CHAPTER IV

POLLEN MORPHOLOGY
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Pollen grains are characterized by the astounding morphological features in their exine, constituting important criteria for morphological comparisons in the flowering plants. As such, the most bewildering variety of pollen grains from the point of view of contour, size, configuration and the sculpture pattern on the surface including germinal apertures, grooves, protuberances and warts, has served as a special booster for the popularity of pollens in taxonomic and phylogenetic studies. It was Radlkofer (cf. Ayyangar, 1978) who for the first time, stressed the significance of the pollen attributes in taxonomy in his work on the family Acanthaceae. Besides, pollen morphological characters were also fully appreciated by authors such as Lindley, von Mohl and Fritzshe as early as 1830-1840 (cf. Naik, 1988). However, the first comprehensive work on palynology in relation to taxonomy was made by Modehouse (1935) wherein he stated, "the pollen grains are as much a part of the plant as the various organs upon which the taxonomist has drawn his imaginative and surprisingly beautiful classification. But in this, he has thrown away, perhaps, the richest part of the heritage, for in no other part of the plant are found packed in so small a space so many readily available characters." In support of the above contention Heywood (1967) may also be quoted, "The details of the
exine (of pollen) are such that it can be used in plant identification much in the way that fingerprints are used for identification of criminals." There is a remarkable relationship between morphological types of pollen and taxonomic subdivisions in Angiosperm families (Muller, 1970). As early as 1943, Bailey and Nast also observed "there are families of dicotyledons in which the pollen is of very considerable significance not only in the differentiation of subfamilies and tribes but also of genera and species." Thus the study of pollen morphology has come to occupy an important place in the realm of comparative morphology of plants, owing to the growing conviction that the pollens being a gene pool of all variations during the life cycle of plants reflect in them, to a fair degree, the trends and directions of evolution and interrelationships among plants (Katiyar, 1982). The monumental work on Pollen morphology and Plant Taxonomy/Angiosperms by Erdtman (1952) provided a true picture of the immense use of pollen morphology in plant taxonomy at various taxa levels. The contemporary progress in the study of pollen morphology has been reviewed and presented in the book Pollen Morphology of Angiosperms- A historical and phylogenetic study by Nair (1970b). These and a host of similar literature since the time of Wodehouse (l.c.) including those of Wodehouse (1936a), Sayeeduddin et al (1942), Bailey and Nast (l.c.), Bhaduri (1944), Selling (1946), Maheswari (1949), Rao (1950), Mukherjee (1951), Sampat & Ramanathan (1951), Cranwell (1952),

Erdtman (1963) suggested a new method of classification of plants which he called the NPC (Number-Position-Character) classification system, N refers to the number of apertures of the pollen grains, P the position of the aperture on the grain and C refers to character of the same. Considering the pollen grains of seed plants and the spores of lower plants together, it has
been contended that the morphological character relating to the germinal aperture is the most conservative and hence the most Primary in consideration of evolution, while that to the exine ornamentation appears Secondary and other characters Tertiary in the order of their degree of importance. In a morphological analysis of the sporepollen morphoforms in the Plant Kingdom and subsequent observations led to the suggestion that the Plant Kingdom could be classified into three divisions, namely Primorphosporophyta (Syn. Thallophyta), Trimorphosporophyta (Syn. Archegoniatae composed of Bryophyta, Pteridophyta and Gymnosperms) and Polymorphosporophyta (Syn. Anthophyta or Angiospermae) (Nair, 1977). Further, in a series of communications Nair (1970b c, 1974a b) enunciated the triphyletic theory of evolution of Angiosperms which suggests that the Angiosperms have their phylogenetic root in the Pteridosperms, at which level the group diverged along three directions, namely Monocot stock, Magnolian stock and the Ranalian stock respectively. Of the above three lines the Magnolian stock and Monocot stock by having the dominance of monocolpate grain have been considered to be nearer to the Preangiosperms, while the Ranalian dicots with the tricolpate and its derivatives represent new evolution in the Plant Kingdom.

The separation of Paeoniaceae from Ranunculaceae, of Nelumbonaceae from Nymphaeaceae, of Fumariaceae from Papaveraceae, of Bombacaceae from Malvaceae, and of Cuscutaceae from
Convolvulaceae, finds support from pollen morphology. In a detailed pollen morphological study of 41 species of the genera *Fagus* and *Nothofagus* (Fagaceae), Hanks and Fairbrothers (1976) revealed the insight into the pollen type relationships by using data from other disciplines. Also in a very recent work in some species of Helianthoideae (Asteraceae), Shukla and Gupta (1989) observed that the pollen morphological data provide some support for the separation of the genus *Xanthium* from other members of the tribe. Further, it becomes apparent that pollen variations are very specific for particular taxa within the tribe Helianthoideae.


It appears that the pollen morphology of the Fabaceae (Papilionaceae) in contrast to the Mimosaceae and Caesalpiniaceae
has not received much attention. However, the first scientific study of the pollen grains of the Fabaceae was done as early as 1890 by Fritzshe who described tricolporate grains in the family. Martin (1932) reported great variation in the shape and exine pattern of the pollen grains in the Fabaceae. Since then morphology of the Papilionaceous pollen has been studied and mentioned in various works dealing with the pollen floras and taxonomy, of which mention may be made of Selling (1947), Faegri (1956), Ikuse (1956), Lesins & Lesins (1963), Melhem (1964, 1965, 1968, 1971), Sharma (1968), Mehler (1970, 1976), Huang (1972), Gillett et al. (1973), Rao & Ong (1973), Graham & Tomb (1974, 1977), Tiwari (1976), Poole (1979), Ravi Kumar et al. (1979) and others.

The interesting survey made by Erdtman (1952) referred to great pollen morphological variation within the Leguminosae but it accounted only 13 genera for the Fabaceae (Papilionaceae) most of which were from the tribe Phaseoleae. In the most extensive work on the pollen types in the Leguminosae including Papilionaceae by Vishnu-Mitte and Sharma (1970c) indicated the dominance of the 3-zonocolporate pollen types in the family and observed that the utility of pollen morphology in the taxonomy of the family, on the whole, appeared to be very limited. Nair (1970c), too, noticed that the family contain advanced pollen morphotypes dominated by the 3-colporate pollen. Ohashi (1971, 1973) had surveyed the large genus Desmodium and its
allies and a widely interpreted tribe Coronilleae, and undoubtedly made the most significant recent contribution to our knowledge of the pollen morphology of the family Fabaceae. Clarke and Kupicha (1976) also carried out a survey of the pollen morphology in Cicer, the other genera of the Vicieae, the Trifolieae and the Ononideae to determine the relationships of Cicer, a genus usually placed under the tribe Vicieae. They observed that the Vicieae (s.s.) is very homogeneous palynologically and Cicer is more close to Ononideae rather than to Vicieae (s.l.), and hence the genus does not belong to the Vicieae as far as pollen characters are concerned. This and that earlier palynomorphological work of Gapotchka (1974) lend quite convincing support for raising the genus Cicer to the rank of a tribe Cicereae in a subsequent synthetic work of Kupicha (1977). While signifying the importance of exine patterns even in recognising hybrids, Srivastava (1978) distinguished different cultivars and their hybrids of Cajanus cajan basing on the different sizes of areoles on exine surface in them. A detailed study of apertural forms and their evolutionary trends in the pollen grains of Indian Papilionaceae (Tiwari & Nair, 1978), held that Rosales (sensu Bentham) containing also the Papilionaceae constitute the second tier in the evolution of Ranalian dicots. Further, it was indicated that the tribe Hedysareae of the family with the dominance of tricolpate pollen is the most primitive, while the tribe Phaseoleae with the concentration of triporate pollen and the
other tribes with tricolporate pollen have evolved along two independent lines from Hedysareae. The very recent treatise of Ferguson and Skvarla (1981) on the pollen morphology of the Fabaceae emphasised the exploitation of most modern techniques of scanning and transmission electron microscopy (SEM and TEM) in pollen morphological research. The study set out to summerise the essential features of the pollens gained from these techniques including those from light microscopy in the 32 tribes of the Fabaceae (considered as the subfamily Papilionoideae) by Polhill (1981) and to discuss their relationships as reflected by pollen morphology. This provided a general understanding of the variation encountered in the pollen morphological features of the group which becomes a base on which further palynological informations can be established.

In view of the above informations regarding the palynomorphological support or otherwise in the taxonomy and phylogeny of the family Fabaceae and of the absence of any palynological work on the plants of the group from the Assam region, the present investigation has been taken up. It has been intended to evaluate and assess the pollen morphological features in the taxonomy and interrelationships of some taxa of the family that occur in Assam. Pollen attributes encountered in the investigation comprise apertural forms, size and shape of the grains, size of ectocolpium, nature and size of endocolpium, and thickness and surface feature of exine. A comparative chart
showing the pollen morphological features including the variations from those reported by other workers, has also been appended. (cf. Table 4).

Palynomorphological characters (in brief) of the species of Fabaceae:

1. *Crotalaria anagyroides* H.B. & K.

   Pollen grains 3-zonocolporate, prolate, (39.61-37.53) x (29.19-25.02) \( \mu m \); endocolpium lalongate, average 12.5 x 6.25 \( \mu m \); ectocolpium average 29.19 x 3.12 \( \mu m \); exine foveolate, 3.12 \( \mu m \) thick (ectoexine 0.78 \( \mu m \) and endoexine 2.34 \( \mu m \)). (Plate 31. fig. 1; based on slide 291).

2. *C. bialata* Schrank

   Pollen grains 3-zonocolporate, subprolate to prolate, (31.27-29.19) x (25.02-16.68) \( \mu m \); endocolpium circular, average 4.17 \( \mu m \) in diameter; ectocolpium average 27.10 x 3.12 \( \mu m \); exine faintly punctate, 3.12 \( \mu m \) thick (ectoexine 0.78 \( \mu m \) and endoexine 2.34 \( \mu m \) ) (Plate 31. fig. 2; based on slide 311).

3. *C. calycine* Schrank

   Pollen grains 3-zonocolporate, prolate, (27.10-25.02) x (18.76-16.68) \( \mu m \); endocolpium slightly lolongate, average 6.25 x 4.17 \( \mu m \); ectocolpium average 22.93 x 2.91 \( \mu m \); exine faintly
Explanation of Plate 31.

Figs. 1-21: Photomicrographs of pollen grains.
(All the photomicrographs are original from the untouched negatives)

2. C. bialata Schrank do
3. C. calycina Schrank do
4. C. ferruginea Grah. do
5. C. juncea L. do
6. C. pallida Ait var. pallida do
7. C. spectabilis Roth do
8. C. verrucosa L. do
9. Tephrosia candida (Roxb.) DC. do
10. T. purpurea (L.) Pers. do
11. Alysicarpus vaginalis (L.) DC (Polar view)
12. do (Equatorial view)
13. Desmodium caudatum (Thunb.) DC. do
14. D. gangeticum (L.) DC. do
15. D. heterocarpon (L.) DC. do
16. D. heterophyllum (Willd.) DC. (Polar view)
17. D. laxiflorum DC. (Equatorial view)
18. D. motorium (Houtt.) Merr. do
19. D. triangulare (Retz.) Merr. do
20. D. triflorum (L.) DC. do
21. D. velutinum (Willd.) DC. do
foveolate, 2.08 \mu m thick (ectoexine 0.7 \mu m and endoexine 1.38 \mu m) (Plate 31. fig. 3; based on slide 279).


Pollen grains 3-zonocolporate, prolate, (33.36-31.27) x (20.85-16.68) \mu m; endocolpium circular, average 6.25 \mu m in diameter; ectocolpium average 27.52 x 4.17 \mu m; exine foveolate, 3.1 \mu m thick, endoexine as thick as ectoexine. (Plate 31. fig. 4; based on slide 328).

5. *C. juncea* L.

Pollen grains 3-zonocolporate, prolate, (37.53-35.44) x (20.85-18.76) \mu m; endocolpium circular, average 7.29 \mu m in diameter; ectocolpium average 29.19 x 4.17 \mu m; exine punctate, 2.08 \mu m thick (ectoexine 0.52 \mu m and endoexine 1.56 \mu m). (Plate 31. fig. 5; based on slide 296).

6. *C. pallida* Ait. var. *pallida*

Pollen grains 3-zonocolporate, prolate, (29.19-25.02) x (18.76-16.68) \mu m; endocolpium circular, average 4.58 \mu m in diameter; ectocolpium average 18.34 x 4.17 \mu m; exine psilate, 2.08 \mu m thick (ectoexine 0.52 \mu m and endoexine 1.56 \mu m). (Plate 31. fig. 6; based on slide 264).
7. *C. spectabilis* Roth

Pollen grains 3-zonocolporate, prolate, (29.19-27.10) x (18.76-16.68) μm; endocolpium lalongate, average 10.42 x 4.17 μm; ectocolpium average 22.93 x 3.12 μm; exine foveolate; 2.08 μm thick, endoexine as thick as ectoexine. (Plate 31. fig. 7; based on slide 283).

8. *C. verrucosa* L.

Pollen grains 3-zonocolporate, prolate, (29.19-27.10) x (18.76-16.68) μm; endocolpium slightly lalongate, average 5.21 x 4.17 μm; ectocolpium average 20.85 x 2.08 μm; exine faintly foveolate, 2.08 μm thick (ectoexine 0.52 μm and endoexine 1.56 μm), (Plate 31. fig. 8; based on slide 316).

9. *Tephrosia candida* (Roxb.) DC.

Pollen grains 3-zonocolporate, subprolate, (39.61-37.53) x (33.36-29.19) μm; endocolpium lalongate, average 10.42 x 8.34 μm; ectocolpium average 25.02 x 4.17 μm; exine psilate, 6.25 μm thick, endoexine as thick as ectoexine. (Plate 31. fig. 9; based on slide 300).


Pollen grains 3-zonocolporate, subprolate, (35.44-25.02) x (27.10-20.80) μm; endocolpium slightly lolongate, average
11. *Alysicarpus vaginalis* (L.) DC.

Pollen grains 3-zonocolporate, subprolate, average 45.89 x 36.48 μm; endocolpium lolongate, average 10.42 x 7.29 μm; ectocolpium average 29.19 x 4.17 μm; exine faintly reticulate, 3.12 μm thick (ectoexine 1.04 μm and endoexine 2.08 μm), (Plate 31. figs. 11 and 12; based on slide 259).

12. *Desmodium caudatum* (Thunb.) DC.

Pollen grains 3-zonocolporate, subprolate, (29.19-27.10) x (22.93-20.85) μm; endocolpium circular, average 7.29 μm in diameter; ectocolpium average 22.93 x 2.08 μm; exine psilate, 2.08 μm thick, endoexine as thick as ectoexine. (Plate 31. fig. 13; based on slide 303).

13. *D. gangeticum* (L.) DC.

Pollen grains 3-zonocolporate, subprolate to prolate, (35.44-33.36) x (27.10-25.02) μm; endocolpium circular, average 7.29 μm in diameter; ectocolpium average 25.02 x 4.17 μm; exine psilate, 2.08 μm thick, endoexine as thick as ectoexine. (Plate 31. fig. 14; based on slide 272).
14. *D. heterocarpon* (L.) DC.

Pollen grains 3-zonocolporate, prolate-spheroidal to subprolate, \((50.04-45.87) \times (45.87-39.61) \mu m\); endocolpium circular, average 6.25 \(\mu m\) in diameter; ectocolpium average 29.19 \(\times 6.25 \mu m\); exine faintly punctate, 2.08 \(\mu m\) thick (ectoexine 0.52 \(\mu m\) and endoexine 1.56 \(\mu m\)). (Plate 31 fig. 15; based on slide 320).

15. *D. heterophyllum* (Willd.) DC.

Pollen grains 3-zonocolporate, prolate-spheroidal, average 47.95 \(\times 43.78 \mu m\); endocolpium obscure; ectocolpium average 25.02 \(\times 6.25 \mu m\); amb spherical to almost triangular, apocolpium large; exine distinctly reticulate, 4.17 \(\mu m\) thick endoexine as thick as ectoexine. (Plate 31 fig. 16; based on slide 255).

16. *D. laxiflorum* DC.

Pollen grains 3-zonocolporate, subprolate to prolate, \((33.36-31.27) \times 25.02 \mu m\) endocolpium lalongate, average 12.51 \(\times 8.34 \mu m\); ectocolpium average 25.02 \(\times 6.25 \mu m\); exine psilate, 2.08 \(\mu m\) thick (ectoexine 1.38 \(\mu m\) and endoexine 0.7 \(\mu m\)). (Plate 31 fig. 17; based on slide 275).

17. *D. motorium* (Houtt.) Merr.

Pollen grains 3-zonocolporate, prolate to subprolate,
(50.04-31.27) x (29.19-25.02) μm; endocolpium lolongate, average 8.34 x 5.0 μm; ectocolpium average 25.02 x 2.08 μm; exine faintly foveolate, 2.08 μm thick, endoexine as thick as ectoexine. (Plate 31. fig. 18; based on slide 288).

18. **D. triangulare** (Retz.) Merr.

Pollen grains 3-zonocolporate, prolate, (31.27-29.19) x (20.85-16.68) μm; endocolpium circular, average 4.17 μm in diameter; ectocolpium average 22.93 x 3.12 μm exine psilate, 2.08 μm thick (ectoexine 1.38 μm and endoexine 0.69 μm). (Plate 31. fig. 19; based on slide 323).

19. **D. triflorum** (L.) DC.

Pollen grains 3-zonocolporate, prolate, (39.61-33.36) x (26.06-25.02) μm; endocolpium circular, average 8.34 μm in diameter; ectocolpium average 25.02 x 5.21 μm; exine psilate, 2.08 μm thick, endoexine as thick as ectoexine. (Plate 31. fig. 20; based on slide 251).

20. **D. velutinum** (Willd.)DC.

Pollen grains 3-zonocolporate, prolate, (33.36-31.27) x (25.02-20.85) μm; endocolpium circular, average 12.51 μm in diameter; ectocolpium average 27.1 x 2.08 μm; exine psilate, 2.08 μm thick, endoexine as thick as ectoexine. (Plate 31. fig. 21; based on slide 307).
The study clearly reveals that all the investigated species under the genera *Crotalaria*, *Tephrosia*, *Alysicarpus* and *Desmodium* possess 3-zono-colporate pollen and as such they appear to be unipalynous (stenopalynous) as regards to the apertural forms. This also corroborates to the most extent, with the earlier works of Vishnu-Mittre and Sharma (1962), and Tiwari and Nair (1978). However, the reported absence of a 3-zono-colporate pollen type in *Alysicarpus vaginalis* and 3-zono-colporoidate ones in *Crotalaria pallida* var. *pallida* fairly contradicts those findings of Vishnu-Mittre and Sharma (l.c.), and Tiwari and Nair (l.c.) respectively. The uniform occurrence of unipalyny makes this pollen character out of place to exploit in taxonomy of the taxa investigated supporting a view contended by Katiyar (1982).

It appears that variation in pollen size even within a species, is a common feature as was also reported by almost all earlier workers and it is as common in all the species investigated. The largest pollen type is reported in *Desmodium heterocarpon* (size range 50.04-45.87 x 45.87-39.61 µm) and *D. motorium* (50.04-31.27 x 29.19-25.02 µm), and the smallest in *Crotalaria calycina* (27.10-25.02 x 18.76-16.68 µm). Similarly, the commonest type of grain shape is the prolate while in some instances subprolate ones are also seen. The occurrence of prolate-spheroidal type is found only in *Desmodium heterocarpon*
and *D. heterophyllum*. While there has been some difference in the size range, but a fair degree of shape difference has been noticed as compared to those of Vishnu-Mittre and Sharma (*l.c.*). (cf. Table 4). The size and shape characteristics frequently overlap in different species within a genus and even in those of under different genera. Moreover, according to Nair and Kapoor (1974) slight variations in pollen shape are of no taxonomic significance. Therefore, these characters appear taxonomically meaningless unless they are added to the totality of pollen attributes to be exploited for classification purpose. Similarly, size characteristics of the ectocolpium are also of least or no taxonomic significance.

It has been observed that the nature of endocolpium is also very variable within a genus. It is lalongate in *Crotalaria anagyroides*, *C. spectabilis* and *C. verrucosa*; circular in *C. bialata*, *C. ferruginea*, *C. juncea* and *C. pallida* var. *pallida*; and lolongate in *C. calycina*. Whereas all the species of *Desmodium* reveal a circular endocolpium except in *D. laxiflorum* and *D. motorium* in which it is lalongate and lolongate respectively. Out of the two investigated species of *Tephrosia*, *T. candida* with a lalongate endocolpium differs from *T. purpurea* where it is lolongate. The endocolpium characteristics appear quite at variance with the earlier works of Vishnu-Mittre and Sharma (*l.c.*)) and Ferguson and Skvarla (*l.c.*). Moreover, the overlapping
nature of this characteristics too, tend it to be of very limited significance in the delimitation of species and even genera within the Fabaceae. The occurrence of an obscure endocolpium in the grains of *Desmodium heterophyllum* approaching nearly a colporoidate condition deserves special mention.

The surface of the exine appears to be psilate, foveolate, punctate or very rarely faintly reticulate. It is to be noted that a distinct reticulate pattern has been noticed only in *D. heterophyllum* although a faint reticulation has also been observed in *Alysicarpus vaginalis*. Thus a comparatively large and nearly 3-zono-colporoidate grain with a much larger apocolpium and distinctly reticulate exine has been quite distinct to delimit *Desmodium heterophyllum* palynomorphologically from rest of the species within the genus as well as from those of the other genera investigated.

Tiwari and Nair (*l.c.*) observed that the taxonomic division of the Fabaceae (Papilionaceae) into tribes finds some support from morphology, whereas Vishnu-Mitre and Sharma (*l.c.*) and Ferguson and Skvarla (*l.c.*) advocated that it is not possible to define all the tribes of the Fabaceae by their pollen morphology nor it is practical to try to define strict pollen types and meaningfully compare these with established macromorphological groups. The present investigation also reveals that because of the existence of great overlap and
parallels in pollen morphological features among different taxa, the palynomorphological support, that too as supplementary, for the separation of different species as well as genera of the Fabaceae has been of least or negative significance. However, a totality in pollen morphology may be of diagnostic significance of lesser degree for identification of species within the Fabaceae. In this regard it may be suggested that exploitation of modern techniques such as SEM and TEM has been very much necessary to gain more insight into the pollen morphology as also was suggested by Hanks and Fairbrothers (l.c.), Ferguson and Skvarla (l.c.) and other workers of modern times.

As such, while it has been impossible to delimit the investigated genera basing on pollen morphology, a trial has been made here to key out tentatively the different species of respective genera as far as practicable with the support of the observed pollen attributes. This may however, be considered as purely artificial.

I. Tentative palynomorphological key to the identification of species belonging to Crotalaria:

1. Endocolpium lalongate:
2. Exine surface foveolate:
   3. Endoexine as thick as ectoexine; grain size (29.19-27-10)x(18.76-16.68)μm ; .. 7. C. spectabilis
3. Endoexine thicker than ectoexine; 
grain size (39.61-37.53) x (29.19-25.02) 
\(\mu m\) ... ... 1. C. anagyroides

2. Exine surface indistinctly foveolate .. 8. C. verrucosa

1. Endocolpium lolongate or circular:

4. Endocolpium lolongate; grain size 
\((27.10-25.02) \times (18.76-16.68) \mu m\) .. 3. C. calycina

4. Endocolpium circular; grain size more 
than 27.10 x 18.76\(\mu m\):

5. Exine surface psilate; ectocolpium 
\(ca\ 18.3^{4/5} \mu m\) long ... 6. C. pallida var. 
pallida

5. Exine surface punctate or foveolate; 
extocolpium longer than 18.34\(\mu m\):

6. Exine surface punctate; endo-
exine thicker than ectoexine:

7. Grain size (37.53-35.44) x 
\((20.85-18.76) \mu m\) .. 5. C. juncea

7. Grain size (31.27-29.19) x 
\((25.02-16.68) \mu m\) .. 2. C. hialata

6. Exine surface foveolate; 
endoexine as thick as 
extoexine .. .. 4. C. ferruginea
II. Tentative palynomorphological key to the identification of species belonging to Tephrosia:

1. Endocolpium lalongate; exine psilate; endoexine as thick as ectoexine; grain size (39.61-37.53) x (33.36-29.19) μm .. 1. T. candida

1. Endocolpium slightly lolongate; exine faintly punctate; grain size (35.44-27.10) x (25.02-20.80) μm .. 2. T. purpurea

III. Tentative palynomorphological key to the identification of species belonging to Desmodium:

1. Endocolpium obscure; exine surface distinctly reticulate ... .. 4. D. heterophyllum

1. Endocolpium distinct; exine surface not reticulate:

2. Endocolpium lalongate or lolongate

3. Endocolpium lalongate; exine surface psilate; endoexine thinner than ectoexine ... .. 5. D. laxiflorum

3. Endocolpium lolongate; exine surface faintly foveolate; endoexine as thick as ectoexine .. 6. D. motorium

2. Endocolpium circular:

4. Exine surface faintly punctate; endoexine thicker than ectoexine;
grain size 50.04-35.87 x
45.87-39.61 \( \mu m \)  ... 3. \textit{D. heterocarpon}

4. Exine surface psilate; endoexine
as thick as or thinner than
ectoexine; grain size less
than 45.87 x 39.61 \( \mu m \) :

5. Endoexine thinner than
ectoexine; endocolpium
diameter 4.17 \( \mu m \)  ... 7. \textit{D. triangulare}

5. Endoexine as thick as
ectoexine; endocolpium
diameter more than 4.17 \( \mu m \):

6. Grain 29.19-22.93 \( \mu m \)
long; ectocolpium 22.93
\( \mu m \) long  ... 1. \textit{D. caudatum}

6. Grain longer than 29.19 \( \mu m \);
ectocolpium longer than
22.93 \( \mu m \):

7. Endocolpium diameter
7.29 \( \mu m \); grains subprolate
to prolate  ... 2. \textit{D. gangeticum}

7. Endocolpium diameter more
than 7.29 \( \mu m \); grains
prolate:
8. *Endocolpiura* diameter
   8.34 μm; grain size 39.61-33.36 x
   26.06-25.02 μm² ... 8. *D. triflorum*

8. *Encocolpium* diameter 12.51 μm;
   grain size 35.36-31.27 x
   25.02-20.85 μm² ... 9. *D. velutinum*

**Phylogenetic Consideration:**

It may be pointed out that the 3-zonocolpate grain is considered to be a relatively primitive form from which the other forms, namely the colporoidate, the colporate, the porate including the pantoporate have evolved. In principle the occurrence of 3-zonocolpate element in any one family is considered to suggest primitiveness, followed in the order of succession by colporoidate, the colporate and pororate elements (Katiyar, l.c.). The reported occurrence of 3-zonocolporate grains in the present investigation in *Alysicarpus* and *Desmodium* as against the dominance of 3-zonocolpate type in the tribe *Hedysareae* (Tiwari and Nair, l.c.) proves that these two genera are advanced within the *Hedysareae* (sensu Bentham). In turn, this also lend some support for the creation of separate tribe *Desmodieae* including *Desmodium* and *Alysicarpus* and the *Hedysareae* (s.g.) by Hutchinson (1964) and Polhill (1981) and that too, justifying the far advanced position of *Desmodieae* over *Hedysareae*.
Fig. 6 Relationship of tribes of Fabaceae [After Polhill, 1981]
as suggested by Polhill (l.c.) (cf. Fig. 6). As a whole, the dominance of 3-zonocolporate grains in the investigated species provides additional support for consideration of the Fabaceae to be highly evolved palynomorphologically, also confirming the views brought forth by Nair (1970c) and Tiwari and Nair (l.c.).