

## Morphology of Some Species in the Subfamily Papilionoideae

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### Abstract

Morphological study of ten species in the subfamily Papilionoideae was carried out with the view to documenting diagnostic characters that would distinguish or group the species. The species studied belong to four tribes, namely: 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 Crotalariaeae – *Crotalaria retusa* Linn., tribe Robinieae – *Gliricidia sepium* (Jacq.) Walp. Qualitative and quantitative traits which had not been documented in previous works, especially in Nigeria, were studied. These include plant life span; leaf/leaflet apex, base, margin and pubescence; stem type, colour, shape and pubescence; sepal colour and pubescence; nature of margin of petal standard and presence or absence of pedicel; fruit colour, pubescence, tip and shape; seed colour, shape, surface and presence or absence of prominent hilum on the seed; number of seeds per fruit; pedicel length; length and width of petal standard, keel and wing. Characters of taxonomic value documented in this study were leaf type, leaf shape, leaf base, petiole type, stem type, seed shape, petal standard length, petal keel length and petal wing width. Data were subjected to one - way analysis of variance using Duncan's multiple range test. It was noted that the important characters that can be used in establishing taxonomic relationship in the sub-family Papilionoideae were leaf type, leaf shape, leaf base, petiole type, stem shape, petal colour, petal margin and seed shape.

**Keywords:** morphology, Papilionoideae, tribe, character, taxonomy

### Introduction

The subfamily Papilionoideae belongs to the family Leguminosae. The subfamily is sometimes recognized as a separate family Papilionaceae. The species of this subfamily are generally identifiable by their characteristic papilionaceous (butterfly-like) flowers (ILDIS, 2005; Cullen *et al.*, 2011). Papilionoideae is the largest group of legumes, with about two-thirds of all the genera and species of the family Leguminosae. The homogenous subfamily is also the most widespread, generally distributed throughout the world; it is most numerous and extending further into warmer temperate regions compared with the other two subfamilies, Caesalpinoideae and Mimosoideae, in Leguminosae (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) out of which about 335 species were recorded in Nigeria (Hutchinson and Dalziel, 1954). The members of subfamily Papilionoideae are predominantly herbs or herbaceous climbers; sometimes they are erect or climbing shrubs, trees or lianas (Datta and Mukherji, 1952; Hutchinson and Dalziel, 1958; Watson and Dallwitz, 1999; Gurcharan, 2004; ILDIS, 2005). It is an extremely important subfamily and finds a wide range of usefulness (Datta and Mukherji, 1952; ILDIS, 2005).

Most plants are classified based on their external morphological structures. The morphology and ontogenies of taxa are important for intra-generic systematics (Sayantan and Amal, 2004). Alexander (2004) presented an illustrated survey of abaxial leaf surface of 22 *Desmodium* species found in North Carolina and a diagnostic key to facilitate the identification and teaching of the species. He reported that *Desmodium* Desv. (Papilionoideae) is perhaps the most difficult genus among Carolina legumes. El-Gazzar *et al.* (2013) recorded 81 morphological characters for 226 species and intra-specific taxa belonging to 75 genera representing 21 of the 32 tribes currently recognized in the subfamily Papilionoideae, to know the extent to which the currently accepted classification of the subfamily by Polhill and Raven (1981) would withstand the test of numerical analyses. The authors concluded that the currently accepted circumscription and inter-relationships among the disrupted tribes and genera of Papilionoideae are in need of much more detailed investigation.

A search in the literature also shows that the information about the comparative morphology of most species in the subfamily Papilionoideae, especially those found in Nigeria, is scanty. This study therefore aimed to document the morphological traits of taxonomic value in the species studied.

## 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 as follows: 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 from different locations in Ile-Ife, latitude 07° 30'N and longitude 04° 40'E, Osun State, Nigeria.

Qualitative data observed and recorded were plant habit; plant life span; leaf type; leaf/leaflet shape, base, apex, margin, colour, pubescence; stem type, colour, shape, pubescence; presence or absence of stipule; inflorescence type; sepal aestivation, colour; standard petal margin; fruit type, segmentation, indentation or ribbing; fresh fruit colour; dry fruit colour; fruit shape, tip shape; seed shape and colour; presence or absence of depression on the seed; nature of seed surface; hilum prominent or not prominent.

Quantitative data taken were leaf length and width; petiole length; fruit length and width; number of seeds per fruit; pedicel length; petal standard length and width; petal keel length and width; petal width length and width.

Quantitative 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 the minimum, maximum, means and standard error of means for each trait.

## Results

The qualitative and quantitative traits of the species studied are hereby presented. They are summarised on Tables 1 – 3, whereas descriptive terminologies used are according to Metcalfe and Chalk (1979).

Photographs of the diagnostic morphological traits of the studied species are presented on Figs. 1 – 10.

*Desmodium tortuosum* (Sw.) DC. (Fig. 1)

Habit: Herb/ under shrub (Fig. 1A).

Lifespan: Annual

Leaf: compound (trifoliolate), leaflet: 4.10 – 18.90 cm long and 2.20 – 9.90 cm wide, ovate in shape, acute at base, acute at apex, entire at margin, green, pubescent, stipulate, petiolate, petiole was between 1.70 – 6.90 cm long (Fig. 1B).

Stem: erect, woody, solid, green and reddish brown, cylindrical, ringed and pubescent (Fig. 1C).

Inflorescence: Terminal and axillary panicle (Fig. 1D).

Flower: zygomorphic, pedicellate; Sepal: green, polysepalous, ovate in shape, 5 in number, pubescent; Petals: standard: 0.40 – 0.50 cm long and 0.40 – 0.45 cm wide, keel: 0.40 – 0.50 cm long and 0.50 – 0.30 cm wide, wing: 0.40 – 0.45 cm long and 0.20 – 0.25 cm wide, pinkish purple, papilionaceous shape, 5 in number, pedicel 1.20 – 1.50 cm long (Fig. 1E).

Fruit: lomentum, segmented, segment orbicular, deeply indented on both sides twisted, obtuse at apex, 2.30 – 3.00 cm long and 0.30 – 0.40 cm wide, green with reddish brown pattern when fresh, brown when dry, pubescent, one row of seed per fruit (Fig. 1G and Fig. 1I).

Seed: bean shape, occasionally triangular, light brown to dark brown, shiny, glabrous, depressed around the middle, 5 – 7 seeds per fruit (Fig. 1F).

*Desmodium scorpiurus* (Sw.) Desv. (Fig. 2)

Habit: herbaceous creeper (Fig. 2A).

Lifespan: perennial.

Leaf: compound (trifoliolate), leaflet; 2.20 – 10.50 cm long and 1.00 – 3.90 cm wide, ovate to elliptic in shape, obtuse at base, acute at apex, entire at margin, green, pubescent, stipulate, petiolate, petiole 2.90 – 6.90 cm long (Fig. 2B).

Stem: weak, creeper, herbaceous, roots at nodes, solid, green, slightly twisted, triangular and pubescent (Fig. 2C and D).

Inflorescence: terminal and axillary raceme (Fig. 2E - G).

Flower: zygomorphic, sub sessile; sepal: green, polysepalous, ovate in shape, 5 in number, pubescent; petals: standard of 0.40 – 0.50 cm long and 0.40 – 0.50 cm wide, keel: 0.40 – 0.45 cm long and 0.20 – 0.25 cm wide, wing: 0.40 – 0.50 cm long and 0.20 – 0.25 cm wide, pinkish purple, papilionaceous, 5 in number, pedicel 0.20 – 0.30 cm long (Fig. 2H).

Fruit: lomentum, segmented, slightly indented on both sides, cylindrical, obtuse at apex, 2.10 – 4.30 cm long and 0.20 cm wide, light green when fresh, brown when dry, pubescent, one row of seed per fruit (Fig. 2I and K).

Seed: cylindrical, green when fresh, brown when dry, smooth, 4 – 8 seeds per fruit (Fig. 2J).

*Desmodium adscendens* (Sw.) DC. (Fig. 3)

Habit: herbaceous creeper (Fig. 3A).

Life span: perennial.

Leaf: compound (trifoliolate), leaflet; 1.80 – 4.60 cm long and 1.20 – 3.30 cm wide, obovate in shape, obtuse to round at base, round/retuse at apex, entire at margin, green, pubescent, stipulate, petiolate, petiole 1.40 – 2.50 cm long (Fig. 3B).

Stem: weak, creeper, herbaceous, roots at nodes, solid, green, cylindrical and pubescent (Fig. 3C and D).

Inflorescence: terminal and axillary raceme (Fig. 3E).

Flower: zygomorphic, pedicellate; sepal: green, polysepalous, ovate in shape, 5 in number, pubescent; petals: standard of 0.40 – 0.50 cm long and 0.50 – 0.55 cm wide, keel: 0.40 – 0.50 cm long and 0.20 – 0.25 cm wide, wing: 0.40 – 0.50 cm long and 0.20 – 0.25 cm wide, faded pinkish purple, papilionaceous, 5 in number, pedicel 0.6 – 1.2 cm long (Fig. 3F and G).

Fruit: lomentum, segmented, deeply indented on one side, short aristate at apex, 0.80 – 2.40 cm long and 0.25 – 0.35 cm wide, deep green when fresh and brown when dry, flat, pubescent, one row of seed per fruit (Fig. 3H and J).

Seed: bean shape occasionally triangular, green when fresh, brown when dry, glabrous, 1 – 4 seeds per fruit (Fig. 3I).

*Mucuna pruriens* (Linn.) Walp. (Fig. 4)

Habit: herbaceous twinner (Fig. 4A).

Lifespan: annual.

Leaf: compound (trifoliolate), leaflet; 7.90 – 18.20 cm long and 4.70 – 11.10 cm wide, wide ovate to wide elliptic in shape, lateral leaflets asymmetric, obtuse at base, obtuse at apex, entire at margin, green, pubescent, stipulate, petiolate, petiole 4.40 – 14.10 cm long (Fig. 4B).

Stem: weak, twinner, woody, solid, brown, cylindrical, minutely pubescent (Fig. 4F).

Inflorescence: axillary raceme (Fig. 4G).

Flower: zygomorphic, sub sessile; sepal: green, gamosepalous,

campanulate in shape, pubescent; petals: standard of 2.00 – 2.20 cm long and 1.60 – 1.80 cm wide, keel: 2.80 – 2.90 cm long and 1.40 – 1.50 cm wide, wing: 3.10 – 3.20 cm long and 1.60 – 1.70 cm wide, deep purple, papilionaceous in shape, 5 in number, pedicel 0.40 – 0.60 cm long (Fig. 4E).

Fruit: legume, obtuse at apex, sickle shape 8.40 – 8.80 cm long and 2.10 – 2.30 cm wide, rusty brown when fresh, brown when dry, pubescent – densely clothed with rusty stinging hairs, one row of seed per fruit (Fig. 4C and D).

Seed: bean shaped with prominent hilum, light brown to dark brown, glabrous, depressed around the middle, 4 – 5 seeds per fruit (Fig. 4H).

*Calopogonium mucunoides* Desv. (Fig. 5)

Habit: herbaceous creeper (Fig. 5A).

Life span: perennial.

Leaf: compound (trifoliate), leaflet; 5.20 – 11.60 cm long and 4.10 – 7.40 cm wide, wide ovate to wide elliptic in shape, lateral leaflets asymmetric, obtuse at base, obtuse at apex, entire at margin, green, pubescent, covered with brown rusty hairs, stipulate, petiolate, petiole 5.60 – 15.40 cm long (Fig. 5B).

Stem: weak, creeper, woody, roots at nodes, solid, green, cylindrical and pubescent (Fig. 5C and D).

Inflorescence: axillary cluster (Fig. 5E).

Flower: zygomorphic, sessile; sepal: green, polysepalous, ovate in shape, 5 in number, pubescent; petals: standard of 0.50 – 0.60 cm long and 0.50 – 0.60 cm wide, keel: 0.70 – 0.80 cm long and 0.30 – 0.35 cm wide, wing: 0.50 – 0.55 cm long and 0.20 – 0.25 cm wide, bluish lilac, papilionaceous in shape, 5 in number (Fig. 5I).

Fruit: legume, mucronate at apex, 2.90 – 4.30 cm long and 0.30 – 0.50 cm wide, green when fresh, brown when dry, pubescent, one row of seed per fruit (Fig. 5F and G).

Seed: bean shaped, largely square, light brown to brown, shinny, glabrous, depressed around the middle, 6 – 8 seeds per fruit (Fig. 5H).

*Cajanus cajan* (L.) Millsp. (Fig. 6)

Habit: shrub (Fig. 6A).

Lifespan: annual.

Leaf: compound (trifoliate), leaflet; 6.50 – 13.70 cm long and 2.30 – 4.10 cm wide, elliptic in shape, acute at base, acuminate at apex, entire at margin, green, pubescent, stipulate, petiolate, petiole 3.80 – 7.00 cm long (Fig. 6B).

Stem: erect, woody, solid, green, angular-cylindrical (angles looking like white straight lines), pubescent (Fig. 6E).

Inflorescence: axillary cluster (Fig. 6D).

Flower: zygomorphic, pedicellate; sepal: green, gamosepalous, campanulate in shape, pubescent; Petals: standard of 1.60 – 1.70 cm long and 1.60 – 1.70 cm wide, keel: 1.50 – 1.60 cm long and 0.70 – 0.80 cm wide, wing: 1.30 – 1.40 cm long and 0.60 – 0.70 cm wide, bright yellow with reddish brown veining at the back of the standard, indented at margin of the standard, papilionaceous in shape, 5 in number, pedicel 0.90 – 1.40 cm long (Fig. 6F).

Fruit: legume, ribbed, acuminate at apex, 5.70 – 6.90 cm long and 0.70 – 0.90 cm wide, green with reddish brown pattern when fresh, brown when dry, pubescent, one row of seed per fruit (Fig. 6G).

Seed: orbicular with prominent hilum, greyish-brown, rough, shinny, glabrous, 3 – 6 seeds per fruit (Fig. 6C).

*Crotalaria retusa* Linn. (Fig. 7)

Habit: shrub (Fig. 7A).

Lifespan: annual.

Leaf: simple, leaf of 4.70 – 10.10 cm long and 2.10 – 3.60 cm wide, oblanceolate in shape, cuneate at base, retuse at apex, entire at margin, green, minutely pubescent, stipulate and sub sessile, petiole 0.20 – 0.30 cm long (Fig. 7B).

Stem: erect, woody, hollow, green, cylindrical with vertical ridges, minutely pubescent (Fig. 7C).

Inflorescence: terminal raceme (Fig. 7D).

Flower: zygomorphic, sub sessile; sepal: green, gamosepalous, campanulate in shape, minutely pubescent; petals: standard: 2.20 – 2.40 cm long and 2.70 – 2.90 cm wide, keel: 1.40 – 1.60 cm long and 1.20 – 1.30 cm wide, wing: 1.40 – 1.60 cm long and 1.00 – 1.20 cm wide, bright yellow with reddish-brown veining on the standard alone, papilionaceous in shape, 5 in number, pedicel 0.80 – 1.00 cm long (Fig. 7E).

Fruit: legume, aristate curved at apex, oblong-cylindrical 3.30 – 4.40 cm long and 0.90 – 1.30 cm wide, green when fresh, black when dry, glabrous, one row of seed per fruit (Fig. 7F and G).

Seed: reniform in shape, dark brown, glabrous, 9 – 22 seeds per fruit (Fig. 7H).

*Vigna unguiculata* (Linn.) Walp. (Fig. 8)

Habit: herbaceous creeper or climber (Fig. 8A).

Lifespan: perennial.

Leaf: compound (trifoliate), leaflet; 5.30 – 14.70 cm long and 3.20 – 7.80 cm wide, ovate, lateral leaflets asymmetric, acute at base, sharp acute at apex, entire at margin, green, minutely pubescent, stipulate, petiolate, petiole 6.00 – 17.00 cm long (Fig. 8B).

Stem: weak, creeper or climber, roots at nodes, herbaceous, solid, green with reddish-brown patch, cylindrical and glabrous (Fig. 8C).

Inflorescence: axillary cluster (Fig. 8H).

Flower: zygomorphic, sessile; sepal: green, gamosepalous, campanulate, glabrous; petals: standard: 2.50 – 2.70 cm long and 3.30 – 3.50 cm wide, keel: 2.40 – 2.60 cm long and 1.50 – 1.70 cm wide, wing: 2.00 – 2.20 cm long and 1.40 – 1.60 cm wide, lilac, papilionaceous in shape, 5 in number (Fig. 8E).

Fruit: legume, obtuse at apex, cylindrical, 7.30 – 11.60 cm long and 0.30 – 0.40 cm wide, green when fresh, black when dry, glabrous, one row of seed per fruit (Fig. 8D and F).

Seed: bean-shaped, dark-brown with black patches, glabrous, 6 – 17 seeds per fruit (Fig. 8G).

*Centrosema molle* Mart. ex Benth. (Fig. 9)

Habit: herbaceous climber or creeper (Fig. 9A and B).

Lifespan: perennial.

Leaf: compound (trifoliate), leaflet; 5.00 – 7.40 cm long and 3.00 – 4.60 cm wide, ovate in shape, obtuse at base, acuminate at apex, entire at margin, dark green, minutely pubescent, stipulate, petiolate, petiole 2.00 – 6.00 cm long (Fig. 9C and Fig. 9D).

Stem: weak, creeper or climber, woody, root at nodes, solid, brown, twisted, minutely pubescent (Fig. 9G).

Inflorescence: axillary cluster.

Flower: zygomorphic, sub sessile; sepal: green, gamosepalous, campanulate in shape, minutely pubescent;



Fig 1. Morphology of *Desmodium tortuosum* (Sw.) DC  
 A. Habit (herb/under shrub), B. Leaf, C. Stem, D. Inflorescence, E. Flower, F. Seeds (arrow points at depression), G. Fruit (fresh), H. Fruit (dry and twisted), I. Fruit (showing reddish brown pattern and hairs on fruits)

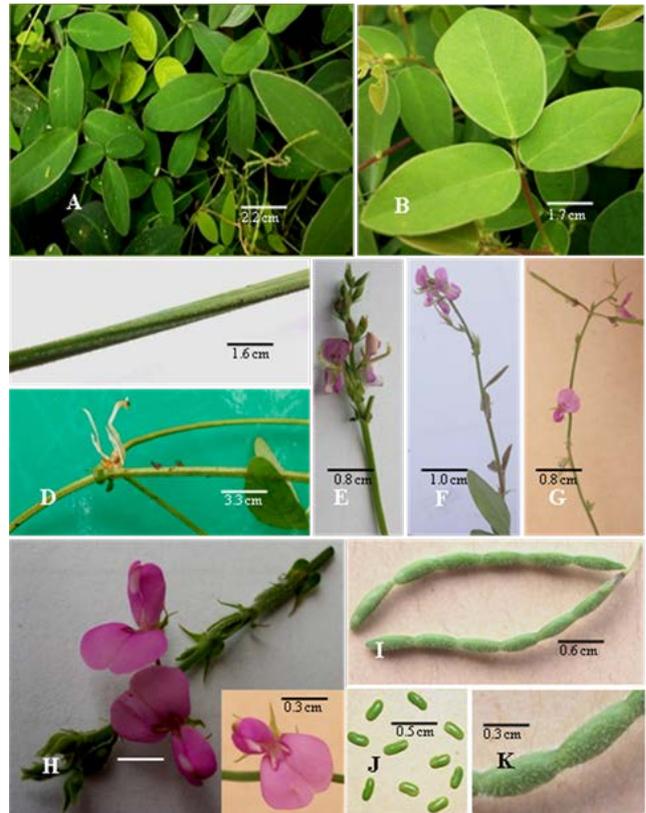


Fig 2. Morphology of *Desmodium scorpiurus* (Sw.) Desv  
 A. Habit (herbaceous creeper), B. Leaf, C. Stem, D. Stem (rooting at node), E - G. Inflorescences, H. Flowers, I. Fruits (fresh), J. Seeds, K. Fruits (showing hairs)

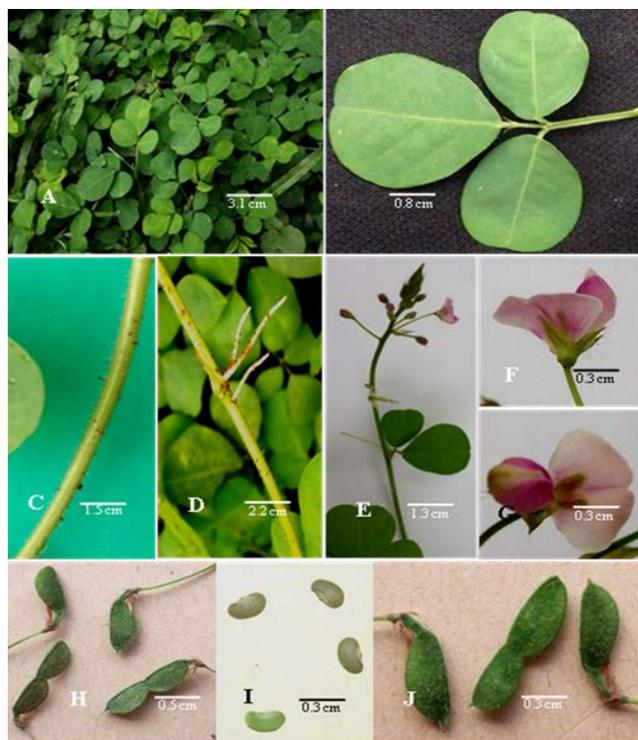


Fig 3. Morphology of *Desmodium adscendens* (Sw.) DC.  
 A. Habit (herbaceous creeper), B. Leaf, C. Stem, D. Stem rooting at node, E. Inflorescence, F - G. Flowers, H. Fruits, I. Seeds (fresh and dry), J. Fruits (showing hairs)



Fig 4. Morphology of *Mucuna pruriens* (Linn.) Walp.  
 A. Habit (herbaceous twinner), B. Leaf, C. Fruits, D. Fruits, E. Flower, F. Stem, G. Inflorescence, H. Seeds (arrow points at depression)

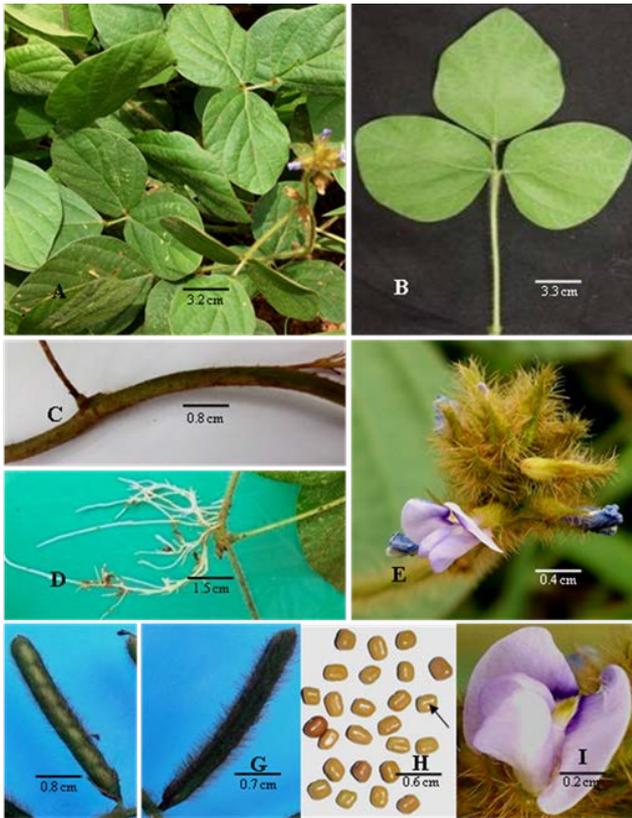


Fig 5. Morphology of *Calopogonium mucunoides* Desv.  
 A. Habit (herbaceous creeper), B. Leaf, C. Stem, D. Stem (rooting at node), E. Inflorescence (axillary cluster), F. Fruit (fresh), G. Fruit (showing hairs), H. Seeds (arrow points at depression), I. Flower

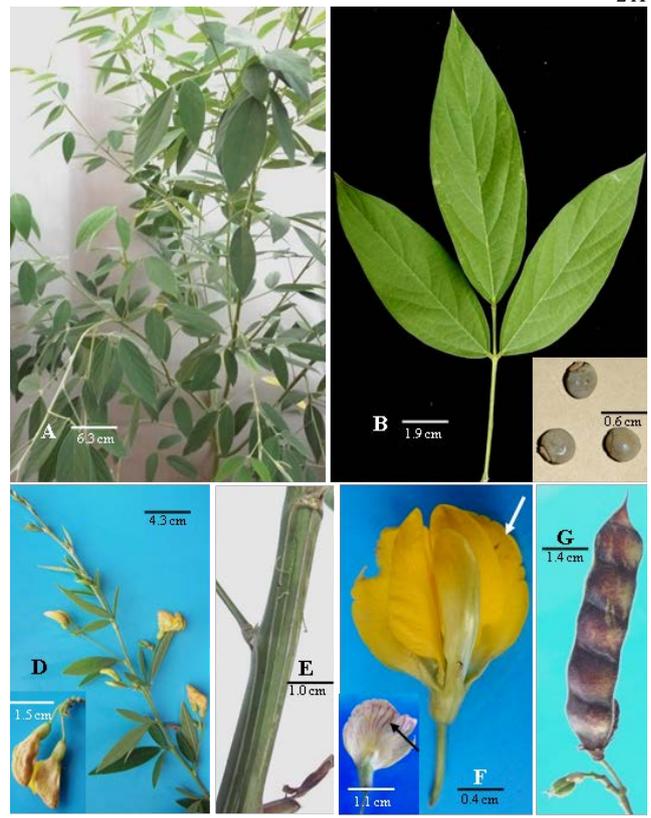


Fig 6. Morphology of *Cajanus cajan* (L.) Millsp.  
 A. Habit (shrub), B. Leaf, C. Seeds, D. Inflorescence (axillary cluster), E. Stem, F. Flower (black arrow points at reddish-brown veining and red arrow points at indented margin of the standard), G. Fruit (fresh)



Fig 7. Morphology of *Crotalaria retusa*: Linn.  
 A. Habit (shrub), B. Leaf, C. Stem, D. Inflorescence (terminal raceme), E. Flower (arrow points at reddish-brown veining on the standard alone), F. Fruit (fresh), G. Fruit (dry), H. Seeds



Fig 8. Morphology of *Vigna unguiculata* (Linn.) Walp.  
 A. Habit (herbaceous creeper or climber), B. Leaf, C. Stem, D. Fruit (fresh), E. Flower, F. Fruits (dry), G. Seeds, H. Inflorescence (axillary cluster)

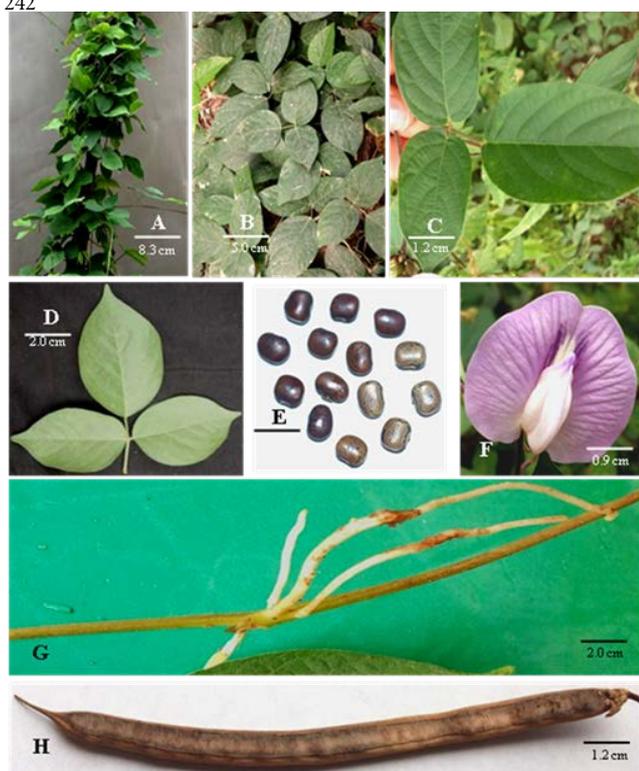


Fig. 9. Morphology of *Centrosema molle* Mart. ex. Benth.

A and B. Habit (herbaceous creeper or climber, A as a climber, B as a creeper), C and D. Leaves, E. Seeds, F. Flower, G. Stem (rooting at node), H. Fruit (dry)

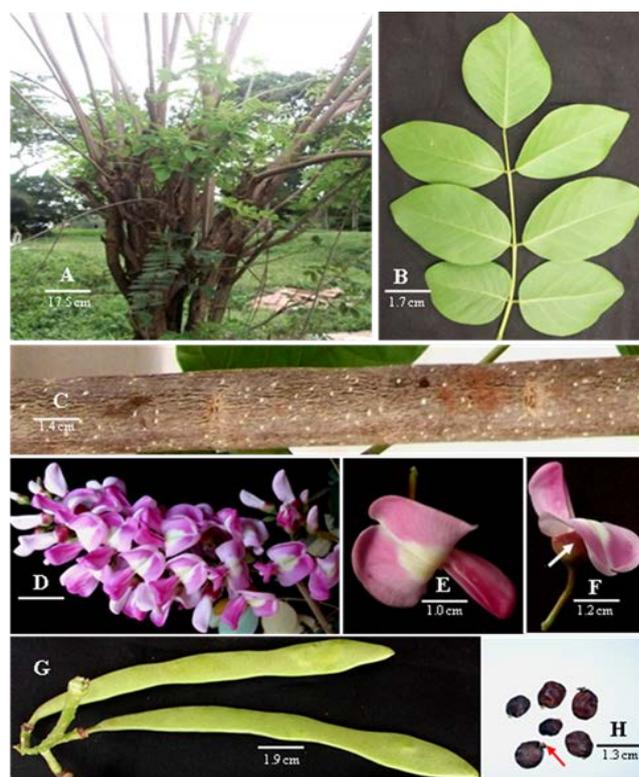


Fig. 10. Morphology of *Gliricidia sepium* (Jacq.) Walp.

A. Habit (tree), B. Leaf, C. Stem, D. Inflorescence (terminal panicle), E and F. Flower (arrow pointing at the calyx), G. Fruit (fresh), H. Seeds (arrow pointing at prominent hilum)

Table 1. Summary of the qualitative morphological traits of the studied species of the subfamily Papilionoideae

Species	Plant habit	Life span	Leaf type	Leaf/Leaflet shape	Lateral leaflet	Leaf apex	Leaf base	Leaf margin
<i>Desmodium tortuosum</i>	Shrub	Annual	Trifoliate	Ovate	Symmetric	Obtuse	Obtuse	Entire
<i>Desmodium scorpiurus</i>	Herb	Perennial	Trifoliate	Elliptic	Symmetric	Obtuse	Obtuse	Entire
<i>Desmodium adscendens</i>	Herb	Perennial	Trifoliate	Obovate	Symmetric	Retuse	Obtuse	Entire
<i>Mucuna pruriens</i>	Herb	Perennial	Trifoliate	Wide ovate/ wide elliptic	Asymmetric	Obtuse	Obtuse	Entire
<i>Calopogonium mucunoides</i>	Herb	Perennial	Trifoliate	Wide ovate/ wide elliptic	Asymmetric	Obtuse	Obtuse	Entire
<i>Cajanus cajan</i>	Shrub	Annual	Trifoliate	Elliptic	Symmetric	Acuminate	Acute	Entire
<i>Crotalaria retusa</i>	Shrub	Annual	Simple	Oblanceolate	Symmetric	Retuse	Cuneate	Entire
<i>Vigna unguiculata</i>	Herb	Perennial	Trifoliate	Ovate	Asymmetric	Acute	Acute	Entire
<i>Centrosema molle</i>	Herb	Perennial	Trifoliate	Ovate	Symmetric	Acuminate	Obtuse	Entire
<i>Gliricidia sepium</i>	Tree	Perennial	Unipinnate	Elliptic	Symmetric	Acute	Obtuse	Entire

Table 1. Summary of the qualitative morphological traits of the studied species of the subfamily Papilionoideae (Contd)

Species	Leaf colour	Leaf pubescence	Stipule	Petiole	Stem	Stem type	Stem colour
<i>Desmodium tortuosum</i>	Green	Minutely pubescent	+	+	Erect	Woody/Solid	Green/reddish brown
<i>Desmodium scorpiurus</i>	Green	Pubescent	+	+	Weak/ root at node	Herbaceous/Solid	Green
<i>Desmodium adscendens</i>	Green	Pubescent	+	+	Weak/ root at node	Herbaceous/Solid	Green
<i>Mucuna pruriens</i>	Green	Pubescent	+	+	Weak	Woody/Solid	Brown
<i>Calopogonium mucunoides</i>	Green	Pubescent	+	+	Weak/ root at node	Woody/Solid	Green
<i>Cajanus cajan</i>	Green	Pubescent	+	+	Erect	Woody/Solid	Green
<i>Crotalaria retusa</i>	Green	Minutely pubescent	+	±	Erect	Woody/Hollow	Green
<i>Vigna unguiculata</i>	Green	Minutely pubescent	+	+	Weak/ root at node	Herbaceous/Solid	Green/ reddish brown
<i>Centrosema molle</i>	Green	Minutely pubescent	+	+	Weak/ root at node	Woody/Solid	Brown
<i>Gliricidia sepium</i>	Green	Glabrous	-	+	Erect	Woody/Solid	Brown/white spot

Key: + : Present; - : Absent; ± : Sub sessile

Table 1. Summary of the qualitative morphological traits of the studied species of the subfamily Papilionoideae (Contd)

Species	Petal colour	Standard margin	Flower	Pedicel	Fruit	Fruit segment	Fresh Fruit colour	Dry Fruit Colour
<i>Desmodium tortuosum</i>	Pinkishpurple	Entire	Zygomorphic	Pedicellate	Lomentum	Bothsidesindented	Green/Red	Brown
<i>Desmodium scorpiurus</i>	Pinkishpurple	Entire	Zygomorphic	Subsessile	Lomentum	Bothsidesindented	Green	Brown
<i>Desmodium adscendens</i>	Fadedpinkishpurple	Entire	Zygomorphic	Pedicellate	Lomentum	Onesidesindented	Green	brown
<i>Mucuna pruriens</i>	Deeppurple	Entire	Zygomorphic	Subsessile	Legume	Ribbed	Brown/green	Brown
<i>Calopogonium mucunoides</i>	Bluishlilac	Entire	Zygomorphic	Sessile	Legume	Notribbed	Green	Brown
<i>Cajanus cajan</i>	Yellow/redveining	Indented	Zygomorphic	Pedicellate	Legume	Ribbed	Green/Red	Brown
<i>Crotalaria retusa</i>	Yellow/redveining	Entire	Zygomorphic	Subsessile	Legume	Notribbed	Green	Black
<i>Vigna unguiculata</i>	Lilac	Entire	Zygomorphic	Sessile	Legume	Notribbed	Green	Black
<i>Centrosema molle</i>	Lilac/violetveining	Entire	Zygomorphic	Subsessile	Legume	Notribbed	Green	Brown
<i>Gliricidia sepium</i>	Pinkishpurple/white	Entire	Zygomorphic	Subsessile	Legume	Notribbed	Green	Brown

Table 1. Summary of qualitative morphological characters of the species of the subfamily Papilionoideae studied (Contd)

Species	Fruit Pubescence	Fruit tip	Fruit shape	Seed shape	Seed Colour	Seed Depression	Seed Surface	Hilum
<i>Desmodium tortuosum</i>	Pubescent	Obtuse	Flat/Twisted	Bean-shaped	Brown	Depressed	Smooth	Notprominent
<i>Desmodium scorpiurus</i>	Pubescent	Obtuse	Cylindrical	Cylindrical	Brown	Notdepressed	Smooth	Notprominent
<i>Desmodium adscendens</i>	Pubescent	Shortaristate	Flat	Bean-shaped	Brown	Notdepressed	Rough	Notprominent
<i>Mucuna pruriens</i>	Pubescent	Obtuse	Sickle-shaped	Bean-shaped	Light-darkbrown	Depressed	Smooth	Prominent
<i>Calopogonium mucunoides</i>	Pubescent	Mucronate	Flat	Bean-shaped	Light-darkbrown	Depressed	Smooth	Notprominent
<i>Cajanus cajan</i>	Pubescent	Acuminate	Notflat	Orbicular	Greyishbrown	Notdepressed	Rough	Prominent
<i>Crotalaria retusa</i>	Glabrous	Aristate	Oblong/cylindrical	Heart-shaped	Darkbrown	Notdepressed	Smooth	Notprominent
<i>Vigna unguiculata</i>	Glabrous	Obtuse	Cylindrical	Bean-shaped	Darkbrown/blackpatches	Notdepressed	Smooth	Notprominent
<i>Centrosema molle</i>	Glabrous	Aristate	Flat	Bean-shaped	Light/Darkbrown+blackpatches	Notdepressed	Smooth	Notprominent
<i>Gliricidia sepium</i>	Glabrous	Obtuse	Flat	Orbicular	Darkbrown	Depressed	Rough	Prominent

Table 2. Minimum, mean, standard error of mean and maximum values of the quantitative morphological traits of Papilionoideae species studied

Species	Leaf length (cm)		Leaf width (cm)		Petiole length (cm)		Fruit length (cm)		Fruit width (cm)		No of seeds per fruit	
	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
<i>Desmodium tortuosum</i>	4.10(11.06±1.00)	18.90	2.20(5.57±0.45)	9.90	1.70(3.94±0.27)	6.90	2.30(2.56±0.04)	3.00	0.30(0.32±0.01)	0.40	5.00(6.00±0.10)	7.00
<i>Desmodium scorpiurus</i>	2.20(6.26±0.50)	10.50	1.00(2.67±0.17)	3.90	2.90(5.15±0.2)	6.90	2.10(3.30±0.14)	4.30	0.20(0.21±0.00)	0.25	4.00(5.85±0.32)	8.00
<i>Desmodium adscendens</i>	1.80(2.94±0.18)	4.60	1.20(2.13±0.12)	3.30	1.40(1.76±0.06)	2.50	0.80(1.35±0.11)	2.40	0.25(0.30±0.00)	0.35	1.00(2.22±0.22)	4.00
<i>Mucuna pruriens</i>	7.90(12.90±0.67)	18.20	4.70(7.93±0.46)	11.10	4.40(9.52±0.61)	14.10	8.40(8.58±0.0)	8.80	2.10(2.22±0.02)	2.30	4.00(4.45±0.11)	5.00
<i>Calopogonium mucunoides</i>	5.20(7.94±0.47)	11.60	4.10(5.70±0.22)	7.40	5.60(9.84±0.53)	15.4	2.90(3.53±0.07)	4.30	0.30(0.43±0.00)	0.50	6.00(6.75±0.14)	8.00
<i>Cajanus cajan</i>	6.50(10.07±0.50)	13.70	2.30(3.09±0.1)	4.10	3.80(5.57±0.19)	7.00	5.70(6.29±0.09)	6.90	0.70(0.79±0.01)	0.90	3.00(4.55±0.15)	6.00
<i>Crotalaria retusa</i>	4.70(8.15±0.35)	10.10	2.10(2.99±0.10)	3.60	0.20(0.25±0.01)	0.30	3.30(3.91±0.06)	4.40	0.90(1.05±0.02)	1.30	9.00(14.70±0.74)	22.00
<i>Vigna unguiculata</i>	5.30(10.01±0.51)	14.70	3.20(6.16±0.24)	7.80	6.00(12.25±0.61)	17.00	7.30(8.92±0.24)	11.60	0.30(0.39±0.01)	0.40	6.00(12.10±0.62)	17.00
<i>Centrosema molle</i>	5.00(6.20±0.17)	7.40	3.00(3.75±0.12)	4.60	2.00(3.81±0.24)	6.00	8.20(13.76±0.51)	16.60	0.40(0.61±0.02)	0.80	11.00(13.00±0.43)	16.00
<i>Gliricidia sepium</i>	4.30(7.69±0.41)	10.60	3.20(4.62±0.21)	6.30	3.10(3.86±0.09)	4.60	12.30(15.24±0.47)	19.50	1.50(1.92±0.05)	2.20	4.00(7.10±0.36)	10.00

Key: Min=Minimum value, Max=Maximum value, S.E.M=Standard error of mean

Table 3. Species grouping from Duncan's multiple range test based on morphology

Species	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Fruit length (cm)	Fruit width (cm)	No of seeds per fruit	Pedicel length (cm)	Petal standard length (cm)	Petal standard width (cm)	Petal keel length (cm)	Petal keel width (cm)	Petal wing length (cm)	Petal wing width (cm)
<i>Desmodium tortuosum</i>	11.06 <sup>b</sup>	5.57 <sup>b</sup>	3.94 <sup>d</sup>	2.56 <sup>f</sup>	0.32 <sup>s</sup>	6.00 <sup>cd</sup>	1.37 <sup>a</sup>	0.48 <sup>f</sup>	0.41 <sup>h</sup>	0.48 <sup>h</sup>	0.29 <sup>e</sup>	0.41 <sup>s</sup>	0.21 <sup>s</sup>
<i>Desmodium scorpiurus</i>	6.26 <sup>d</sup>	2.67 <sup>ef</sup>	5.15 <sup>c</sup>	3.30 <sup>e</sup>	0.21 <sup>h</sup>	5.85 <sup>d</sup>	0.22 <sup>e</sup>	0.47 <sup>f</sup>	0.47 <sup>gh</sup>	0.41 <sup>h</sup>	0.21 <sup>f</sup>	0.47 <sup>fg</sup>	0.21 <sup>s</sup>
<i>Desmodium adscendens</i>	2.94 <sup>e</sup>	2.13 <sup>f</sup>	1.76 <sup>c</sup>	1.35 <sup>s</sup>	0.30 <sup>s</sup>	2.20 <sup>f</sup>	0.93 <sup>c</sup>	0.48 <sup>f</sup>	0.51 <sup>fg</sup>	0.48 <sup>h</sup>	0.21 <sup>f</sup>	0.48 <sup>fg</sup>	0.21 <sup>s</sup>
<i>Mucuna pruriens</i>	12.90 <sup>a</sup>	7.93 <sup>a</sup>	9.52 <sup>b</sup>	8.58 <sup>c</sup>	2.22 <sup>a</sup>	4.45 <sup>e</sup>	0.50 <sup>d</sup>	2.13 <sup>d</sup>	1.74 <sup>c</sup>	2.88 <sup>a</sup>	1.46 <sup>b</sup>	3.16 <sup>a</sup>	1.65 <sup>a</sup>
<i>Calopogonium mucunoides</i>	7.94 <sup>c</sup>	5.70 <sup>b</sup>	9.84 <sup>b</sup>	3.53 <sup>c</sup>	0.43 <sup>f</sup>	6.75 <sup>cd</sup>	0.00 <sup>f</sup>	0.58 <sup>f</sup>	0.58 <sup>f</sup>	0.77 <sup>g</sup>	0.31 <sup>e</sup>	0.51 <sup>f</sup>	0.21 <sup>s</sup>
<i>Cajanus cajan</i>	10.07 <sup>b</sup>	3.09 <sup>de</sup>	5.57 <sup>c</sup>	6.29 <sup>d</sup>	0.79 <sup>d</sup>	4.55 <sup>e</sup>	1.08 <sup>b</sup>	1.69 <sup>c</sup>	1.68 <sup>c</sup>	1.59 <sup>e</sup>	0.78 <sup>d</sup>	1.38 <sup>e</sup>	0.68 <sup>e</sup>
<i>Crotalaria retusa</i>	8.15 <sup>c</sup>	2.99 <sup>e</sup>	0.25 <sup>f</sup>	3.91 <sup>e</sup>	1.05 <sup>e</sup>	14.70 <sup>a</sup>	0.91 <sup>c</sup>	2.35 <sup>c</sup>	2.82 <sup>c</sup>	1.50 <sup>f</sup>	1.28 <sup>c</sup>	1.49 <sup>d</sup>	1.17 <sup>d</sup>
<i>Vigna unguiculata</i>	10.01 <sup>b</sup>	6.16 <sup>b</sup>	12.25 <sup>a</sup>	8.92 <sup>c</sup>	0.39 <sup>f</sup>	12.10 <sup>b</sup>	0.00 <sup>f</sup>	2.66 <sup>b</sup>	3.46 <sup>a</sup>	2.52 <sup>b</sup>	1.59 <sup>a</sup>	2.10 <sup>c</sup>	1.50 <sup>b</sup>
<i>Centrosema molle</i>	6.20 <sup>d</sup>	3.75 <sup>d</sup>	3.81 <sup>d</sup>	13.76 <sup>b</sup>	0.61 <sup>e</sup>	13.00 <sup>b</sup>	0.90 <sup>c</sup>	3.92 <sup>a</sup>	3.05 <sup>b</sup>	2.22 <sup>c</sup>	0.76 <sup>d</sup>	2.46 <sup>b</sup>	1.40 <sup>c</sup>
<i>Gliricidia sepium</i>	7.69 <sup>de</sup>	4.62 <sup>c</sup>	3.86 <sup>d</sup>	15.24 <sup>a</sup>	1.92 <sup>b</sup>	7.10 <sup>c</sup>	0.94 <sup>c</sup>	2.17 <sup>d</sup>	2.17 <sup>d</sup>	1.90 <sup>d</sup>	0.78 <sup>d</sup>	1.35 <sup>e</sup>	0.46 <sup>f</sup>

Means with the same superscript down the column were not significantly different (P < 0.0001)

petals: standard: 3.20 – 4.50 cm long and 2.40 – 3.50 cm wide, keel: 1.80 – 2.50 cm long and 0.6 – 0.90 cm wide, wing: 1.90 – 2.90 cm long and 1.00 – 1.80 cm wide, bright lilac with violet veining, papilionaceous in shape, 5 in number, pedicel 0.70 – 1.20 cm long (Fig. 9F).

Fruit: legume, aristate at apex, 8.20 – 16.60 cm long and 0.40 – 0.80 cm wide, green when fresh, brown when dry, glabrous, one row of seed per fruit (Fig. 9H).

Seed: bean-shaped, light brown to dark brown with black patches, shiny, glabrous, 6 – 8 seeds per fruit (Fig. 9E).

*Gliricidia sepium* (Jacq.) Walp. (Fig. 10)

Habit: tree (Fig. 10A).

Lifespan: perennial.

Leaf: compound-unipinnate, leaflet; 4.30 – 10.60 cm long and 3.20 – 6.30 cm wide, elliptic, obtuse at base, acute at apex, entire at margin, green, glabrous, exstipulate, petiolate, petiole 3.10 – 4.60 cm long (Fig. 10B).

Stem: erect, woody, solid, brown with white spots, cylindrical, glabrous (Fig. 10C).

Inflorescence: terminal panicle (Fig. 10D).

Flower: zygomorphic, sub sessile, calyx tube: green and reddish brown, campanulate, gamosepalous, glabrous; petals: standard: 2.10 – 2.20 cm long and 2.10 – 2.20 cm wide, keel: 1.80 – 2.00 cm long and 0.70 – 0.90 cm wide, wing: 1.30 – 1.40 cm long and 0.40 – 0.50 cm wide, pinkish purple with white at the middle of the standard, papilionaceous, 5 in number, pedicel 0.70 – 1.10 cm long (Fig. 10E and F).

Fruit: legume, flat, slightly ribbed, elongated, obtuse at apex, base narrow than apex, 12.30 – 19.50 cm long and 1.50 – 2.20 cm wide, green when fresh, brown when dry, glabrous, one row of seed per fruit (Fig. 10G).

Seed: orbicular with prominent hilum, dark brown and coarse, not pubescent, 4 – 10 seeds per fruit (Fig. 10H).

## Discussion

Many authors have stressed morphological characters as taxonomic tools. These include Hutchinson and Dalziel (1958), Terrel and Winters (1974), Isawumi (1985), Adedeji and Illoh (2005) and Adedeji (2005, 2006).

El-Gazzar *et al.* (2013) reported that the only common feature of all classificatory systems of the Papilionoideae is the recognition of tribes and sub-tribes on the basis of a limited range of floral traits, with greater emphasis on petal morphology and stamen arrangement. Such a limited number of characters were used often singly to distinguish between chunky assemblages of genera.

In the current study, additional traits, further from those reported by Hutchinson and Dalziel (1958), which are quite diagnostic for the taxonomy of the subfamily, were herein reported. Additional traits which previous researchers have not reported include life span; leaf/leaflet apex, base, margin and pubescence; stem type, colour, shape and pubescence; sepal colour and pubescence; nature of margin of petal standard and presence or absence of pedicel; fruit colour, pubescence, tip and shape; seed colour, shape, surface and presence or absence of prominent hilum on the seed.

The morphological characters used for this study are sufficient in establishing the relationships among the species

of Papilionoideae studied. Thirty eight qualitative and thirteen quantitative traits employed have been reported in the current study.

Joelri *et al.* (2011) reported in their work on *Crotalaria* in South India that leaves, simple or compound, is a major feature in developing taxonomic key based on morphological characters. In this study, leaves were compound except in the case of *Crotalaria retusa*, which was the only species with simple leaves; this can be used to delimit it from the other species. *Gliricidia sepium* (Tribe Robinieae) which was the only species that had compound-once pinnate leaves, can further be separated from the other species which had compound-trifoliolate leaves. This also justifies its separation from other tribes. Rahman and Rahman (2012) used leaf shape to group *Desmodium alatum* and *Desmodium auriculatum* together and separated them among 14 species of *Desmodium* studied. Adedeji (2006) also reported that the shape of the upper leaves can be used in the taxonomy of the genus *Emilia*. Leaf shape was also used by Joelri *et al.* (2011) to discriminate *Crotalaria verrucosa* from the rest of *Crotalaria* species studied in South India.

In the hereby study, leaf/ leaflet shapes can also be used to delineate the species of *Desmodium* from one another and other species studied. Leaflets of *Desmodium tortuosum* were ovate, those of *Desmodium scorpiurus* were elliptic, while those of *Desmodium adscendens* were obovate in shape. Leaflets of *Mucuna pruriens* and *Calopogonium mucunoides* were wide ovate to wide elliptic. *Crotalaria retusa* in the tribe Crotalarieae was the only species with oblanceolate leaf shape and this also delineated it from other tribes.

The stem of *Crotalaria retusa* was cylindrical in shape, with vertical ridges, while that of *Cajanus cajan* was cylindrical, with distinct angles. *Desmodium tortuosum* was the only species that had ringed stem. *Desmodium scorpiurus* had triangular shaped stem, while that of *Centrosema molle* was twisted. *Crotalaria retusa* was the only species with hollow stem, whereas all others had solid stems. These characters of stem can be used to delimit the taxa studied.

Variation also occurred within the petal colour among the species. However, all *Desmodium* species studied had pinkish purple flowers. This supports their grouping into the same tribe Desmodieae. Joelri *et al.* (2011) separated *Crotalaria laburnifolia* and *Crotalaria pallida* from other *Crotalaria* species studied using reddish brown stripes at the keel petals. In this study, bright yellow petals with reddish brown veining on the standard were recorded for *Cajanus cajan* and *Crotalaria retusa*. This can be used to group them apart; even more, standard petal of *Cajanus cajan* was indented at margin and this can be used to separate it from *Crotalaria retusa* and other species which were entire at margin.

Daiane *et al.* (2014) reported the importance of the form of loment margin as identification key for *Desmodium* species studied in Santa Catarina, Brazil. Fruits were legume except in *Desmodium* species from the tribe Desmodieae, which were lomentum, and this delimited the tribe from other tribes studied. However, *Desmodium adscendens* can be separated from other *Desmodium* species because its

fruit were deeply indented on one side only, while others were indented on both sides. There were variations also in the shape, colour and surface of seeds. These characters can also delimit the species. *Crotalaria retusa* had reniform (kidney-shaped) seeds, *Desmodium scorpiurus* was cylindrical, while others were bean shaped. This can be of taxonomic value.

The current study reports that *Crotalaria retusa* was the only species with simple leaves, oblanceolate leaf shape, cuneate leaf base, sub sessile leaves, hollow stem and reniform seed shape. These distinct characters justify the delimitation of *Crotalaria retusa* in the tribe Crotalariaeae from the other tribes in the sub-family. Quantitatively, *Desmodium adscendens* had the lowest leaf size (both length and width). Petiole length of the pair *Mucuna pruriens* and *Calopogonium mucunoides*, as well as the pair *Centrosema molle* and *Gliricidia sepium* were not significantly different. These characters can be used to separate these taxa from other species. *Desmodium tortuosum* had the longest pedicel length.

As regards petal values, petal standard length, petal keel length and petal wing width are more useful in separating or delineating the genera and tribes than the values for leaf length and width, petiole length, fruit length and width, number of seeds per fruit and pedicel length. These petal values were not significantly different within the three species in the genus *Desmodium*, but were significantly different between the other genera studied. However, the leaf length, petiole length, fruit length, number of seeds per fruit and pedicel length values can be used to delineate the species within the genus *Desmodium* as the values were significantly different within each character for the *Desmodium* species.

## Conclusions

This study hereby reported that the important characters that can be used in establishing taxonomic relationship in the sub-family Papilionoideae are leaf type, leaf shape, leaf base, petiole type, stem shape, petal colour, petal margin and seed shape.

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