TAXONOMIC DELIMITATION OF SPECIES OF *Senna* AND *Cassia* IN AHMADU BELLO UNIVERSITY, ZARIA

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Abstract: The foliar epidermal characters of species of *Senna* and *Cassia* were studied in Ahmadu Bello University, Zaria in search for useful taxonomic characters; these include *Senna alata* (L.) Roxb., *S. hirsuta* (L.) Irwin and Barneby, *S. obtusifolia* (L), *S. occidentalis* (L.), *S. siamea* (Lam.), *S. singueana* (L), *S. siberiana* (L) and *Cassia absus*. All species were shruby except for *senna siamea* and *S. alata* which are either shruby or trees. The stomata found were paracytic and anisocytic in most of the studied species except for *S. hirsutae and S. siberiana* which were paracytic all through. There was variability in the length which was highest in *S. hirsutae* (2.22 µm) and lowest in *S. siamea* (1.32 µm) of their stomata and the frequency, highest in *S. hirsutae* (42.75 µm) and lowest in *S. obtusfolia* (18.55 µm) reflects their taxonomic delimitation. These stomata were found both on the abaxial and adaxial surfaces of the studied plants (amphistomata). A dichotomous taxonomic key was constructed to aid the identification of the studied *Senna* and *Cassia* species.

Keywords: Folia mophology, delimitation, leaf, *Stomata*, *Cassia*, *Ceasalpinoideae*

Introduction

Ceasalpinoideae is a large sub-family of about 150 genera with 2000-3000 species of flowering plants in the order fabales (Eddy, 1997). The genus *senna* is native throughout the tropics with a few species extending in to the temperate regions. Many of them have economic importance for ornamental and natural medicine purposes, wood production, degraded area restoration (Kissmann *et al*., 1992) and also vegetable source. *Senna* comprises around 350 species and was divided into six sections: Psilorhegma, Chamaefistula, Senna, Peiranisia, Paradyction and Astroites (Irwin & Barneby, 1982; Randell and Barlow, 1998). In West Africa, the genus contains about 22 indigenous species apart from those introduced (Hutchinson and Daziel, 1958). Then, Burkill (1995) reported about 19 species in West African floristic region with the whole 19 species in Nigeria (Soladoye and Lewis, 2003) and at least 8 species in South Western Nigeria especially in Oyo and Ogun States. There is great diversity in habits ranging from trees approaching 34 m in height to prostrate annual herbs. Some members are ornamental e.g. *Senna siamea* (Olorode, 1984). Other members are used as commercial timbers and a great number of them have been reported to be used in herbal medicines especially laxatives (Ayensu, 1978). The type species for the genus is *Senna alexandrina*. The leaves are pinnate with opposite paired leaflets. The inflorescences are racemes located at the ends of branches or emerging from the leaf axils (Olorode, 1988). The flower is one of the constant characters found in this genus despite its great diversity of forms. The flower has five sepals and five yellow petals. There are ten straight stamens which can be of different sizes, and some are staminodes. The fruit is a legume pod containing several seeds of varying length, size and may assume different shapes (Olorode, 1988). *Senna* species are pollinated by a variety of bees, especially large female bees in genera such as *Xylocopa* (Marazzi *et al.*, 2000).

Species delimitation is an integrative field that depends on increasingly diverse data types, yet it remains rife with arguments and opposing approaches. The use of leaf micro morphological and epidermal features has been found to be of immense interest in taxonomy and have been used by many authors in plant identification (Nwachukwu *et al.*, 2007). Taxonomy of *Senna* and *Cassia* species is also important because of the medicinal values of the genus which when taken in excess may be poisonous to the body hence proper identification of the species using epidermal structures, It is in view of this, that this study is designed to delimit these plant species and provide more taxonomic evidence in order to reduce the misuse of the species.

Materials and Method

Study site

This research was carried out at the Botany Department, Ahmadu Bello University (ABU), Zaria (Altitude 610 m above sea level, latitude 11˚ 12'N and longitude 07˚33'E), Nigeria. Samaru lies in the Northern Guinea Savanna agro ecological zone of Nigeria with a mean annual rainfall of about 1100 m. Rainfall is essentially between May - October and dry season between October - April. Hottest month is around March - April, and the mean daily Temperature is about 27^{0}C. The coldest Month is between November – Mid February (Osuhor *et al*., 2004).

Plant collection

Seven species of *Senna* were studied which include *Senna alata* (L.) Roxb., *S. hirsutae*(L.) Irwin and Barneby, *S. obtusifolia* (L.) Irwin and Barneby, *S. occidentalis* (L.) Link,*S. siamea* (Lam.) Irwin and Barneby, *S.singueana* (L),*S. siberiana* (L) and *C. absus*.The specimens were collected from different locations within the University premises.The names of the species and coordinates are provided in Table 1.

Table 1: Location of *Senna* and *Cassia* species in Ahmadu Bello University, Zaria

S/No	Name of Taxa	Longitude	Latitude	Voucher Number	Site of collection
1	*Senna alata*	E007˚ 38.23	N11˚ 09.39	1236	Botanical Garden, ABU, Zaria.
2	*Senna siberiana*	E007˚ 39.40	N 11˚ 08.62	900218	Botanical Garden, ABU, Zaria.
3	*Senna obtusfolia*	E007˚ 38,79	N11˚ 09. 07	1370	ABU Press, Zaria.
4	*Senna hirsutae*	E007˚ 38.78	N11˚ 09. 22	7174	ABU Water Board, Zaria.
5	*Senna siamea*	E007˚ 36. 84	N11˚ 09. 39	900202	Botanical Garden, ABU, Zaria.
6	*Senna singueana*	E007˚ 39. 40	N11˚ 08.63	900109	Botanical Garden, ABU, Zaria.
7	*Senna occidentalis*	E007˚38. 84	N11˚ 09.06	1047	ABU Waterboard, ABU, Zaria.
8	*Cassia absus*	E007˚ 38.85	N11˚ 09.07	3106	ABU Press, ABU, Zaria.

Foliar morphology
Fifty (50) samples of matured leaf per species were used for assessment of morphological character. Characters such as leaf texture, leaf shape, leaf base, leaf apex and leaf margin were observed and qualitative photographs were taken using a Samsung HD camera model.

Stomatal study
The method of Pant and Verma (1974) was adopted. Fresh foliar materials were collected from mature plants in the study area. The leaves were fixed in formalin acetic alcohol (FAA) for 24 h and washed in 70% ethanol. For mature stomatal types study, epidermal peels were obtained using a pair of sharp forceps on both surfaces of mature leaves after loosening the epidermis with a razor blade. The peels were placed on a microscope slide and stained with methylene blue and covered with a clean cover slip and observed under the microscope. Characters of upper epidermal cell number, lower epidermal cell number, upper epidermal cell pattern, lower epidermal cell pattern, stomata type, stomata number on both epidermal cell surfaces, stomata length on both surfaces, stomata width on both surfaces, stomata size on both surfaces and frequency were observed, measured and then recorded. In addition, trichome type, number, length, width and size were observed, measured and recorded using a calibrated eye piece micrometer from 50 different epidermal cell peels. Photomicrograph was taken using a Samsung HD camera model A4CDNOC7000RDZ attached to a light microscope.

Results and Discussion
The studied species all were amphistomatic, meaning stomata occurs on both surfaces. The stomata varied among the species with paracytic occurring in all except *Sennasiamea* and *Cassia absus* where only anisocytic stomata was observed. Both paracytic and anisocytic stomata were observed in the abaxial surface of *Senna alata*, *Sennaoccidentalis* and *Senna obtusfolia*. The epidermal cell shape found in the species was polygonal except in *Senna alata* and *Sennahirsutea* where irregular pattern was observed (Table 2). Anticlinal wall found was wavy to straight in the studied species except *Senna siamea* that was found to be curved. The seed properties were also considered where the seed color varied, seed texture was smooth except in *Senna alata* and *Senna singueana* that were rough textured. The leaf morphological variations of all the plant species were shown, where the apex of the leaves was round in *S. alata* and acuminate in *Senna occidentalis*. Habit was all shrubby except *S. alata* and *S. siamea* that were either shrubby or trees. The leaf shape was ovate in most species except *Senna siamea* that was linear. Leaf base was either acute or obtuse (Table 3).

Table 2: Epidermal characters in *Senna* and *Cassia* species in Ahmadu Bello University, Zaria

S/N	Taxa	Epidermal cell shape		Anticlinal wall shape		Stomatal type	
		Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial
1	*S. alata*	Polygonal	Irregular	Straight	Curved	Anisocytic	Paracytic and anisocytic
2	*S. siberiana*	polygonal	polygonal	Curved	Curved	Paracytic	Paracytic
3	*S. hirsutae*	Polygonal	Irregular	Slightly straight	Curved	Paracytic	Paracytic
4	*S. siamea*	Polygonal	Polygonal	Slightly straight	curved	Anisocytic	Anisocytic
5	*S. singueana*	Polygonal	Polygonal	Slightly straight	Straight	Paracytic	Anomocytic
6	*S. obtusfolia*	Polygonal	polygonal	Slightly straight	Straight	Paracytic	Paracytic and anisocytic
7	*S. occidentalis*	Irregular	Polygonal	Slightly curved	Curved	Paracytic	Anisocytic and paracytic
8	*C. absus*	polygonal	Polygonal	Curved	Irregular	Anisocytic	Anisocytic

Table 3: Leaf morphological features of *Senna* and *CassiaSpecies* studied in Ahmadu Bello University, Zaria

S/N	Taxa	Apex	Shape	Base	Habit	Hausa Name
1	*S.alata*	Round	Oblong	Oblong-Obov	Shrub/tree	Claskonbature
2	*S. siberiana*	Obtuse	Oblong	Round	Shrub	Gamafada
3	*S.hirsutae*	Acute	Ovate	Acute	Shrub	Asuta
4	*S.singueana*	Round/obtuse	Ovate	Obtuse	Shrub	Runhu
5	*S.siamea*	Micronulates	linear	Obtuse	Tree	Runhunbature
6	*S. obtusfolia*	Obtuse	Obovate	Acute	Shrub	Tafasa
7	*S.occidentalis*	Acuminate	Ovate	Acute	Shrub	Rai dore
8	*C.absus*	Obtuse	Ovate	Round	Shrub	Pidili

There was presence of non-glandular unicellular and unbranched trichome in all species except *S. obtusfolia* which had multiseriate trichomes. *S. siberiana* (83.85 µm) had significant number per field of view in the upper surface and the least number was in *S. alata* (25.90 µm). There was significant difference in length in the upper trichrome which was highest in *S. singueana* (25.13 µm) and the least was in *S. siamea* (0.50 µm). The width was highest in *S. alata* (4.55 µm) and least in *S. siberiana* (1.68 µm).

There was significant difference in the number per field of view in the lower trichrome surface as *S. singueana* had a highest number of non-glandular unicellular unbranched trichrome recordings (80.80 µm) (Table 4). The least was recorded in *S. siamea* (3.74 µm). Length was found to be highest in *Cassia absus* (24.57-1.48 µm) and *S. siamea* (5.32 µm) recorded the least length in the lower surface. The width was highest in *S. alata* (4.34 µm) and *S. obtusfolia* (0.53-0.23 µm).

The components of stomata in various sampled species of plants are shown in Table 5 where *S. obtusifolia* (25.60 µm) had the highest number with *C. absus* (11.05 µm) been the least. In the lower surfaces, *S. hirsutae* (42.75 µm) recorded the highest NPV value and the least was *S.siberiana* (3.12-0.02 µm). *Senna siberiana* (166.95 µ) had highest NE contents in the upper surface where *C. absus* (51.05-1.92 µm) recorded the lowest. The number of epidermal cell in lower surfaces of plants species was highest in *S. siamea* (162.40 µm) and the least in *C. absus* (70.9-1.96 µm). Upper surfaces of *S. hirsutae* (6.00 µ) had the highest SL while *S. siamea* (4.20 µm) had the least. *Senna hirsutae* (2.22 µ) recorded significantly better SL also in the lower surface while *S. siamea* (1.32 µm) recorded the least.

There was significant decrease in SW concentration upper surfaces of leaves plants species from *S. occidentalis* (3.70 µm) with *S. singueana* (1.36-0.10 µm). There was no significant difference in SW value in the lower leave surfaces of all the sampled plants species. The highest and the lowest SW value was obtained in *S. hirsutae* (1.51 µm) and *S. obtusifolia* (0.85 µm), respectively. The PL value of the upper leave surface was highest in *C. absus* (3.05 µm) while *S. siamea* (1.80 µm) had the least. Similarly, PL concentration in the leave lower surface did not differ significantly among the plants species; *S. occidentalis* (1.42 µm) was the highest, while *S. alata* (0.83 µm) had the least.

The PW value in the upper surface was highest in *S. singueana* (3.83-0.17 µm) with *S. siamea* (1.15 µm) having the least. PW value in lower surfaces of plant species did not differ significantly. The highest and the lowest SW value was obtained in *S. hirsutae* (1.51 µm) and *S. obtusifolia* (0.85 µm). The PL value of the upper leave surface was highest in *C. absus* (3.05 µm) while *S. siamea* (1.80 µm) had the least. Similarly, PL concentration in the leave lower surface did not differ significantly among the plants species; *S. occidentalis* (1.42 µm) was the highest, while *S. alata* (0.83 µm) had the least.

The PW value in the upper surface was highest in *S. singueana* (3.83-0.17 µm) with *S. siamea* (1.15 µm) having the least. PW value in lower surfaces of plant species did not differ significantly. S-size of the upper surface of *S. occidentalis* (21.42 µm) was highest and *S. siamea* (9.68 µm) had the least S-Size. The S-size in the lower surface was highest in *S. hirsutae* (340-0.21 µm) and the lowest S-size value was obtained in *S. obtusifolia* (1.36 µm).The upper surface P-Size of *S. hirsutae* (4.80 µ) was highest. The P-size of the all the lower leave surfaces of plants species did not differ significantly but it was largest in *C. absus* (0.78 µ), while *S. alata* (0.32 µ) had the lowest value.

Table 4: Distribution of Trichome in the surfaces of *Senna* and *Cassia* species in Ahmadu Bello University, Zaria (µm)

S/N	Plant species		Unicellular			Multicellular		
		Surfaces	NPV	LT	WT	NPV	LT	WT
1	*S. obtusfolia*	Upper	14.70±1.72^{d}	18.31±2.38^{bc}	4.45±1.49^{a}	1.35±0.68^{c}	3.78±1.74^{bc}	0.81±0.35^{b}
		Lower	20.65±2.07^{c}	22.61±3.85^{a}	1.89±0.13^{bc}	2.05±1.11^{e}	6.58±2.65^{d}	0.53±0.23^{c}
2	*S. siamea*	Upper	20.95±2.74^{cd}	10.5±0.98^{d}	2.00±0.17^{b}	ND	ND	ND
		Lower	3.74±1.61^{e}	5.32±1.53^{c}	0.91±0.25^{d}	ND	ND	ND
3	*S. singueana*	Upper	46.80±1.88^{d}	25.13±2.00^{a}	2.42±0.13^{b}	ND	ND	ND
		Lower	80.80±3.53^{a}	22.68±1.87^{a}	1.96±0.11^{b}	ND	ND	ND
4	*S.occidentalis*	Upper	ND	ND	ND	ND	ND	ND
		Lower	11.10±0.73^{d}	19.18±1.27^{b}	3.96±0.15^{a}	ND	ND	ND
5	*S. alata*	Upper	25.90±2.63^{c}	20.65±1.05^{abc}	4.55±0.22^{a}	ND	ND	ND
		Lower	26.60±2.23^{b}	16.38±0.87^{b}	4.34±0.25^{a}	ND	ND	ND
6	*S. siberiana*	Upper	83.85±4.43^{a}	17.50±1.20^{c}	1.68±0.07^{c}	ND	ND	ND
		Lower	47.65±3.60^{a}	14.84±0.88^{c}	1.47±0.05^{b}	ND	ND	ND
7	*S.hirsutae*	Upper	14.70±1.89^{d}	22.89±2.31^{ab}	1.71±0.19^{b}	ND	ND	ND
		Lower	12.90±1.22^{d}	22.61±2.08^{a}	1.51±0.12^{c}	ND	ND	ND
8	*C. absus*	Upper	39.9±3.34^{b}	15.75±0.99^{c}	1.96±0.15^{b}	ND	ND	ND
		Lower	40.6±1.55^{b}	24.57±1.48^{a}	1.79±0.19^{b}	ND	ND	ND

Means with different superscripts along the column differed significantly ($P < 0.05$)

NPV = Number per view, LT= length, WT= width, ± Plus or minus standard error, ND= not detected

Table 5: Distribution of stomata in the leave surfaces of *Senna and Cassia* species in Ahmadu Bello University, Zaria

S/N	Plants species	Surfaces	NPV	NE	SL(µm)	SW(µm)	PL(µm)	PW(µm)	S-Size(µm)	P-Size(µ)
1	*S. obtusfolia*	Upper	25.60±2.02^{a}	141.25±7.08^{b}	4.83±0.25^{c}	2.60±0.14^{de}	2.35±0.13^{c}	1.40±0.09^{bc}	13.34±1.21^{c}	3.33±0.35^{b}
		Lower	18.55±1.56^{bc}	126.15±1.80^{b}	1.56±0.09^{d}	0.85±0.04^{a}	0.99±0.07^{a}	0.34±0.00^{b}	1.36±0.12^{c}	0.33±0.02^{c}
2	*S. siamea*	Upper	20.40±1.92^{ab}	153.80±7.71^{ab}	4.20±0.26^{d}	2.25±0.18^{e}	1.80±0.14^{d}	1.15±0.05^{c}	9.68±1.31^{c}	2.06±0.20^{c}
		Lower	18.35±2.30^{bc}	162.4±4.69^{a}	1.32±0.09^{e}	1.32±0.51^{a}	1.22±0.51^{a}	0.37±0.02^{b}	1.94b±0.88^{bc}	0.44±0.88^{a}
3	*S. singuena*	Upper	10.15±0.60^{c}	83.95±4.59^{d}	1.87±0.07^{e}	1.36±0.10^{f}	5.52±0.32^{a}	3.83±0.17^{a}	2.13±0.18^{d}	0.22±0.02^{d}
		Lower	4.05±0.36^{d}	85.79±2.49^{d}	1.70±0.07^{c}	0.86±0.05^{a}	0.71±0.02^{a}	0.39±0.02^{b}	1.39±0.14^{c}	0.26±0.02^{d}
4	*S. occidentalis*	Upper	25.85±2.88^{a}	155.9±9.19^{ab}	5.75±0.16^{ab}	3.70±0.15^{a}	2.75±0.14^{bc}	1.48±0.09^{b}	21.42±1.15^{a}	4.07±0.35^{ab}
		Lower	22.85±1.76^{b}	158.1±7.62^{a}	1.96±0.06^{bc}	1.39±0.07^{a}	1.42±0.50^{a}	0.54±0.05^{a}	2.72±0.16^{bc}	0.68±0.16^{a}
5	*S. alata*	Upper	19.25±1.43^{b}	145.5±9.64^{ab}	5.35±0.20^{bc}	3.13±0.17^{bc}	2.50±0.13^{c}	1.30±0.08^{bc}	16.95±1.25^{b}	3.31±0.34^{b}
		Lower	22.35±1.64^{b}	107.45±6.51^{c}	1.9±0.06^{c}	1.09±0.05^{a}	0.83±0.04^{a}	0.38±0.02^{b}	2.12±0.13^{bc}	0.32±0.13^{c}
6	*S. siberiana*	Upper	20.20±1.07^{ab}	166.95±7.88^{a}	5.05±0.15^{c}	2.55±0.14^{de}	2.63±0.17^{bc}	1.18±0.08^{c}	13.05±0.91^{c}	3.30±0.48^{b}
		Lower	3.12±0.02^{e}	79.34±3.54^{e}	1.53±0.05^{d}	0.72±0.04^{a}	0.57±0.01^{a}	0.34±0.01^{b}	1.04±0.10^{d}	0.24±0.01^{d}
7	*S. hirsute*	Upper	21.55±1.90^{ab}	105.20±3.06^{c}	6.00±0.18^{a}	3.48±0.19^{ab}	3.00±0.14^{b}	1.55±0.10^{b}	21.33±1.63^{a}	4.80±0.46^{a}
		Lower	42.75±1.87^{a}	126.60±9.25^{b}	2.22±0.08^{a}	1.51±0.07^{a}	1.16±0.05^{a}	0.57±0.05^{a}	3.40±0.21^{a}	0.69±0.08^{a}
8	*C. abrus*	Upper	11.05±0.45^{c}	51.05±1.92^{e}	5.65±0.17^{ab}	2.95±0.15^{cd}	3.05±0.14^{b}	1.30±0.08^{bc}	16.90±1.19^{b}	4.03±0.37^{ab}
		Lower	15.25±0.73^{c}	70.9±1.96^{d}	2.14±0.08^{ab}	1.12±0.07^{a}	1.16±0.07^{a}	0.53±0.06^{a}	2.52±0.24^{abc}	0.78±0.24^{a}

Means with different superscripts along the column differed significantly ($P<0.05$)

NPV=Number Per View, S-Size=Stomata Size, P-Size=Pore size, NE=Number of Epidermal Cell, SL=Stoma length, PW=Pore width SW=Stomata width, PL=Pore length,± Plus or minus standard error

The variations among the species were used to construct the dichotomous Taxonomic key below;

1. Trees-----2
1. Shrubs-----4

2. Leaflets linear------ *Senna siamea*
2. Leaflets ovate------3

3. Seed colour black----- *Senna singueana*
3. Seed colour white-----4

4. Fruit hairy------ *Senna hirsutae*
4. Fruit not hairy----5

5. Seed obovate------ *Cassia absus*
5. Seed Oval-------6

6. Abaxial Trichomes glandular and multicellular----7
6. Adaxial Trichomes non glandular and multiseriate------ *Senna obtusfolia*

7. Adaxial Trichomes non glandular and unicellular------ *Senna alata*
7. Adaxial Trichomes and glandular multicellular-----8

8. Abaxial Stomata anomocytic-------9
8. Adaxial and Abaxial Stomata paracytic----*Senna siberiana*

9. Epidermal cell irregular
9. Epidermal cell polygonal--------*Senna occidentalis*

Taxonomically, *Senna* and *Cassia* are very complex genus owing to the polymorphism of a number of species and the absence of intrageneric incompatibility. Interspecific and unprogressive hybridization between related species is a very common feature of these genera and the main cause of variation. The resulting hybrids often have intermediate or mixed morphological characteristics and chemical compounds (Horwath *et al*., 2008). According to Dalin *et al.* (2008), trichome density and morphology vary among species, population and within individual plants and that trichome density evolve as a result of response to several environmental factors as plants with high trichome density are expected in areas that are dry or cold and the ultraviolet radiation is intense. Metcalf and Chalk (2006) were also of the opinion that trichome frequency and size are environmentally controlled as species within same genera vary with respect to trichome number and size. The trichome number produced and density vary also genetically with several species. The non-glandular trichomes associated with cystoliths bodies in the basal portion and with partially calcified walls, called cystoliths-hairs, are widely distributed in *Senna* and *Cassia* species and responsible for the wrinkled leaf surface as the case of *S. singueana* as stated by Metcalfe and Chalk (1957).

The stomata characters in the studied species show the presence of different types of stomata with paracytic type occurring in almost all species. The occurrence of these stomata indicates how closely related these species are. In addition to paracytic stomata, anisocytic stomata were found in *Senna siamea* and *Cassia absus.* Metcalf and Chalk (1979) reported the occurrence of paracytic stomata in *Mimosaceae* family. The diversity of stomata types on the same surface of an organ indicates its weakness in using stomata as a taxonomic tool (Kidwai and Pant, 1964). However, Gopal (1970) is of the opinion that the most frequent stomata type can be used as a taxonomic character. *Senna hirsutea* has the highest length which according to Abubakar *et al*. (2011), may be an indication of efficient gaseous exchange as increased stomatalength ensures efficient gaseous exchange that affect the efficiency of photosynthesis of the plant species and that such features ensure high adaptability to new environment. The frequency of stomata was found to be higher in the upper than lower surface in the studied species. The preponderance of stomata on the upper than lower surface is a mechanism to reduce water loss through transpiration (Adegbite, 2008). Several ecological factors may influence this distribution very strongly (e.g. humidity, wind, position of the leaf on the stem). The number of upper epidermal cell was also generally high compared to lower surface in all the plants species. High epidermal cells that are associated with upper stomata may be due to their location in the leave which is directly in contact with the sun light. Exposure to direct sun rays could lead to development of thicker epidermal cells as noted in all the species.

This study has also shown that *S. siamea* and *C. absus* also have some relations in that they have polygonal epidermal cells and anisocytic stomata but differ in anticlinal wall type. *S. obtusfolia* can easily be distinguished from the other species of *Senna* by presence of glandular multicellular trichomes *S. occidentalis* and *S. hirsutae* also share some characteristics with epidermal cells been polygonal, paracytic stomata, morphological characteristics also like acute base, ovate leaf shape, acute apex and oval seed shape (Saheed and Illo, 2010). Results obtained from the present study have been found congruent with that of Ogundipe *et al*. (2009) and Shaheed and Illo (2010).

Conclusion

Results obtained from this study show that the morphological features of the leaves revealed vital information which may play an important role in identification of species. The similarities in epidermal structure showed interspecies relationship and reason for them to be in the same family while differences showed reason for them to exist as distinct species.

References

Abubakar BY, Muazu S, Khan AU & Adamu AK 2011. Morpho-anatomical variation in some accession of *Moringa oleifera* Lam. From Northern Nigeria. *Afri. J. Plant Sci.*, 5(12): 742-748.

Adegbite A 1995. Leaf epidermal studies in three Nigerian species of *Aspilia* (Heliantheae-Asteraceae) and Two hybrids. *Nig. J. Bot*any, 8: 25-33.

AyensuEZ 1978. Medicinal Plants of West Africa. Reference Publication Inc. Michigan USA.

Burkill HM 1995.. *The Useful Plants of West Tropical Africa*, Ed2, Vol. 3, Royal Botanic Gardens, Kew. London, pp. 150-167.

Dalin P, Jon A, Christer B, Pirita H & Katri K 2008. Leaf trichome formation and plant resistance to herbivory book chapter, p. 4.

Eddy MQ 1997. Taxonomic significance of foliar epidermal dermo types and floral trichomes in some taxa of *Cuban indigofera* L.(Fabaceae). *Polibotanica*, 6: 1-8.

Gopal BV 1970. Structure and development of stomata on vegetative and floral organs of some *Amaryllidaceae. Annals of Botany* 34: 737-749.

Hutchison J & Dalziel JM 1958. *Flora of West Tropical Africa*. Vol I part 2. The Whitefraius press Ltd. London.

Irwin HS & Barneby RC 1982. *Review of Cassinae in the New World*. Memoirs of the New York Botanical Garden, 35: 1 – 918.

Kidwai P & Pant DD1964. Diversity in the development and organization of stomata in the *Phylanodiflora* (L). *Green Current Science*, 33: 653-654.

Kissmann KG & Groth D 1992. *Plantas infestantes e nocivas*. BASF Brasileira S.A., S˜ao Paulo, 798.

Marazzi B, Endress KP, de Queiroz LP & Conti E 2006. Phylogenetic relationships within *Senna* (Leguminosae, Cassiinae) based on three chloroplast DNA regions: patterns in the evolution of floral symmetry and extrafloral nectaries. *Amer. J. Botany*, 9(2): 288–303. doi:10.3732/ajb.93.2.288

Metcalfe CR & Chalk L 1957. *Anatomy of the dicotyledons*. Volume 2. Oxford University Press, Oxford.

Nwachukwu CU, Mbagwu FN & Onyeji AN 2007. Morphological and leaf epidermal features of *Capsicum annuum* and *Capsicum frutescens* Solanaceae. *Nature and Science*, 5(3): 54-60.

Ogundipe OT, Kadiri, AB & Adekanmbi OH 2009. Foliar epidermal morphology of some Nigerian species of *Senna* (Caesalpiniaceae). *Indian J. Sci. and Techn.*, 2(10): 5-9.

OgunkunleATJ & Ladejobi TA 2006. Ethnobotanical and phytochemical studies on some species of *Senna* in Nigeria. *Afri. J. Biotechnology*, 5(21): 2020-2023.

Olorode O 1984. *Taxonomy of West African flowering plants*. Longman Group Limited. The Book Project, Obafemi Awolowo University, Ile-Ife, Nigeria.

Pant DD & Verma BK 1974. Taxonomy of the genus *Ephedra*. Significance of stem and leaf epidermis and cuticle. *Botanical J. Linnean Society.*, 9: 287-308.

Randell BR & Barlow BA 1998. In: A. S. George (executive editor). Australian Government Publishing Service: Canberra, Australia. *Flora of Australia*, 12: 89-138.

Saheed SA & Illoh HC 2010. A taxonomic study of some species in *Cassiinae* (Leguminosae) using leaf epidermal characters. *Not. Bot. Hort. Agrobot. Cluj.*, 38(1): 21-27.

Soladoye MO & Lewis GP 2003. A checklist of Nigerian legumes. *CENRAD*, 12-14.

APPENDICES

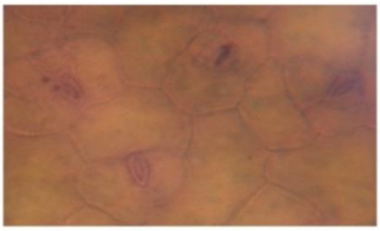

Plate 1a: Abaxial Surface of *Cassia absus* showing anisocytic stomata with polygonal epidermal walls using mg 40x

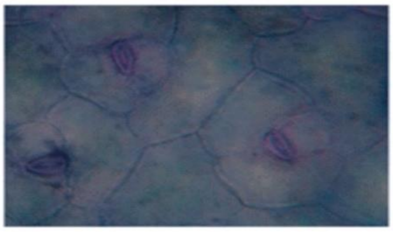

Plate 1b: Adaxial Surface of *Cassia absus* showing anisocytic stomata with polygonal epidermal walls using mg 40x

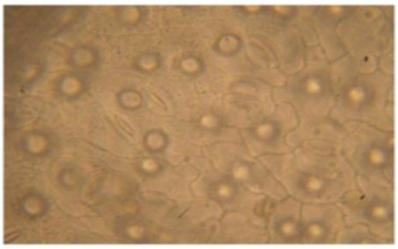

Plate 2a: Abaxial Surface of *Senna alata* showing anisocytic stomata with polygonal epidermal walls using mg 40x

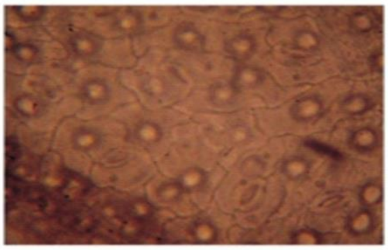

Plate 2b: Adaxial Surface of *Senna alata* showing anisocytic stomata with polygonal epidermal walls using mg 40x

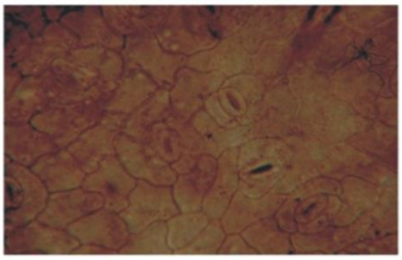

Plate 3a: Abaxial Surface of *Senna siamea* showing anisocytic stomata with polygonal epidermal walls using mg 40x

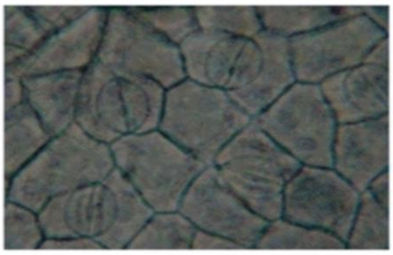

Plate 3b: Adaxial Surface of *Senna siamea* showing anisocytic stomata with polygonal epidermal walls using mg 40x

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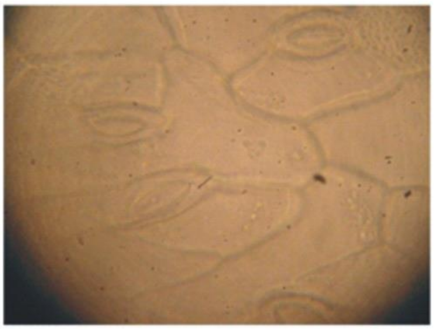

Plate 4a: Abaxial Surface of *Senna siberiana* showing *para*cytic stomata with polygonal epidermal walls using mg 40x

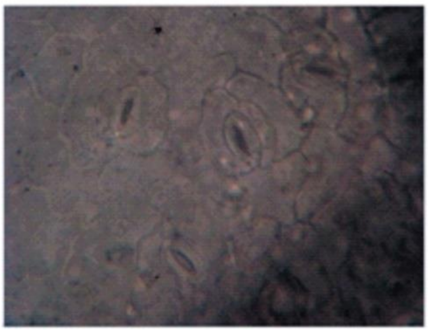

Plate 4b: Adaxial Surface of *Senna siberiana* showing *aniso*cytic stomata with polygonal epidermal walls using mg 40x

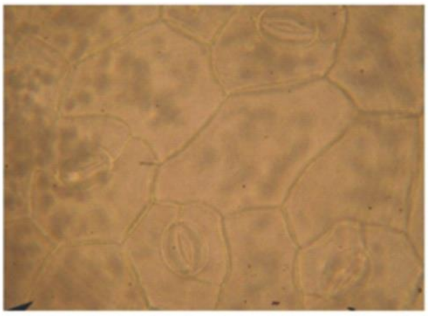

Plate 5a: Abaxial Surface of *Senna Obtusfolia* showing paracytic stomata with polygonal epidermal walls using mg 40x

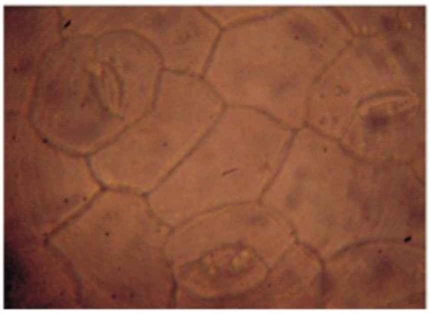

Plate 5b: Adaxial Surface of *Senna Obtusfolia* showing paracytic stomata with polygonal epidermal walls using mg 40x

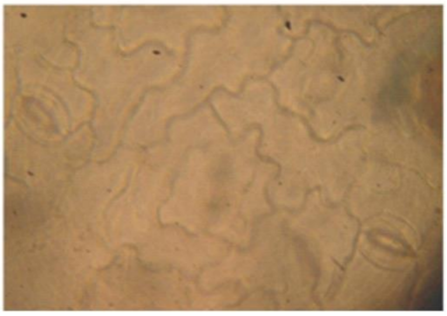

Plate 6a: Abaxial Surface of *Senna hirsuta* showing *aniso*cytic stomata with *Curved*l epidermal walls using mg 40x

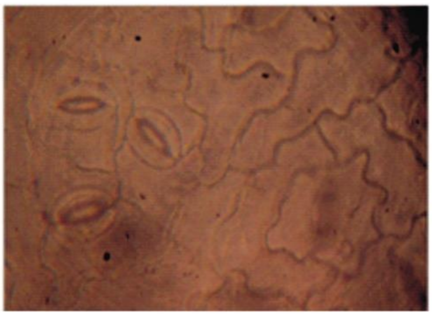

Plate 6b: Adaxial Surface of *Senna hirsuta* showing paracytic stomata with irregular epidermal walls using mg 40x

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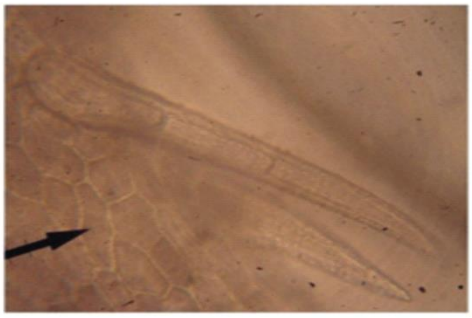

Plate 7a: Adaxial Surface of *Senna obtusfolia* showing Non-glandular Multicellular trichome using mg 40x

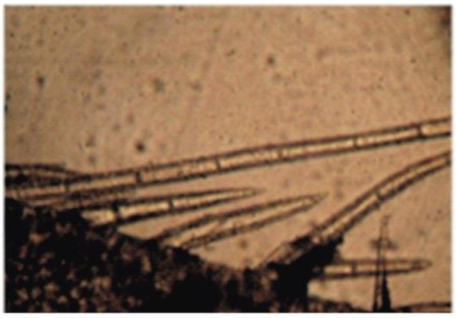

Plate 7b: Abaxial Surface of *Senna obtusfolia* showing Non-glandular Multicellular trichome using mg 40x

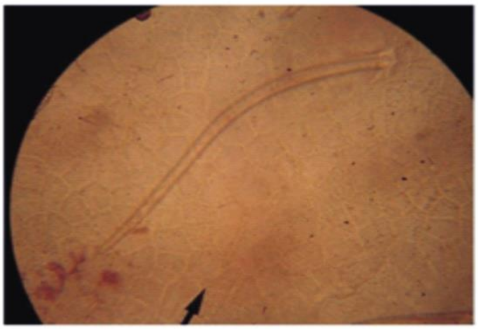

Plate 8a: Adaxial Surface of *Senna siberiana* showing Non-glandular Unicellular trichome using mg 40x

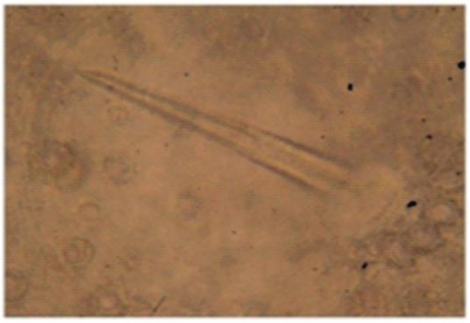

Plate 8b: Abaxial Surface of *Senna siberiana* showing Non-glandular trichome using mg 40x

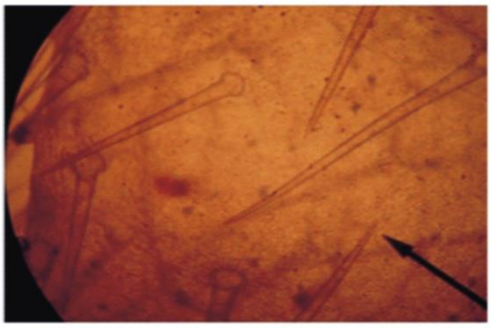

Plate 9a: Adaxial Surface of *Senna hirsuta* showing Non-glandular trichome using mg 40x

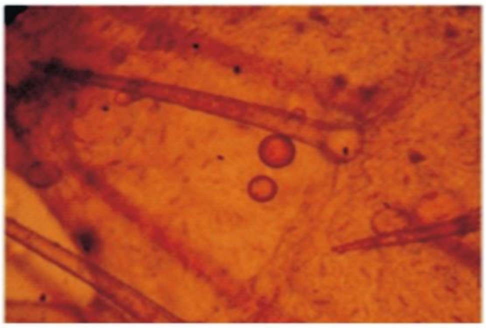

Plate 9b: Abaxial Surface of *Senna hirsuta* showing Non-glandular trichome using mg 40x

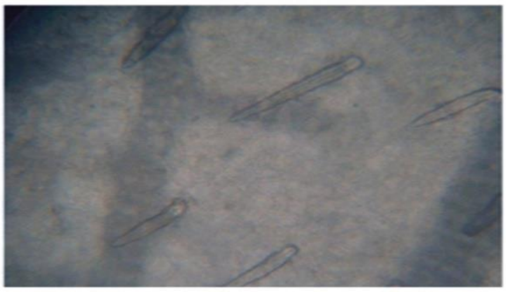

Plate 10a: Adaxial Surface of *Senna occidentalis* showing Non-glandular trichome using mg 40x

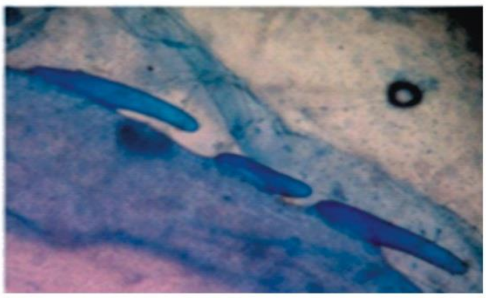

Plate 10b: Abaxial Surface of *Senna occidentalis* showing Non-glandular trichome using mg 40x

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Plate 11a: Adaxial Surface of C*assia absus* showing Non-glandular trichome using mg 40x

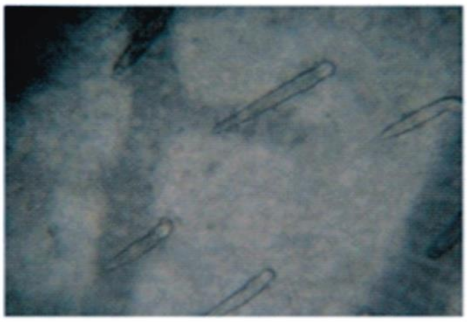

Plate 11b: Abaxial Surface of *Cassia absus* showing Non-glandular trichome using mg 40x

Plate 12a: Adaxial Surface of *Senna siamea* showing Non-glandular trichome using mg 40x

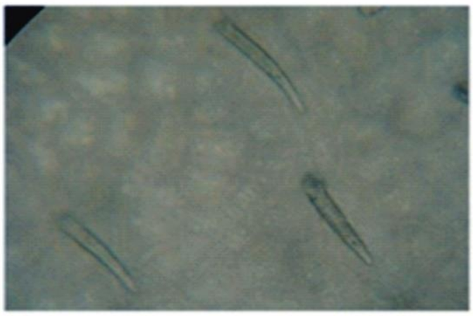

Plate 12b: Abaxial Surface of *Senna siamea* showing Non-glandular trichome using mg 40x

Plate 13a: Adaxial Surface of *Senna alata* showing Non-glandular trichome using mg 40x

Plate 13b: Abaxial Surface of *Senna alata* showing Non-glandular trichome using mg 40x