CHAPTER III

EPIDERMAL MORPHOLOGY
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It has been recognized that anatomical characters of the vegetative organs can be employed with success to the solution of taxonomic problems and to the elucidation of phylogenetic relationships of the plants and plant groups. Metcalf and Chalk (1950) stated "... Anatomical structure .... is most likely to provide evidence concerning the interrelationships of larger groups such as families, or in helping to establish the real affinities of genera of uncertain taxonomic status". Stace (1966), too, remarked that apart from genetic, biochemical and physiological characters the anatomy of many parts of the plant has provided much valuable evidence beyond that offered by the classical morphological study of the shoot. The application of anatomical characters in plant classification dates back to Bureau (1864) who for the first time used them for delimitation of taxa of various levels within the family Bignoniaceae. Since then, the guiding principles of systematic anatomy have been laid by many workers (Solereder, 1908; Bailey and Tupper, 1918; Bailey, 1933, 1944, 1953, 1957; Chalk, 1937, 1944; Vestal, 1940; Metcalf, 1946, 1954; Metcalf and Chalk, 1950; Puri, 1952a,b; Carlquist, 1961, 1969; Eames, 1961; Esau, 1961; Dickison, 1975; Eyde, 1975 and others). Out of a large number of anatomical features the taxonomic and phylogenetic importance of the foliar
epidermal characters such as those of stomata, epidermal cells and epidermal hairs have amply been demonstrated in different plant groups. While making an exhaustive review of the systematic value and accounting in detail of the epidermal characters of the Angiosperm leaves Stace (1965) stated "I do not claim that cuticular characters are of any outstanding fundamental or all-important significance, as did some of the early exponents of the taxonomic use of pollen grain or chromosome features. They are, however, to be regarded as characters of undoubted importance as further pieces of the jigsaw of complete systematic evidence, and at times they in fact of greater value in identification and taxonomy than are any other characters of which we know." In the same context Van Cotthem (1973) may also be quoted, "Even if it is true that a particular character never will override all others in importance, it cannot be denied that the stomatal type has turned out to be taxonomically valuable in so many and so diverse groups, and that its validity can be accepted as quite general for most of the higher plants."

Varma and Murty (1989) showed how the foliar and floral stomatal features provide support on the justified subfamilial status of Thunbergioideae within the family Acanthaceae.

Metcalf and Chalk (1950) seem to be the first authors to give a general account of the epidermal morphology in the family Fabaceae (Papilionaceae). Although the subsequent literatures on the epidermal features of this family are not so meagre (Misra et al., 1968; Shah, 1968; Shah and Gopal, 1969 a b c; Simola, 1968; Krishnamurthy and Kannabiran, 1970; Kothari and Shah, 1974a, b, 1975; Kupicha, 1977), most of the works have been devoted to the structure and development of stomata as well as hairs without giving much emphasis on the systematic and phylogenetic significance of these features. In an intensive survey of the stomatal features in Fabaceae Shah and Gopal (1969) found sufficient affirmative clue for inclusion of the species concerned in the tribe Phaseoleae. Whereas the taxonomic significance of stomata and hairs had been discussed by Shah and Kothari (1973, 1975) and Kothari and Shah (l.c.) in various taxa of the Fabaceae under different tribes viz. Vicieae, Trifolieae, Dalbergiaceae, Sophoreae, Podalyrieae and Hedysareae. Further, similar evidences had successfully been supplemented with other taxonomic evidences for raising the genus Cicer to the rank of a tribe Cicereae (Kupicha, l.c.). In a detailed comparative study of the foliar epidermal characters in 10 species of the genus Crotalaria, Kannabiran and Krishnamurthy (1974) demonstrated
that these features were characteristically constant at section level of the genus. This study substantiated the traditional classification of the genus based on gross morphology and these authors suggested the consideration of the foliar epidermal characters in the systematics of the genus.

The stomatal abnormalities such as contiguous stomata, abortive stomata, stomata with single guard cell etc. have been described and their occurrence in different plant groups are reviewed to a greater extent by Farooqui (1979). These structures have also been reported in the Fabaceae (Bora and Baruah, 1979), although their taxonomic significance has not been focused as yet.

In the family Combretaceae Stace (1965b, 1969a, b, 1973a) found that trichome anatomy is of immense significance in classification at all levels, from the circumscription of the family down to the separation of the species and even varieties. In particular, it has led to an improved classification of tribes within the family and an improved subgeneric and sectional classification within the largest genus Combretum. In a recent study Leelavathi and Ramayya (1983) presented the detailed structure, organographic distribution, classification and taxonomic significance of trichomes in 34 species of the Caesalpiniaceae and keyed them out solely on the basis of trichome features. In the Fabaceae, too, Baudet and Marechal (1976) demonstrated
that the presence of hooked hairs is characteristic of the genus *Desmedium* and related genera among the tribe Hedysareae.

In the present study, it has therefore, been intended to survey the foliar epidermal features in some taxa of the family Fabaceae for better understanding the interrelationships among them and to fill the lacuna of informations on these features in taxonomy of the family which remains almost empty for this part of the country. The salient features of the epidermal morphology of the investigated species have been presented in the Table 3.
Explanation of Plate 21.

Figs. 1(a - c) Crotalaria anagyroides H.B. & K.

1a. Lower foliar epidermis
1b. Upper foliar epidermis
1c. Epidermis over costal area

Figs. 2(a - c) C. bialata Schrank

2a. Lower foliar epidermis
2b. Upper foliar epidermis
2c. Epidermis over costal area

Figs. 3(a - c) C. calycina Schrank

3a. Lower foliar epidermis
3b. Upper foliar epidermis
3c. Epidermis over costal area
EPIDERMAL FEATURES OF THE SPECIES OF FABACEAE

1. Crotalaria anagyroides H.B. & K.

Leaves amphistomatic. Stomata more on lower surface, predominantly anisocytic, rarely mixed with amphiparacytic type on both the surfaces and rarely also with few diacytic type on lower surface. Intercostal cells slightly elongate, 4-6-walled, with moderately sinuous on lower and nearly straight or slightly undulate walls on upper surface. Costal cells polygonal to rectangular, with straight walls, slightly longer and narrower than the intercostal cells. Hairs unicellular fusiform, on lower surface only, common, on costal and intercostal area. (Plate 21. figs.1. a, b, c and Plate 28. fig.1; based on slide 201).

2. C. bialata Schrank

Leaves amphistomatic. Stomata much more on lower surface, predominantly anisocytic mixed with amphiparacytic rarely anomocytic and tetracytic on lower surface, whereas predominantly amphiparacytic rarely mixed with anisocytic type on upper surface. Intercostal cells slightly elongate, 5-6-walled, with moderately sinuous on lower and slightly sinuous walls on upper surface. Costal cells mostly rectangular, with nearly straight walls, slightly longer and narrower than the intercostal cells. Hairs unicellular conical, very frequent on lower and sparse on upper surface, on costal and intercostal area. (Plate 21. figs.2. a, b, c and Plate 28. fig.2; based on slide 240).
3. **C. calycina** Schrank

Leaves amphistomatic. Stomata much on lower surface, predominantly anisocytic mixed with amphiparacytic on both the surfaces, rarely with anomocytic on lower and diacytic as well as paracytic on upper surface. Intercostal cells elongate, 5-6 walled, with slightly undulate walls on both the surfaces. Costal cells rectangular to polygonal, with straight walls, longer and narrower than the intercostal cells, with few stomata. Hairs unicellular fusiform, much longer, on lower surface only, common, on costal and intercostal area. (Plate 21. Figs. 3.a b c and Plate 28. Fig. 3; based on slide 205).

4. **C. ferruginea** Grah.

Leaves amphistomatic. Stomata much more on lower surface, predominantly anisocytic mixed with amphiparacytic on both the surfaces, rarely also with anomocytic on lower surface. Intercostal cells nearly isodiametric, polygonal (5-6-walled), with nearly straight walls on both the surfaces, much larger on upper than those on lower surface. Costal cells polygonal, with straight walls, longer and narrower than the intercostal cells. Hairs unicellular conical, much dense on lower than upper surface, on costal and intercostal area. (Plate 22. figs. 1.a b c and Plate 28. fig. 4; based on slide 208).
Explanation of Plate 22.

Figs. 1(a - c) Crotalaria ferruginea Grah.

1a Lower foliar epidermis
1b Upper foliar epidermis
1c Epidermis over costal area

Figs. 2(a - d) C. juncea L.

2a Lower foliar epidermis
2b Upper foliar epidermis
2c Epidermis over costal area
2d Stomata with single guard cell

Figs. 3(a - e) C. pallida Ait var. pallida

3a Lower foliar epidermis
3b Upper foliar epidermis
3c Epidermis over costal area
3d & 3e Contiguous stomata
5. C. juncea L.

Leaves amphistomatic. Stomata more on lower surface, predominantly anisocytic mixed with amphiparacytic on both the surfaces, also with few anomocytic, of single guard cell and rarely actinocytic types on lower surface. Intercostal cells irregular, mostly 5-walled, with sinuous on lower and nearly sinuous walls on upper surface. Costal cells rectangular to polygonal, with slightly undulate or nearly straight walls, longer and narrower than the intercostal cells with few stomata. Hairs unicellular, on both the surfaces, common, on costal and intercostal area. (Plate 22. fig. 2. a b c and Plate 28. fig.5; based on slide 225).

6. C. pallida Ait. var. pallida

Leaves amphistomatic. Stomata more on lower surface, predominantly anisocytic on both the surfaces, mixed with anomocytic and rarely polar contiguous types on lower, with amphiparacytic and rarely anomocytic as well as parallel contiguous types on upper surface. Intercostal cells irregular, mostly 5-walled, with nearly sinuous on lower and undulate walls on upper surface. Costal cells polygonal, with nearly straight walls, longer than the intercostal cells, frequently with stomata. Hairs unicellular fusiform, on lower surface only, sparse, on costa and intercosta. (Plate 22. figs. 3.a b c and Plate 28. fig. 6; based on slide 211).
Explanation of Plate 23

Figs. 1(a - c) Crotalaria spectabilis Roth.

1a. Lower foliar epidermis
1b. Upper foliar epidermis
1c. Epidermis over costal area

Figs. 2(a - c) C. verrucosa L.

2a. Lower foliar epidermis
2b. Upper foliar epidermis
2c. Epidermis over costal area
7. **C. spectabilis** Roth

Leaves amphistomatic. Stomata more on lower surface, predominantly anisocytic mixed rarely with amphiparacytic and anomocytic on both the surfaces. Intercostal cells irregular, 5-6-walled, with sinuous on lower and undulate walls on upper surface. Costal cells polygonal, with nearly straight walls, much longer than the intercostal cells, frequently with stomata. Hairs unicellular fusiform, on lower surface only, sparse, more on costal than intercostal area. (Plate 23. figs. 1. a b c and Plate 28. fig. 7; based on slide 218).

8. **C. verrucosa** L.

Leaves amphistomatic. Stomata much more on lower surface, predominantly anisocytic mixed with anomocytic type on both the surfaces, rarely also with amphiparacytic type on upper surface. Intercostal cells irregular, mostly 5-walled, with undulate on lower and nearly straight or slightly undulate walls on upper surface. Costal cells polygonal, with straight walls, nearly as long as but narrower than the intercostal cells. Hairs unicellular fusiform, on both the surfaces most frequent, on costal and intercostal area. (Plate 23. figs. 2. a b c and Plate 28. fig. 8; based on slide 230).

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

Leaves hypostomatic. Stomata predominantly anisocytic
mixed with anomocytic type; subsidiary cells much similar to the epidermal cells. **Intercostal cells** nearly isodiametric, polygonal (5-6-walled), with straight walls on both the surfaces. **Costal cells** polygonal and rectangular, with straight walls, slightly longer than the intercostal cells. **Hairs** unicellular conical, slender, on lower surface only, common, on costal and intercostal area. (Plate 2k. figs. 1.a b c and Plate 28. fig. 9; based on slide 221).


**Leaves** amphistomatic. **Stomata** much more on lower surface, predominantly anisocytic mixed with amphiparacytic and anomocytic types on both the surfaces; subsidiary cells much similar to the epidermal cells. **Intercostal cells** usually nearly isodiametric, polygonal (5-6-walled), with straight walls on both the surfaces, larger on upper than those on lower surface. **Costal cells** polygonal and rectangular, with straight walls, much longer and narrower than the intercostal cells. **Hairs** unicellular conical, on lower surface only, sparse, on costal and intercostal area. (Plate 24. figs. 2 a b c and Plate 28. fig. 10; based on slide 210).
Explanation of Plate 24.

Figs. 1(a - c) *Tephrosia candida* (Roxb.) DC.

1a Lower foliar epidermis
1b Upper foliar epidermis
1c Epidermis over costal area

Figs. 2(a - c) *T. purpurea* (L.) Pers.

2a Lower foliar epidermis
2b Upper foliar epidermis
2c Epidermis over costal area

Figs. 3(a - c) *Alysicarpus vaginalis* (L.) DC.

3a Lower foliar epidermis
3b Upper foliar epidermis
3c Epidermis over costal area
11. **Alysicarpus vaginalis** (L.) DC.

- **Leaves** amphistomatic. **Stomata** much more on lower surface, predominantly paracytic mixed with anisocytic type on both the surfaces, also with few anomocytic type on lower surface. **Intercostal cells** usually nearly isodiametric, polygonal (mostly 6-walled), with straight walls on both the surfaces. **Costal cells** polygonal, with straight walls, much narrower than the intercostal cells. **Hairs** of 3 types; 2-celled hooked, uniseriate, thick-walled, common on lower and sparse on upper surface, on costal and intercostal area; unicellular glandular spherical, on both the surfaces, frequent on margins and intercostal area; unicellular conical, thick-walled, on lower surface only, common, on costal and intercostal area. (Plate 24. figs. 3. a b c and Plate 29. figs. 1. a b c ; based on slide 233).

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

- **Leaves** hypostomatic. **Stomata** predominantly paracytic mixed with anisocytic and a few anomocytic types. **Intercostal cells** nearly isodiametric, mostly 5-walled, with deeply sinuous on lower and slightly undulate walls on upper surface. **Costal cells** polygonal, with nearly straight walls, much narrower than the intercostal cells. **Hairs** of 3 types; 2-celled hooked, uniseriate, on lower surface only, frequent, on costal and intercostal area; multicellular glandular, narrowly clavate,
Explanation of Plate 25.

Figs. 1(a - c) Desmodium caudatum (Thunb.) DC.

1a Lower foliar epidermis
1b Upper foliar epidermis
1c Epidermis over costal area

Figs. 2(a - e) D. gangeticum (L.) DC.

2a Lower foliar epidermis
2b Upper foliar epidermis
2c Epidermis over costal area
2d & 2e Contiguous stomata

Figs. 3(a - e) D. heterocarpon (L.) DC.

3a Lower foliar epidermis
3b Upper foliar epidermis
3c Epidermis over costal area
3d & 3e Contiguous stomata
uniseriate, on lower surface only, sparse, on intercostal area; unicellular hooked, on lower surface only, common, on costal and intercostal area. (Plate 25. figs. 1.a b c and Plate 29. figs. a b c; based on slide 245).

13. D. gangeticum (L.) DC.

Leaves incipiently amphistomatic with very few stomata adjacent to the costal area only on upper surface. Stomata predominantly paracytic on both the surfaces, mixed with anisocytic, anomocytic and rarely polar as well as parallel contiguous types on lower surface, and very rarely mixed with anisocytic type on upper surface. Intercostal cells nearly isodiametric, 5-6-walled, with sinuous walls on both the surfaces. Costal cells rectangular to polygonal, with straight walls, narrower than the intercostal cells, with few stomata. Hairs of 3 types; 2-celled hooked, uniseriate, on upper surface only, common, on costal and intercostal area; multicellular glandular, clavate, with obliquely septate terminal cell, on lower surface only, frequent, on costal and intercostal area; unicellular conical, frequent on lower and rare on upper surface, on costal and intercostal area. (Plate 25. figs. 2.a b c and Plate 29. figs 3. a b c; based on slide 195).
14. *D. heterocarpon* (L.) DC.

Leaves amphistomatic. Stomata much more on lower surface, predominantly paracytic on both the surfaces, mixed with anisocytic, anomocytic and rarely polar contiguous types on lower, and rarely mixed with parallel contiguous type on upper surface. Intercostal cells irregular, mostly 6-walled, with sinuous walls on both the surfaces. Costal cells polygonal, with straight walls, much longer and narrower than the intercostal cells. Hairs of 3 types; 2-celled hooked, uniseriate, frequent on lower and sparse on upper surface, on costal and intercostal area; multicellular glandular, clavate, with obliquely septate terminal cell, on both the surfaces towards margins only, common; unicellular conical, frequent on lower and sparse on upper surface, on costal and intercostal area. (Plate 25. figs. 3.a b c and Plate 29. figs. 4.a b c ; based on slide 190).

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

Leaves amphistomatic. Stomata much more on lower surface, predominantly paracytic on both the surfaces, mixed with anisocytic anomocytic, actinocytic and rarely of single guard cell, abortive as well as parallel contiguous types on lower surface. Intercostal cells irregular, mostly 5-walled, with undulate on lower and sinuous walls on upper surface. Costal cells polygonal, with slightly undulate walls, much narrower than the intercostal cells.
Explanation of Plate 26

Figs. 1(a - f) *Desmodium heterophyllum* (Wild.) DC.

1a Lower foliar epidermis  
1b Upper foliar epidermis  
1c Epidermis over costal area  
1d Contiguous stomata  
1e Stomata with single guard cell  
1f Abortive stomata

Figs. 2(a - c) *D. laxiflorum* DC.

2a Lower foliar epidermis  
2b Upper foliar epidermis  
2c Epidermis over costal area

Figs. 3(a - d) *D. motorium* (Houtt.) Merr.

3a Lower foliar epidermis  
3b Upper foliar epidermis  
3c Epidermis over costal area  
3d Abortive stomata
Hairs of 3 types; 2-celled hooked, uniseriate, on lower surface only, frequent, on costal and intercostal area; multicellular glandular, spherical, uniseriate, on lower surface towards margin, frequent; unicellular conical, on lower surface only, sparse, on costal and intercostal area. (Plate 26. figs. 1.a b c d e and Plate 29. figs. 5.a b c; based on slide 185).

16. **D. laxiflorum** DC.

Leaves hypostomatic or incipiently amphistomatic with none or very few stomata adjacent to main costal areas on upper surface. **Stomata** predominantly paracytic mixed with anisocytic type. **Intercostal cells** irregular, 5-6-walled, with undulate on lower and sinuous on upper surface. **Costal cells** polygonal, with slightly undulate walls, much narrower than the intercostal cells. Hairs of 3 types; 2-celled hooked, uniseriate, on both the surfaces, frequent, on costal and intercostal area; 2-celled glandular, obliquely septate, spherical, on lower surface only, frequent, on costal and intercostal area; unicellular conical, much longer and slender, frequent on lower and sparse on upper surface, on costal and intercostal area. (Plate 26. figs. 2.a b c and Plate 30. figs. 1.a b c; based on slide 187).

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

Leaves hypostomatic. **Stomata** predominantly paracytic mixed
with few anisocytic, tetracytic and very rarely abortive types. **Intercostal cells** elongate, mostly 5-walled, with deeply sinuous walls on both the surfaces. **Costal cells** usually rectangular, mostly joined end to end, with nearly undulate walls, much narrower than the intercostal cells. **Hairs** of 4 types; 2-celled hooked, uniseriate, on upper surface only, sparse on costal and common on intercostal area; multicellular glandular, spherical, uniseriate, on upper surface only, common on intercostal and sparse on costal area; unicellular glandular, nearly spherical, on both surfaces, common, on costal and intercostal area; unicellular conical, on lower surface only, common, on costal and intercostal area. (Plate 26. figs. 3.a b c and Plate 30. figs. 2.a b c e; based on slide 215).

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

*Leaves* hypostomatic or incipiently amphistomatic with none or occasional occurrence of very few stomata on upper surface. **Stomata** predominantly paraacytic mixed with anisocytic and rarely anomocytic types. **Intercostal cells** irregular, mostly 5-walled, with undulate on lower and sinuous walls on upper surface. **Costal cells** polygonal to rectangular, much narrower than the intercostal cells. **Hairs** of 3 types; 2-celled hooked, uniseriate, on lower surface only, frequent on costal and sparse on intercostal area; unicellular glandular, nearly spherical,
Explanation of Plate 27.

Figs. 1(a - c) *Desmodium triangulare* (Retz.) Merr.

1a Lower foliar epidermis
1b Upper foliar epidermis
1c Epidermis over costal area

Figs. 2(a - f) *D. triflorum* (L.) DC.

2a Lower foliar epidermis
2b Upper foliar epidermis
2c Epidermis over costal area
2d Contiguous stomata
2e Stomata with single guard cell
2f Abortive stomata

Figs. 3(a - d) *D. velutinum* (Willd.) DC.

3a Lower foliar epidermis
3b Upper foliar epidermis
3c Epidermis over costal area
3d Contiguous stomata
on upper surface only, common, on costal area; unicellular conical, much longer and slender, on lower surface only, common, on costal area. (Plate 27. figs 1.a b c and Plate 30. figs 3. a b c; based on slide 237).

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

*Leaves* amphistomatic. *Stomata* much more on lower surface, predominantly paracytic mixed with anisocytic type on both the surfaces, also mixed with few anomocytic and rarely of single guard cell types on lower, and very rarely parallel contiguous type on upper surface. *Intercostal cells* slightly elongate, 5-6-walled, with sinuous walls on both the surfaces. *Costal cells* mostly rectangular, with slightly undulate walls, slightly longer and narrower than the intercostal cells. *Hairs* of 4 types; 2-celled hooked, uniseriate, lower surface only, frequent, on costal and intercostal area; multicellular glandular, narrowly clavate, mostly 4-celled, uniseriate, on lower surface towards margin only, rare; unicellular glandular, spherical, on lower surface only, common, on costal and intercostal area; unicellular conical, on lower surface only, sparse on costal and intercostal area. (Plate 27. figs. 2.a b c d e and Plate 30. figs. 4.a b c d; based on slide 180).
20. *D. velutinum* (Willd.) DC.

Leaves amphistomatic. Stomata more on lower surface, predominantly paracytic mixed with anisocytic on both the surfaces, also mixed with few actinocytic on lower and rarely parallel contiguous type on upper surface, paracytic ones sometimes with 2 subsidiary cells on one side. Intercostal cells slightly elongate, 6-7-walled, with sinuous on lower and undulate walls on upper surface. Costal cells rectangular to polygonal, much narrower than intercostal cells. Hairs of 3 types; 2-celled hooked, uniseriate, on both surfaces, common, on costal and intercostal area; multicellular glandular, clavate, with obliquely septate terminal cell, on both the surfaces, frequent, on costal and intercostal area; unicellular conical, stiff, with abruptly pointed tip, on both the surfaces, frequent, on costal and intercostal area. (Plate 27. figs 3. a b c and Plate 30. figs 5. a b c; based on slide 197).
It has been observed that majority of the investigated species are amphistomatic, whereas *Tephrosia candida*, *Desmodium caudatum* and *D. motorium* are hypostomatic. However, *D. gangeticum*, *D. laxiflorum* and *D. triangulare* appear to be incipiently amphistomatic with rare or occasional occurrence of very few stomata on upper surface of the leaf restricted mostly to the adjacent costal areas. In all amphistomatic species stomata are much more on lower surface than those on upper surface of the leaf. It appears that stomata are mainly distributed in the intercostal areas except in *Crotalaria calycina*, *C. juncea*, *C. pallida* var. *pallida*, *C. spectabilis* and *Desmodium gangeticum* where stomata are present both on costal and intercostal areas.

The investigation clearly reveals that not a single species bears sole type of stomata but of mixed types (cf. Table 3). Moreover, in most of the species there are differences in stomatal type on lower and upper surfaces of the leaf. It is also clear that different genera possess different predominant stomatal types and as such stomata are predominantly anisocytic mixed with anomocytic and amphiparacytic in *Crotalaria* as well as in *Tephrosia*. Whereas they are predominantly paracytic mixed with anisocytic and anomocytic in *Alysicarpus* as well as in *Desmodium*. Rare occurrence of tetracytic type in *Crotalaria bialata*, *C. juncea*, *Desmodium motorium* and *D. triangulare* of actinocytic type in *Crotalaria juncea*, *Desmodium heterophyllum* and
D. velutinum; and of diacytic type in Crotalaria anagyroides deserve mention. Further, mention may be made of the occasional appearance of some paracytic stomata with 2 subsidiary cells on one side as well as the absence of amphiparacytic stomata in Desmodium velutinum, the latter is a common mixing type in that genus.

Therefore, the intermingling appearance of various types of stomata in the investigated species nicely corroborates with the earlier findings of Metcalf and Chalk (1950) in the family Fabaceae who observed that stomata are very variable in this family, no single type being present throughout any one of the tribes nor is the distribution constant throughout many of the genera. The study also confirms the similar findings in the family (Shah, 1968; Shah and Gopal, 1969a,b, .; Shah and Kothari 1973, 1975; Kannabiran and Krishnamurthy, 1974).

It is pertinent to suggest that as regards the dominant stomatal types, this feature can help to a certain extent the delimitation of different genera. However, the delimitation of different species on this basis appears to be impossible which definitely requires the aid of other epidermal features.

It is to be pointed out here that some of the investigated species show the occurrence of different stomatal abnormalities such as contiguous stomata, stomata with single guard cell and
Abortive stomata which appears to be supplementary to the earlier works of Farooqui (l.c.) and Bora and Baruah (l.c.). While contiguous stomata occur in Crotalaria palida var. pallida, Desmodium gangeticum, D. heterocarpon, D. heterophyllum, D. triflorum and D. velutinum, the stomata with single guard cell are found in Crotalaria juncea, Desmodium heterophyllum and D. triflorum, and abortive stomata occasionally in D. heterophyllum, D. motorium and D. triflorum. Therefore, although these structures are morphologically distinct, their occurrence is not uniform within a particular genus. Hence, no taxonomic importance can be attributed to these features for delimiting genera, but their supplementary diagnostic value may be suggestive in identifying species.

It has been observed that while the costal cells in different taxa are almost identical in being polygonal or rectangular usually with straight walls and lacking any taxonomic significance, the wall configuration of the intercostal cells is found to be distinct in different genera. The intercostal cell walls are sinuous and undulate in the members of Crotalaria and Desmodium and straight in those of Tephrosia as well as Alysicarpus. Therefore, they can afford some evidence at least supplementary, in generic and specific delimitation.
Explantion of Plate 28.

Figs. 1 - 10. Foliar epidermal hairs

1. Fusiform in *Crotalaria anagyroides* H.B. & K.
2. Conical in *C. bialata* Schrank
3. Fusiform in *C. calycina* Schrank
5. Conical in *C. juncæa* L.
6. Fusiform in *C. pallida* Ait. var. *pallida*
7. Fusiform in *C. spectabilis* Roth
8. Fusiform in *C. verrucosa* L.
9. Conical in *Tephrosia candida* (Roxb.) DC.
Explanation of Plate 29.

Figs. 1 - 5 Foliar epidermal hairs.

1(a,b,c) *Alysicarpus vaginalis* (L.) DC.
   a. Hooked, b. Glandular, c. Conical

2(a,b,c) *Desmodium caudatum* (Thunb.) DC.
   a. Hooked, b. Glandular, c. Conical

3(a,b,c) *D. gangeticum* (L.) DC.
   a. Hooked, b. Glandular, c. Conical

4(a,b,c) *D. heterocarpon* (L.) DC.
   a. Hooked, b. Glandular, c. Conical

5(a,b,c) *D. heterophyllum* (Willd.) DC.
   a. Hooked, b. Glandular, c. Conical
Explanation of Plate 30.

Figs. 1 - 5 Foliar epidermal hairs.

1(a,b,c) *Desmodium laxiflorum* DC.
   a. Hooked, b. Glandular, c. Conical

2(a,b,c,d) *D. motorium* (Houtt.) Merr
   a. Hooked, b & c. Glandular, d. Conical

3(a,b,c) *D. triangulare* (Retz.) Merr.

4(a,b,c,d) *D. triflorum* (L.) DC.
   a. Hooked, b & c. Glandular, d. Conical

5(a,b,c) *D. velutinum* (Willd.) DC.
   a. Hooked, b. Glandular, c. Conical
The investigation further reveals that the distinctiveness in the characteristics of epidermal hairs of different genera and species offer some classificatory significance. In *Crotalaria anagyroides*, *C. calycina*, *C. pallida* var. *pallida*, *C. spectabilis* and *C. verrucosa* hairs are entirely unicellular fusiform, while in *C. bialata*, *C. ferruginea* and *C. juncea* they are unicellular conical. This is as relevant as to the findings of Kannabiran and Krishnamurthy (l.c.). Unicellular conical hairs also appear solely in the species of *Tephrosia*. Whereas the occurrence of 2-celled, uniseriate hooked hairs invariably in all the species of *Desmodium* and *Alysicarpus* is of much significance as was suggested by Baudet and Marechal (l.c.). Moreover, the presence or absence of an oblique septa in the terminal cell of multicellular glandular hairs and their structure ranging from spherical to clavate in different species of *Desmodium* are of ample systematic value. Therefore, epidermal hair types and their distribution can definitely help in the separation of different genera and species in the family Fabaceae.

A tentative delimitation of genera and species has been attempted on the basis of epidermal features such as stomatal types and distribution, wall configuration of intercostal cells as well as hair types and distribution. Besides, additional support may be gathered for the purpose, from the characteristics of size and frequency of these epidermal features as presented in the Table 3.
A. Key to the identification of genera:

1. Stomata predominantly anisocytic;
hairs of 1 type, fusiform or conical;

2. Subsidiary cells distinct from
epidermal cells; intercostal cell
walls sinuous, undulate or nearly
so; hairs if conical distributed
on both surfaces ... 1. Crotalaria

2. Subsidiary cells much similar to
epidermal cells; intercostal
cell walls straight; hairs
entirely conical, distributed on
lower surface only ... 2. Tephrosia

1. Stomata predominantly paracytic;
hairs of at least 3 types, hooked,
glandular and conical:

3. Intercostal cell walls sinuous
or undulate; glandular hairs
usually multicellular ... 4. Desmodium

3. Intercostal cell walls straight;
glandular hairs invariably
unicellular ... ... 3. Alysicarpus
B.I. **Key to the identification of species belonging to Crotalaria:**

1. Hairs fusiform:
   2. Costal area with stomata:
      3. Contiguous stomata present .. 6. *C. pallida* var. *pallida*
      3. Contiguous stomata absent:
         4. Diacytic and paracytic stomata present; intercostal cell walls sinuous or undulate .. 3. *C. calycina*
         4. Diacytic and paracytic stomata absent; intercostal cell walls slightly undulate 7. *C. spectabilis*
   2. Costal area without stomata:
      5. Anomocytic stomata present;
         hairs frequent on both surfaces .. 8. *C. verrucosa*
      5. Anomocytic stomata absent;
         hairs common on lower surface .. 1. *C. anagyroides*

1. Hairs conical:
   6. Stomata with single guard cell present; costal area with stomata .. 5. *C. juncea*
   6. Stomata with single guard cell absent; costal area without stomata:
7. Paracytic and tetracytic stomata present; intercostal cell walls moderately sinuous ... 2. C. hialata

7. Paracytic and tetracytic stomata absent; intercostal cell walls nearly straight ... 4. C. ferruginea

II. **Key to the identification of species belonging to Tephrosia:**

1. Leaves hypostomatic; amphiparacytic stomata present; hairs common, much longer ... ... 1. *T. candida*

1. Leaves amphistomatic; amphiparacytic stomata absent; hairs sparse, shorter.. 2. *T. purpurea*

III. **Key to the identification of species belonging to Desmodium:**

1. Leaves hypostomatic or incipiently amphistomatic:

2. Leaves hypostomatic

3. Tetracytic and abortive stomata present, anomocytic absent; intercostal cell walls deeply sinuous on both surfaces; glandular hair spherical ... 6. *D. motorium*
3. Tetracytic and abortive stomata absent, anomocytic present; intercostal cell walls sinuous on lower but undulate on upper surface; glandular hair narrowly clavate ... 1. *D. caudatum*

2. Leaves incipiently amphistomatic:
   4. Contiguous stomata present
      intercostal cell walls sinuous on both surfaces; costal area with stomata ... ... 2. *D. gangeticum*

4. Contiguous stomata absent; intercostal cell walls undulate on lower surface; costal area without stomata:
   5. Glandular hair obliquely 2-celled, conical and hooked hairs on both surfaces ... 5. *D. laxiflorum*
   5. Glandular hair 1-celled, conical and hooked hairs on lower surface ... 7. *D. triangulare*

1. Leaves amphistomatic:
   6. Abortive stomata and with single guard cell present, terminal cell of multicellular glandular hair nonseptate:
7. Actinocytic stomata present; intercostal cell walls sinuous on both surfaces; multicellular glandular hair spherical ...

4. D. heterophyllum

7. Actinocytic stomata absent; intercostal cell walls undulate on upper surface, multicellular glandular hair clavate ...

8. D. triflorum

6. Abortive stomata and with single guard cell absent; terminal cell of multicellular glandular hair obliquely septate:

8. Actinocytic stomata present, anomocytic absent; intercostal cell walls sinuous on lower and undulate on upper surface; glandular hairs distributed allover ...

9. D. velutinum

8. Actinocytic stomata absent, anomocytic present, intercostal cell walls sinuous on both surfaces; glandular hairs towards margins ...

3. D. heterocarpon
Takhtajan (1969) and Baranova (1972) considered paracytic stomata as primitive or basic type within the Angiosperms because of the nearly uniform occurrence of paracytic stomata in the Magnoliaceae (sensu Takhtajan). Moreover, the anomocytic type is derivative and that it arose from types with subsidiary cells (Takhtajan l.c.). If this is the case, the occurrence of mixed type of stomata including paracytic and anomocytic types in the members of Fabaceae it becomes difficult to judge the evolutionary level of different taxa basing entirely on stomatal features. Moreover, it would be presumptuous to interpret the results of studying a few species in a limited number of genera or to specify the trends of evolution based on stomatal evolution which is in itself still obscure (Dickison, 1975).

If, however, the predominant types are concerned, the predominant occurrence of paracytic stomata in the members of Alysicarpus and Desmodium, qualifies these taxa to be primitive than the members belonging to Crotalaria where the predominant stomatal type is anisocytic mixed with few anomocytic type. This becomes not concurrent with a recent taxonomic treatment by Polhill (1981) where in the tribe Desmodieae including Desmodium and Alysicarpus has been placed far advanced over the tribe Crotalarieae including Crotalaria in a scheme showing
relationships of the tribes of Papilionoideae. Moreover, this also contradicts the treatments made by Bentham and Hooker, f. (1862-1883) and Hutchinson (1964) where the genus Crotalaria precedes Alysicarpus and Desmodium.