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DIVERSITY OF FOLIAR TRICHOMES, TRICHOMES BASAL INSERTION CELLS AND CELLS SURROUNDING THE BASAL INSERTION CELLS IN FAMILY ASTERACEAE

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ABSTRACT

Foliar trichome morphology, trichome basal insertion cells (TBIC) and cells surrounding trichome insertion basal cells (CSTIBC) on the leaves of fourteen species of family Asteraceae were investigated by light microscopy. TBIC and CSTIBC are the two novel characters investigated in this work, in search of unique character states that could improve the taxonomy of the family. Epidermal peels were made following standard procedure. Data obtained showed that both non-glandular and glandular trichomes were present, the glandular was observed in the genus *Vernonia* only. The non-glandular trichomes were unicellular, bicellular, tricellular and multicellular uniseriate. Shriveled cells within the multicellular uniseriate cells were common in *Emilia sonchifolia* and *Emilia praertermissa* and occurred sparsely in *Ageratum conyzoides*. Uniquely pigmented multicellular uniseriate trichomes with apical cells shriveled or transparent delimits *Bidens pilosa* from the other species studied. Amoeboid shaped multicellular uniseriate trichomes delimit *Chromolaena odorata* from the other species, while T-shaped trichomes (regular and irregular) delimit the genus *Vernonia* from the other genera studied. Shape and width of apical cells of the trichomes differentiate *Vernonia cinerea* from *Vernonia amygdalina*. Surface of trichomes in *Aspilia africana, Synedrella nodiflora* and *Eclipta alba* are uniquely papillate and diagnostic for the three species. TBIC have varying shapes with different combinations of 1-4 shapes per species. It is noteworthy that the two species of *Emilia* can be delimited from each other based on the shapes of the TBIC on the abaxial epidermis. The number of CSTIBC was observed to be the same on the adaxial epidermis of the two species of genus *Emilia*. Shapes of CSTIBC in the species studied are diverse. Coefficient of Variation for all the characters studied showed species with more variation within each character. Novel characters, TIBC and CSTIBC, were found to be useful as additional tools in the taxonomy of family Asteraceae.

Keywords: Asteraceae, Trichomes, Morphology, Basal Cells, Genus *Vernonia*, Shriveled cells.

INTRODUCTION

The Asteraceae family is the largest among the angiosperms, comprising about 23,000 species across over 1,600 genera, 13 subfamilies, and 44 tribes (Panero *et al*., 2014). Members of this family are mainly herbaceous, with simple, typically lobed leaves. Their inflorescence is of the capitulum type, and their fruit, known as a cypsela, along with the pappus, serves as their dispersal unit. The family is also medicinally and economically important (Bahadur *et al*., 2023).

One of the unique morphological features documented for members of the family Araceae is Trichome, both glandular and non-glandular (Sari *et al*., 2021; Abdulrashid *et al*., 2022). Trichomes which are outgrowths from the epidermis of plants have been extensively described (Adedeji *et al*., 2007; Wang *et al*., 2021; Watts and Kariyat, 2021) Trichomes act as a protective barrier for plants, shielding them from dangerous temperatures, UV radiation, herbivores and outbreaks of insects (Glas *et al*., 2012; Wang *et al*., 2021). The formation of trichomes is governed by intricate signalling paths and cellular adaptableness, which determine whether cells will develop into trichomes or stay as normal epidermal cells (Kabir *et al*., 2024).

Attributes that are used to describe and distinguish an organism in taxonomy are known as taxonomic characters. These are any features that set members of one taxon apart from those of another. Additionally, a feature shared by members of two taxa but not present in a third is also considered a taxonomic character (Judd *et al*., 2023). In order to establish classifications and phylogenies, taxonomic evidence is collected from multiple sources (Haider, 2018). Since every part of a plant, at all stages of development, can offer valuable taxonomic characters for identification and classification, it is essential to gather data from

diverse origins. Taxonomists frequently seek out new characters to enhance classification and diagnostic processes. (Adedeji, 2019). Many characters had been used relating to the classification of foliar trichomes in the family Asteraceae but there has been no documentation on the studies of trichome basal insertion cells and cells surrounding the trichome basal insertion cells in association with the trichomes in the literature. The aim of this study was therefore to investigate the usefulness of these two novel characters (trichome basal insertion cells and cells surrounding trichome insertion basal cells in association with trichomes) in the taxonomy of the family Asteraceae, also taking into consideration the trichome types available in the species under study. This will go a long way in contributing additional characters for study in the family Asteraceae.

MATERIALS AND METHODS

Fourteen species from the family Asteraceae were used for this study. They are- *Ageratum conyzoides* L., *Spilanthes filicaulis* (Schumach. & Thonn.) C.D. Adams., *Aspilia africana* (*Pers.) C.D. Adams, Tithonia diversifolia (Hemsl) A. Gray*, *Emilia sonchifolia* (L.) DC. ex Wight, *Emilia praetermissa* Milne-Redh., *Bidens pilosa* L., *Synedrella nodiflora* (L.) Gaertn., *Chromolaena odorata* (L.) R. M. King & H. Rob., *Acanthospermum hispidum* DC., *Eclipta alba* (L.) *Hassk.*, *Tridax procumbens* L., *Vernonia cinerea* (L.) Less. and *Vernonia amygdalina* Del. Fresh leaves of each of the species collected from different areas of Ile-Ife, Osun State, Nigeria (7.4905° N, 4.5521° E) were used for this foliar anatomical study. Substantial sections were cut from the median parts of mature, fully expanded leaves. These sections were boiled in 90% alcohol at approximately 60^{0}C for 25 minutes to remove the chlorophyll. The epidermal peels were then obtained using the scrape technique, where the unwanted mesophyll was scraped away. The peels were stained with 1% Safranin O for 5-10 minutes and then carefully rinsed with water to remove excess stain. Temporary mounts were prepared on slides using 25% glycerol for microscopic examination.

Both qualitative and quantitative micromorphological characteristics of foliar trichomes, trichome insertion basal cells (TIBC) and cells surrounding trichome insertion basal cells (CSTIBC) were observed and documented. Photomicrographs of important characters were taken with the aid of MD900E AmScope camera equipped light microscope. Basic terminologies used in trichome classification and description are as suggested by Pyne (1978) and Harris and Harris (2001). However, simple self-explanatory terms are added to identify the specific types of trichomes.

Trichome insertion basal cell (TIBC) is defined in this work as that space or hole where each trichome is directly inserted; while cells surrounding trichome insertion basal cells (CSTIBC) are defined as cells immediately surrounding each of the spaces or holes where each trichome is directly inserted (TIBC). The SPSS statistical package was used to compute the means, standard deviation and coefficient of variation of all the quantitative data generated.

RESULTS

Summary of the data of quantitative and qualitative characters studied are presented on Tables 1-8. Photomicrographs of the characters are presented on Figures 1-4.

***Ageratum conyzoides* L.** (Figures 1-2, Tables 1-8.)

Trichomes: They are largely non-glandular, very long multicellular uniseriate with occasional shriveled cells on both the adaxial and abaxial epidermal surfaces. They are largely on non-venous region on the abaxial surface but evenly spread on both venous and non-venous regions on the adaxial surface. Number per x100 magnification microscope view ranges from 1-6 on adaxial surface and 2-22 on abaxial surface.

Trichome Insertion Basal Cells: Largely circular on both surfaces, occasionally ellipsoid to conical shaped on abaxial surface; anticlinal wall pattern, straight on both surfaces.

Cells Surrounding Trichome Basal Cells: Largely rectangular to polygonal to cylindrical, occasionally irregular on both epidermal surfaces. Anticlinal wall pattern is largely straight, occasionally undulating to sinuous on both surfaces. Number ranges from 39 on adaxial surface and 3-7 on abaxial surface.

Spilanthes filicaulis **(Schum. & Thonn.) C.D. Adams.** (Figures 1-2, Tables 1-8)

Trichomes: They are largely non-glandular multicellular uniseriate, with occasional bicellular and tricellular trichomes on both adaxial and abaxial surfaces. Number per x100 magnification microscope view ranges from 0-3 on adaxial surface and 0-5 on abaxial surface.

Trichome Insertion Basal Cells: Largely circular to polygonal to occasionally rectangular to ellipsoid on adaxial surface; largely circular to oblong on abaxial surface. Anticlinal wall pattern is straight on both surfaces.

Cells Surrounding Trichome Basal Cells: Largely conical to rectangular to occasionally irregular on both ad axial and abaxial epidermal surfaces. Anticlinal wall pattern is largely undulating to sinuous on both surfaces. Occasionally, cells are straight at the sides and wavy at the base. Number ranges from 4-10 on adaxial surface and from 5-6 on abaxial surface.

Aspilia africana **(Pers.) C.D. Adams** (Figures 1-2, Tables 1-8)

Trichomes: Trichomes are non -glandular: short unicellular, long bicellular (more in distribution than other types) and tricellular, all with pointed apex, straight to curved on both adaxial and abaxial epidermal surfaces. Abaxial trichomes are papillate on the surfac e. Number per x100 magnification microscope view ranges from 10-14 on adaxial surface and 27-32 on abaxial surface.

Trichome Insertion Basal Cells: Polygonal to conical to circular in shape on adaxial surface; polygonal to rectangular on abaxial surface. Anticlinal wall pattern is straight.

Cells Surrounding Trichome Basal Cells: Often polygonal in shape on adaxial surface, irregular to slightly polygonal on abaxial surface. Anticlinal wall pattern is straight to occasionally wavy on both surfaces. Number ranges from 7-11 on adaxial surface and 7-9 on abaxial surface.

Tithonia diversifolia **(Hemsl.) A. Gray** (Figures 1-2, Tables 1-8)

Trichomes: Non-glandular: bicellular, multicellular uniseriate, straight to hooked on both surfaces, occasionally unicellular a nd tricellular too. Basal cell often multicellular uniseriate and markedly bulbous on both surfaces Number per x100 magnification microscope view ranges from 8 -60 on adaxial surface and from 28-70 on abaxial surface.

Trichome Insertion Basal Cells: Largely circular in shape with straight anticlinal wall pattern on both surfaces.

Cells Surrounding Trichome Basal Cells: Rectangular, conical, occasionally polygonal in shape on both surfaces, with straight to wavy anticlinal wall pattern often; undulate to sin uous anticlinal wall pattern occasionally. Number ranges from 4 -8 on adaxial surface and 5-8 on abaxial surface.

Emilia sonchifolia **(L.) DC. ex Wight** (Figures 1-2, Tables 1-8)

Trichomes: Non-glandular multicellular uniseriate, with some cells often shriveled, largely distributed on veins on both the adaxial and abaxial epidermal surfaces. Number per x100 magnification microscope view ranges from 0-3 on adaxial surface and 1-8 on abaxial surface.

Trichome Insertion Basal Cells: Polygonal to irregular in shape on adaxial surface, conical to ellipsoid largely, to occasionally circular on abaxial surface; anticlinal wall pattern straight to wavy on both surfaces.

Cells Surrounding Trichome Basal Cells: Largely polygonal in shape on both surfaces. Anticlinal wall pattern is straight to wavy on adaxial surface, wavy to sinuous on abaxial surface. Number ranges from 7-9 on adaxial surface and 6-10 on abaxial surface.

Emilia praetermissa **Milne-Redh.** (Figures 1-2, Tables 1-8)

Trichomes: Non-glandular, multicellular uniseriate, often shriveled on some cells. Number per x100 magnification microscope view ranges from 0-4 on adaxial surface and 1-10 on abaxial surface.

Trichome Insertion Basal Cells: Polygonal to irregular in shape on adaxial surface, irregular on abaxial surface. Anticlinal wall pattern is straight to wavy on both surfaces.

Cells Surrounding Trichome Basal Cells: Polygonal to circular to occasionally conical on adaxial surface, largely irregular on abaxial surface. Anticlinal wall pattern is straight at the sides, wavy at the base, occasionally wavy throughout on the adaxial surface, sinuous as in normal epidermal cells on abaxial surface. Number ranges from 7-9 on adaxial surface and 8-9 on abaxial surface.

***Bidens pilosa* L.** (Figures 1-3, Tables 1-8)

Trichomes: Non-glandular on both surfaces; short unicellular and bicellular, occasionally tricellular on the adaxial surface, bicellular and unique multicellular uniseriate pigmented trichomes with the apical cell either shriveled or transparent on the abaxial surface. Number per x100 magnification microscope view ranges from 0-3 on adaxial surface and 1-10 on abaxial surface.

Trichome Insertion Basal Cells: Often rectangular to cylindrical, occasionally circular in shape, on the adaxial surface; conical to ellipsoid in shape on the abaxial surface with wavy anticlinal wall pattern on both surfaces.

Cells Surrounding Trichome Basal Cells: Largely irregular to polygonal in shape on both surfaces, with anticlinal wall undulate to sinuous occasionally straight on adaxial surface, sinuous on abaxial surface. Number ranges from 3-8 on adaxial surface and 3-12 on abaxial surface.

***Synedrella nodiflora* (L.) Gaertn.** (Figures 1-2, Tables 1-8)

Trichomes: Non-glandular on both surfaces, often bicellular, long, and occasionally multicellular uniseriate with sharp pointed ends on the adaxial and abaxial surfaces. Surface of the trichomes is papillate on the abaxial surface. Number per x100 magnification microscope view ranges from 1-7 on the adaxial surface and 12-15 on the abaxial surface.

Trichome Insertion Basal Cells: Often rectangular to polygonal to circular in shape on the adaxial surface, circular to conical on the abaxial surface with wavy anticlinal wall pattern on both surfaces.

Cells Surrounding Trichome Base: Largely polygonal in shape, with straight to wavy to occasionally undulate anticlinal wall on the adaxial surface, while they are largely irregular in shape, with wavy to sinuous, occasionally straight wall pattern on the abaxial surface. Number ranges from 5-10 on adaxial surface and 6-11 on abaxial surface.

***Chromolaena odorata* (L.) R.M. King & H. Rob.** (Figures 1-3, Tables 1-8)

Trichomes: Non-glandular multicellular uniseriate types often straight and amoeboid in shape on both surfaces; occasionally bicellular. Number per x100 magnification microscope view ranges from 1-8 on adaxial surface and 56-75 on abaxial surface.

Trichome Insertion Basal Cells: Often circular to polygonal to conical in shape on both surfaces. Anticlinal wall pattern often straight.

Cells Surrounding Trichome Base: Often irregular in shape on b oth surfaces with undulate anticlinal wall on the adaxial surface, while they are undulate to sinuous to occasionally straight on the abaxial surface. Number ranges from 5-8 on both adaxial and abaxial surfaces.

***Acanthospermum hispidum* D.C.** (Figures 1-2, Tables 1-8)

Trichomes: non-glandular multicellular uniseriate on both surfaces. Number per x100 magnification microscope view ranges from 2-7 on adaxial surface and 4-18 on abaxial surface.

Trichome Insertion Basal Cells: often circular in shape on both surfaces, with straight anticlinal wall.

Cells Surrounding Trichome Base: polygonal to conical in shape on both surfaces, anticlinal wall is straight to slightly wavy on both surfaces. Number ranges from 6-8 on the adaxial surface and 8-9 on the abaxial surface.

Eclipta alba* (L.) *Hassk. (Figures 1-2, Tables 1-8)

Trichomes: Non-glandular on both surfaces; largely unicellular, occasionally bicellular with pointed apex and papillate on both surfaces. Number per x100 magnification microscope view ranges from 2-4 on adaxial surface to 2-12 on abaxial surface.

Trichome Insertion Basal Cells: Often polygonal to occasionally conical and rectangular on the adaxial surface; largely circular to polygonal on the abaxial surface. Anticlinal wall pattern is often straight on both the adaxial and abaxial epidermal surfaces.

Cells Surrounding Trichome Base: Largely cylindrical to circular in shape on the adaxial surface, while they are largely conical to polygonal in shape on the abaxial. Anticlinal wall pattern is straight, wavy at the base occasionally on both surfaces. Number ranges from 6-10 on adaxial surface to 6-9 on abaxial surface.

Tridax procumbens **L.** (Figures 1-2, Tables 1-8)

Trichomes: Non-glandular; often tricellular occasionally bicellular on both adaxial and abaxial epidermal surfaces. Trichomes are pointed at the apex, often straight, occasionally hooked. Number per x100 magnification microscope view ranges from 4-9 on adaxial surface and 5-20 on abaxial surface. On the abaxial surface, longest trichomes were observed on the venous regions.

Trichome Insertion Basal Cells: Often polygonal to circular in shape on the adaxial surface and polygonal to ellipsoid on the abaxial surface. Anticlinal wall is straight on both surfaces.

Cells Surrounding Trichome Base: Largely polygonal to conical to cylindrical in shape on the adaxial surface while they are rectangular to conical to irregular on the abaxial surface. Anticlinal wall pattern is largely straight at the sides, wavy at the base on the adaxial surface while they a re straight to wavy to occasionally sinuous on the abaxial surface. Number per x100 magnification microscope view ranges from 5-10 on the adaxial surface, to 6-8 on the abaxial surface.

Vernonia cinerea **(L.) Less.** (Figures 1-4, Tables 1-8)

Trichomes: Non-glandular largely, but occasionally, sessile glandular bicellular trichomes were observed. Non-glandular types were largely tricellular, bicellular and multicellular which occurred often on both adaxial and abaxial epidermal surfaces. T-shaped non-glandular trichomes were also observed on both surfaces. Number per x100 magnification microscope view ranges from 15-24 on the adaxial surface and 35-64 on the abaxial surface.

Trichome Insertion Basal Cells: Often circular to conical on both surfaces, anticlinal wall straight.

Cells Surrounding Trichome Base: Often polygonal on both surfaces. Anticlinal wall is straight to undulating on the adaxial surface, more of undulating, occasionally straight on the abaxial surface. Number ranges from 6-12 on adaxial surface to 3-9 on abaxial surface.

Vernonia amygdalina **Del.** (Figures 1-4, Tables 1-8.)

Trichomes: Non-glandular largely, but occasionally, sessile glandular bicellular trichomes were observed. Non -glandular types were with broad triangular shaped terminal unicellular head on 2-3 uniseriate cells, occasionally shallowly or irregularly T-shaped. Number per x100 magnification microscope view ranges from 8-20 on the adaxial surface and 30-45 on the abaxial surface.

Trichome Insertion Basal Cells: Often circular to conical to polygonal on both surfaces, anticlinal wall straight.

Cells Surrounding Trichome Base: Polygonal in shape on both surfaces; anticlinal wall straight on adaxial surface, straight to wavy on abaxial surface. Number ranges from 6-8 on adaxial surface and 8-10 on abaxial surface.

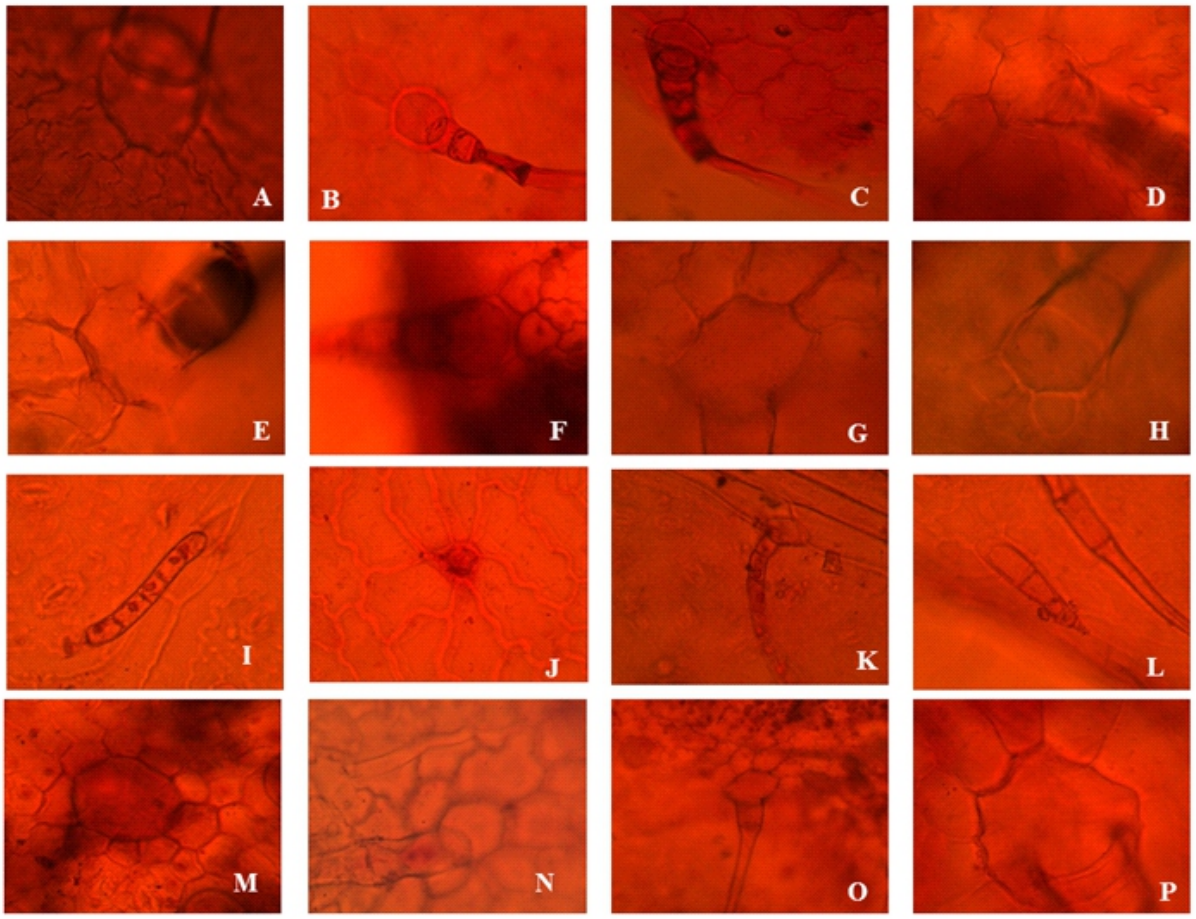

Figure 1: Trichome Insertion Basal Cells (TIBC) and Cells Surrounding Trichome Insertion Basal Cells (CSTIBC) in the family Asteraceae.

A. Circular Trichome Insertion Basal Cell (TIBC) with irregular shape, undulate anticlinal wall pattern (AWP) of cells surrounding trichome insertion basal cells (CSTIBC) – X400 magnification.
B. Circular TIBC with conical shape, straight AWP of cells surrounding trichome insertion basal cells – X400 magnification.
C. Circular to ellipsoid TIBC with polygonal to irregular shape, straight to wavy AWP of cells surrounding trichome insertion basal cells – X400 magnification.
D. Polygonal shaped TIBC with polygonal to irregular shape, undulate to sinuous AWP of cells surrounding trichome insertion basal cells – X400 magnification.
E. Polygonal to rectangular shaped TIBC with cylindrical to irregular shape, straight to wavy AWP of cells surrounding trichome insertion basal cells – X400 magnification
F. Polygonal shaped TIBC with conical shape, straight at sides, wavy at base AWP of cells surrounding trichome insertion basal cells – X400 magnification.
G. Polygonal shaped TIBC with polygonal to irregular shape, straight to wavy AWP of cells surrounding trichome insertion basal cells – X400 magnification.
H. Polygonal to rectangular shaped TIBC with cylindrical to conical shape, straight AWP of cells surrounding trichome insertion basal cells – X400 magnification
I. Conical shaped TIBC with rectangular to irregular shape, straight to undulate AWP of cells surrounding trichome insertion basal cells – X400 magnification
J. Conical shaped TIBC with rectangular to conical to irregular shape, wavy to undulate AWP of cells surrounding trichome insertion basal cells – X400 magnification
K. Cylindrical to rectangular TIBC with polygonal to rectangular shape, straight to wavy AWP of cells surrounding trichome insertion basal cells. – X400 magnification

L. Cylindrical to rectangular TIBC with irregular shape, straight to wavy AWP of cells surrounding trichome insertion basal cells – X400 magnification
M. Ellipsoid TIBC with polygonal shape, straight AWP of cells surrounding trichome insertion basal cells - X400 magnification
N. Ellipsoid to polygonal TIBC, with polygonal to irregular shape, straight AWP of cells surrounding trichome insertion basal cells – X400 magnification
O. Rectangular TIBC, with polygonal shape, straight AWP of cells surrounding trichome insertion basal cells – X100 magnification
P. Irregular TIBC, with polygonal shape, straight AWP of cells surrounding trichome insertion basal cells – X400 magnification.

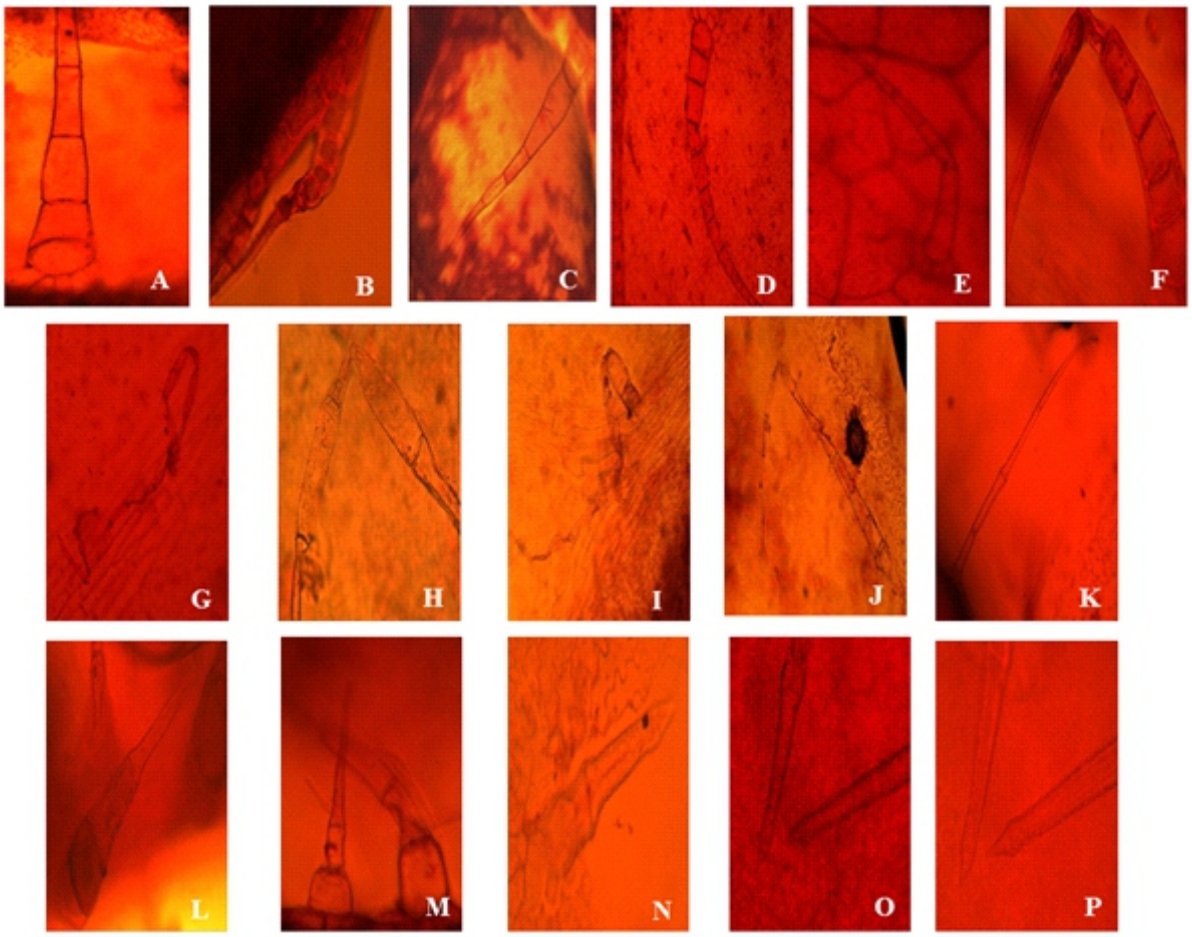

Figure 2: Non-Glandular trichome Types in the Family Asteraceae.
A-F Multicellular uniseriate trichomes straight to prostrate to curved to hooked (magnification: C, D, E = x100; A, B, F = x400)
G-J Multicellular uniseriate trichomes with some cells shrivelled (magnification: G, I, J = x100; H = x400
K-M Tricellular (magnification: M = x100; N-Q = x400)
N Bicellular (magnification: x400)
O Unicellular (magnification: x400)
P Trichome surface papillate (magnification: x400)

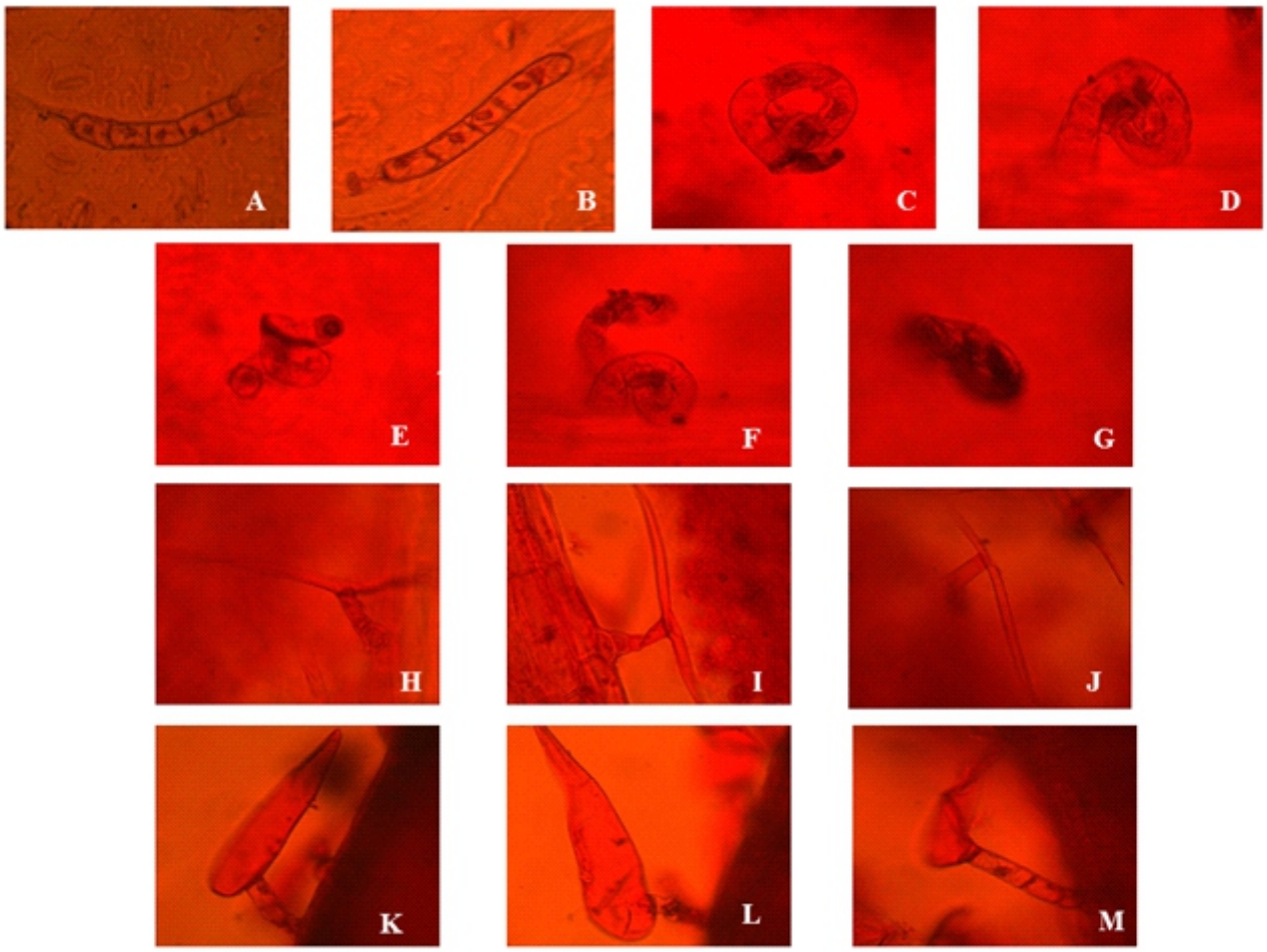

Figure 3: Unique Trichome Types in the Family Asteraceae.
A-B Multicellular uniseriate pigmented non-glandular trichomes in *Bidens pilosa* (Magnification: A = x100; B = x400)
C-G Multicellular amoeboid-shaped non-glandular trichomes in *Chromolaena odorata* (Magnification: E = x100; C, D, F, G = x400)
H-J Regular T-shaped non-glandular trichomes in *Vernonia cinerea* (Magnification: x100)
K-M Irregular T-shaped trichomes in *Vernonia amygdalina*. (Magnification: M = x100; K, L = x400)

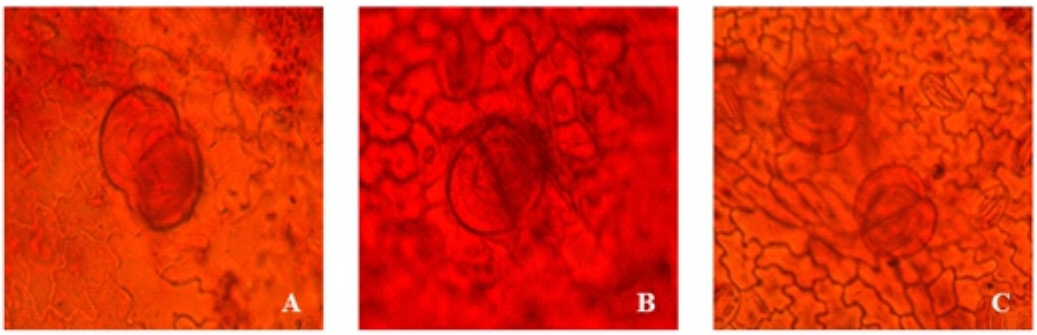

Figure 4: A-C - Bicellular Sessile Glandular Trichomes in the Species of *Vernonia* in the Family Asteraceae. (Magnification: x400)

Table 1: Simple Descriptive Statistics of the Length of the Adaxial and Abaxial Foliar Trichomes in the Species of Asteraceae Studied.

Species	Minimum Adaxial (µm)	Minimum Abaxial (µm)	Maximum Adaxial (µm)	Maximum Abaxial (µm)	Mean Adaxial (µm)	Mean Abaxial (µm)	Standard Deviation Adaxial	Standard Deviation Abaxial	Coefficient of Variation Adaxial (%)	Coefficient of Variation Abaxial (%)
Ageratum conyzoides	225.00	279.00	1476.00	1215.00	1059.00	958.80	315.73	240.17	29.81	25.05
Spilanthes filicaulis	297.00	261.00	585.00	408.00	451.00	320.60	92.40	49.53	20.49	15.45
Aspilia africana	252.00	117.00	864.00	1035.00	642.60	665.40	201.61	254.57	31.37	38.26
Tithonia diversifolia	117.00	63.00	585.00	495.00	352.80	325.80	137.68	136.46	39.02	41.88
Emilia sonchifolia	540.00	540.00	783.00	1080.00	671.40	859.20	80.84	133.40	12.04	15.53
Emilia praetermissa	621.00	378.00	909.00	1170.00	781.80	712.20	99.23	241.18	12.69	33.86
Bidens pilosa	37.50	100.00	162.50	237.50	72.33	201.17	31.97	32.13	44.20	15.97
Synedrella nodiflora	144.00	198.00	387.00	495.00	276.03	332.17	74.08	90.29	26.84	27.18
Chromolaena odorata	180.00	117.00	765.00	675.00	493.80	442.20	178.35	163.63	36.12	37.00
Acanthospermum hispidum	549.00	324.00	1656.00	1485.00	971.53	1048.20	349.25	376.76	35.95	35.94
Eclipta alba	157.50	157.50	432.00	540.00	272.17	326.00	82.08	125.91	30.16	38.62
Tridax procumbens	414.00	468.00	1035.00	1152.00	762.20	742.20	208.22	205.85	27.32	27.74
Vernonia cinerea	162.00	117.00	945.00	585.00	735.00	424.80	243.85	173.99	33.18	40.96
Vernonia amygdalina	105.00	105.00	247.50	237.50	184.17	171.17	44.36	38.64	24.09	22.57

Table 2: Simple Descriptive Statistics of the Breadth of Adaxial and Abaxial Foliar Trichomes in the Species of Asteraceae Studied.

Species	Minimum Adaxial (µm)	Minimum Abaxial (µm)	Maximum Adaxial (µm)	Maximum Abaxial (µm)	Mean Adaxial (µm)	Mean Abaxial (µm)	Standard Deviation Adaxial	Standard Deviation Abaxial	Coefficient of Variation Adaxial (%)	Coefficient of Variation Abaxial (%)
Ageratum conyzoides	36.00	36.00	117.00	81.00	85.20	62.40	20.37	11.01	23.91	17.64
Spilanthes filicaulis	27.00	27.00	45.00	54.00	31.80	39.60	5.76	9.50	18.11	23.99
Aspilia africana	18.00	13.50	36.00	27.50	25.50	24.03	4.39	5.03	17.22	20.93
Tithonia diversifolia	27.00	13.50	54.00	49.50	40.20	33.30	10.13	10.86	25.20	32.61
Emilia sonchifolia	22.50	31.50	45.00	45.00	28.50	38.70	6.29	4.43	22.07	11.45
Emilia praetermissa	27.00	22.50	40.50	36.00	32.40	27.30	4.56	3.59	14.07	13.15
Bidens pilosa	12.50	12.50	50.00	25.00	21.83	16.83	8.93	4.17	40.91	24.78
Synedrella nodiflora	12.50	12.50	27.00	36.00	18.47	20.30	4.30	7.21	23.28	35.52
Chromolaena odorata	13.50	9.00	45.00	45.00	29.10	26.70	10.74	11.08	36.91	41.50
Acanthospermum hispidum	36.00	36.00	63.00	81.00	53.70	54.30	9.69	12.89	18.04	23.74
Eclipta alba	17.50	17.50	45.00	36.00	31.67	27.27	8.34	5.66	26.33	20.76
Tridax procumbens	18.00	18.00	36.00	31.50	29.70	24.90	5.84	4.12	19.66	16.55
Vernonia cinerea	5.00	9.00	54.00	45.00	33.50	27.30	16.62	11.84	49.61	43.37
Vernonia amygdalina	20.00	5.00	40.50	32.50	30.87	25.63	6.65	6.86	21.54	26.77

Table 3: Simple Descriptive Statistics of the Length of Adaxial and Abaxial Trichome Insertion Basal Cells in the Species of Asteraceae Studied.

Species	Minimum Adaxial (µm)	Minimum Abaxial (µm)	Maximum Adaxial (µm)	Maximum Abaxial (µm)	Mean Adaxial (µm)	Mean Abaxial (µm)	Standard Deviation Adaxial	Standard Deviation Abaxial	Coefficient of Variation Adaxial (%)	Coefficient of Variation Abaxial (%)
Ageratum conyzoides	65.00	70.00	127.50	112.50	100.90	83.57	18.55	14.96	18.38	17.90
Spilanthes filicaulis	50.00	50.00	75.00	75.00	62.67	65.89	7.53	8.58	12.02	13.00
Aspilia africana	30.00	30.00	75.00	52.50	50.00	41.61	14.36	7.11	28.72	17.09
Tithonia diversifolia	50.00	30.00	72.50	57.50	58.83	43.93	7.06	9.18	12.00	20.90
Emilia sonchifolia	50.00	75.00	82.50	102.50	64.17	87.86	7.94	8.19	12.37	9.32
Emilia praetermissa	55.00	87.50	72.50	137.50	62.67	114.46	5.13	16.15	8.19	14.11
Bidens pilosa	42.50	30.00	87.50	90.00	69.50	60.89	13.47	22.24	19.38	36.52
Synedrella nodiflora	37.50	40.00	62.50	62.50	51.83	48.57	8.15	7.45	15.72	15.34
Chromolaena odorata	32.50	22.50	70.00	50.00	47.33	35.18	12.55	7.37	26.52	20.95
Acanthospermum hispidum	47.50	30.00	62.50	70.00	56.33	55.54	4.81	11.06	8.53	19.91
Eclipta alba	25.00	105.00	75.00	162.50	56.83	135.54	12.73	15.60	22.40	11.51
Tridax procumbens	112.50	77.50	162.50	142.50	137.83	111.79	15.03	20.08	10.90	17.96
Vernonia cinerea	32.50	22.50	95.00	82.50	62.57	46.96	21.66	21.95	34.62	46.74
Vernonia amygdalina	17.50	17.50	30.00	27.50	25.17	22.50	3.59	3.79	14.26	16.84

Table 4: Simple Descriptive Statistics of the Breadth of Adaxial and Abaxial Trichome Insertion Basal Cell in the Species of Asteraceae Studied.

Species	Minimum Adaxial (µm)	Minimum Abaxial (µm)	Maximum Adaxial (µm)	Maximum Abaxial (µm)	Mean Adaxial (µm)	Mean Abaxial (µm)	Standard Deviation Adaxial	Standard Deviation Abaxial	Coefficient of Variation Adaxial (%)	Coefficient of Variation Abaxial (%)
Ageratum conyzoides	37.50	50.00	92.50	80.00	72.83	69.00	18.07	9.15	24.81	13.26
Spilanthes filicaulis	30.00	35.00	62.50	60.00	50.17	47.67	9.56	7.23	19.06	15.17
Aspilia africana	25.00	25.00	62.50	50.00	39.33	33.50	10.75	6.53	27.33	19.49
Tithonia diversifolia	45.00	27.50	65.00	52.50	52.33	39.67	6.65	8.96	12.71	22.59
Emilia sonchifolia	37.50	45.00	55.00	55.00	48.00	49.17	4.25	2.62	8.85	5.33
Emilia praetermissa	42.50	55.00	55.00	90.00	48.67	68.50	3.39	9.53	6.97	13.91
Bidens pilosa	25.00	15.00	55.00	60.00	40.83	36.83	8.49	12.37	20.79	33.59
Synedrella nodiflora	37.50	27.50	55.00	37.50	45.67	33.00	5.94	3.16	13.01	9.58
Chromolaena odorata	17.50	15.00	42.50	32.50	29.67	26.00	7.13	4.71	24.03	18.12
Acanthospermum hispidum	45.00	25.00	55.00	57.50	50.17	48.83	3.47	9.06	6.92	18.55
Eclipta alba	25.00	87.50	52.50	132.50	35.50	114.17	9.27	15.05	26.11	13.18
Tridax procumbens	87.50	75.00	132.50	97.50	112.67	80.50	14.89	6.56	13.22	8.15
Vernonia cinerea	25.00	20.00	67.50	62.50	48.83	38.33	17.80	16.65	36.45	43.44
Vernonia amygdalina	15.00	15.00	27.50	25.00	21.67	18.83	3.86	3.39	17.81	18.00

Table 5: Simple Descriptive Statistics of the Length of Adaxial and Abaxial Cells Surrounding Trichome Basal Cells in the Species of Asteraceae

Species	Minimum Adaxial (µm)	Minimum Abaxial (µm)	Maximum Adaxial (µm)	Maximum Abaxial (µm)	Mean Adaxial (µm)	Mean Abaxial (µm)	Standard Deviation Adaxial	Standard Deviation Abaxial	Coefficient of Variation Adaxial (%)	Coefficient of Variation Abaxial (%)
Ageratum conyzoides	60.00	27.50	110.00	102.50	80.00	68.50	14.11	24.85	17.64	36.28
Spilanthes filicaulis	37.50	37.50	105.00	117.50	66.17	75.67	16.53	23.44	24.98	30.98
Aspilia africana	22.50	12.50	52.50	67.50	42.67	48.00	7.76	16.96	18.19	35.33
Tithonia diversifolia	35.00	27.50	62.50	72.50	47.50	47.50	9.73	13.69	20.48	28.82
Emilia sonchifolia	67.50	47.50	97.50	87.50	81.00	73.33	9.10	11.98	11.23	16.34
Emilia praetermissa	55.00	55.00	115.00	127.50	85.00	102.83	18.47	23.73	21.73	23.08
Bidens pilosa	52.50	65.00	102.50	112.50	81.83	86.50	16.86	14.20	20.60	16.42
Synedrella nodiflora	42.50	37.50	92.50	95.00	74.50	61.33	18.38	17.67	24.67	28.81
Chromolaena odorata	22.50	30.00	65.00	55.00	46.00	45.67	12.13	8.42	26.37	18.44
Acanthospermum hispidum	40.00	30.00	60.00	65.00	50.50	41.33	5.76	11.05	11.41	26.74
Eclipta alba	37.50	32.50	90.00	57.50	59.00	45.50	19.86	9.78	33.66	21.49
Tridax procumbens	70.00	50.00	115.00	100.00	96.83	80.83	15.96	18.87	16.48	23.35
Vernonia cinerea	27.50	17.50	70.00	65.00	46.50	47.33	9.63	13.93	20.71	29.43
Vernonia amygdalina	25.00	22.50	55.00	40.00	36.17	29.50	8.50	5.69	23.50	19.29

Table 6: Simple Descriptive Statistics of the Breadth of Adaxial and Abaxial Cells Surrounding Trichome Basal Cells in the Species of Asteraceae

Species	Minimum Adaxial (µm)	Minimum Abaxial (µm)	Maximum Adaxial (µm)	Maximum Abaxial (µm)	Mean Adaxial (µm)	Mean Abaxial (µm)	Standard Deviation Adaxial	Standard Deviation Abaxial	Coefficient of Variation Adaxial (%)	Coefficient of Variation Abaxial (%)
Ageratum conyzoides	37.50	40.00	90.00	75.00	50.83	57.50	14.60	9.06	28.72	15.76
Spilanthes filicaulis	22.50	20.00	62.50	90.00	39.67	32.67	12.21	16.16	30.78	49.46
Aspilia africana	20.00	17.50	35.00	52.50	27.83	29.17	4.10	10.03	14.73	34.38
Tithonia diversifolia	27.50	25.00	57.50	50.00	36.00	32.53	8.75	6.67	24.31	20.50
Emilia sonchifolia	37.50	22.50	72.50	50.00	47.00	32.33	11.73	8.26	24.96	25.55
Emilia praetermissa	35.00	32.50	82.50	100.00	51.00	66.83	13.59	18.29	26.65	27.37
Bidens pilosa	32.50	32.50	60.00	62.50	46.67	47.33	8.80	7.76	18.86	16.40
Synedrella nodiflora	27.50	20.00	47.50	42.50	35.83	32.50	5.72	5.35	15.96	16.46
Chromolaena odorata	22.50	15.00	62.50	30.00	34.00	25.67	13.98	4.06	41.12	15.82
Acanthospermum hispidum	27.50	22.50	40.00	37.50	31.83	28.50	3.72	3.64	11.69	12.77
Eclipta alba	22.50	17.50	62.50	45.00	37.33	29.67	10.92	9.68	29.25	32.63
Tridax procumbens	45.00	35.00	77.50	57.50	65.17	46.83	11.24	7.16	17.25	15.29
Vernonia cinerea	20.00	15.00	32.50	50.00	26.83	28.17	3.83	9.38	14.28	33.30
Vernonia amygdalina	17.50	15.00	27.50	22.50	22.00	19.67	2.87	2.08	13.05	10.57

Table 7: Summary of the Characters of Trichomes and Trichome Insertion Basal Cells of the Species of Family Asteraceae Studied.

Species	Trichome type (Ad.)	Trichome type (Ab.)	NTPMV (Ad.)	NTPMV (Ab.)	TIBC shape (Ad.)	TIBC shape (Ab.)	TIBC AWP (Ad.)	TIBC AWP (Ab.)
Ageratum conyzoides	NG, multicellular uniseriate with occasional shriveled cells	NG, multicellular uniseriate with occasional shriveled cells	1-6	2-22	Circular	Circular, ellipsoid, conical	Straight	Straight
Spilanthes filicaulis	NG, multicellular, uniseriate, occasionally bicellular and unicellular	NG, multicellular, uniseriate, occasionally bicellular and unicellular	0-3	0-5	Circular to polygonal to occasionally rectangular to ellipsoid	Circular to oblong	Straight	Straight
Aspilia africana	NG, short unicellular, long bicellular, tricellular	NG, short unicellular, long bicellular, tricellular, papillate.	10-14	27-32	Polygonal to conical to circular	Polygonal to rectangular	Straight	Straight
Tithonia diversifolia	NG, unicellular, bicellular, tricellular, occasionally multicellular	NG, unicellular, bicellular, tricellular, occasionally multicellular	8-60	28-70	Circular	Circular	Straight	Straight
Emilia sonchifolia	NG, multicellular uniseriate, some cells shriveled	NG, multicellular uniseriate, some cells uniseriate	0-3	1-8	Polygonal to irregular	Conical to ellipsoid	Straight to wavy	Straight to wavy
Emilia praetermissa	NG, multicellular uniseriate with often shriveled cells	NG, multicellular uniseriate with often shriveled cells	0-4	1-10	Polygonal to irregular	Irregular	Straight to wavy	Straight to wavy
Bidens pilosa	NG, unicellular, short bicellular, occasionally tricellular	NG, bicellular and multicellular uniseriate, pigmented trichomes with apical cells shriveled or transparent	0-3	1-10	Rectangular to cylindrical	Conical to ellipsoid	Wavy	Wavy
Synedrella nodiflora	NG, often bicellular long, occasionally multicellular uniseriate	NG, often bicellular long, occasionally multicellular uniseriate, surface papillate	1-7	12-15	Circular to polygonal to conical	Circular to polygonal to conical	Straight	Straight

Table 7: Summary of the Characters of Trichomes and Trichome Insertion Basal Cells of the Species of Family Asteraceae Studied. Contd

Species	Trichome type (Ad.)	Trichome type (Ab.)	NTPMV (Ad.)	NTPMV (Ab.)	TIBC shape (Ad.)	TIBC shape (Ab.)	TIBC AWP (Ad.)	TIBC AWP (Ab.)
Chromolaena odorata	NG, occasionally bicellular, often multicellular uniseriate straight to curved to amoeboid	NG, occasionally bicellular, often multicellular uniseriate straight to curved to amoeboid	1-8	56-75	Circular to polygonal to conical	Circular to polygonal to conical	Straight	Straight
Acanthospermum hispidum	NG, multicellular, uniseriate	NG, multicellular, uniseriate	2-7	4-18	Circular	Circular	Straight	Straight
Eclipta alba	NG, unicellular, occasionally bicellular, surface papillate	NG, unicellular, occasionally bicellular, surface papillate	2-4	2-12	Polygonal to conical and rectangular	Circular to polygonal	Straight	Straight
Tridax procumbens	NG, tricellular, occasionally bicellular	NG, tricellular, occasionally bicellular	4-9	5-20	Polygonal to circular	Polygonal to ellipsoid	Straight	Straight
Vernonia cinerea	Glandular and NG; Glandular: sessile, bicellular; NG: bicellular, tricellular and multicellular, often regular T-shaped	Glandular and NG; Glandular: sessile, bicellular; NG: bicellular, tricellular and multicellular, often regular T-shaped	15-24	35-64	Circular to conical	Circular to conical	Straight	Straight
Vernonia amygdalina	Glandular and NG; Glandular: sessile, bicellular; NG: with broad triangular shaped apical unicellular head on 2-3 uniseriate cells; often irregulalrly T-shaped	Glandular and NG; Glandular: sessile, bicellular; NG: with broad triangular shaped apical unicellular head on 2-3 uniseriate cells; often irregularly T-shaped	8-20	30-45	Circular to conical to polygonal	Circular to conical to polygonal	Straight	Straight

Key:

Ad. Adaxial
Ab. Abaxial
NG Non-glandular
NTPMV Number of Trichomes per x100 Magnification Microscope View
TIBC Trichome Insertion Basal Cell
AWP Anticlinal Wall Pattern

Table 8: Summary of the Characters of Cells Surrounding Trichome Insertion Basal Cells (CSTIBC)

Species	Number of CSTIBC (Adaxial)	Number of CSTIBC (Abaxial)	Shape of CSTIBC (Adaxial)	Shape of CSTIBC (Abaxial)	Anticlinal Wall Pattern of CSTIBC (Adaxial)	Anticlinal Wall Pattern of CSTIBC (Abaxial)
Ageratum conyzoides	3-9	3-7	Polygonal to rectangular to cylindrical and occasionally irregular	Polygonal to rectangular to cylindrical and occasionally irregular	Straight, occasionally undulate to sinuous	Straight, occasionally undulate to sinuous
Spilanthes filicaulis	4-10	5-6	Conical to rectangular to occasionally irregular	Conical to rectangular to occasionally irregular	Undulate to sinuous	Undulate to sinuous
Aspilia africana	7-11	7-9	Polygonal	Irregular to slightly polygonal	Straight to occasionally wavy	Straight to occasionally wavy
Tithonia diversifolia	4-8	5-8	Rectangular to conical to occasionally polygonal	Rectangular to conical to occasionally polygonal	Straight to wavy to undulate to sinuous occasionally	Straight to wavy to undulate to sinuous occasionally
Emilia sonchifolia	7-9	6-10	Polygonal	Polygonal	Straight to wavy	Wavy to sinuous
Emilia praetermissa	7-9	8-9	Polygonal to occasionally conical	Irregular	Straight to wavy at sides, wavy at base	Sinuous
Bidens pilosa	3-8	3-12	Irregular to polygonal	Irregular to polygonal	Undulate to sinuous, occasionally straight	Sinuous
Synedrella nodiflora	5-10	6-11	Irregular	Irregular	Undulate	Undulate to sinuous
Chromolaena odorata	5-8	5-8	Irregular	Irregular	Undulate	Undulate to sinuous to occasionally straight
Acanthospermum hispidum	6-8	8-9	Polygonal to conical	Polygonal to conical	Straight to slightly wavy	Straight to slightly wavy
Eclipta alba	6-10	6-9	Cylindrical to circular	Conical to polygonal	Straight, wavy at base occasionally	Straight, wavy at base occasionally
Tridax procumbens	5-10	6-8	Polygonal to conical to cylindrical	Rectangular to conical to irregular	Straight at sides, wavy at the base	Straight to wavy to occasionally sinuous
Vernonia cinerea	6-12	3-9	Polygonal	Polygonal	Straight to undulate	Straight to undulate
Vernonia amygdalina	6-8	8-10	Polygonal	Polygonal	Straight	Straight to wavy

DISCUSSIONS

In this study, we examined the trichome morphology, trichome insertion basal cells (TIBC), and the cells surrounding trichome insertion basal cells (CSTIBC) in the leaves of fourteen plant species from the family Asteraceae. The type of trichome is crucial for identifying plant species and understanding their relationships (Bahadur *et al*., 2023). Furthermore, trichomes are essential for complementing taxonomic data, serving as a foundation for taxonomic and evolutionary studies (Sari *et al*., 2021).

Numerous researchers have found that examining trichomes at the species level is highly valuable (Adedeji, 2004; Adedeji *et al*., 2007; Perveen *et al*., 2016 and Sari *et al.* 2021). Foliar trichomes in the species of the family studied are largely non-glandular except in the two species of *Vernonia* where sessile glandular trichomes were observed. They are largely non-glandular multicellular uniseriate on both surfaces of *Ageratum conyzoides, Spilanthes filicaulis, Emilia sonchifolia, Emilia praetermissa* and *Acanthospermum hispidum*; occasionally non-glandular multicellular uniseriate on both surfaces of *Tithonia diversifolia, Synedrella nodiflora, Bidens pilosa, Chromolaena odorata* and *Vernonia cinerea*. Shriveled cells within the uniseriate multicellular cells were common in *Emilia sonchifolia* and *Emilia praetermissa* while they occurred sparsely in *Ageratum conyzoides*.

Non-glandular unicellular trichomes were observed on the two foliar epidermal surfaces of *Aspilia africana, Bidens pilosa, Tithonia diversifolia* and *Eclipta alba*. They are bicellular on both surfaces of *Aspilia africana, Tithonia diversifolia, Bidens pilosa, Synedrella nodiflora, Spilanthes filicaulis* and occasionally bicellular on both surfaces of *Eclipta alba* where more unicellular non-glandular trichomes were observed. They are tricellular on both surfaces of *Aspilia africana, Tridax procumbens, Vernonia cinerea, Spilanthes filicaulis, Tithonia diversifolia*, and occasionally tricellular on the adaxial surface of *Bidens pilosa* where unicellular and short bicellular non-glandular trichomes are more prominent. These species of Asteraceae can be delimited based on the type of non-glandular trichomes observed in them. Several authors have employed trichome types in the delimitation and identification of plant species (Adedeji *et al*., 2007; Glas *et al*., 2012; Sari *et al*., 2021and Abdulrashid *et al*., 2022).

Some unique trichomes were observed in some of the species of the family studied. This clearly delimits them from the other species studied. According to Metcalfe and Chalk (1979), the presence of a particular type of trichome can frequently delimit species, genera or even whole families. Uniquely pigmented multicellular uniseriate trichomes with apical cells shriveled or transparent were observed only on the foliar epidermal abaxial surface of *Bidens pilosa*. This separated *Bidens pilosa* from the other species studied. Amoeboid shaped multicellular uniseriate trichomes were observed in *Chromolaena odorata* only and T-shaped trichomes were observed in the species of the genus *Vernonia* only. However, the T-shaped trichomes in both species of the genus (*V. cinerea* and *V. amygdalina*) differ in that while the T-shape in *Vernonia cinerea* is the perfect or regular T-shape, the T-shape trichomes in *V. amygdalina* are shallowly or irregularly T-shaped. The T-shapes also differ in the shape and size of the apical cell. While the apical cell in *V. cinerea* is narrowly cylindrical, it is widely triangular in *V. amygdalina*. Length of apical cell in *V. cinerea* ranges from 80 μm to 232.5 μm, while breadth ranges from 5 μm to 15 μm. Length in *V. amygdalina* ranges from 115μm to 170 μm, while breadth ranges from 30 μm to 40 μm. Kemka-Evans *et al.* (2014) also reported the regular and irregular T-shaped trichomes in the species of the genus *Vernonia* that they studied, but did not report on the differences in the apical cells forming the T-shape in the species studied.

Simple descriptive statistics revealed that trichomes are longest on the foliar adaxial and abaxial epidermal surfaces of *Acanthospermum hispidum*, followed by *Ageratum conyzoides* and shortest in *Bidens pilosa* and *Vernonia amygdalina* on both epidermal surfaces. They are widest on the adaxial and abaxial surfaces of *Ageratum conyzoides* and narrowest on the adaxial surface of *Vernonia cinerea* and abaxial surface of *Vernonia amygdalina*. Coefficient of Variation (CV) for length of trichomes on the adaxial surface is highest in *Bidens pilosa* and lowest in *Emilia sonchifolia*. On the abaxial surface, it is highest in *Tithonia diversifolia*

and lowest in *Spilanthes filicaulis*. High coefficient of variation signifies higher variation within the character under study and lower coefficient of variation signifies lower variation within the character. This indicates that there is much variation in the length of trichomes in *Bidens pilosa* on the adaxial surface than in *Emilia sonchifolia* and on the abaxial surface, there is more variation in the length of trichomes in *Tithonia diversifolia* than in *Spilanthes filicaulis*. Coefficient of Variation for the width of the trichomes is highest in *Vernonia cinerea*, lowest in *Emilia praetermissa* on the adaxial surface while it is highest in *Vernonia cinerea*, lowest in *Emilia sonchifolia* on the abaxial surface.

Number of trichomes per x100 magnification microscope view clearly reveals the presence of more trichomes on the abaxial surface than on the adaxial surface in all the species studied. Highest density was observed on the abaxial surface of *Aspilia africana, Chromolaena odorata* and *Vernonia cinerea*. A large number of trichomes is an adaptive strategy to the adverse conditions of the Nigerian biome and its morphological diversity can be useful in the family systematics (Bahadur *et al*., 2023).

Surfaces of trichomes in *Aspilia africana, Synedrella nodiflora* and *Eclipta alba* are papillate. This separates these three species from the other species of the family studied. Fornero *et al.* (2017) reported that *Arabidopsis* trichomes exhibit distinct cell wall characteristics including papillae. They described the cell walls of *Arabidopsis* trichomes papillae as raised, rounded sub-cuticular structures that give trichome cell surface a bumpy appearance visible under the microscope. This description agrees with the structure of the papillae observed on the trichomes of the species of the family Asteraceae studied. While the mechanisms behind papillae formation and their molecular composition remain largely unknown, it has been long speculated that these structures might contribute to the high calcium content observed in trichomes (Rerie *et al*., 1994). Previous studies analyzing the cell wall composition of trichomes have shown that papillae contain magnesium and calcium and are enriched in phosphorus (Esch *et al*., 2003; Marks *et al*., 2009).

Trichome insertion basal cells (TIBC) shape, which is a novel attribute in this study, ranges from circular, to ellipsoid to conical to polygonal to rectangular to cylindrical to irregular with different combinations of one to four shapes per species. It is the same shape on both adaxial and abaxial epidermal surfaces of *Tithonia diversifolia* (circular), *Synedrella nodiflora* (circular to polygonal to conical), *Chromolaena odorata* (circular to polygonal to conical), *Acanthospermum hispidum* (circular), *Vernonia cinerea* (circular to conical) and *Vernonia amygdalina* (circular to conical to polygonal), but are not necessarily the same on both surfaces of the remaining of the species studied. This shows species specific trichome insertion basal cell types which can also be employed in the identification of the species in this study (Abdulrashid *et al*., 2022)

It is noteworthy that the two species of *Emilia* can be delimited from each other on the basis of the shapes of the trichome insertion basal cells on the abaxial epidermal surface. While they are conical to ellipsoid on the abaxial epidermal surface of *Emilia sonchifolia*, they are irregular on the abaxial epidermal surface of *Emilia praetermissa*. Anticlinal wall pattern of trichome insertion basal cells (TIBC) is generally straight on both surfaces except in *Emilia sonchifolia* and *Emilia praetermissa* where it is straight to wavy and *Bidens pilosa* where it is wavy.

Trichome Insertion Basal Cells (TIBC) are longest in *Tridax procumbens* and shortest in *Vernonia amygdalina* on the adaxial surface, while they are longest in *Eclipta alba* and shortest in *Vernonia amygdalina* on the abaxial surface. They are widest in *Tridax procumbens* and narrowest in *Vernonia amygdalina* on the adaxial surface, while they are widest in *Eclipta alba* and narrowest in *Vernonia amygdalina* on the abaxial surface. Coefficient of Variation (CV) is highest in *Vernonia cinerea* and lowest in *Acanthospermum hispidum* on the adaxial surface, while they are highest in *Vernonia cinerea* and lowest in *Emilia sonchifolia* on the abaxial surface. For the width of trichome insertion basal cells, Coefficient of Variation is highest in *Vernonia cinerea* on both the adaxial and abaxial surfaces, while it is lowest in *Acanthospermum hispidum* on adaxial surface and lowest in *Emilia sonchifolia* on abaxial surface.

Shapes of cells surrounding trichome insertion basal cells range from polygonal to rectangular to cylindrical to conical to irregular. They are the same on both surfaces of *Ageratum conyzoides, Spilanthes filicaulis, Tithonia diversifolia, Emilia sonchifolia, Bidens pilosa, Synedrella nodiflora, Chromolaena odorata, Acanthospermum hispidum, Vernonia cinerea* and *Vernonia amygdalina*. They differ markedly on both surfaces of *Emilia praetermissa, Eclipta alba* and *Tridax procumbens*. The two species of *Emilia* can be delimited from each other by this character on the abaxial surface. Whereas it is largely polygonal in *Emilia sonchifolia*, it is largely irregular in *Emilia praetermissa*. It is polygonal on both surfaces in the species of the genus *Vernonia* studied.

The anticlinal wall pattern of cells surrounding trichome insertion basal cells (CSTIBC) ranges from straight to wavy to undulate to sinuous with a foliar surface having more than one pattern. The pattern is the same on both surfaces of *Ageratum conyzoides, Spilanthes filicaulis, Aspilia africana, Tithonia diversifolia, Acanthospermum hispidum* and *Eclipta alba*, but differ in the other species studied.

Number of cells surrounding trichome insertion basal cells (CSTIBC) vary with not less than three and not higher than twelve in number. The lowest – three (3) is reported in *Ageratum conyzoides. Bidens pilosa* and *Vernonia cinerea*, while the highest – 12, is reported in *Bidens pilosa*. There is an overlap in the number for the two species of *Emilia* in this study: 7-9 on the adaxial surfaces of both species of *Emilia*; 6-10 on the abaxial surface of *Emilia sonchifolia* and 8-9 in *Emilia praetermissa*. This character could be diagnostic for the genus. However, the two species of the genus *Vernonia* can be delimited from each other by the number of cells surrounding trichome insertion basal cells (CSTIBC) on the abaxial surface, whereas they are 3-9 in *Vernonia cinerea*, they are 8-10 in *Vernonia amygdalina*.

Cells surrounding trichome insertion basal cells (CSTIBC) are longest in *Emilia praetermissa* and *Tridax procumbens* while they are shortest in *Aspilia africana* and *Chromolaena odorata* on the adaxial surface while they are longest in *Emilia praetermissa* and shortest in *Aspilia africana* on the abaxial surface. They are widest in *Ageratum conyzoides* and narrowest in *Vernonia amygdalina* on the adaxial surface, while they are widest in *Emilia praetermissa* and narrowest in *Chromolaena odorata, Vernonia cinerea and Vernonia amygdalina* on the abaxial surface. Coefficient of Variation for length is highest in *Eclipta alba* and lowest in *Emilia sonchifolia* on the adaxial surface, while they are highest in *Ageratum conyzoides* and lowest in *Emilia sonchifolia* on the abaxial surface. For the width, Coefficient of Variation is highest in *Chromolaena odorata* and lowest in *Acanthospermum hispidum* on the adaxial surface, while it is highest in *Spilanthes filicaulis* and lowest in *Acanthospermum hispidum* on the abaxial surface.

CONCLUSION

The foregoing clearly reveals that attributes from trichome insertion basal cells (TIBC) and cells surrounding trichome insertion basal cells (CSTIBC) can be used as additional characters in the taxonomy of the family Asteraceae. It will also be interesting to study the applicability of these novel characters in the taxonomy of other families of plants too.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

AUTHOR CONTRIBUTIONS

A.O.O.: Conceptualization, Methodology, Validation, Writing - Review& Editing, Visualization

A.O.: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing - Original Draft, Visualization

O.I.I.: Conceptualization, Validation, Investigation, Resources, Visualization

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