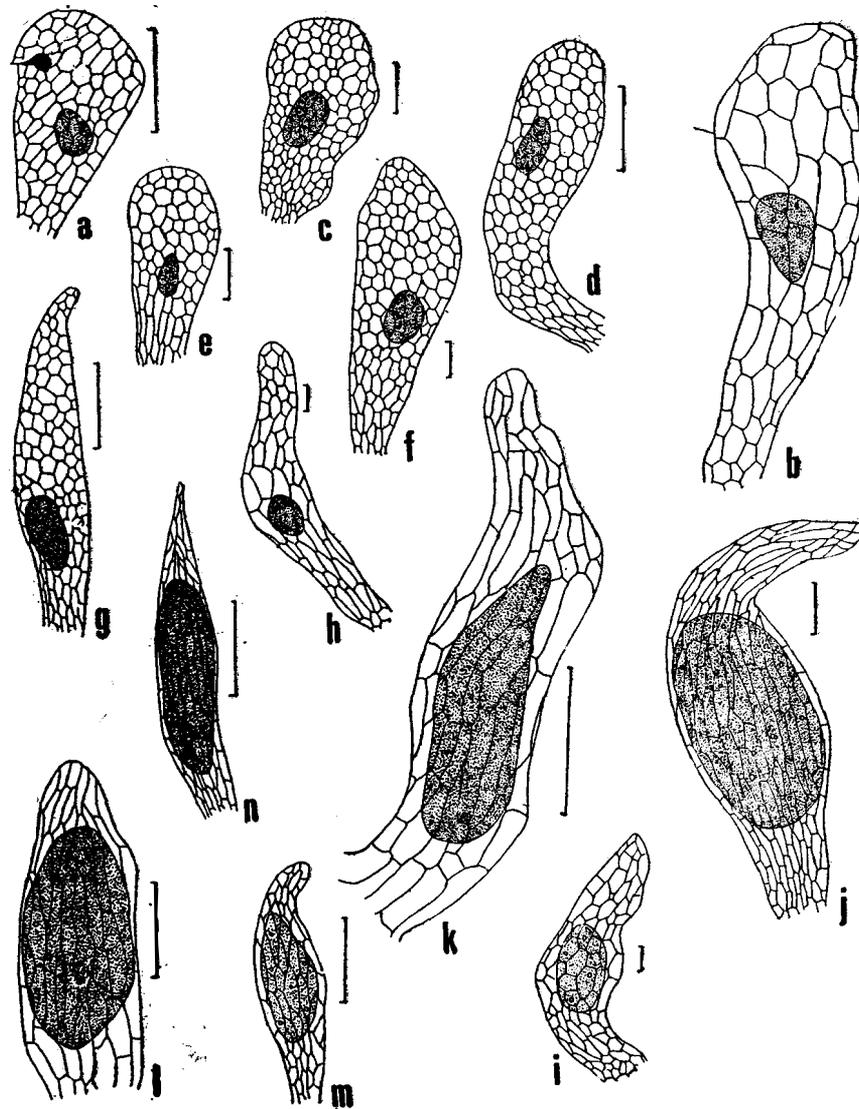


Fig. 1. a-f. Seeds of Group 1. a. *Epipogium roseum* Lindl. (Acc. No. 11367, MH); b. *Geodorum densiflorum* Schltr. (J. L. Ellis 18044, CAL); c. *Liparis atropurpurea* Lindl. (B. V. Shetty 37577, MH); d. *L. Prazer*. King & Pantl. (J. L. Ellis 32666, MH); e. *Malaxis acuminata* D. Don (K. Vivekananthan 48593, MH); f. *M. rhedii* Sw. (G. Jeeja 37, Alathur). g-i. Seeds of Group II. g. *Chrysoglossum maculatum* Hook. f. (Bourne 2939, MH); h. *Phaius tankervilleae* Blume (G. Jeeja 76, Alathur); i. *Spathoglottis plicata* Blume (G. Jeeja 102, Alathur). j-n. Seeds of Group III: j. *Arundina graminifolia* Hochr. (A. G. Pandurangan 79263, MH); k. *Habenaria richardiana* Wight (E. Vajravelu 36860, MH); l. *Liparis viridiflora* Lindl. (P. Bhargavan 65730, MH); m. *Pachystoma senile* Reichb. f. (B. D. Sharma 43912, MH); n. *Spiranthes sinensis* Ames. (C. A. Barber 7245, MH). (Scale = 0.1 mm).

Seed surface morphology in Orchidaceae

the embryo and the seed coat is produced by disorganisation of the inner layers of the integuments (Withner, 1959). This type of seeds is restricted to the primitive terrestrial forms (Bennett, 1983) like species of *Epipogium*, *Geodorum*, *Liparis* (except *L. viridiflora*) and *Malaxis*.

The plants of this group are kept under widely separated tribes in many systems of classification, though Bentham and Hooker (1883) and Dressler and Dodson (1960) included *Malaxis* (*Microstylis*) and *Liparis* in the tribe, *Epidendreae*. Among the species of *Liparis*, in the epiphytic *L. viridiflora* the cells of testa are elongated and the embryo is much larger, and hence is included under Group III. This shows that *L. viridiflora* is more advanced in the genus.

Group II. *Spathoglottis* type

(Fig. 1. g-i)

Seeds with acicular or fusiform testa. Cells of testa equilateral at least at the chalazal end. Cell walls without thickening. Embryo much smaller than the testa.

This type of seeds were found in species of *Chrysoglossum*, *Phaius* and *Spathoglottis*. Except for the fusiform or acicular shape of testa, the seeds of this group are closely related to those of group I. Bentham & Hooker (1883) brought the genera *Chrysoglossum*, *Phaius* and *Spathoglottis* under the same tribe *Epidendreae* and Schlechter (1926) treated *Phaius* and *Spathoglottis* under the subtribe *Phajeeae*.

Group III. *Arundina* type

(Fig. 1. j-n)

Seeds with fusiform testa. Cells of testa elongated. Cell walls without thickening. Embryo very large, not less than half the length of testa.

All plants included under this group (*Habenaria richardiana* and species of *Arundina*, *Pachystoma* & *Spiranthes*) are terrestrials, except *Liparis viridiflora* which grows in crevices of rocks or on tree-trunks. The seeds of this group show affinity to those of Group II and IV in the shape of testa, but are kept under a separate group considering the large embryo which reaches at least about half the length of seed coat. However, in most classifications which are mainly based on floral morphology, the plants of this group are kept widely separated.

Group IV. *Acanthephippium* type

(Fig. 2. a-q)

Seeds with acicular or fusiform testa. Cells of testa elongated; cell walls without thickening. Embryo much smaller than the testa leaving long chalazal and micropylar arms.

G. Jeeja and R. Ansari



Fig. 2. a-q. Seeds of Group IV. a. *Acanthephippium bicolor* Lindl. (A. V. N. Rao 23069, MH); b. *Calanthe masuca* Lindl. (N. C. Nair 81140, MH); c. *C. triplicata* Ames (E. Vajravelu 37035, MH); d. *Cymbidium aloifolium* Sw. (G. Jeeja 115, Alathur); e. *C. ensifolium* Sw. (C. J. Saldanha 14763, CAL); f. *Didymoplexis pallens* Griff. (E. Vajravelu 33227, MH); g. *Eulophia epidendreae* Fischer (C. A. Barber 6764, MH); h. *E. ramentacea* Wight (Bourne, 1205, MH); i. *Goodyera procera* Hook. (N. C. Nair 70104, MH); j. *Habenaria digitata* Lindl. (G. V. Subbarao 47416, MH); k. *H. grandifloriformis* Blatt. & Mc Cann (V. J. Nair 5582, MH); l. *H. plantaginea* Lindl. (C. A. Barber 4989, MH); m. *H. roxburghii* Nicolson (J. L. Ellis 42165, MH); n. *Nervilia aragoana* Gaudich (G. Jeeja 23, Alathur); o. *Pecteilis gigantea* Rafin (C. A. Barber 3802, MH); p. *Peristylus goodyeroides* Lindl. (G. Jeeja 71, Alathur); q. *Zeuxine longilabris* Benth. ex Hook. f. (E. Vajravelu 3340, MH). (Scale = 0.1 mm).

Seed surface morphology in Orchidaceae

This type of seeds were observed in the investigated species of *Acanthephippium*, *Calanthe*, *Cymbidium*, *Didymoplexis*, *Eulophia*, *Goodyera*, *Habenaria*, *Nervilia*, *Pecteilis*, *Peristylus* and *Zeuxine*. The seeds of this group show great affinity to those of group III in the shape of testa and its cell orientation. The plants are predominantly terrestrial or saprophytic except for the epiphytic species of *Cymbidium*, which forms an exception for the general tendency of developing lignified cell walls as in epiphytic plants. Thus, it is reasonable to consider the genus *Cymbidium* as one of the transitional forms of primitively terrestrial to advanced epiphytic habit in the family Orchidaceae. The seeds of *Acanthephippium bicolor* is the longest of seeds studied, reaching to about 4 mm.

Group V. *Coelogyne* type

(Fig. 3. a-p)

Seeds with acicular or fusiform testa. Cells of testa elongated, but not reaching the length of seeds. Cell walls lignified. Embryo considerably smaller than the testa leaving distinct chalazal and micropylar arms.

This is seen in the investigated species of *Aerides* (*A. maculosum*), *Coelogyne*, *Dendrobium* (*D. anamalayanum*, *D. heyneanum*, *D. macrostachyum* & *D. wightii*), *Eria*, *Gastrochilus*, *Habenaria* (*H. longicornu* & *H. rariflora*), *Oberonia* (*O. brunoniana*), *Pholidota*, *Trichoglottis* and *Vanda* (*V. spathulata*). The characteristic feature of the seeds of the group V and VIII is lignified thickening in the radial walls of seed coat cells. However, this group can be differentiated from groups VII and VIII by the strikingly small embryos situated at the centre of the testa leaving distinct chalazal and micropylar arms, whereas it differs from group VI by the smaller cells of the testa. All plants, except *Habenaria longicornu* and *H. rariflora*, are epiphytic. The above two species of *Habenaria* are exceptions noted among the species of the genus where generally no thickening of the cell wall occurs.

Schlechter (1926) and Dressler & Dodson (1960) kept *Coelogyne* and *Pholidota* together under the subtribe *Coelogyneae*, which is now supported by the seed characters. However, they kept the other genera of this group under widely separated subtribes.

Group VI *Malleola* type

(Fig. 4. a-h)

Seeds oblong-fusiform or acicular. Cells of testa elongated, reaching the length of seeds; cell walls lignified. Embryo considerably smaller than the testa leaving chalazal and micropylar arms.

The investigated species of *Bulbophyllum* (*B. neilghrense*), *Dendrobium*, *Loxoma* and *Malleola* are included under this group. Seeds of this group are much allied to those in group V, but, as stated elsewhere, differ by the elongated cells of testa which stretch from end to end of the seed coat. Most of the

G. Jeeja and R. Ansari



Fig. 3. a-p. Seeds of Group V. a. *Aerides maculosum* Lindl. (J. Joseph 17896, MH); b. *Coelogyne brevicaapa* Lindl. (E. Vajravelu 39676, MH); c. *C. nervosa* A. Rich (V. S. Ramachandran 62051, MH); d. *C. odoratissima* Lindl. (J. L. Ellis 37858, CAL); e. *Dendrobium anamalayanum* Chandrab. et al. (B. V. Shetty 31796, MH); f. *D. heyneanum* Lindl. (C. A. Barber 440, MH); g. *D. macrostachym* Lindl. (B. D. Sharma 43887, MH). h *D. wightii* A. Hawkes & A. H. Heller (G. Jeeja 53, Alathur); i. *Eria nana* A. Rich (N. Parthasarathy 779, MH); j *Gastrochilus calceolaris* D. Don (C. A. Barber 468 MH); k. *Habenaria longicornu* Lindl. (G. Jeeja 48, Alathur); l. *H. rariflora* A. Rich (A. V. N. Rao 18203, MH); m. *Oberonia brunoriana* Wight (B. D. Sharma 40301, MH); n. *Pholidota imbricata* Lindl. (J. L. Ellis 18622, MH); o. *Tiichoglottis tenera* Schl. (J. L. Ellis 38466, MH); p. *Vanda spathulata* Spreng. (C. A. Barber 6765, MH). Scale = 0.1 mm.

Seed surface morphology in Orchidaceae



Fig. 4. a-h. Seeds of Group VI. a. *Bulbophyllum neilgherrense* Wight (V. S. Ramachandran 61950, MH); b. *Dendrobium aqueum* Lindl. (K. C. Jacob 83923, MH); c. *D. herbaceum* Lindl. (V. S. Ramachandran 62264, MH); d. *D. microbulbon* A. Rich. (Collector? s. n., MH); e. *D. nanum* Hook. f. (E. Vajravelu 29197, MH); f. *D. nutans* Lindl. (R. Gopalan 39294, MH); g. *Loxoma maculata* Garay (A. N. Henry 61526, MH); h. *Malleola gracilis* Schl. (E. Vajravelu 33225, MH); i-s. Seeds of Group VIII. i. *Bulbophyllum tremulum* Wight (P. Bhargavan 60414, MH); j. *Cottonia Peduncularis* Reichb. f. (E. Vajravelu 32159, MH); k. *oberonia chandrasekharanii* V, J. Nair et al. (E. Vajravelu 46154, MH); l. *O. denticulata* Wight (C. N. Mohanan 61116, MH); m. *O. ensiformis* Lindl. (G. V. Subbarao 87247, MH); n. *O. santapauli*; Kapadia (G. Jaaja 56, Alathur); o. *O. verticillata* Wight (J. Joseph 44615 A, MH); p. *O. wightiana* Lindl. (E. Vajravelu 39629, MH); q. *Podochilus malabaricus* Wight (B. D. Sharma 42476, CAL); r. *Polystachya concreta* Garay & Sweet (G. Jaaja 118, Alathur); s. *Porpax reticulata* Lindl. (C. N. Mohanan 79910, MH); (Scale = 0.1: mm)

G. Geeja and R. Ansari

species of *Dendrobium* exhibit characters of this group. Thus, the inclusion of subtribes *Liparideae* (*Liparidinae*) and *Dendrobieae* (*Dendrobinae*) under the same tribe in all the three classifications referred here (Bentham & Hooker, 1883; Schlechter, 1926; Dressler & Dodson, 1960) seems to be quite unnatural.

Group VII. *Flickingeria* type (Fig. 5. a-p)

Seeds with fusiform testa. Cells of testa elongated; but mostly not reaching the length of seeds; cell walls lignified. Embryo almost equalling the size of testa, leaving little or no space at the ends.

This is the type of seeds observed in the investigated species of *Aerides* (except *A. maculosum*), *Diplocentrum*, *Eria* (except *E. nana*), *Flickingeria*, *Luisia*, *Papilionanthe*, *Sirhookera* and *Vanda* (except *V. spathulata*). Group VII and VIII can readily be recognised by the large embryos which almost fill the seed coat and by the greatly thickened cell walls. All plants coming under these groups are advanced epiphytic forms (Garay, 1972, Bennett, 1983).

Schlechter (1926) correctly brought the genera *Aerides*, *Bulbophyllum*, *Diplocentrum*, *Eria*, *Luisia*, *Oberonia*, *Polystachya*, *Sirhookera*, and *Vanda* under the same tribe *Kerosphaeraeae*. But, surprisingly he included the primitive genera like *Liparis* and *Malaxis* also under the same tribe. While analysing the seeds, the above taxa could further be separated into two groups based on the length of testa cells. Accordingly, seeds with the cells of testa equalling the length of seeds are now brought under a separate group.

Group VIII *Podochilus* type (Fig. 4. i-s)

Seeds with fusiform testa. Cells of testa elongated, equalling the length of seed coat; cell walls lignified. Embryo almost filling the testa.

All species of *Oberonia* (except *O. brunoniana*) come under this advanced group. But, in the system of Bentham and Hooker (1883), the genus *Oberonia* is treated as the most primitive form, along with *Malaxis* and *Liparis*. Schlechter (1926) and Dressler & Dodson (1960) also felt *Oberonia* to be closely allied to the above terrestrial genera. The other plants exhibiting characters of this group are species of *Bulbophyllum* (*B. tremulum*), *Cottonia*, *Podochilus*, *Polystachya* and *Porpax*.

DISCUSSION

Despite the fact that the seed morphological characters, by themselves, do not shed much light on the tribal classification and affinities of the genera,

Seed surface morphology in Orchidaceae

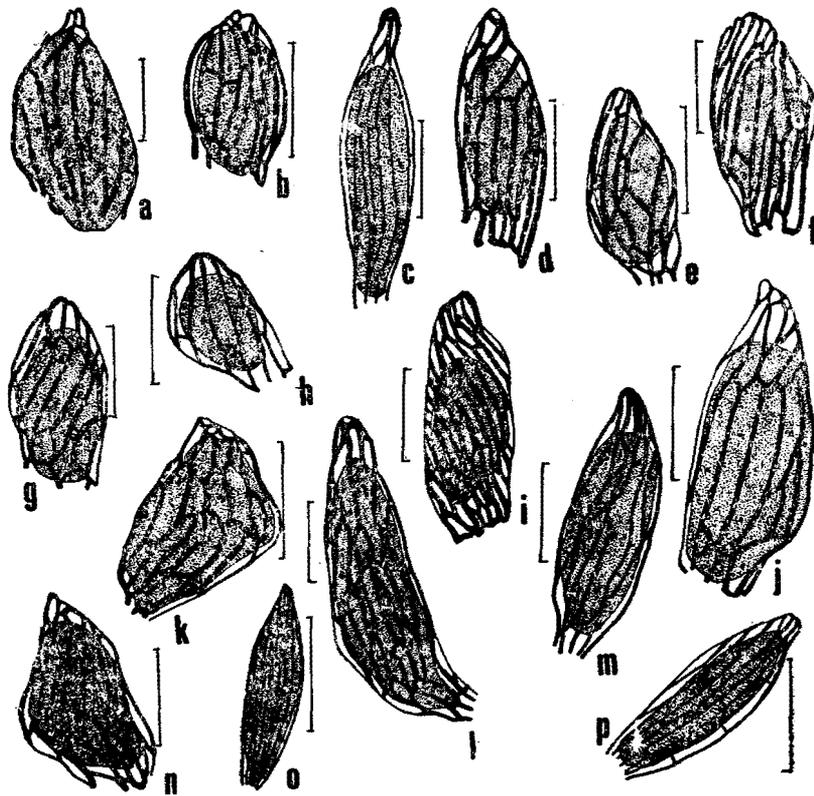


Fig. 5. a-p. Seeds of Group VII. a. *Aerides crispum* Lindl. (E. Vajravelu 43771, MH); b. *A. ringens* C. Fischer (E. Vajravelu 36797, MH); c. *Diplocentrum recurvum* Lindl. (G. Jeeja 57, Alathur); d. *Eria bambusifolia* Lindl. (G. Jeeja 54, Alathur); e. *E. dalzellii* Lindl. (J. L. Ellis 43252, MH); f. *E. pauciflora* Wight (G. Jeeja 81, Alathur); g. *E. reticosa* Wight (K. Vivekananthan 48639, MH); h. *E. spicata* Hand.-Mazz. (G. Jeeja 52, Alathur); i. *Flickingeria macraei* Seidenf. (G. Jeeja 49, Alathur); j. *Luisia birchea* Blume (K. M. Sebastine 4059, MH); k. *L. zeylanica* Lindl. (A. V. N. Rao 23059, MH); l. *Papilionanthe subulata* Garay (D. B. Deb 31617, MH); m. *Sirhookera lanceolata* O. Kuntze (J. Joseph 15544, MH); n. *S. latifolia* O. Kuntze (C. A. Barber 3056, MH); o. *Vanda tessellata* Hook. ex G. Don (S. Raghupathy 263, MH); p. *V. testacea* Reichb. f. (G. V. Subbarao 62451, MH). (Scale=0.1 mm).

G. Jeeja and Ansari

as they stand now, it is seen that there is an emerging pattern of seed morphology in orchids, which, if carefully analysed and studies in correlation with other characters, can be useful in tracing interrelationships and consequently for improving the existing classification. This, however, requires a detailed study of great magnitude covering the entire range of their distribution and variation, which is beyond the scope of the present work.

During this modest work, however, we found that, seed morphologically the South Indian taxa fall under 8 groups, which could be recognised by the following Key.

Key to the groups

- 1a. Cells of testa with thickening in the radial walls.....5
- b. Cells of testa without thickening in the radial walls.....2
- 2a. Cells of testa elongated.....4
- b. Cells of testa equilateral at least at the chalazal arm.....3
- 3a. Testa obovoid and inflated.....Group I
- b. Testa fusiform or acicularGroup II
- 4a. Embryo large, not less than half the length of testa.....Group III
- b. Embryo much smaller than the testa...Group IV
- 5a. Embryo considerably smaller than the testa leaving distinct chalazal and micropylar arms.....6
- b. Embryo almost filling the testa leaving little or no space at the chalazal or micropylar end.....7
- 6a. Cells of testa equalling the length of seedGroup VI
- b. Cells of testa not equalling the length of seed Group V
- 7a. Cells of testa equalling the length of seed Group VIII
- b. Cells of testa not equalling the length of seedGroup VII

Acknowledgements

The authors are grateful to the authorities of Botanical Survey of India, for herbarium and library facilities during the course of the work. One of us (GJ) thankfully acknowledges the encouragement and facilities provided by the Principal, S. N. College, Alathur, and the financial assistance provided by the UGC.

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