

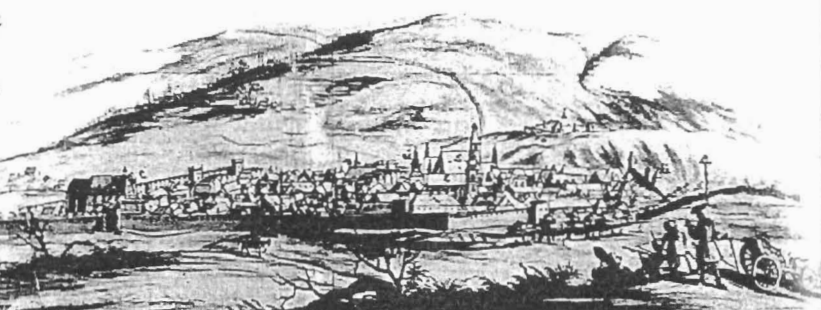


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NOTULAE BOTANICAE HORTI AGROBOTANICI

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Importance of Leaf Epidermal Characters in the *Asteraceae* Family

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Abstract

A comparative study of the leaf epidermis of twelve species in the *Compositae* (*Asteraceae*) family was undertaken in order to document characters that are important in the taxonomy of the family. It was observed that trichomes can be successfully used for the delimitation of genera within the family. Within each species however, there are varied assortment of trichomes with occasional transitions among them. *Launaea taraxacifolia* was unique in being the only species without any trichome. Stellate trichome type and K-shaped or tetradiate trichomes were observed in *Tridax procumbens* only. The genus *Vernonia* can be delimited from the other genera by the possession of T-shaped trichomes which are absent in the other genera, while amoeboid-shaped trichomes can be found in the genus *Chromolaena* only. Within the same genus, the species can also be delimited on the basis of possession of unique trichome types, for example in the genera *Vernonia* and *Emilia*. Cuticular striations occur in only two species out of the twelve studied, on the abaxial surface of *V. amygdalina* and on both surfaces of *Bidens pilosa*. Four stomatal types were recorded for the family, anomocytic, brachyparacytic, anisocytic and diacytic. Stomatal type was observed to delimit not only at generic level, but also at specific or species level. *Ageratum conyzoides* and *Synedrella nodiflora* are the only two species with occasional diacytic stomatal types. Results of the statistical correlation analysis for stomatal size and stomatal index at the 0.05 and 0.01 levels revealed high positive correlation for species in the same tribe, as well as for species in different tribes affirming close interrelationship and overlap of the values of stomatal indices and sizes within the family. Foliar anatomical characters that justify the separation of *Vernonia amygdalina* and *Vernonia cinerea* into separate tribes are highlighted.

Keywords: taxonomy, trichomes, stomata, *Asteraceae*

Introduction

The family *Compositae* (*Asteraceae*) is a very large cosmopolitan family. It is represented by 13 tribes, 84 genera and over 240 species, (Adams, 1963). The family is highly advanced, easily recognized and with worldwide distribution. The members of the family are largely woody herbs or shrubs, a few are trees and climbing herbs (Olorode, 1984). The leaves are simple, pinnately lobed in some species, alternate or opposite and prickly in some genera. The inflorescence is a capitulum, the flowers are either actinomorphic or zygomorphic. They may be hermaphroditic, male, female or neuter. The inflorescence is surrounded by an involucre of one (in *Emilia* and *Crassocephalum*) or more series of free or connate bracts.

Many plants in the family *Asteraceae* are economically important as weeds, ornamentals, medicinals and green vegetables. Important weed species in this family include *Chromolaena odorata* Linn. (which is widespread in the disturbed areas of forests), *Tridax procumbens* Linn., *Ageratum conyzoides* Linn., *Aspilota* sp. (Pers.) C. D. Adams,

Melanthera sp. (Schum and Thonn). The ornamental species include *Zinnia*, *Tagetes* (marigold) and *Helianthus annuus* (sunflower). Some of the important vegetable species are cultivated while others grow in the wild. They include *Vernonia amygdalina* (bitter leaf), *Launaea taraxacifolia*, *Crassocephalum crepidioides* and *Lactuca sativa* (lettuce). The seeds of *Helianthus annuus* yield oil. Some members of the family are also known to be of ethnomedicinal uses in Nigeria.

The taxonomic value of leaf epidermal characters is well documented (Palmer and Gerbeth-Jones, 1986; Jayeola et al., 2001; Adedeji and Illoh, 2004; Adedeji, 2004). Metcalfe and Chalk (1950) gave a sparse description of the general anatomy of the family *Asteraceae*. Given the available information, the report on the family *Asteraceae* in Nigeria is very scanty. The present study is therefore aimed at identifying, describing and documenting the leaf epidermal characters that are diagnostic and taxonomically important in the family *Asteraceae* occurring in Nigeria.

Materials and methods

For the purpose of this work, twelve species in the family Asteraceae were studied: *Ageratum conyzoides* Linn., *Aspilia Africana* (Pers.) C.D. Adams, *Bidens pilosa* Linn., *Chromolaena odorata* (Linn.) R.M. King and Robinson (= *Eupatorium odoratum* L.), *Emilia coccinea* (Sims) G. Don, *Emilia praetermissa* Milne-Redhead, *Launaea taraxacifolia* (Willd.) Amin ex C. Jeffrey., *Synedrella nodiflora* (L.) Gaertn., *Tithonia diversifolia* (Hemsl.), *Tridax procumbens* Linn., *Vernonia amygdalina* Del., *Vernonia cinerea* Linn. The plant materials used for this investigation were collected from the wild in Ile-Ife, Osun State, Nigeria. Fully matured leaves on plants at the flowering stage were collected for study. To obtain epidermal surfaces for studies, portions of the leaf blade were boiled for about 25 minutes in 90% alcohol and placed in the oven at 60°C to remove the chlorophyll. The leaf portions were then washed in 4 to 5 changes of water after which they were boiled in 5% Sodium Hydroxide Solution for about 20 minutes as the materials became decolourised. They were washed thoroughly in water to remove the alkaline solution. The partly cleared portions of the leaves were finally cleared in 5% solution of domestic bleaching agent (Jik) for about 30 minutes. The leaf portions were finally washed in 3-4 changes of water. The epidermal surfaces were stained in 1% aqueous safranin and mounted in glycerine for microscopic study. Terminologies of the stomatal complex types used in this study are those of Dilcher (1974) and Metcalfe and Chalk (1988). Stomatal size was the product of the length and breadth of the stoma. Stomatal Index was determined as number of stomata per square millimeter/ number of stomata + number of epidermal cells per square millimeter X 100 (Dilcher, 1974). Trichome description was according to Metcalfe and Chalk (1979) and Inamdar et al., (1990).

Results and discussion

Vernonia cinerea Linn.

Epidermal cells polygonal to slightly irregular in shape with undulating to wavy anticlinal cell walls on adaxial surface (Figure 1A), irregular to polygonal with sinuous anticlinal walls on the abaxial surface (Figure 2A). Leaf surface amphistomatic, stomata largely anomocytic, occasionally brachyparacytic (Figures 1B and 2B). Leaf surface amphistomatic, stomata anomocytic to brachyparacytic and anisocytic, largely elliptic to circular in shape; stomatal size – adaxial 564.5 – 823.2µm², abaxial 392.0 – 768.3µm², stomatal index – adaxial 6.5-13.7%, abaxial 11.5-19.6%. Cuticular striations absent on both surfaces.

Trichomes (Figures 3C, P; 4 G; 5 H, J, K; 6D, K)

Glandular and non-glandular trichome types present. Non-glandular are the unicellular and the multicellular types, some cell segments occasionally shriveled and regular T-shaped types often occur too. Glandular trichomes

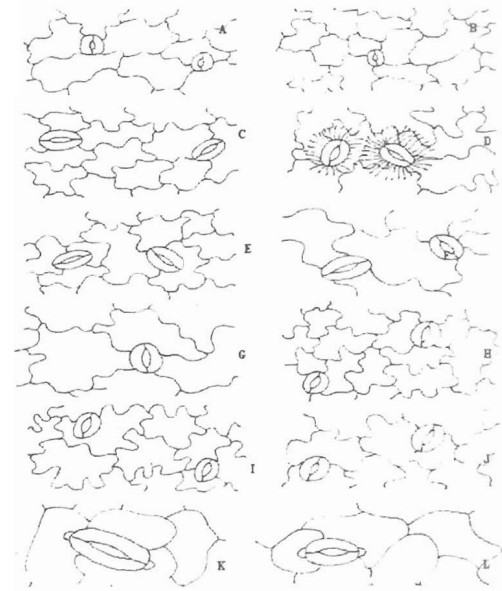


Figure 1 Adaxial epidermal surface in the species of the family Asteraceae

- | | |
|---------------------------------|--------------------------------|
| A. <i>Vernonia cinerea</i> | G. <i>Tridax procumbens</i> |
| B. <i>Vernonia amygdalina</i> | H. <i>Chromolaena odorata</i> |
| C. <i>Aspilia africana</i> | I. <i>Ageratum conyzoides</i> |
| D. <i>Bidens pilosa</i> | J. <i>Synedrella nodiflora</i> |
| E. <i>Tithonia diversifolia</i> | K. <i>Emilia coccinea</i> |
| F. <i>Launaea taraxacifolia</i> | L. <i>Emilia praetermissa</i> |

are often sessile, occasionally capitate with unicellular head and multicellular stalk.

Vernonia amygdalina Del.

Epidermal cells polygonal to irregular to occasionally rectangular with wavy to undulating anticlinal walls on adaxial surface (Figure 1B), largely irregular with deeply sinuous anticlinal walls on the abaxial surface (Figure 2B). Leaf surface amphistomatic, stomata largely anomocytic, occasionally brachyparacytic (Figures 1B and 2B), elliptic to circular in shape, stomatal size – adaxial 768.3 – 1058.4µm², abaxial 564.5-896.8µm², stomatal index – adaxial 5.6-10.2%, abaxial 13.9-21.7%. Cuticular striations absent on adaxial surface, present on abaxial surface.

Trichomes (Figures 3 J; 4 H, I; 5 I; 6 J, K)

Glandular and non-glandular trichome types present. Non-glandular are bicellular, multicellular and irregular T-shaped. Glandular trichomes are sessile largely, occasionally capitate with unicellular head and multicellular stalk.

Table 3 Statistical correlation analysis for stomatal index (Adaxial Surface)

	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
X2		-0.008	0.106	0.502*	-0.267	-0.161	0.307	0.434	-0.102	0.461*	0.631**	0.413
X3			-0.313	-0.166	0.428	-0.057	-0.076	-0.111	0.167	-0.371	-0.139	0.352
X4				0.488*	-0.267	0.348	-0.166	0.001	0.018	0.222	-0.058	0.121
X5					-0.342	0.321	0.469*	0.555*	0.012	0.219	-0.201	0.542*
X6						0.002	0.048	-0.123	0.255	0.467*	-0.047	-0.019
X7							-0.315	0.103	0.044	-0.176	0.282	-0.308
X8								0.158	0.656**	0.095	-0.003	-0.335
X9									0.317	0.151	-0.239	0.121
X10										0.107	-0.027	0.103
X11											-0.181	0.313
X12												-0.158
X13												

Table 4 Statistical correlation analysis for stomatal index (Abaxial Surface)

	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
X2		0.266	-0.297	-0.277	0.414	0.195	-0.296	0.181	0.234	0.482*	0.124	0.117
X3			0.054	-0.214	0.446*	0.045	0.009	0.111	0.335	-0.241	0.068	0.228
X4				-0.138	-0.195	-0.262	0.107	0.501*	-0.343	0.014	-0.113	-0.103
X5					-0.109	0.334	-0.096	-0.394	-0.044	0.067	-0.001	-0.393
X6						0.347	-0.376	-0.201	-0.186	0.156	0.221	-0.058
X7							-0.343	-0.221	0.449*	0.054	0.464*	-0.328
X8								-0.248	0.258	-0.395	-0.049	0.607**
X9									-0.104	-0.111	0.136	-0.063
X10										0.484*	0.498*	0.111
X11											-0.081	-0.264
X12												0.244
X13												

X2 - *Ageratum conyzoides*
X3 - *Aspilia Africana*
X4 - *Bidens pilosa*
X5 - *Chromolaena odorata*
X6 - *Emilia coccinea*
X7 - *Emilia praetermissa*

X8 - *Launaea taraxacifolia*
X9 - *Synedrella nodiflora*
X10 - *Tithonia diversifolia*
X11 - *Tridax procumbens*
X12 - *Vernonia amygdalina*
X13 - *Vernonia cinerea*

* Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level

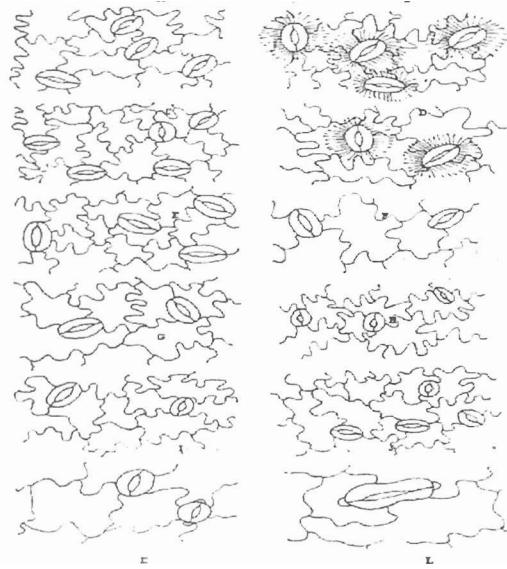


Figure 1 Adaxial epidermal surface in the species of the family Asteraceae

- | | |
|---------------------------------|--------------------------------|
| A. <i>Vernonia cinerea</i> | G. <i>Tridax procumbens</i> |
| B. <i>Vernonia amygdalina</i> | H. <i>Chromolaena odorata</i> |
| C. <i>Aspilula africana</i> | I. <i>Ageratum conyzoides</i> |
| D. <i>Bidens pilosa</i> | J. <i>Synedrella nodiflora</i> |
| E. <i>Tithonia diversifolia</i> | K. <i>Emilia coccinea</i> |
| F. <i>Launaea taraxacifolia</i> | L. <i>Emilia praetermissa</i> |

Aspilula africana (Pers.) C.D. Adams

Epidermal cells polygonal to slightly irregular and rectangular with deeply undulating to sinuous anticlinal cell walls on adaxial surface (Figure 1C), largely irregular with anticlinal walls sinuous on the abaxial surface (Figure 2C). Leaf surface amphistomatic, stomata largely anomocytic, occasionally brachyparacytic and anisocytic (Figures 1C and 2C), elliptic to circular in shape, stomatal size – adaxial $313.6-768.3\mu\text{m}^2$, abaxial $295.0-658.6\mu\text{m}^2$; stomatal index – adaxial 8.5-13.3%, abaxial 19.2-22.8%. Cuticular striations, absent on adaxial and abaxial surfaces.

Trichomes (Figures 3 D, F, G, L, R; 4 J; 5 A, C)

Glandular and non-glandular trichome types present. Non-glandular are bicellular to multicellular, often with long thin and pointed apical cells, occasionally short and pointed too. Unique tetrastrate K or H-shaped non-glandular trichomes observed. Glandular trichomes absent.

Bidens pilosa Linn.

Epidermal cells rectangular to irregular shape with sinuous anticlinal cell walls on adaxial surface (Figure 1D), irregular to polygonal with sinuous anticlinal walls on

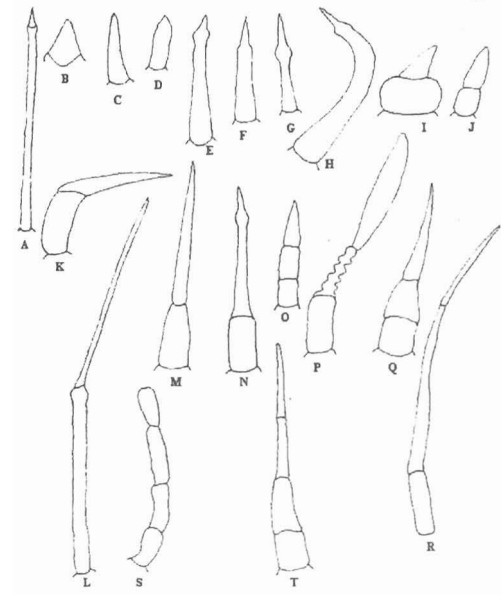


Figure 3 Non-glandular trichome types in the family Asteraceae

- A. Unicellular (long and narrow)
 B. Spine-like
 C-H. Different unicellular types (H is hooked)
 I-N. Different bicellular types
 O-T. Different multicellular types

the abaxial surface (Figure 2D). Leaf surface amphistomatic, stomata largely anisocytic to anomocytic, occasionally brachyparacytic (Figures 1D & 2D), largely elliptic in shape; stomatal size – adaxial $658.6-1176.0\mu\text{m}^2$, abaxial $431.2 - 878.1\mu\text{m}^2$; stomatal index – adaxial 10.0-22.3%, abaxial 17.4-23.4%. Cuticular striations present on both adaxial and abaxial epidermal surfaces.

Trichomes (Figures 3 B, C, J, O, T; 4 D-F; 6 D-F)

Glandular and non-glandular trichome types present. Spine-like, unicellular, bicellular, multicellular non-glandular types present, one or two cells occasionally shriveled. Glandular types are largely capitate with multicellular stalk, unicellular head.

Tithonia diversifolia (Hemsl.)

Epidermal cells polygonal to irregular in shape with undulating anticlinal walls on adaxial surface (Figure 1E), irregular with sinuous anticlinal walls on the abaxial surface (Figure 2E). Leaf surface amphistomatic, stomata largely anisocytic, often anomocytic, occasionally brachyparacytic (Figures 1 E and 2E), elliptic, occasionally circular in shape; stomatal size – adaxial $658.6-940.8\mu\text{m}^2$, abaxial $431.2 - 713.4\mu\text{m}^2$; stomatal index – adaxial 6.5-

12

10.0%, abaxial 17.3-20.4%. Cuticular striations absent on both surfaces.

Trichomes (Figures 3 B, C, I-K, M, Q, T; 4 K; 6 J)

Glandular and non-glandular trichome types present. Non-glandular are spine-like, unicellular, bicellular and multicellular. Glandular trichomes are few and sessile.

Launaea taraxacifolia (Willd.) Amin, ex C. Jeffrey

Epidermal cells polygonal to rectangular in shape with undulating anticlinal walls on adaxial surface (Figure 1F), irregular with undulating to sinuous anticlinal walls on abaxial surface (Figure 2F). Leaf surface amphistomatic, stomata largely anomocytic, often anisocytic and brachyparacytic (Figures 1F and 2F), elliptic to circular in shape, stomatal size – adaxial $392.0 - 768.3 \mu m^2$, abaxial $282.2 - 517.4 \mu m^2$; stomatal index – adaxial 8.2-12.8%, abaxial 13.8-18.4%. Cuticular striations absent on both surfaces. Trichomes: Absent.

Tridax procumbens Linn.

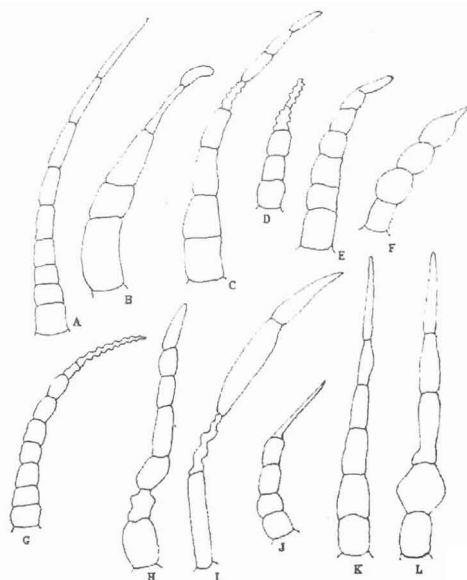


Figure 4 Multicellular non-glandular trichome types in the family Asteraceae

- | | |
|---|---|
| A. Apex pointed | G. Apical cell shriveled |
| B. Apex sickle | H. One cell slightly shriveled |
| C. With one shriveled cell | I. One cell shriveled |
| D. 2 apical cells shriveled | J. Apical cell acicular |
| E. Apical cell globular | K. Apical cell pointed to slightly round |
| F. Apical cell acicular toward the end, cells bulbous | L. Apical cell pointed to round, one cell bulbous |

Epidermal cells polygonal to rectangular and occasionally slightly irregular with wavy to undulating anticlinal walls on the adaxial surface (Figure 1G), irregular to occasionally rectangular with sinuous anticlinal wall on the abaxial surface (Figure 2G). Leaf surface amphistomatic. Stomata largely anisocytic to brachyparacytic, occasionally anomocytic (Figures 1G and 2G), circular to elliptic in shape on adaxial surface, elliptic to circular on abaxial surface; stomatal size – adaxial $1379.8 - 2195.2 \mu m^2$, abaxial $823.2 - 1811.0 \mu m^2$; stomatal index – adaxial 8.1-13.0%, abaxial 22.0-27.8%. Cuticular striations absent on both surfaces.

Trichomes (Figures 3 R, T, Q; 5 A, B; 6B)

Both glandular and non-glandular trichome types present. Glandular trichomes are capitate, often with bicellular stalk unicellular head. Non-glandular are largely tricellular, occasionally stellate.

Chromolaena odorata (Linn.) R.M. King & Robinson

Epidermal cells polygonal to irregular to rectangular in shape; anticlinal walls deeply undulating to slightly sinuous on adaxial surface (Figure 1H), irregular with sinuous anticlinal walls on abaxial surface (Figure 2H). Leaf surface amphistomatic, stomata anisocytic to brachyparacytic

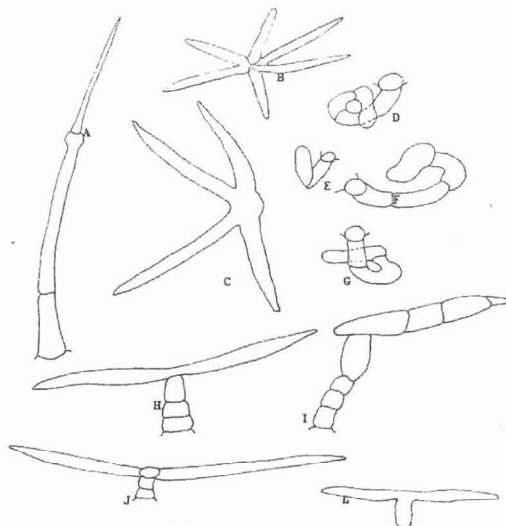


Figure 5 Additional non-glandular trichome types in the family Asteraceae

- | | |
|-------------------------------|---------------------------|
| A. Tricellular/ Multicellular | F. Amoeboid shaped |
| B. Stellate | G. Amoeboid shaped |
| C. K-shaped tetrastrate | H, J, K. Regular T-shaped |
| D. Amoeboid shaped | I. Irregular T-shaped |
| E. V-shaped | |

and anomocytic in shape on both surfaces; stomatal size – adaxial $1058.4 \mu m^2$, abaxial $2.9 - 7.6 \mu m^2$; stomatal index – adaxial 2.9-7.6%, abaxial 13.8-18.4%. Cuticular striations absent on both surfaces.

Trichomes (Figures 3 S, U; 6C, D)

Glandular and non-glandular trichome types present. Glandular are capitate, often with bicellular stalk unicellular head, unicellular, spine-like and amoeboid trichomes.

Ageratum conyzoides L.

Epidermal cells polygonal to rectangular in shape with sinuous wall on adaxial surface (Figure 2I). Leaf surface amphistomatic, stomata anisocytic to brachyparacytic, stomatal size – adaxial $705.6 \mu m^2$, abaxial $23.4 - 34.7 \mu m^2$; stomatal index – adaxial 23.4-34.7%, abaxial 13.8-18.4%. Cuticular striations absent on both surfaces.

Trichomes (Figures 3 V, W; 6E, F)



Figure 6 Glandular trichome types in the family Asteraceae

- | |
|-------------------------------|
| A – B - Capitate |
| C – F - Capitate |
| G - Capitate with long stalk |
| H - Capitate with short stalk |
| I – K - Sessile |

and anomocytic (Figures 1H and 2H), circular to elliptic in shape on both surfaces; stomatal size – adaxial $713.4-1058.4\mu\text{m}^2$, abaxial $470.4-752.6\mu\text{m}^2$; stomatal index – adaxial 2.9-7.6%, abaxial 16.3-21.1%. Cuticular striations absent on both surfaces.

Trichomes (Figures 4 A, K; 5 D-G; 6 A, H)

Glandular and non-glandular trichome types present. Glandular occur very occasionally, capitate with unicellular to bicellular stalk, unicellular head and unicellular stalk. Non-glandular often multicellular, spine-like and unicellular types absent. V-shaped and amoeboid trichome types occur.

Ageratum conyzoides (Linn.)

Epidermal cells irregular to rectangular in shape; with sinuous wall on adaxial surface (Fig. 1I), irregular to slightly polygonal with sinuous walls on the abaxial surface (Fig. 2I). Leaf surface amphistomatic, stomata anisocytic, brachyparacytic and anomocytic; elliptic to circular in shape; stomatal size – adaxial $615.2-1199.5\mu\text{m}^2$, abaxial $313.6-705.6\mu\text{m}^2$, stomatal index – adaxial 9.2-15.7%, abaxial 23.4-34.7%. Cuticular striations absent on both surfaces.

Trichomes (Figures 3 H, S, T; 4 K, L; 6 A, C, D, I)

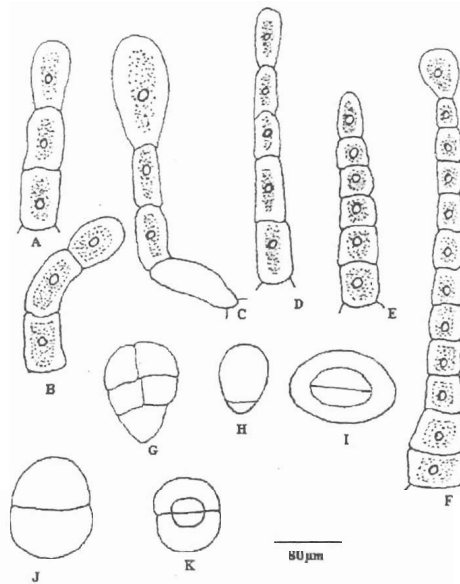


Figure 6 Glandular trichome types in the family *Asteraceae*

A – B - Capitate with bicellular stalk, unicellular head
C – F - Capitate with multicellular stalk, unicellular head
G - Capitate with unicellular stalk, multicellular head
H - Capitate with unicellular head, unicellular stalk
I – K - Sessile glandular trichomes

Glandular and non-glandular trichome types present. Stalked glandular types are capitate with bicellular stalk unicellular head, capitate with multicellular stalk unicellular head. Some of the glandular trichomes are sessile. Non-glandular trichomes are largely multicellular.

Synedrella nodiflora (L.) Gaertn.

Epidermal cells irregular to polygonal, occasionally rectangular; anticlinal cell wall deeply undulating to sinuous (Figure 1T), irregular to polygonal with sinuous anticlinal walls on the abaxial surface (Figure 2T). Leaf surface amphistomatic, stomatal type largely anisocytic, occasionally diacytic, anomocytic and brachyparacytic, largely circular, occasionally elliptic in shape; stomatal size – adaxial $352.8-658.6\mu\text{m}^2$, abaxial $282.2-564.5\mu\text{m}^2$, stomatal index – adaxial 3.8-9.3%, abaxial 14.0-20.0%. Cuticular striations absent on both surfaces.

Trichomes (Figures 3 A, E, G, H, N; 4 B)

Glandular and non-glandular trichomes present. Stalked glandular trichome types are sparse, capitate with multicellular stalk, unicellular head. Non-glandular are largely unicellular and bicellular with very pointed ends. Multicellular is very rare.

Emilia coccinea (Sims) G. Don

Epidermal cells polygonal to rectangular with straight to slightly wavy anticlinal walls on adaxial surface (Figure 1K), polygonal to irregular with sinuous anticlinal walls on abaxial surface (Figure 2K). Leaf surface amphistomatic, stomata largely anisocytic often anomocytic; often circular in shape with small protrusions at the polar ends in some stomata, stomatal size – adaxial $564.5-815.4\mu\text{m}^2$, abaxial $470.4-611.5\mu\text{m}^2$, stomatal index – adaxial 2.5-9.0%, abaxial 28.1-36.9%. Cuticular striations absent on both surfaces.

Trichomes (Figures 3 B, J, P)

Only non-glandular trichome types present. They are spine-like, bicellular and multicellular types, occasionally with one cell shriveled.

Emilia praetermissa Milne-Redhead

Epidermal cells largely polygonal, occasionally rectangular with straight to slightly wavy anticlinal walls on adaxial surface (Figure 1L), irregular with deeply undulating to sinuous anticlinal walls on the abaxial surface (2L). Leaf surface amphistomatic, stomata anisocytic occasionally anomocytic or brachyparacytic, elliptic in shape, occasionally irregularly shaped appearing malformed (Figure 2L), often with small protrusions at the polar ends in some of the stomata; stomatal size – adaxial $752.6-1254.4\mu\text{m}^2$, abaxial $588.0-987.8\mu\text{m}^2$; stomatal index – adaxial 7.9-13.5%, abaxial 19.0-23.8%. Cuticular striations absent on both surfaces.

Trichomes (Figures 3 S, T; 4 C; 6 G)

Stalked glandular and non-glandular trichome types present. The stalked glandular is capitate with multicellular head and unicellular stalk. Non-glandular trichomes are essentially multicellular.

At the specific level, studies of trichomes have been found to be of value by many workers (Faust and Jones 1973; Rollins and Shaw, 1973; Adedeji, 2004; Adedeji et al., 2007). According to Metcalfe and Chalk 1979, the presence of a particular type of trichome can frequently delimit species, genera or even whole families. Isawumi (1989) in his study on the genus *Vernonia* found the trichomes to be more useful taxonomically in the discrimination of the species into sections than any of the other epidermal characters.

The distribution of trichomes is amazingly complex. Complexity results from, firstly, the diversity in types of trichomes, secondly, marked differences in the density of trichome types taken individually and collectively, and thirdly, differences in the distribution of trichome types on different parts of a given plant. Within the space limitation of this presentation, Figures 1 – 6 provide illustrative examples of trichome types found on the leaf epidermal surfaces of the species of the family Asteraceae studied.

Unique unicellular trichome types were observed in *Synedrella nodiflora*, *Bidens pilosa*, *Tithonia diversifolia* and *Emilia coccinea*. *Synedrella nodiflora* is the only species with very long, thin and narrow unicellular types. Spine-like unicellular types were observed in *Bidens pilosa*, *Tithonia diversifolia* and *Emilia coccinea* only. Unicellular trichome types were completely absent in *Vernonia amygdalina*, *Tridax procumbens*, *Chromolaena odorata* and *E. praetermissa*.

Bicellular non-glandular types were observed in *Vernonia amygdalina*, *Aspilia africana*, *Bidens pilosa*, *Tithonia diversifolia*, *Synedrella nodiflora* and *Emilia coccinea*. Long, thin and pointed apical cells occasionally short and pointed were observed in *Aspilia africana*. Unicellular and bicellular trichome types were completely absent in *Tridax procumbens*, *Chromolaena odorata* and *Emilia praetermissa*.

Occasional shriveled cells in the non-glandular multicellular cell trichome types were encountered in *Ageratum conyzoides*, *Bidens pilosa*, *Vernonia cinerea*, *Vernonia amygdalina*, *Ageratum conyzoides*, *Emilia coccinea* and *Emilia praetermissa*.

For glandular trichomes, unicellular stalk with unicellular head was encountered in *Chromolaena odorata*, unicellular stalk with multicellular head in *Emilia praetermissa*, unicellular head with multicellular stalk in *Tridax procumbens*, *Chromolaena odorata* and *Ageratum conyzoides*.

Sessile glandular trichomes were observed in *Vernonia cinerea*, *Vernonia amygdalina*, *Tithonia diversifolia* and *Ageratum conyzoides*. *Launaea taraxacifolia* was unique in being the only species without any trichomes. Stellate

trichome and K-shaped or tetrastrate trichome were observed in *Tridax procumbens* only.

The genus *Vernonia* can be separated from the other genera in the family by the possession of various types of T-shaped trichomes, regular in *V. cinerea*, irregular in *V. amygdalina*. This can be used to separate the two species of *Vernonia* from each other. *Chromolaena odorata* can be separated from all the other species in the family studied on the basis of possession of V-shaped and amoeboid shaped trichome types.

Absence of unicellular and bicellular non-glandular trichome types in *E. praetermissa* separates it from *E. coccinea* which has spine-like unicellular and bicellular trichomes. This supports the report of Adedeji (2004) on the leaf epidermal studies of the species of *Emilia* Cass. in Nigeria.

The stomatal apparatus in Asteraceae consists of two guard cells bounding a lenticular pore, the orientation of which is largely parallel to the guard cells. This apparatus is surrounded either by typical epidermal cells or by one or more subsidiary cells. Four stomatal types were recorded in the species of the family Asteraceae studied: anomocytic, brachyparacytic, anisocytic and diacytic.

It is largely anomocytic occasionally brachyparacytic in *Vernonia amygdalina*, largely anisocytic occasionally anomocytic or brachyparacytic in *Emilia praetermissa*, *Ageratum conyzoides*, *Synedrella nodiflora*, *Chromolaena odorata*, *Tridax procumbens*, *Tithonia diversifolia*, *Bidens pilosa*, anomocytic to anisocytic and brachyparacytic in *Vernonia cinerea* and *Launaea taraxacifolia*, largely anomocytic occasionally brachyparacytic and anisocytic in *Aspilia africana*, largely anisocytic often anomocytic in *Emilia coccinea*.

On the basis of stomatal type, *Vernonia cinerea* can be delimited from *Vernonia amygdalina* in the same genus by the presence of anisocytic stomatal types, *Emilia praetermissa* can be delimited from *E. coccinea* by the presence of brachyparacytic stomatal types. *Ageratum conyzoides* and *Synedrella nodiflora* are the only two species with occasional diacytic stomatal types.

The outline of the pair of guard cells as seen in surface view, i.e. stomatal shape is of taxonomic importance as emphasized by Adedeji (2004). Stomatal shape of the species studied varied between elliptic and circular.

It is largely elliptic often or occasionally circular in *Vernonia cinerea*, *Vernonia amygdalina*, *Aspilia africana*, *Tithonia diversifolia*, *Launaea taraxacifolia*, *Tridax procumbens* and *Ageratum conyzoides*, circular to elliptic in *Chromolaena odorata*, elliptic shape only was found in *Bidens pilosa* and *Emilia praetermissa*, circular shape only in *Emilia coccinea*, thus stomatal shape can be used to separate the two species of *Emilia*. It is largely circular to occasionally elliptic in *Synedrella nodiflora*.

Stomatal size, although quantitative is also noteworthy. On the adaxial surface, it was highest in *Tridax procumbens* and lowest in *Synedrella nodiflora* and *Aspilia afri-*

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cana. On the abaxial surface it was also highest in *Tridax procumbens* and lowest in *Launaea taraxacifolia* and *Synedrella nodiflora*. Stomatal size was consistently higher on the adaxial surface than on the abaxial surface in all the species studied.

Based on the statistical correlation analysis carried out, stomatal size showed relationship among species in the same tribe, for example, *Synedrella nodiflora* and *Aspilia africana* of the tribe *Heliantheae*.

However, species which are not of the same tribe also showed some closeness, affirming their inter-relationships based on stomatal size, for example, *Launaea taraxacifolia* and *Vernonia amygdalina*, *Emilia coccinea* and *Tridax procumbens*, *Chromolaena odorata* and *Tithonia diversifolia*, *Aspilia africana*, *Vernonia amygdalina* and *Vernonia cinerea* show correlation on their adaxial surfaces, while *Chromolaena odorata* showed relationship with *Emilia coccinea*, *Tridax procumbens* and *Vernonia cinerea* on the abaxial surface. *Vernonia cinerea* with *Emilia coccinea*, *Bidens pilosa* with *Ageratum conyzoides* also showed relationship on the abaxial surface.

The observation of a wide range of stomatal size in the species studied agree with the observations of Wilkinson (1971) in his study of some families. According to Olatunji (1983), stomatal index can be used for species delimitation. On the adaxial surface, it was highest in *Bidens pilosa* and lowest in *Emilia coccinea* and *Chromolaena odorata* while on the abaxial surface, it was highest in *Emilia coccinea* and lowest in *Vernonia cinerea*.

Statistical correlation analysis of the stomatal index of the species studied revealed that some species of the same tribe showed relationship (high correlation), for example, on the abaxial surface, *Synedrella nodiflora* and *Bidens pilosa* of the tribe *Heliantheae*; on the adaxial surface, *Ageratum conyzoides* and *Chromolaena odorata* of the tribe *Eupatorieae*.

In addition, some species which are not of the same tribe also showed some correlation which indicate close interrelationship among the species in the family, for example on the adaxial surface, *Chromolaena odorata* with *Ageratum conyzoides*, *Bidens pilosa*, *Launaea taraxacifolia*, *Synedrella nodiflora* and *Vernonia cinerea*; *Ageratum conyzoides* with *Tridax procumbens* and *Vernonia amygdalina*; *Tithonia diversifolia* with *Launaea taraxacifolia*; *Tridax procumbens* with *Emilia coccinea*. On the abaxial surface, *Emilia coccinea* with *Aspilia africana*, *Tithonia diversifolia* with *Emilia praetermissa*; *Tridax procumbens* with *Ageratum conyzoides*; *Vernonia cinerea* with *Launaea taraxacifolia*. Anticlinal cell wall pattern on the adaxial surface can be used to separate the species.

It is straight to slightly wavy in both species of *Emilia*, this separates the genus from the other genera in the family. It is undulating to wavy in both species of *Vernonia* and *Tridax procumbens*, undulating in *Tithonia diversifolia* and *Launaea taraxacifolia*, deeply undulating to sinuous in *As-*

pilia africana, *Chromolaena odorata* and *Synedrella nodiflora*; sinuous in *Bidens pilosa* and *Ageratum conyzoides*.

On the abaxial surface, the anticlinal cell wall pattern is largely sinuous except in two species, *Launaea taraxacifolia* and *Emilia praetermissa* where they are undulating to sinuous. Isawumi (1989), Adedeji and Illoh (2004) used the presence or absence of cuticular striations for the delimitation or separation of some species in the genus *Vernonia* and *Hibiscus* respectively.

Cutin folds occur as striations in the epidermides of only two species of the twelve species studied. This can be used to separate the two species in two different genera from the others. It is present on the abaxial surface of *Vernonia amygdalina*, but absent on the adaxial surface, while it is present on both surfaces of *Bidens pilosa*. They radiate from the guard cells of the stomata and from trichome bases.

The presence of cuticular striations on the abaxial surface of *Vernonia amygdalina* in addition to the presence of irregular T-shaped trichomes in this taxon and absence of anisocytic stomata earlier mentioned, separates it from *Vernonia cinerea* in the same genus which tend to conform with some classification systems where *Vernonia cinerea* has consistently been put in section *Tephrodes*, while *Vernonia amygdalina* has at different times been proposed for section *Decaneurum* (Kingham, 1976), section *Orbivestus* (Jones, 1981) and section *Strobocalyx* (Isawumi, 1995).

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Abstract

The aim of the Timisoara, by taking / *Amaranthaceae* flowering starts in J belonging to *Chen* Timisoara, Roman of the annual total in which 90% of the was identified in 20

Keywords: air plan

Introduction

Chenopodium (quarter) is a part that has been reported areas. Many met closely related *A* in inducing allergy (1997). Both *Ch* shed locally large areas of the tral and southern pod pollinosis h and arid environ (Ezeamuzie et al.

The character *nopodium album* to its concomitant gens of 14 and 3 (1985) and prote ed by Würtzen e reported the isol (17 kd), which t within this pollen

Most of the showed a high c and other less

Table 1 Statistical correlation analysis for stomatal size (Adaxial Surface)

	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
X2		0.084	-0.056	0.023	-0.352	-0.107	0.272	-0.309	-0.113	-0.014	0.061	0.082
X3			-0.106	-0.091	0.349	-0.402	-0.093	0.494*	-0.118	0.082	0.478*	0.521*
X4				-0.133	0.042	0.154	-0.357	-0.207	0.008	0.354	0.281	-0.283
X5					0.072	0.021	0.221	-0.109	0.591*	0.245	-0.437	0.374
X6						-0.172	-0.386	0.124	0.238	0.466*	0.412	0.194
X7							0.001	0.299	-0.338	0.123	-0.161	-0.101
X8								0.086	-0.146	-0.022	0.474*	0.141
X9									-0.071	0.059	-0.299	-0.231
X10										0.342	-0.256	-0.134
X11											-0.132	0.151
X12												-0.235
X13												

Table 2 Statistical correlation analysis for stomatal size (Abaxial Surface)

	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
X2		-0.061	0.603*	0.314	-0.017	0.405	-0.301	0.311	-0.101	0.386	-0.055	0.201
X3			-0.093	-0.002	-0.221	0.077	0.101	-0.297	0.145	0.117	-0.462	-0.041
X4				-0.052	-0.253	0.106	0.372	-0.067	0.331	-0.027	-0.063	-0.087
X5					0.576*	0.109	0.342	0.152	0.136	0.651**	-0.101	0.625*
X6						-0.286	-0.061	0.006	-0.472	-0.362	0.389	0.635*
X7							-0.141	0.019	-0.124	0.019	-0.196	0.082
X8								0.366	0.231	0.498	-0.228	0.136
X9									-0.074	0.482	-0.269	0.245
X10										0.247	-0.121	0.168
X11											-0.387	0.409
X12												0.031
X13												

X2 - *Ageratum conyzoides*
X3 - *Aspilia Africana*
X4 - *Bidens pilosa*
X5 - *Chromolaena odorata*
X6 - *Emilia coccinea*
X7 - *Emilia praetermissa*

X8 - *Launaea taraxacifolia*
X9 - *Synedrella nodiflora*
X10 - *Tithonia diversifolia*
X11 - *Tridax procumbens*
X12 - *Vernonia amygdalina*
X13 - *Vernonia cinerea*

* Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level