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Research Article

MICROMORPHOLOGICAL STUDY OF SOME SPECIES OF PAPILIONOIDEAE FROM NIGERIA

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ABSTRACT

The leaves of ten species in the subfamily Papilionoideae in Ile-Ife, Nigeria, were studied anatomically with the light microscope with the view to document diagnostic characters that could enhance the Taxonomy of the sub-family. The following species which belong to four tribes were studied: tribe Desmodieae-*Desmodium tortuosum* (Sw.) DC., *Desmodium scorpiurus* (Sw.) Desv., *Desmodium adscendens* (Sw.) DC., tribe Phaseoleae-*Cajanus cajan* (L.) Millsp., *Calopogonium mucunoides* Desv., *Centrosema molle* (Mart.) ex. Benth., *Mucuna pruriens* (Linn.) Walp., *Vigna unguiculata* (Linn.) Walp., tribe Crotalarieae-*Crotalaria retusa* Linn., tribe Robinieae-*Gliricidia sepium* (Jacq.) Walp. Leaf venation pattern is brochidodromous in all species except in *Cajanus cajan* where it is craspedodromous. The presence of papillae on the epidermis on both surfaces in Desmodium species only separates the tribe Desmodieae from other tribes. Mucilaginous cells on both leaf surfaces and prevalence of anisocytic stomata type instead of paracytic as in other species, are unique characters to *Crotalaria retusa*. *Desmodium scorpiurus* and *Gliricidia sepium* are the only two hypostomatic species while the others are amphistomatic. Stomata shape is a unifying character in the genus as all the species are elliptic in shape. Eglandular trichomes are present on adaxial and abaxial leaf epidermal surfaces in all the species studied but absent on adaxial surface of *Crotalaria retusa* only. The presence of mucilaginous cells on the epidermis; anticlinal cell wall pattern; type, distribution of eglandular trichomes; stomata type, presence and distribution on leaf surfaces; stomata index and venation pattern are the foliar anatomical characters of taxonomic value in the subfamily Papilionoideae.

INTRODUCTION

The subfamily Papilionoideae is the largest group of legumes, the most widespread and generally distributed throughout the world than the other groups of legumes i.e. Caesalpinoideae and Mimosoideae (Hutchinson and Dalziel, 1958; Gurcharan, 2004; Duane and Paul, 2012). The subfamily consists of about 475 genera and nearly 14,000 species grouped in 14 tribes (APG, 2012; Duane and Paul, 2012) worldwide and about 335 species recorded in Nigeria (Hutchinson and Dalziel, 1954). Leaves of Papilionoideae are usually compound, sometimes simple, rarely with a tendril (Klitgard and Lewis, 2010). Papilionoideae are easily recognized by their characteristic papilionaceous (butterfly-like) flowers. The sub division of the Papilionoideae into taxa of lower rank was for many decades highly controversial (El- Gazzar and El-Fiki, 1977; El-Gazzar, 1979 and 1981; Kass and Wink, 1995, 1996 and 1997; Doyle *et al.*, 1997; Doyle and Luckow, 2003; Wojciechowski *et al.*, 2004; Champagne *et al.*, 2007).

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It was subject for major discrepancies between traditional classifications while more recent phylogenetic studies provided no decisive answer to this problem (El- Gazzar *et al.*, 2013).

Most plants are classified based on external morphological structures, such as flower and fruit. However, these structures are not always available on plant because they are seasonal in production (Kadiri *et al.*, 2005). Therefore, other means of identification and classification need to be involved, one of which is leaf epidermal studies. Epidermal characters have proved to be useful in systematics and phylogeny. These features can be employed as useful taxonomic characters in segregating the major groups of plants (Umar *et al.*, 2014).The taxonomic significance of epidermal morphology is well documented in botanical literature.

Desmodium Desv. (Papilionoideae) is perhaps the most difficult genus among Carolina legumes (Alexander, 2004). Diagnostic recognition of *Desmodium* species has historically been based on mature loment and flower characters (Alexander, 2004). Mohini (1980) described the structure of trichomes occurring on the floral parts of eighteen Indian and African species of *Crotalaria* and reported that arrangement of

unicellular trichomes on the petals appeared species-specific that most of the trichomes occurring on the floral organs of this genus could be used for species delineation. Metcalfe and Chalk (1950) also mentioned the presence of glandular and non- glandular hairs in Papilionaceae. Sonje and Bhukta (2013) reported the presence of non-glandular, uniseriate, unicellular trichome on leaf and stem of *Crotalaria hirsute* Willd. (Papilionoideae). Also, they reported that the stomata type on the leaf epidermis were anisocytic. Adedeji (2012) also described and compared the systematic significance of trichomes and foliar epidermal morphology in the species of *Starchytarpheta* in Nigeria.

Crow *et al.* (1997) described the leaf anatomy of 17 species of *Psoralea (Papilionoideae)* which include 4 species of the genus *Hallia* Thunberg. and they reported that *Hallia* species are distinguished by the presence of large tannin cells in the bundle sheaths and a narrow length: width ratio of palisade cells. Illoh and Inyang (1998) reported the use of foliar epidermis and petiole anatomy in establishing the taxonomic relationships between six species of *Solanum* occurring in Nigeria. Many aspects of plant characterization in tropical legumes lack sufficient study (Novaes and Penteado, 1993). Despite the immense economic importance of the legumes and the physiological importance of stomata apertures, reports on the frequency and the structure of the stomata are lacking or incomplete for many species (Sayantan and Amal, 2004). The description of members of the subfamily Papilionoideae is generally based on morphology. Besides, there is little information on the comparative foliar anatomy of most species of Papilionoideae, especially in Nigeria. The aim of this study is therefore to document the foliar venation and epidermal characters of diagnostic value that will enhance the Taxonomy of the subfamily.

MATERIALS AND METHODS

For the purpose of this work, ten species belonging to four tribes in the subfamily Papilionoideae were studied. The species studied were; tribe Desmodieae-*Desmodium tortuosum* (Sw.) DC., *Desmodium scorpiurus* (Sw.) Desv., *Desmodium adscendens* (Sw.) DC., tribe Phaseoleae-*Cajanus cajan* (L.) Millsp., *Calopogonium mucunoides* Desv., *Centrosema molle* (Mart.) ex. Benth., *Mucuna pruriens* (Linn.) Walp., *Vigna unguiculata* (Linn.) Walp., tribe Crotalarieae-*Crotalaria retusa* Linn., tribe Robinieae-*Gliricidia sepium* (Jacq.) Walp. All plant species were collected at different locations in Ile-Ife, Osun State, Nigeria.

For the purpose of venation study, small sizeable portions of the leaves of each species were cut from the median parts of mature and well expanded leaves, that is, midway between the base and the apex, for each species. The portions of the leaf blades were boiled for about 25minutes in 90% alcohol in order to remove the chlorophyll. The leaf portions were then washed in 4-5 changes of water, after which they were boiled in 5% sodium hydroxide solution for about 40 minutes until the materials were decolourised. They were then washed thoroughly to remove the alkaline solution. The partly cleared portions were finally cleared in 5% solution of domestic bleach (parazone) for about 30 minutes. The portions of the leaf were finally washed properly in 3-4 changes of water and stored in 50% ethanol for anatomical studies. The cleared portions of the leaves were stained in 1% aqueous solution of Safranin O for 3-5 minutes, washed in 3-4 changes of water to remove the excess stain and mounted in 10% glycerol for venation studies.

For the preparation of epidermal peels, the scrape technique of Metcalfe (1960 and Adedeji, 2012) was used whereby the required epidermis was obtained by scraping off the mesophyll that was not required. Epidermal peels of both adaxial and abaxial surfaces were made by placing the desired epidermal surfaces face down and scraping off with a sharp blade all tissues above the desired epidermis and intermittently irrigating with water until the required epidermis was reached. The epidermal peels were then stained in 1% aqueous Safranin O for 5-10 minutes, rinsed carefully in water to remove excess stain and mounted in dilute glycerol. Stomata size was calculated by multiplying the length and breadth of stomata. Stomata index was calculated as the percentage proportion of the number of stomata to the epidermal cells present on each leaf.

Qualitatively, microscopic observations and descriptions of characters such as types of anticlinal cell wall pattern, stomata, subsidiary cells, trichomes, ergastic substances were made and recorded. Photomicrographs of the characters studied were taken using ACCU-SCOPE microscope. Tissue and cell identification and description were made according to Metcalfe (1968) and Fahn (1997). Quantitative measurements were made for trichomes, stomata and epidermal cells using ocular micrometer. Data generated from this work were subjected to one - way Analysis of Variance using Duncan Multiple Range Test to show significant differences. Simple Descriptive Statistics from SPSS Analysis were also used to calculate minimum values, maximum values, means and standard error of mean. Cluster Analysis by the use of dendrogram was also carried out on the data using Palaeontological Statistics (PAST) to show species affinities and closeness

RESULTS

Desmodium tortuosum (Sw.) Dc. (Plate 1, A-F)

Epidermal cells: Irregular in shape with sinuous anticlinal walls on adaxial and abaxial surfaces; papilla is present in every epidermal cell on both surfaces; epidermal cell size, adaxial 37.50 µm-57.50 µm long, 27.50 µm-47.50 µm wide, abaxial 27.50 µm-42.50 µm long, 15.00 µm-30.00 µm wide.

Stomata: Amphistomatic, largely paracytic, occasionally anisocytic on both surfaces and occasionally anomocytic on abaxial surface, elliptic in shape on both surfaces; stomata size -adaxial 17.00 µm-25.00 µm long, 15.00 µm-17.50 µm wide, abaxial 15.00 µm-20.00 µm long, 12.50 µm-15.50 µm wide; stomata area, adaxial 262.50-393.75µm², abaxial 187.50-300.00µm²; stomata index, adaxial 6.95 % - 9.33 %, abaxial 21.77 % - 23.53 %.

Trichomes: Only eglandular trichomes, unicellular and hooked present on adaxial surface, glandular, eglandular-unicellular and hooked present on abaxial surface; eglandular 40.00 µm-327.50 µm long on adaxial, 77.50µm-210.00µm long on abaxial surfaces.

Venation: Pinnate camptodromous brochidodromous. Areoles irregular, occasionally quadrangular to pentagonal in shape; areole size 190.00 µm² - 260.00 µm²; veinlet endings 0-5 per areole, linear, occasionally bifurcated or forked.

Desmodium scorpiurus (Sw.) Desv. (Plate 2, A-H)

Epidermal cells: are irregular in shape with sinuous anticlinal walls on adaxial and abaxial surfaces; papilla is present in every epidermal cell on both surfaces; epidermal cell size, adaxial 40.00 µm-62.50 µm long, 30.00 µm-45.00 µm wide, abaxial 32.50 µm-42.50 µm long, 25.00 µm-30.00 µm wide.

Stomata: Hypostomatic, largely paracytic, occasionally anisocytic and tetracytic, elliptic in shape; stomata size, abaxial 17.50 µm-18.00 µm long, 10.00 µm-15.00 µm wide; stomata area, abaxial175.00-270.00µm²; stomata index, abaxial 24.29 % - 29.00 %.

Trichomes: Only eglandular trichomes, unicellular and hooked are present on both surfaces; eglandular trichome size, adaxial 25.00 µm-640.00 µm long, abaxial 32.50 µm-640.00 µm long.

Venation: Pinnate camptodromous brochidodromous. Areoles irregular, occasionally quadrangular and pentagonal in shape; areole size 230.00 µm-510.00 µm long, 180.00 µm-360.00 µm wide; veinlet endings 0-4 per areole, linear occasionally bifurcated rarely forked.

Desmodium adscendens (Sw.) Dc. (Plate 3, A-F).

Epidermal cells: are irregular in shape with sinuous anticlinal walls on adaxial and abaxial surfaces; papilla is present in every epidermal cell on both surfaces; epidermal cell size, adaxial 25.00 µm-47.50 µm long, 20.00 µm-35.00 µm wide, abaxial 22.50 µm-45.00 µm long, 17.50 µm-32.50 µm wide.

Stomata: Amphistomatic, largely paracytic, occasionally anisocytic on both surfaces and tetracytic on abaxial surface, elliptic in shape on adaxial and abaxial surfaces; stomata size, adaxial 12.50 µm-17.50 µm long, 5.00 µm –12.50 µm wide, abaxial 12.50 µm-17.50 µm long, 10.00 µm-12.50 µm wide; stomata area, adaxial 87.50-187.50µm², abaxial 125.00-218.75µm²; stomata index, adaxial 3.01 % - 5.20 %, abaxial 10.06 % - 12.96 %.

Trichomes: Only eglandular trichomes, unicellular and hooked present on both surfaces; eglandular trichome length 22.50 µm-242.50 µm on adaxial, 25.00µm-452.50µm on abaxial surfaces.

Venation: Pinnate camptodromous brochidodromous. Areoles are irregular, occasionally rectangular to pentagonal in shape; areole size 130.00 µm-450.00 µm long, 150.00 µm-280.00 µm wide; veinlet endings 0-1 per areole.

Mucuna pruriens (Linn.) Walp. (Plate 4, A-G)

Epidermal cells: are irregular in shape with sinuous anticlinal walls on adaxial and abaxial surfaces; epidermal cell size, adaxial 52.50 µm-77.50 µm long, 22.50 µm-62.50 µm wide, abaxial 37.50 µm-65.50 µm long, 27.50 µm-37.50 µm wide.

Stomata: Amphistomatic, largely paracytic, occasionally anisocytic, elliptic in shape on both surfaces, occasionally circular in shape on abaxial surfaces; stomata size, adaxial 20.00 µm-30.00 µm long, 17.50 µm-20.00 µm wide, abaxial 15.00 µm-25.00 µm long, 12.50 µm-20.00 µm wide; stomata area, adaxial 350.00-600.00µm², abaxial 225.00-437.50µm²; stomata index, adaxial 0.00 % - 6.59 %, abaxial 20.42 % - 27.98 %.

Trichomes: Only eglandular trichomes, unicellular present on adaxial and abaxial surfaces, eglandular trichome length, 240.00 µm-720.00 µm on adaxial surface, 380.00µm-910.00µm on abaxial surface.

Venation: Pinnate camptodromous brochidodromous. Areoles irregular, occasionally circular to pentagonal in shape; areole size, 220.00 µm-650.00 µm long, 170.00 µm-420.00 µm wide; veinlet endings 0-5 per areole, linear, occasionally bifurcated rarely forked.

Calopogonium mucunoides Desv. (Plate 5, A-H)

Epidermal cells: are irregular in shape with sinuous anticlinal walls on adaxial and abaxial surfaces; epidermal cell size, adaxial 35.00 µm-87.50 µm long, 22.50 µm-47.50 µm wide, abaxial 40.00 µm-60.00 µm long, 30.00 µm-45.00 µm wide.

Stomata: Amphistomatic, largely paracytic, occasionally anisocytic and tetracytic on both surfaces and occasionally anomocytic on abaxial surface only, elliptic in shape on adaxial surface, elliptic occasionally circular in shape on abaxial surface; stomata size, adaxial 20.00 µm-25.00 µm long, 12.50 µm-15.00 µm wide, abaxial 20.00 µm-22.50 µm long, 12.50 µm-15.00 µm wide; stomata area, adaxial 250.00-375.00µm², abaxial250.00-337.50µm²; stomata index, adaxial 7.63 % - 11.67 %, abaxial 22.60 % - 25.18 %.

Trichomes: Eglandular unicellular and glandular unicellular trichomes present on adaxial and abaxial surfaces, eglandular spine-like present on abaxial surface only; eglandular trichome length 130.00 µm-1420.00 µm on adaxial surface, 190.00µm-1110.00µm on abaxial surface.

Venation: Pinnate camptodromous brochidodromous. Areoles are quadrangular, occasionally triangular to pentagonal in shape; areole size, 100.00 µm-250.00 µm long, 70.00 µm-140.00 µm wide; veinlet endings 0-1 per areole, occasionally linear.

Cajanus cajan (L.) Millsp. (Plate 6, A-K).

Epidermal cells: Largely polygonal to occasionally irregular in shape with straight anticlinal walls on adaxial surface, wavy anticlinal wall on abaxial surface; epidermal cell size adaxial 30.00 µm-57.50 µm long, 15.00 µm-35.00 µm wide, abaxial 15.00 µm-40.00 µm long, 5.00 µm-12.50 µm wide.

Stomata: Amphistomatic, largely paracytic, occasionally anisocytic and anomocytic on both surfaces, elliptic in shape; contiguous stomata are present on both surfaces; stomata size, adaxial 20.00 µm-25.00 µm long, 15.00 µm-17.50 µm wide, abaxial 15.00 µm-25.00 µm long, 12.50 µm-15.00 µm wide; stomata area, adaxial 300.00-437.50µm², abaxial 187.50-375.00 µm²; stomata index, adaxial 5.26 % - 19.40 %, abaxial 26.64 % - 29.33 %.

Trichomes: Glandular, scale-like eglandular, unicellular eglandular trichomes are present on adaxial surface, eglandular unicellular and glandular trichomes are present on abaxial surface, eglandular trichome length 37.50 µm-90.00 µm on adaxial surface, 60.00µm-112.50µm on abaxial surface.

Venation: Pinnate craspedodromous simple craspedodromous. Areoles irregular, occasionally pentagonal in shape; areole size 120.00 µm-280.00 µm long, 60.00 µm-210.00 µm wide; veinlet endings 0-4 per areole, linear, occasionally bifurcated rarely forked.

Crotalaria retusa Linn. (Plate 7, A-H)

Epidermal cells: Largely polygonal in shape with straight anticlinal walls on adaxial and abaxial surfaces. Mucilaginous cells are present on adaxial and abaxial surfaces; epidermal cell size-adaxial 52.50 µm-107.50 µm long, 22.50 µm-47.50 µm wide, abaxial 35.00 µm-62.50 µm long, 27.50 µm-42.50 µm wide.

Stomata: Amphistomatic, anisocytic on adaxial and abaxial surfaces, occasionally paracytic on both surfaces, tetracytic on abaxial surface, elliptic in shape on both surfaces, contiguous stomata present on abaxial surfaces; stomata size, adaxial 20.00 µm-27.50 µm long, 15.00 µm-22.50 µm wide, abaxial 17.50 µm-27.50 µm long, 17.50 µm-20.00 µm wide; stomata area, adaxial 337.50-550.00µm², abaxial306.25-550.00 µm²; stomata index, adaxial 17.59 % - 22.68 %, abaxial 20.54 % - 24.72 %.

Trichomes: Eglandular unicellular trichomes present on abaxial surface only, eglandular trichome length 105.00µm-305.00µm on abaxial surface.

Venation: Pinnate camptodromous brochidodromous. Areoles are polygonal to rectangular occasionally irregular and quadrangular in shape; areole size 300.00 µm-550.00 µm long, 120.00 µm-400.00 µm wide; veinlet endings 0-6 per areole, bifurcated, linear or forked.

Vigna unguiculata (Linn.) Walp. (Plate 8, A-I)

Epidermal cells: Polygonal to irregular in shape with wavy anticlinal walls on adaxial and abaxial surfaces; epidermal cell size, adaxial 62.50 µm-95.00 µm long, 15.00 µm-72.50 µm wide, abaxial 47.50 µm-95.00 µm long, 25.00 µm-45.00 µm wide.

Stomata: Amphistomatic, paracytic, elliptic in shape on adaxial and abaxial surfaces; stomata size, adaxial 25.00 µm-30.00 µm long, 17.50 µm-25.00 µm wide, abaxial 22.50 µm-30.00 µm long, 15.00 µm-17.50 µm wide; stomata area, adaxial 437.50-750.00µm², abaxial 337.50-525.00 µm²; stomata index, adaxial 0.00 % - 7.53 %, abaxial 14.53 % - 23.31 %.

Trichomes: Eglandular unicellular conical and glandular trichomes present on the adaxial and abaxial surfaces; eglandular trichome length 37.50 µm-62.50 µm on adaxial surface, 50.00 µm -62.50µm on abaxial surface.

Venation: Pinnate camptodromous bronchidodromous. Areoles irregular occasionally quadrangular to pentagonal in shape; areole size 280.00 µm-850.00 µm long, 40.00 µm-570.00 µm wide; veinlet endings 0-5 per areole, bifurcated, occasionally linear or forked.

Centrosema molle Mart. ex. Benth. (Plate 9, A-G)

Epidermal cells: Irregular in shape with sinuous anticlinal walls on adaxial and abaxial surfaces; epidermal cell size, adaxial 35.00 µm-57.50 µm long, 12.50 µm-47.50 µm wide, abaxial 25.00 µm-52.50 µm long, 20.00 µm-37.50 µm wide.

Stomata: Amphistomatic, largely paracytic occasionally anisocytic on both adaxial and abaxial surfaces, elliptic on both surfaces; stomata size, adaxial 15.00 µm-22.50 µm long, 10.00 µm-15.00 µm wide, abaxial 15.00 µm-22.50 µm long, 10.00 µm-12.50 µm wide; stomata area, adaxial 150.00-337.50µm², abaxial 150.00-281.25 µm²; stomata index, adaxial 3.72 % - 7.76 %, abaxial 21.81 % - 25.14 %.

Table 1 Summary of Qualitative Foliar Epidermal Characters and Venation of Papilionoideae Species studied

Species		Shape	Papillae	Muc. Cell	Anticlinal Wall	Leaf Surface	Stomata type	Stomata Shape	Glandular	Eglandular	Venation	Areole Shape	Veinlet Ending Divergence
Desmodium tortuosum	Adaxial	Irregular	+	–	Sinuous	Amphistomatic	Paracytic/ anisocytic	Elliptic	–	+	Brochidodromous	Irregular/ Pentagonal	Single
	Abaxial	Irregular	+	–	Sinuous		Paracytic/ anisocytic/ anomocytic	Elliptic	–	+			
Desmodium scorpiurus	Adaxial	Irregular	+	–	Sinuous	Hypostomatic	–	–	–	+	Brochidodromous	Irregular/ Pentagonal	Single
	Abaxial	Irregular	+	–	Sinuous		Paracytic/ anisocytic/ tetracytic	Elliptic	–	+			
Desmodium adscendens	Adaxial	Irregular	+	–	Sinuous	Amphistomatic	Paracytic/ anisocytic	Elliptic	–	+	Brochidodromous	Irregular/ Rectangular/ Pentagonal	Single
	Abaxial	Irregular	+	–	Sinuous		Paracytic/ anisocytic/ tetracytic	Elliptic	–	+			
Mucuna pruriens	Adaxial	Irregular	–	–	Sinuous	Amphistomatic	Paracytic/ anisocytic	Elliptic	–	+	Brochidodromous	Irregular/ Pentagonal/ Circular	Single
	Abaxial	Irregular	–	–	Sinuous		Paracytic/ anisocytic	Elliptic/ circular	–	+			
Calopogonium mucunoides	Adaxial	Irregular	–	–	Sinuous	Amphistomatic	Paracytic/anisocytic/ tetracytic	Elliptic	–	+	Brochidodromous	Quadrangular/ Pentagonal	Single
	Abaxial	Irregular	–	–	Sinuous		Paracytic/anisocytic/ tetracytic/ anomocytic	Elliptic/ circular	+	+			
Cajanus cajan	Adaxial	Polygonal/Irregular	–	–	Straight	Amphistomatic	Paracytic/anisocytic/ anomocytic	Elliptic	+	+	Craspedodromous	Irregular/ Pentagonal	Single
	Abaxial	Polygonal/Irregular	–	–	Wavy		Paracytic/anisocytic/ anomocytic	Elliptic	+	+			
Crotalaria retusa	Adaxial	Irregular	–	+	Straight	Amphistomatic	Anisocytic/ paracytic	Elliptic	–	–	Brochidodromous	Polygonal/ Rectangular	Bifurcated
	Abaxial	Irregular	–	+	Straight		Anisocytic/ paracytic/ tetracytic	Elliptic	–	+			
Vigna unguiculata	Adaxial	Polygonal/Irregular	–	–	Wavy	Amphistomatic	Paracytic	Elliptic	+	+	Brochidodromous	Irregular/ Pentagonal	Bifurcated
	Abaxial	Polygonal/Irregular	–	–	Wavy		Paracytic	Elliptic	+	+			
Centrosema molle	Adaxial	Irregular	–	–	Sinuous	Amphistomatic	Paracytic/ anisocytic	Elliptic	+	+	Brochidodromous	Irregular/ Pentagonal	Single
	Abaxial	Irregular	–	–	Sinuous		Paracytic/ anisocytic	Elliptic	+	+			
Gliricidia sepium	Adaxial	Polygonal	–	–	Straight	Hypostomatic	–	–	+	+	Brochidodromous	Irregular/ Polygonal	Single

+ = Present - = Absent, Muc. Cell = Mucilaginous Cell

Trichomes: Eglandular unicellular, hooked and glandular trichomes present on adaxial surface and on abaxial surface; eglandular trichome length 47.50 µm-207.50 µm on adaxial surface, 97.50µm-310.00µm on abaxial surface.

Venation: Pinnate camptodromous brochidodromous. Areoles irregular, occasionally pentagonal in shape; areole size 150.00µm-330.00 µm long, 110.00 µm-280.00 µm wide; veinlet endings 0-5 per areole, linear occasionally bifurcated or forked.

Gliricidia sepium (Jacq.) Walp. (Plate 10, A-F)

Epidermal cells: Polygonal in shape with straight anticlinal walls on adaxial surface and polygonal to irregular with straight to slightly wavy anticlinal walls on abaxial surface; epidermal cell size, adaxial 30.00 µm-87.50 µm long, 20.00 µm-27.50 µm wide, abaxial 20.00 µm-32.50 µm long, 15.00 µm-20.00 µm wide.

Stomata: Hypostomatic, paracytic occasionally anisocytic and tetracytic, elliptic in shape on abaxial surface; stomata size, abaxial 17.50 µm-27.50 µm long, 12.50 µm-17.50 µm wide; stomata area, abaxial 218.75-481.25 µm²; stomata index, abaxial 22.34 % - 36.87 %.

Trichomes: Eglandular unicellular and glandular trichomes are present on adaxial surface; eglandular unicellular present on abaxial surface; eglandular trichome length 125.00 µm-302.00 µm on adaxial, 110.00 µm-330.00µm on abaxial surface.

Venation: Pinnate camptodromous brochidodromous. Areoles are irregular, occasionally triangular to quadrangular in shape; areole size 260.00 µm-450.00 µm long, 80.00 µm-310.00 µm wide; veinlet ending 0-2 per areole, often linear, occasionally bifurcated.

Fig. 1 shows the dendrogram of the qualitative and quantitative data generated from foliar anatomical characters using Single Linkage Cluster Analysis (SLCA) which originates from one major group and separates into two main clusters.

Table 2 Minimum, Mean, Standard Error of Mean and Maximum Values of Quantitative Foliar Epidermal Characters on Adaxial and Abaxial Surfaces and Venation Study.

Species		Stomata index (%)	Stomata length (µm)	Stomata width (µm)	Stomata size (µm)²	EG trichome L (µm)	No of EG trichome
		Min (Mean±S.E.M) Max	Min (Mean±S.E.M) Max	Min (Mean±S.E.M) Max	Min (Mean±S.E.M) Max	Min (Mean±S.E.M) Max	Min (Mean±S.E.M) Max
Desmodium tortuosum	Adaxial	6.95 (8.04 ± 0.16) 9.33	17.00 - 20.88 ± 0.55) 25.00	15.00 (15.63 ± 0.25 - 17.50	262.50 (325.63 ± 9.02) 393.75	40.00 (149.00 ± 17.01) 327.50	3.00 (4.60 ± 0.24) 6.00
	Abaxial	21.77 (22.69 ± 0.11) 23.53	15.00 - 18.00 ± 0.56) 20.00	12.50 (13.25 ± 0.26 - 15.50	187.50 (238.13 ± 8.29) 300.00	77.50 (150.25 ± 10.92) 210.00	7.00 (7.75 ± 0.18) 9.00
Desmodium scorpiurus	Adaxial	-	-	-	-	25.00 (171.75 ± 46.55) 640.00	21.00 (24.15 ± 0.61) 28.00
	Abaxial	24.29 (26.71 ± 0.26) 29.00	17.50 (17.60 ± 0.05)18.00	10.00 (12.63 ± 0.34) 15.00	175.00 (222.19 ± 5.97) 270.00	32.50 (199.13 ± 41.46) 640.00	3.00 (30.00 ± 1.55) 36.00
Desmodium adscendens	Adaxial	3.01 (4.11± 0.13) 5.20	12.50 (14.38 ± 0.40) 17.50	5.00 (9.38 ± 0.44) 12.50	87.50 (133.13 ± 5.83) 187.50	22.50 (147.25 ± 17.94) 242.50	3.00 (4.40 ± 0.28) 6.00
	Abaxial	10.06 (11.52 ± 0.20) 12.96	12.50 (14.63 ± 0.49) 17.50	10.00 (10.38 ± 0.20) 12.50	125.00 (152.19 ± 6.53) 218.75	25.00 (192.63 ± 37.06) 452.50	6.00 (7.15 ± 0.21) 9.00
Mucuna pruriens	Adaxial	0.00 (3.59 ± 0.41) 6.59	20.00 (24.38 ± 0.77) 30.00	17.50 (18.38 ± 0.27) 20.00	350.00 (449.69 ± 18.47) 600.00	240.00 (394.50 ± 30.86) 720.00	0.00 (1.20 ± 0.14) 2.00
	Abaxial	20.42 (24.33 ± 0.42) 27.98	15.00 (20.88 ± 0.78) 25.00	12.50 (16.13 ± 0.50) 20.00	225.00 (335.94 ± 15.54) 437.50	380.00 (641.00 ± 32.17) 910.00	1.00 (1.95 ± 0.22) 4.00
Calopogonium mucunoides	Adaxial	7.63 (9.68 ± 0.30) 11.67	20.00 (21.88 ± 0.44) 25.00	12.50 (13.50 ± 0.28) 15.00	250.00 (295.31 ± 8.61) 375.00	130.00 (615.00 ± 111.00) 1420.00	0.00 (0.60 ± 0.11) 1.00
	Abaxial	22.60 (24.19 ± 0.15) 25.18	20.00 (21.13 ± 0.29) 22.50	12.50 (13.50 ± 0.28) 15.00	250.00 (285.31 ± 7.36) 337.50	190.00 (597.50 ± 63.10) 1110.00	0.00 (1.05± 0.26) 3.00
Cajanus cajan	Adaxial	5.26 (6.91 ± 0.67) 19.40	20.00 (22.50 ± 0.41) 25.00	15.00 (17.25 ± 0.17) 17.50	300.00 (388.75 ± 9.23) 437.50	37.50 (65.63 ± 3.87) 90.00	119.00 (124.00 ± 0.74) 132.00
	Abaxial	26.64 (27.82 ± 0.19) 29.33	15.00 (19.63 ± 0.82) 25.00	12.50 (14.50 ± 0.23) 15.00	187.50 (286.88 ± 14.72) 375.00	60.00 (89.13 ± 4.31) 112.50	122.00 (222.05 ± 6.23) 256.00
Crotalaria retusa	Adaxial	17.59 (20.05 ± 0.28) 22.68	20.00 (24.38 ± 0.48) 27.50	15.00 (18.25 ± 0.55) 22.50	337.50 (445.31 ± 16.65) 550.00	-	-
	Abaxial	20.54 (22.51 ± 0.21) 24.72	17.50 (23.75 ± 0.48) 27.50	17.50 (19.00 ± 0.28) 20.00	306.25 (451.56 ± 16.76) 550.00	105.00 (195.88 ± 14.85) 305.00	8.00 (10.15 ± 0.34) 12.00
Vigna unguiculata	Adaxial	0.00 (2.39 ± 0.52) 7.53	25.00 (28.50 ± 0.38) 30.00	17.50 (20.13 ± 0.61) 25.00	437.50 (573.75 ± 19.12) 750.00	37.50 (52.88 ± 1.88) 62.50	0.00 (0.30 ± 0.11) 1.00
	Abaxial	14.53 (21.10 ± 0.43) 23.31	22.50 (26.75 ± 0.66) 30.00	15.00 (16.25 ± 0.29) 17.50	337.50 (434.69 ± 13.11) 525.00	50.00 (56.25 ± 1.26) 62.50	0.00 (0.30 ± 0.11) 1.00
Centrosema molle	Adaxial	3.72 (6.21 ± 0.23) 7.76	15.00 (18.75 ± 0.78) 22.50	10.00 (13.00 ± 0.39) 15.00	150.00 (243.44 ± 12.33) 337.50	47.50 (137.50 ± 12.22) 207.50	4.00 (5.55 ± 0.20) 7.00
	Abaxial	21.81 (24.05 ± 0.18) 25.14	15.00 (18.25 ± 0.63 -) 22.50	10.00 (11.50 ± 0.28) 12.50	150.00 (209.06 ± 7.83) 281.25	97.50 (216.13 ± 12.62) 310.00	4.00 (10.70 ± 0.75) 14.00
Gliricidia sepium	Adaxial	-	-	-	-	125.00 (188.75 ± 11.62) 302.50	0.00 (0.75 ± 0.19) 2.00
	Abaxial	22.34 (24.19 ± 0.70) 36.87	17.50 (22.38 ± 0.82)27.50	12.50 (14.75 ± 0.48) 17.50	218.75 (329.06 ± 15.48) 481.25	110.00 (189.88 ± 15.23) 330.00	0.00 (0.35 ± 0.11) 1.00

Min= Minimum value, Max= Maximum value, S.E.M= Standard Error of Mean, - = Absent, EG = Eglandular, L = Length, No = Number

Table 2 Minimum, Mean, Standard Error of Mean and Maximum Values of Quantitative Foliar Epidermal Characters on Adaxial and Abaxial Surfaces and Venation Study (continued).

Species		No of Gtrichome	Epidermal cell length (µm)	Epidermal cell width (µm)	Areole length (µm)	Areole width (µm)	V. Ending per Areole
		Min (Mean±S.E.M)Max	Min (Mean±S.E.M) Max	Min (Mean±S.E.M) Max	Min (Mean±S.E.) Max	Min (Mean±S.E.M) Max	Min (Mean±S.E.M) Max
Desmodium tortuosum	Adaxial	-	37.50 (43.25 ± 1.12) 52.50	27.50 (32.75 ± 1.71) 47.50	190.00 (229.50 ± 5.15) 260.00	130.00 (145.00 ± 2.24) 160.00	
	Abaxial	2.00 (2.70 ± 0.19) 4.00	27.50 (33.75 ± 0.99) 42.50	15.00 (21.75 ± 1.00) 30.00			
Desmodium scorpiurus	Adaxial	-	40.00 (50.25 ± 1.64) 62.50	30.00 (38.38 ± 1.22) 45.00	230.00 (382.50 ± 20.51) 510.00	180.00 (246.50 ± 11.79) 360.00	1.00 (1.85 ± 0.30) 5.00
	Abaxial	-	32.50 (36.50 ± 0.84) 42.50	25.00 (27.63 ± 0.42) 30.00			
Desmodium adscendens	Adaxial	-	25.00(33.88 ± 1.63) 47.50	20.00 (23.50 ± 0.86) 35.00	130.00 (291.00 ± 18.19) 450.00	150.00 (193.50 ± 8.86) 280.00	0.00 (1.50 ± 0.28)4.00
	Abaxial	5.00 (6.85 ± 0.24) 8.00	22.50 (34.88 ± 1.73) 45.00	17.50 (25.25 ± 1.15) 32.50			
Mucuna pruriens	Adaxial	-	52.50 (65.50 ± 1.95) 77.50	22.50 (42.75 ± 2.83) 62.50	220.00 (386.50 ± 23.43) 650.00	170.00 (275.50 ± 18.29) 420.00	0.00 (0.65 ± 0.11)1.00
	Abaxial	-	37.50 (48.25± 2.08) 65.00	27.50 (29.13 ± 0.69) 37.50			
Calopogonium mucunoides	Adaxial	0.00 (0.75 ± 0.18) 2.00	35.00 (56.50 ± 3.55) 87.50	22.50 (36.13 ± 1.83) 47.50	100.00 (174.50 ± 11.84) 250.00	70.00 (106.00 ± 4.78) 140.00	0.00 (1.60 ± 0.33) 5.00
	Abaxial	0.00 (0.70 ± 0.15) 2.00	40.00 (47.50 ± 1.26) 60.00	30.00 (35.50 ± 1.10) 45.00			
Cajanu scajan	Adaxial	0.00 (0.60 ± 0.11) 1.00	30.00(42.50 ± 1.98) 57.50	15.00 (23.00 ± 1.55) 35.00	120.00 (194.00 ± 11.53) 280.00	60.00 (138.50 ± 9.66) 210.00	0.00 (0.25 ± 0.10) 1.00
	Abaxial	-	15.00(23.50 ± 1.59) 40.00	5.00 (8.25 ± 0.70) 12.50			
Crotalaria retusa	Adaxial	-	52.50 (80.63 ± 3.86) 107.50	22.50 (36.13 ± 2.37) 47.50	300.00 (423.00 ± 17.35) 550.00	120.00 (249.00 ± 14.40) 400 .00	0.00 (1.20 ± 0.29) 5.00
	Abaxial	-	35.00 (46.25 ± 1.73) 62.50	27.50 (38.13 ± 2.37) 42.50			
Vigna unguiculata	Adaxial	0.00 (0.75 ± 0.16) 2.00	62.50 (79.88 ± 2.67) 95.00	15.00 (35.38 ± 3.87) 72.50	280.00 (610.00 ± 46.11) 850.00	200.00 (337.50 ± 29.80) 570.00	0.00 (2.05 ± 0.32) 6.00
	Abaxial	0.00 (2.20 ± 0.25) 4.00	47.50 (66.00 ± 4.59) 95.00	25.00 (37.13 ± 1.70) 45.00			
Centrosema molle	Adaxial	0.00 (1.20 ± 0.20) 3.00	35.00 (46.38 ± 1.59) 57.50	12.50 (29.00 ± 2.64) 47.50	150.00 (277.00 ± 13.50) 330.00	110.00 (181.50 ± 9.07) 280.00	0.00 (2.10 ± 0.28) 5.00
	Abaxial	0.00 (0.45 ± 0.11) 1.00	25.00 (45.38 ± 1.69) 52.50	20.00 (26.25± 1.13) 37.50			
Gliricidia sepium	Adaxial	0.00 (1.00 ± 0.18) 2.00	30.00 (46.38 ± 4.67) 87.50	20.00 (23.00 ± 0.67) 27.50	260.00 (354.00 ± 11.53) 450.00	80.00 (239.00 ± 11.26) 310.00	0.00 (1.30 ± 0.30) 5.00
	Abaxial	-	20.00 (24.63 ± 1.03) 32.50	15.00 (17.63 ± 0.50) 20.00			0.00 (0.85 ± 0.13) 2.00

Min = Minimum value, Max= Maximum value, S.E.M= Standard Error of Mean, - = Absent, No of G trichome = Number of Glandular trichome, V. Ending = Veinlet Ending

Table 3 Species grouping from Duncan's Multiple Range Test based on foliar anatomical characters. (Means with the same superscript down the column are not significantly different. P < 0.0001).

Species	Stomata Index adaxial (%)	Stomata Index abaxial (%)	Stomata Length adaxial (µm)	Stomata Width adaxial (µm)	Stomata Length abaxial (µm)	Stomata Width abaxial (µm)	EGT Length adaxial (µm)	EGT Length abaxial (µm)	Number of EGT adaxial	Number of EGT abaxial
Desmodium tortuosum	8.04^{c}	22.69^{d}	20.88^{d}	15.63^{d}	18.00^{ef}	13.25^{d}	149.00^{cd}	150.25^{bc}	4.60^{cd}	7.75^{cd}
Desmodium scorpiurus	0.00^{g}	26.71^{b}	0.00^{g}	0.00^{g}	17.60^{f}	12.63^{d}	171.75^{cd}	199.13^{b}	24.15^{b}	30.00^{b}
Desmodium adscendens	4.11^{e}	11.52^{f}	14.38^{f}	9.38^{f}	14.63^{g}	10.38^{f}	147.25^{cd}	192.63^{b}	4.40^{d}	7.15^{cd}
Mucuna pruriens	3.59^{e}	24.33^{c}	24.38^{b}	18.38^{b}	20.88^{cd}	16.13^{b}	394.50^{b}	641.00^{a}	1.20^{e}	1.95^{de}
Calopogonium mucunoides	9.68^{b}	24.19^{c}	21.88^{cd}	13.50^{e}	21.13^{cd}	13.50^{d}	615.00^{a}	597.50^{a}	0.60^{ef}	1.05^{e}
Cajanus cajan	6.91^{d}	27.82^{a}	22.50^{c}	17.25^{c}	19.63^{de}	14.50^{c}	65.63^{cde}	89.13^{cd}	124.00^{a}	222.05^{a}
Crotalaria retusa	20.05^{a}	22.51^{d}	24.38^{b}	18.25^{b}	23.75^{b}	19.00^{a}	0.00^{e}	195.88^{b}	0.00^{f}	10.15^{c}
Vigna unguiculata	2.39^{f}	21.10^{e}	28.50^{a}	20.13^{a}	26.75^{a}	16.25^{b}	52.88^{de}	56.25^{d}	0.30^{ef}	0.30^{e}
Centrosema molle	6.21^{d}	24.05^{c}	18.75^{e}	13.00^{e}	18.25^{ef}	11.50^{e}	137.50^{cd}	216.13^{b}	5.55^{c}	10.70^{c}
Gliricidia sepium	0.00^{g}	24.19c	0.00^{g}	0.00^{g}	22.38^{bc}	14.75^{c}	188.75^{c}	189.88^{b}	0.75^{ef}	0.35^{e}

EGT = Eglandular Trichome

Table 3 Species grouping from Duncan's Multiple Range Test based on foliar anatomical (Means with the same superscript down the column are not significantly different. P < 0.0001) continued.

Species	Number of Glandular Trichome adaxial	Number of Glandular Trichome abaxial	Ep. Cell Length adaxial (µm)	Ep. Cell Width adaxial (µm)	Ep. Cell Length abaxial (µm)	Ep. Cell Width abaxial (µm)	Areole Length (µm)	Areole Width (µm)	Number of Veinlet Ending per Areole
Desmodium tortuosum	0.00^{d}	2.70^{b}	43.25^{de}	32.75^{bc}	33.75^{c}	21.75^{d}	229.50^{ef}	145.00^{de}	1.85^{ab}
Desmodium scorpiurus	0.00^{d}	0.00^{e}	50.25^{cd}	38.38^{ab}	36.50^{c}	27.63^{bc}	382.50^{bc}	246.50^{b}	1.50^{abc}
Desmodium adscendens	0.00^{d}	6.85^{a}	35.88^{e}	23.50^{d}	34.88^{c}	25.25^{c}	291.00^{c}	193.50^{c}	0.65^{de}
Mucuna pruriens	0.00^{d}	0.00^{e}	65.50^{b}	42.75^{a}	48.25^{b}	29.13^{b}	386.50^{bc}	275.50^{b}	1.60^{abc}
Calopogonium mucunoides	0.75^{bc}	0.70^{d}	56.50^{c}	36.13^{b}	47.50^{b}	35.50^{a}	174.50^{f}	106.00^{e}	0.25^{e}
Cajanus cajan	0.60^{c}	0.00^{e}	42.50^{de}	23.00^{d}	23.50^{d}	8.25^{f}	194.00^{f}	138.50^{e}	1.20^{bcd}
Crotalaria retusa	0.00^{d}	0.00^{e}	80.63^{a}	36.13^{b}	46.25^{b}	38.13^{a}	423.00^{b}	249.00^{b}	2.05^{a}
Vigna unguiculata	0.75^{bc}	2.20^{c}	79.88^{a}	35.38^{b}	66.00^{a}	37.13^{a}	610.00^{a}	377.50^{a}	2.10^{a}
Centrosema molle	1.20^{a}	0.45^{d}	46.38^{d}	29.00^{cd}	45.38^{b}	26.25^{bc}	277.00^{de}	181.50^{cd}	1.30^{abcd}
Gliricidia sepium	1.00^{ab}	0.00^{e}	46.38^{d}	23.00^{d}	24.63^{d}	17.63^{e}	354.00^{c}	249.00^{b}	0.85^{cde}

Ep. Cell = Epidermal Cell

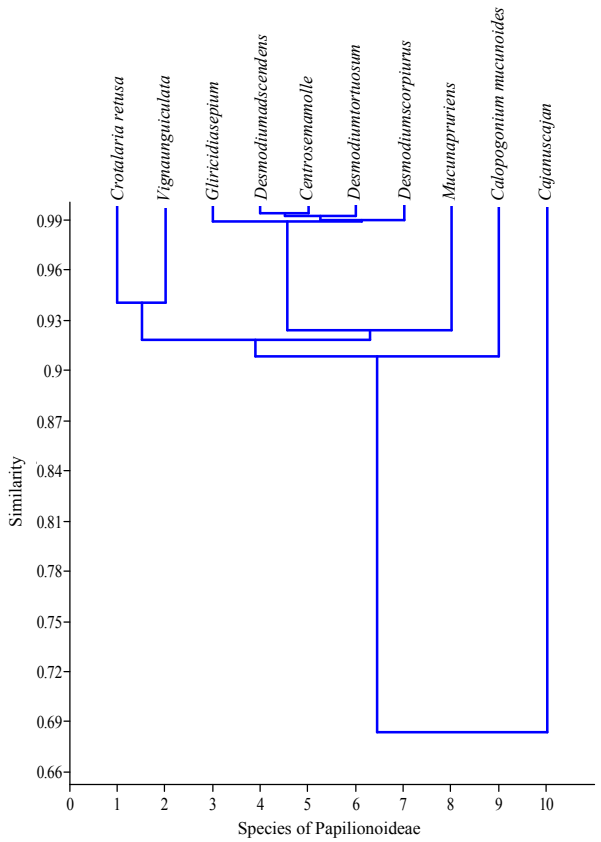

Figure 1 Dendrogram of the Papilionoideae species studied based on the quantitative and qualitative foliar anatomical characters.

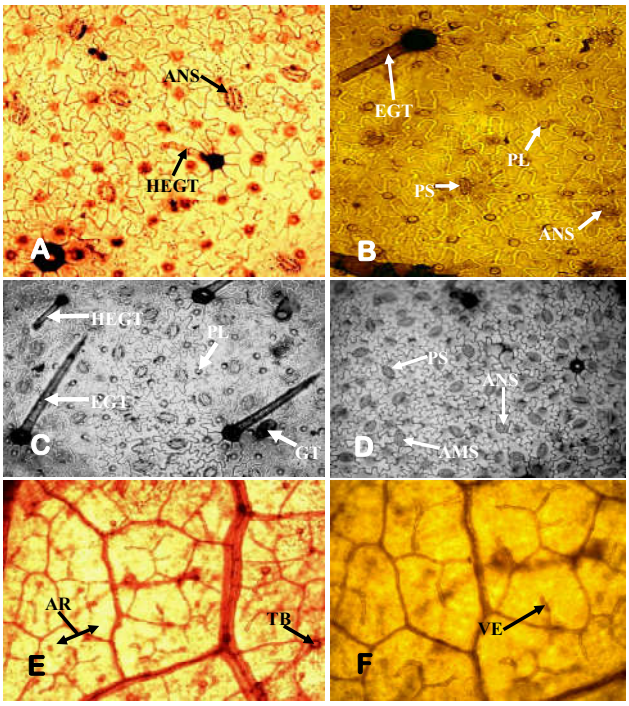

Plate 1 Foliar Anatomical study of *Desmodium tortuosum* (Sw.) Dc.

A-B: Adaxial surface (x400)
C-D: Abaxial surface (x400)
E-F: Venation pattern (E x100, F x200)
PS – Paracytic Stomata
ANS – Anisocytic Stomata
HEGT – Hooked Eglandular Trichome
EGT – Eglandular Trichome
PL – Papilla
AMS – Anomocytic Stomata
AR – Areoles
TB – Trichome Base
VE – Veinlet Ending
GT – Glandular Trichome

The first main cluster distinctly separates *Cajanus cajan* from other species. The second main cluster are delineated into two sub clusters and distinctly separates *Calopogonium mucunoides* (being the only species in the first sub cluster) from other eight species which are clustered together.

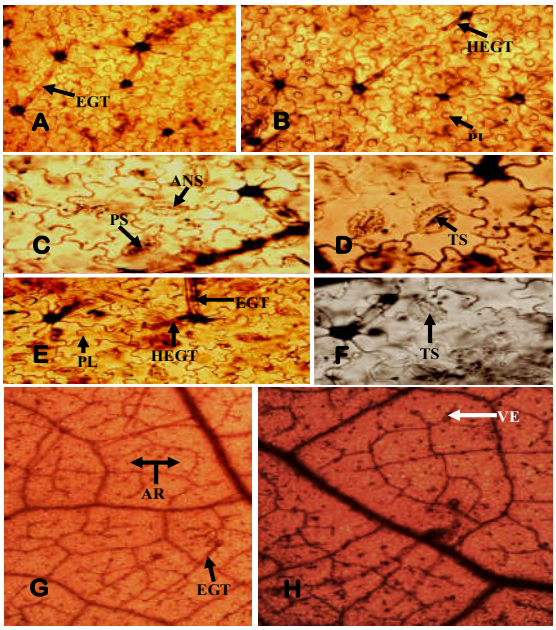

Plate 2 Foliar Anatomical study of *Desmodium scorpiurus* (Sw.) Desv.
A-B: Adaxial surface (x400)
C-F: Abaxial surface (x400)
G-H: Venation pattern (G x40, H x100)
PS – Paracytic Stomata
ANS – Anisocytic Stomata
TS – Tetracytic Stomata
HEGT – Hooked Eglandular Trichome
EGT – Eglandular Trichome
PL – Papilla
AR – Areoles
VE – Veinlet Ending

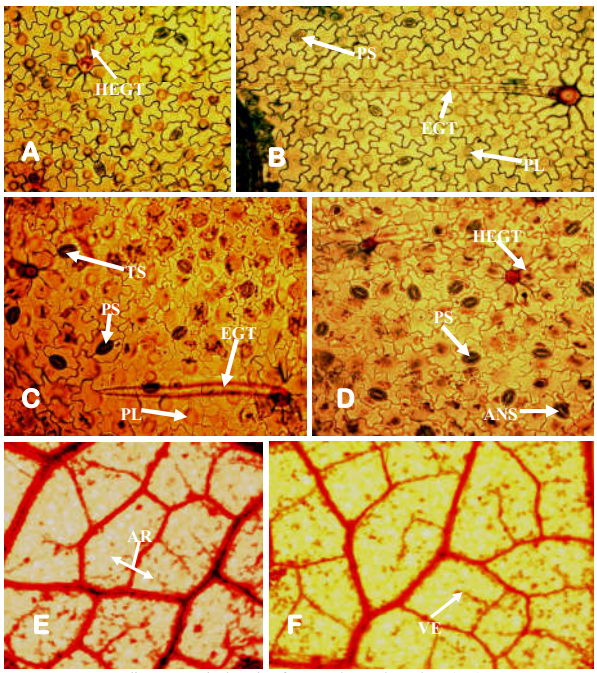

Plate 3 Foliar Anatomical study of *Desmodium adscendens* (Sw.) Dc.
A-B: Adaxial surface (x400)
C-D: Abaxial surface (x400)
E-F: Venation pattern (x100)
PS – Paracytic Stomata
TS – Tetracytic Stomata
ANS – Anisocytic Stomata
HEGT – Hooked Eglandular Trichome
EGT – Eglandular Trichome
PL – Papilla
AR – Areoles
VE – Veinlet Ending
GT – Glandular Trichome

The second sub cluster is further delineated into two groups. *Crotalaria retusa* and *Vigna unguiculata* are separated from others being the only species in the first group. In the second group, *Mucuna pruriens* is distinctly separated from other five species which are clustered together. The last sub cluster groups *Gliricidia sepium*, *Desmodium adscendens*, *Centrosema molle*, *Desmodium tortuosum* and *Desmodium scorpiurus* together (at very close and highest similarity level) as most closely related.

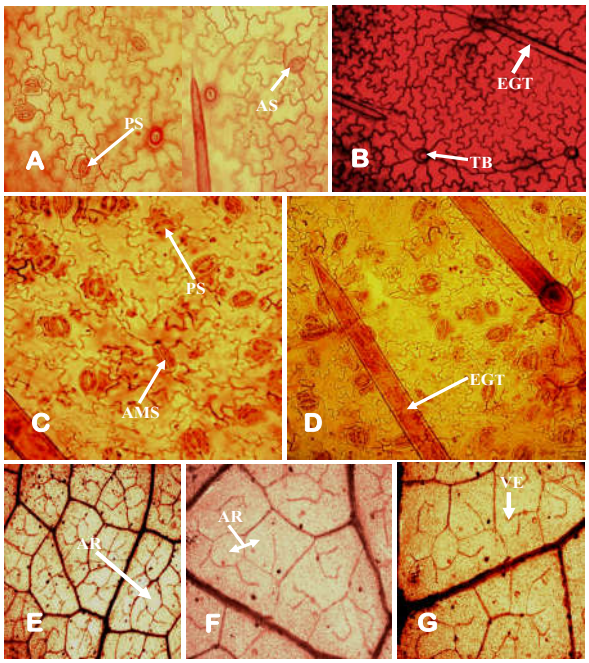

Plate 4 Foliar Anatomical study of *Mucuna pruriens* (Linn.) Walp.
A-B: Adaxial surface (A x400, B x100)
C-D: Abaxial surface (x400)
E-G: Venation patterns (E x40, F&G x100).
AS – Anisocytic Stomata
EGT – Eglandular Trichome
AMS – Anomocytic Stomata
AR – Areoles
TB – Trichome Base
VE – Veinlet Ending

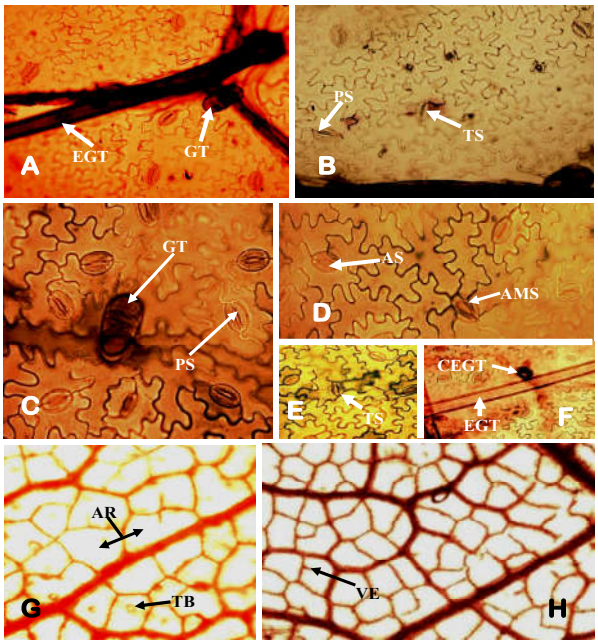

Plate 5 Foliar Anatomical study of *Calopogonium mucunoides* Desv.
A-B: Adaxial surface (x400)
C-F: Abaxial surface (x400)
G-H: Venation pattern (G x40, H x40)
AS – Anisocytic Stoma
EGT – Eglandular Trichome
AMS – Anomocytic Stoma
AR – Areoles
TB – Trichome Base
VE – Veinlet Ending
GT – Glandular Trichome
CEGT – Conical Eglandular Trichome
PS – Paracytic Stomata
TS – Tetracytic Stomata

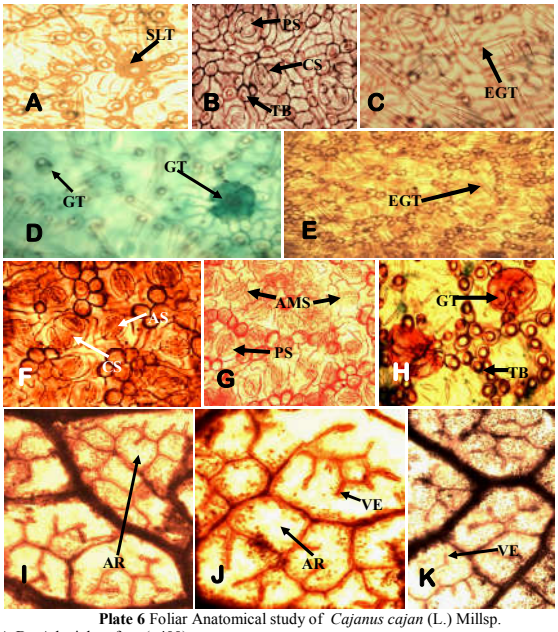

Plate 6 Foliar Anatomical study of *Cajanus cajan* (L.) Millsp.

A-D: Adaxial surface (x400)
E-H: Abaxial surface (x400)
I-K: Venation pattern (x100)
AS – Anisocytic Stoma
EGT – Eglandular Trichome
AMS – Anomocytic Stomata
TB – Trichome Base
VE – Veinlet Ending
GT – Glandular Trichome
PS – Paracytic Stoma
CS – Contiguous Stomata
AR - Areoles

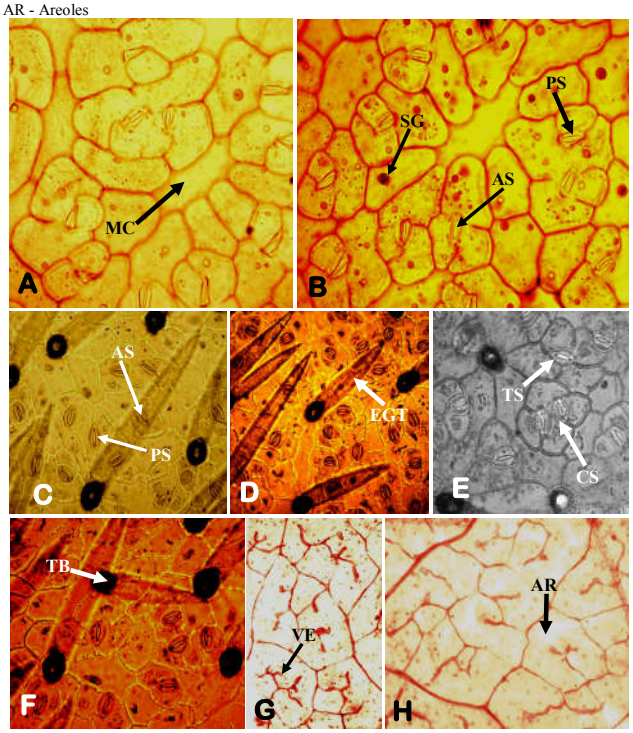

Plate 7 Foliar Anatomical study of *Crotalaria retusa* Linn.

A-B: Adaxial surface (x400)
C-F: Abaxial surface (x400)
G-H: Venation pattern (x100)
PS – Paracytic Stomata
AS – Anisocytic Stomata
ICS – Intercellular Space
EGT – Eglandular Trichome
TB – Trichome Base
VE – Veinlet Ending
TS – Tetracytic Stoma
SG – Starch Grain
PS – Paracytic Stoma
CS – Contiguous Stomata
AR - Areoles

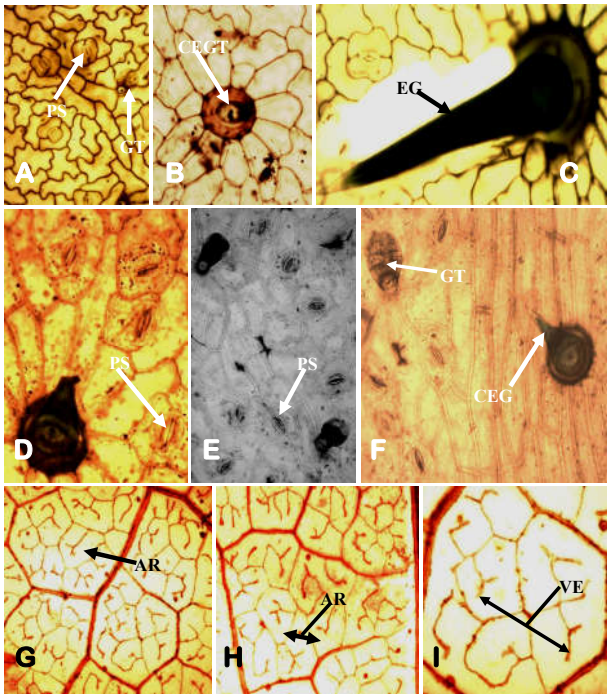

Plate 8 Foliar Anatomical study of *Vigna unguiculata* (Linn.) Walp.

A-C: Adaxial surface (x400)
D-F: Abaxial surface (x400)
G-I: Venation pattern (G & H x40, I x100)
PS – Paracytic Stomata
EGT – Eglandular Trichome
VE – Veinlet Ending
GT – Glandular Trichome
CEGT – Conical Eglandular Trichome
AR - Areoles

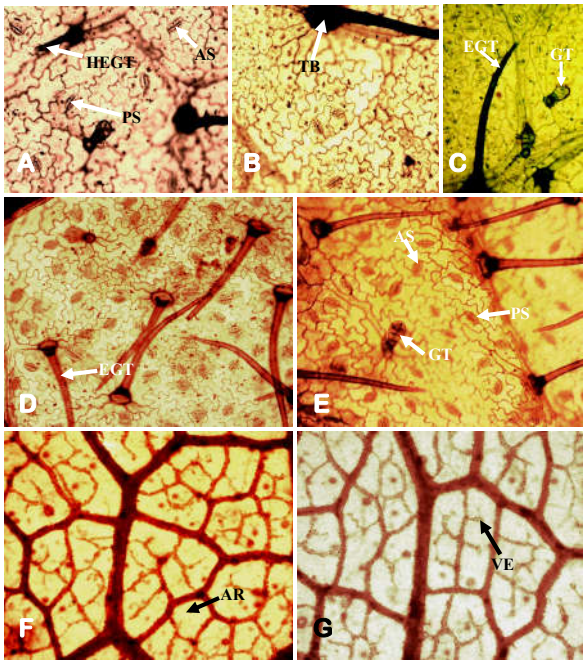

Plate 9 Foliar Anatomical study of *Centrosema molle* Mart. ex. Benth.

A-C: Adaxial surface (x400)
D-E: Abaxial surface (x400)
F-G: Venation pattern (x100)
PS – Paracytic Stomata
AS – Anisocytic Stomata
HEGT – Hooked Eglandular Trichome
VE – Veinlet Ending
EGT – Eglandular Trichome
GT – Glandular Trichome
AR – Areole

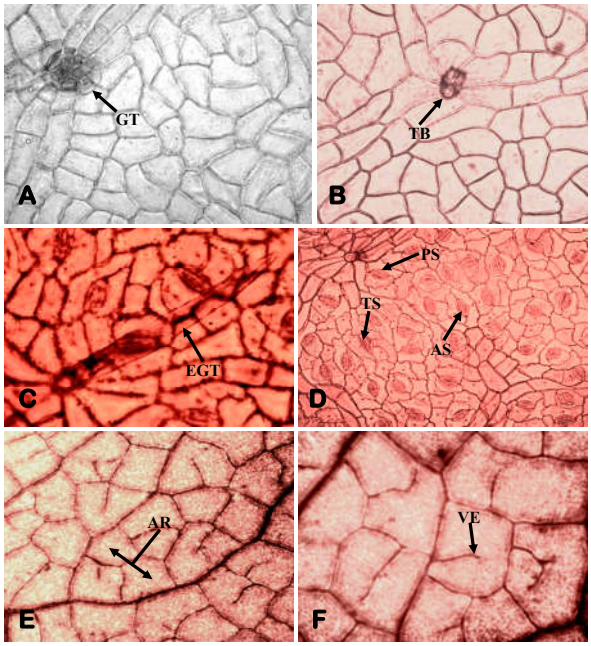

Plate 10 Foliar Anatomical study of *Gliricidia sepium* (Jacq.) Walp.

A-B: Adaxial surface (x400)
C-D: Abaxial surface (x400)
E-F: Venation pattern (E x40, F x100)
PS – Paracytic Stomata
AS – Anisocytic Stomata
TS – Tetracytic Stomata
EGT – Eglandular Trichome
TB – Trichome Base
VE – Veinlet Ending
GT – Glandular Trichome
AR - Areoles

DISCUSSION

The description of members of the subfamily Papilionoideae is generally based on morphology. Kadiri *et al.* (2005) reported that although studies conducted on gross morphology and wood anatomy of plants have proved valuable in the identification of plants; identification criteria would be incomplete without foliar epidermal morphology. Boodle and Fritsch (1908) noted that the significance of the differences of the epidermis of the *Cassia* species they studied was in the shape of the cells or structure of cell walls.

In this work, leaf epidermal cell shape is generally irregular with exception in *Gliricidia sepium*, *Cajanus cajan* and *Vigna unguiculata* which have irregular to polygonal shape on both surfaces. The presence of papilla on both surfaces in *Desmodium* species only, among all species studied can be used to separate the tribe Desmodieae from other tribes where it is absent on both surfaces. The presence of mucilaginous cells on both leaf surfaces is peculiar to *Crotalaria retusa* only and this can be used to separate it from other taxa. Anticlinal walls are variable and can be used for diagnostic purposes in these species studied. They are generally sinuous on both leaf surfaces in most of the species but straight on adaxial surface and wavy on abaxial surface of *Cajanus cajan*, wavy on both surfaces of *Vigna unguiculata*; straight on adaxial surface, straight to wavy on abaxial surface of *Gliricidia sepium* and straight on both surfaces of *Crotalaria retusa*.

Species are *amphistomatic* except in *Desmodium scorpiurus* and *Gliricidia sepium* which are hypostomatic. Stomata are largely paracytic on both leaf surfaces, although other types such as anisocytic, anomocytic and tetracytic were also observed but anisocytic type was prevalent in *Crotalaria retusa* only. This can be of taxonomic value in delimiting this species. This observation is similar to the findings of Sonje and Bhuktar (2013) who reported that the stomata type on the leaf epidermis of *Crotalaria hirsute* Willd. (Papilionoideae) was anisocytic.

Albert and Sharma (2013) reported the significance of stomata distribution, frequency, stomata size in delimiting species of *Bauhinia* (Leguminosae). Adedeji (2004) also established that stomata type is of taxonomic value and used this to separate the *Emilia* species studied. Stomata shape is a major unifying character for the species and genera in this sub family in that it is generally elliptic in all the species studied. Stomata index is one of the useful tools in distinguishing species (Amal & Sayantan, 2012). Highest value of stomata index on abaxial surface of the leaf distinctly separates *Cajanus cajan* from other taxa as seen in the dendrogram.

Adedeji *et al.* (2007) reported the importance of trichome types in different organs of the plant body in the delimitation of genera and species of the family Solanaceae. Eglandular trichomes are found on adaxial and abaxial leaf epidermal surfaces in all the species studied but absent on adaxial surfaces of *Crotalaria retusa* only. This delimits it from other taxa. Sonje & Bhukta (2013) also reported the presence of eglandular, uniseriate, unicellular trichomes on leaf and stem of *Crotalaria hirsute* Willd. (Papilionoideae). Number of eglandular trichomes in *Cajanus cajan* is highest and outstanding on both leaf surfaces compared to other species studied. This perhaps explains its separation from other taxa in the dendrogram. Length of eglandular trichome is highest in *Calopogonium mucunoides* on the adaxial surface of the leaf, this can be used to separate it from other species studied and probably why it is separated from other species in the second main cluster of the dendrogram. However, the value of length of eglandular trichome is highest and not significantly different in both *Calopogonium mucunoides* and *Mucuna pruriens* on the abaxial surface of the leaf. This may justify why they have close similarity levels in the dendrogram.

Adedeji (2012) reported venation patterns as a character of diagnostic importance. Venation pattern is generally brochidodromous except in *Cajanus cajan* which is craspedodromous. This can be used to delimit it from other species. This also supports its separation from other species studied in the dendrogram. Areole shape can also be used to separate *Calopogonium mucunoides* from other species as it is quadrangular largely while it is largely polygonal in *Crotalaria retusa*. Areole shapes in other species are largely irregular. Veinlet ending is largely single in all species but branched or bifurcated in *Crotalaria retusa* and *Vigna unguiculata*. Two to five or six veinlet endings were observed in all the species except in *Desmodium adscendens*, *Calopogonium mucunoides* and *Gliricidia sepium* which were observed to have only one veinlet ending per areole when present.

Stomata values (stomata index and stomata size) on both adaxial and abaxial surfaces of the leaf epidermis; number of glandular trichome on abaxial surface, leaf epidermal cell length and width on adaxial surface, leaf epidermal cell width on abaxial surface, areole length and width and number of veinlet ending per areole can be used to separate the species of

the genus *Desmodium* in the tribe Desmodieae from the other species studied while eglandular trichome length on adaxial surface, number of glandular trichome on adaxial surface of the leaf and leaf epidermal cell length on the abaxial surface are useful in grouping them together. Stomata values were also observed to be important in delimiting species in the other genera and tribes studied.

Conclusively, this study shows that presence of mucilaginous cells on the epidermis, anticlinal walls pattern, type, distribution of eglandular trichomes, stomata type and presence/distribution on leaf surfaces, stomata index and venation pattern are the foliar anatomical characters of taxonomic value.

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