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Trichomes Morphological Diversity in Some Species from Related Tribes of Asteraceae Family in Iraq

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Abstract

This study includedepidermal appendages characters of ten species belongingto the *family*Asteraceae.Most of the studied species are characterized by eglandular, glandular, trichomesand papillae which are variable according to itskind, number of cells, shape, dimensions, characteristicsof surrounding cells, wall thickness and the position. Results showed that all species included glandular and eglandulartrichomes except*Cosmos bipinnatus, Ecliptaprostrate,* and*Eupatoriumcannabinum* that lacked in glandular trichomes and were based on their specific details.Trichomes were divided into different groups. The glandular ones involved sessile glandular or group multicellular and the head wasmace-shaped or rounded.Whereaseglandulartrichomes are classified into various groups,unicellular trichomes group with obtuse or acute apex or with tuft shape or dendroid, dicellular.Trichome group uniserriate or biserriate, and multicellular trichome group which is widely different in their shapes, dimensions, number of cell and the position. Papillae distributed on stem, corolla, and stigma have triangular-shape with acute apex or finger-like shape with obtuse apex.Hence,trichomes reveal a taxonomic importance in species identification and determine the relationships among them in their tribes.

Keywords: Asteraceae, Eglandulartrichomes, Glandular trichomes, Papillae

التباين المظهري لشعيرات انواع عائدة لعشائر متقاربة من عائلة الاستر في العراق

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الخلاصة

تضمنت الدراسة الحالية صفات زوائد البشرة لعشرة انواع نباتية تنتميالى عائلة الاستر،اذ اتصفت معظم الانواع المدروسة بوجود الشعيرات الغدية واللاغدية والحليمات المتباينة تبعا لنوعها،عدد خلاياها،اشكالها،ابعادها،صفات الخلايا المحيطة بقاعدتها،سمك جدرانها،ومواقع تواجدها. واظهرت الدراسة وجود الشعيرات الغدية واللاغدية في جميع الانواع المدروسة باستثناء *Cosmos bipinnatus*، *Eclipta prostrate* و*Eupatorium cannabinum* والتي اتصفت بانعدام الشعيرات الغدية فيها. تم تقسيم الشعيرات الى مجاميع تبعا للصفات الدقيقة،حيث صنفت الشعيرات الغدية الى غدد جالسة وشعيرات متعددة الخلايا ومعنقة ذات راس كروي او مشابه لشكل الدبوس او صولجاني،بينما الشعيرات اللاغدية قسمت المجاميع متباينة منها مجموعة الشعيرات احادية الخلية ذات القمم المقورة او الحادة،او الشعيرات المتجمعة بشكل حزم،او الشعيرات المتفرعة بشكل شجيري والشعيرات ثنائية الخلية او المتعددة الخلايا سواء احادية الصف او المتعددة الصفوف والتي اظهرت تباينا بالاشكال والابعاد وعدد الخلايا ومواقع تواجدها،اما الحليمات فقد انتشرت بكل

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من السيقان والاوراق التويجية والمياسم وكانت باشكال مختلفة منها المثلثة وذات قمم حادة او اصبعية الشكل وذات قمم مقورة،وبذلك اظهرت الشعيرات اهمية تصنيفية لعزل الانواع وتحديد العلاقات فيما بينها وبين العشائر التابعة لها.

1. Introduction

The Family Asteraceae is one of the largest families of flowering plants with a worldwide distribution in the number of species and isimportant economically [1]. It consists of more than 1,600 genera and over 25,000 species, belonging to 17 tribes and three subfamilies [2]. Most members of Asteraceae are shrubs, herbaceous, subshrubs, vines or rarely trees [3].The family isdivided into several groups and tribes that differ according to the researchers and their study sites. Cassini[4]was the first researcher to organize Asteraceae family members into 19 tribes and several sub tribes, based on morphological traits like stems, leaves, flowers and other features.

The classification of family tribes according to their trichomes characters is an important study, revealing the relationships as similarity or distinguished features between the different related taxa [5,6,7]. The family trichomes recorded a high diversity between two major classes, the glandular and non-glandular trichomes. Their shapes, sizes and other features such as types of secretion, and the hair distinction may be based onthe numbers of cells as in unicellular or multicellular hairs or may be branched or un-branched or may consist of one row of cells or several rows [8]. Both unicellular and multicellular glandular trichomes secrete chemical compounds, such as essential oils for specialized function [9]. Hence,due to the importance of trichomes studies in family tribes classification, many studies were conducted on the exact characteristics of closely related taxa to find out the similarities and differences among them as showed in [10,11]. So, for the purpose of completing the information aboutepidermal appendages for genera and species of the family Asteraceae in Iraq, and to determine the importance of these features in isolation and identification of each species as well as finding the relationships among these speciesfrom related tribes, this study was conducted for the first time.

2.Materials and Methods

A total of tenspecies of the family Asteraceae, 4wild and 6cultivated, were collected from different regions of Baghdad and classified according to Iraqi flora, except the species *Tagetespatula* L. which is a new species for flora of Iraq.Epidermis tissue slideswere prepared by peeling the tissue from the leaf and stem, and other parts of the plant body,in the form of the thin pellicleby using razors, needles and forceps [12].

The samples were stained with saffranin0.5% for 5 minutes and washed with ethanol 70%. Later on the samples were first mounted in glycerin after removing the excess of stain, and then were observed under a compound light microscope with 10x and 40x magnifications. Measurement of the trichomes was done by using an ocular micrometer.iPhone 12 camera was used for imaging the specimensslides[13].

Study species include:

Tribe: Coreopsideae -*Cosmos bipinnatus* Cav. -*Dahlia pinnata* Cav.	.Tribe: Heliantheae -*Ecliptaprostrate* L. -*Helianthus annuus*L. -*Zinnia elegans* L. -*Xanthium strumarium L.*	Tribe: Tageteae -*Tageteserecta* L. -*Tagetespatula* L.
Tribe: Eupatorium -*Eupatorium cannabinum* L Tribe: Helenieae -*Bidens tripartite* L		

3.Resultsand Discussion

The results of current study revealed the presence of three types of epidermal appendages (glandular, eglandular, and papillae) in ten plant species in different parts of the plant(Table 1,2,3,4,5).

1-Glandular hairs

- Sessile glandular hair with a swollen biseriate head. Each seriate contains three cells as in calyx, ovary and ray floret of *D. pinnata*, ray floret and palea of *Z. elegans*(Figure1: A).
- Multicellular-uniserriate simple glandular hairs, have very thin wall and mace shaped head as in palea and ovary of *B.tripartite*, disk floret and stem of *X.strumarium*(Figure1: B).
- Multicellular-uniserriate eglandular hair with5-7 filiform cells, has rounded head as in the disk floret of *D. pinnata, H. annuus, T. erecta*, the bract of *T. patula*, and the ray floret of *Z. elegans* and *B. tripartite*(Figure 1:C).
- Multicellular-uniserriate glandular hairs, thin-walled obtuse apex, oblique or straight, consist of 7-11 small rectangular cells Resembling as silkworm, a lower cell is Spheroidal as in the leaves, the bract and the stem of *H. annuus*(Figure 1: D).

2-Eglandularhairs

These trichomes showed a wide variation in the number of cells, shape and type. Therefore these trichomesare arranged into various groups according to its cells and serriate numbers:

- Unicellular are simple eglandular hairs, straight, oblique or curved, unbranched with thin wall, exhibit elongated body with obtuse apex but are quite variable in length (Tables 1,2,3,4,5), as in the stigma of *B. tripartite, C. bipinnatus, T. erecta, T. patula, Z. elegans,* or have undulate ornamentation in the wall as in *C.bipinnatus*, or with acute tips as in *D.pinnata, H. annuus*, or flat wide base and acutest towards the apex with thick wall as in a calyx and the ovary of *B. tripartite, E.cannzbinum, T. erecta* and the ovary of *Z. elegans*also in the anther of *H. annuus* or hairs compact from the middle as in a calyx and the ovary *T.patula* but the thin wall in calyx of*Z.elegans* and *E.prostrate*, or broad in the middle with gundelia tips as in the corolla of *T. patula* and*Z.elegans*(Figure 1: E,F,G,H,I).Somehave thick wall with forked apex and are either small in size as in paleaof*E.cannabinum*(Figure 1: J) or are very thin walled and simple with obtuse apex.In other species it is arranged in tuftshape as in ovary and anther of *X.strumariumm* and anther of B.tripartite(Figure 1: K).oris arranged in biserriate, thick wall, formed of tworow, each contains one cell in dendroid shape as in ovary of E.cannabinum(Figure 1: L).
- Dicellular-uniserriateeglandular hairs are thick-walled.Lower cell is bulbous and immersed with3-7 surrounding basal cells and apical cell is pyramidal having an acute tip, as in the leaves and the bract of *H.annuus*, leaf upper and bract of *Z.elegans* or large in size with two rows of surrounding base cells in lower leaves of *Z.elegans* or are very small in size.Lower cell is spheroidal as in stem *E.cannabinum*(Figure 1: M, N).
- Dicellular-biserriateeglandular hairs and are thick walled.Each hair consists of 2-3 polygonal cells and the apical cell is the longer one with obtuse tips as in stem *C. bipinnatus*(Figure 1: O).
- Dicellular-uniserriateeglandular hairs, with flat terminal and obtuse tip and lower cell is longer than the apical cell as in *T.erecta* or with gundelia tips.The apical cell is longer than the basalone as in disk corolla of *T.patula*or have undulate ornamentation in wall(Figure 1: P).
- Multicellular-uniserriateeglandular hairs:This group is characterized by wide variation in cells properties as the following:

- Oblique hair with thin wall and obtuse apex,composed from 7-11 cylindrical cells.The lower cell are swollen and lean on two cells of basal hair as in stems and leaves of *B.tripartite* and *E.prostrate*, or cells equal in lengths give filiform shape as in *C.bipinnatus, D.pinnata, T.erecta*, and *T.patula*, bract as in *B.tripartite, C.bipinnatus, E.prostrate, T.erecta, and T.patula, E.cannabinum*, palea as in *D.pinnata* corolla in *B.tripartite, C.bipinnatus, D.pinnata, T.erecta*, ovary of as in *E.prostrate, E.cannabinum* or apical cell elongated and longer than other cells as in leaves, stems, bract, palea, style of *Z.elegans*, and this is come along with[14,15](Figure 1: Q,R) and Figure2: A).
- Multicellular hairs composed ofrectangular cells that are arranged horizontally with

- thicknesses of each cell and apical cell with acute tips as in stem and leaves, bract *C.bipinnatus* or with obtuse tips in the ovary of *D.pinnatus, H.annuus*(Figure 2: B).
- Multicellular hair with thick wall and are composed of 2-8 rectangular cells arranged vertically and in equal diameters with acute apex in the apical cell as in stem and leaves of *E.cannabinum.*Itappears expanded at each ends of the trichomescells as ray floret of *H.annuus* or apical cell with obtuse tips as in ovary of *C.bipinnatus*(Figure 2:C,D,E,F,G).
- Multicellular large hair having thick-wall with undulate ornamentation, consisting of 3 cells.Lower one is swollen cylindrical, intermediate is longer and apical cell is smaller with triangle shape as in leaves, stem, bract, calyx, ovary andcorolla of *E.prostrate,*or small cell almost equal in size and acute apex as in bract of *E.prostrate.*This is in agreement with previous studies[16](Figure2: H,I).
- Multicellular hair with thick wall, consists of 2-7 graduated cells in size.The basal cell is very swollen and apical cell is conical with acute tips as in stem *H.annuus* and stem, leaf, bract of *X.strumarium*(Figure 2: J).
- Multicellular hairwith thick wall and multicellular immersed base, exhibits conical body constituting of 5-8 cylindrical cells scaled in size.The apical cell was the longest, narrowest and sharply tapered as in leaves, palea, style and ray floret of *Z.elegans*, in a lower leaf of *H.annuus*, or peg-like foot and immersed inside the spheroidal pore as in ovary, paleaand corolla of *Z.elegans*(Figure 2:K,L).
- Multicellular hair with thick wall, consists of 8-11 swollen cells forming barrel shape in lower and intermediate cellswhile elongated upward with the flat or acute apical cell as leaf and stem of *D.pinnata*, and leaves of *B.tripartite* and *H.annuus*(Figure 2: M).

So, Trichomes results showed wide variations within tribes, species and even within the same plant.This study corroborates with other studies done in the Asteraceae that highlighted the diversity of trichomes as in [17].Most of the important differences of the trichomes study resulted from the details of trichomes cells which is important in comparative systematic investigations of related taxa and successfully aids in the identification of genera, and even of species in tribes as reported in other studiesas [18,19].

3-Papillae

The papillae are distributed in different shapes and positionsas in stem and corolla of *B.tripartite,*or ray floret and stigma of *C.bipinnatus, H.annuus, T.erecta*and*T.patula*. Some of them are triangularshaped with acute apex whileothers are finger-like in shape with obtuse apex (Figure2: N,O,P).

Trichomes bases

The results showed differences in the bases of the hairs.Some of them are based on two base cells as in the leaf upper epidermis of *Z.elegans*, or lean on tworow of a cell as in the lower leaves of *Z.elegans*, or lean on a swollen cells with onerow consisting of 4-5 cell as in the stem of *Z.elegans*, or lean on 1-2 epidermis cells characterized by its sterriate configuration as in the leaves lower epidermis and stem of *C.pinnata* and *B.tritripartite* or lean on three rows of cells as in the leaves lower epidermis of *E.prostrate* and *H.annuus* or lean on ordinary epidermal cell as in leaves of *T.erecta, T.patula, E.cannbinum*(Figure 3: A,B,C,D,E,F,G). So, the current results are revealed as an important taxonomic values for species under study as appeared in [11].

The current results showed various types of trichomes that differed in each of their kinds, size, shapes, positions and numbers of cells as showed in Tables (1,2,3,4,5), that were recorded in different parts of the plant body of all studied species.These results revealed the importance of trichomes as taxonomic characters in the identification of various taxa belonging to the same genus, tribe or family.

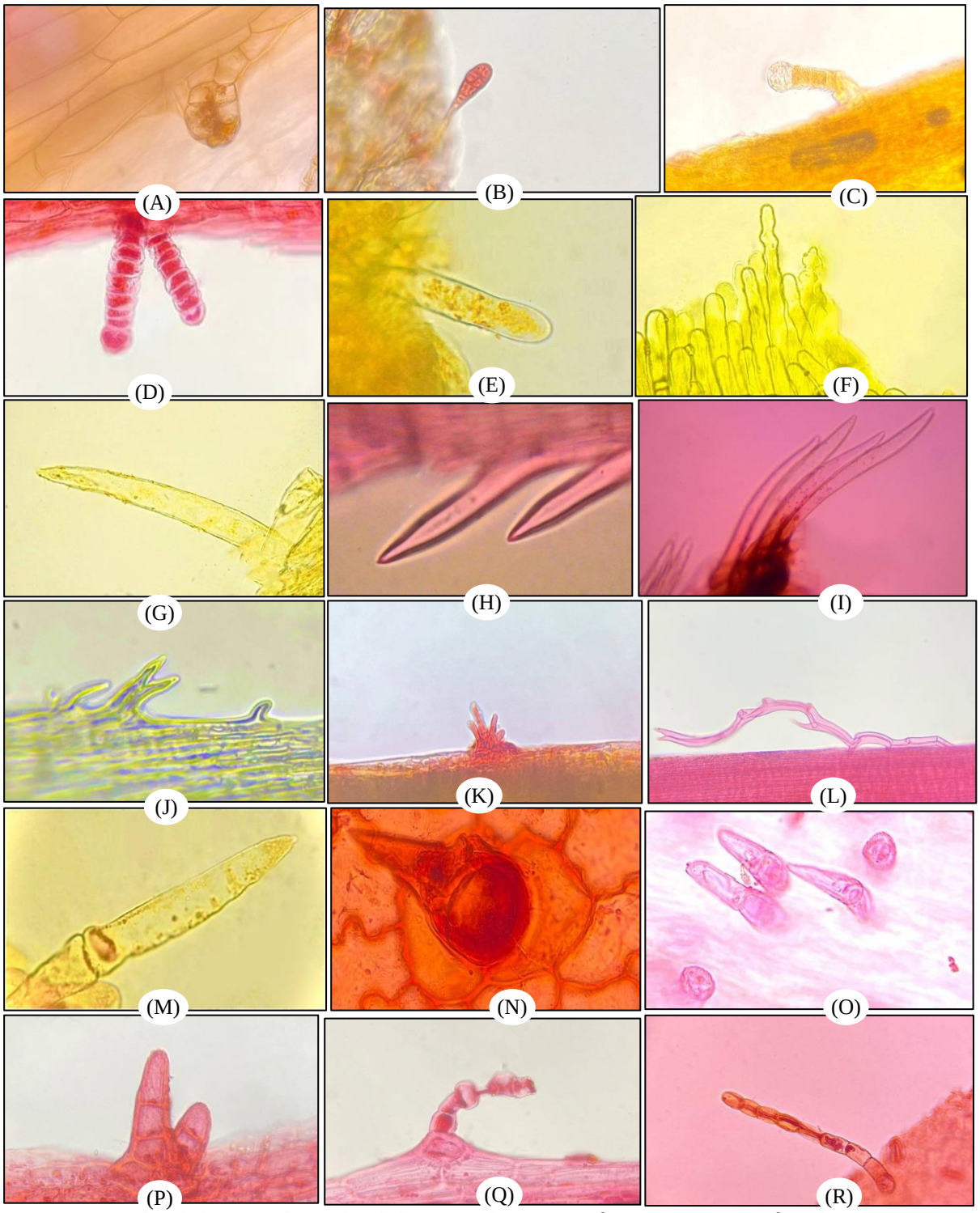

Figure 1-Glandular and eglandular trichomes of Asteraceae family:**(A)** Sessile glandular,**(B,,C,,D),**Glandular hair, **(E,,F,,G,,H**,,**I**) Unicellular hair, **(J**) Forked Unicellular hair, **(K**)Tuft hair, **(L**)Dendroid hair,**(M,N,O**) Dicellular, (**P,Q**, **R**)Multicellular hair.

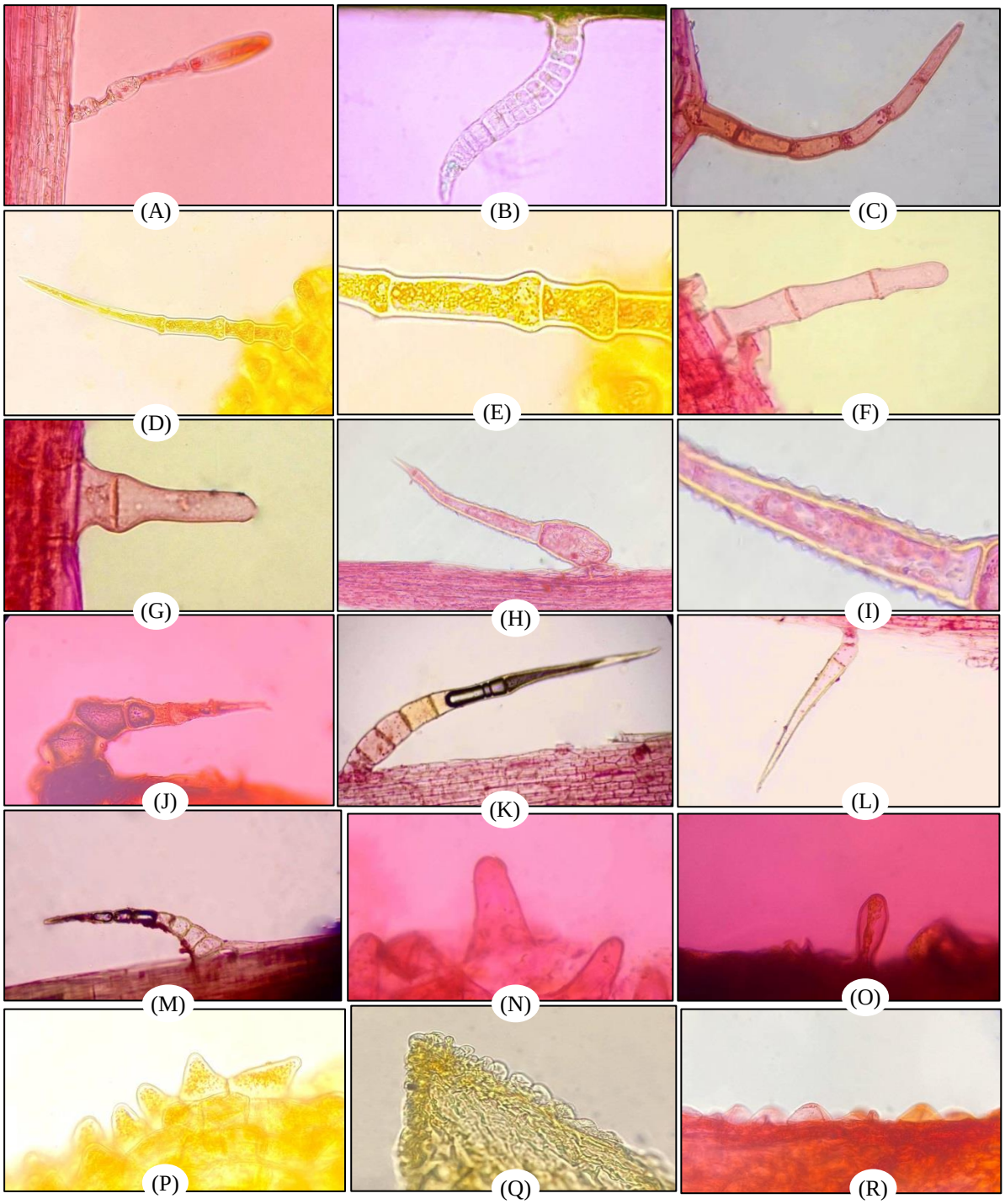

Figure 2-Glandular and Eglandulartrichomes of Asteraceae:**(A)** Multicellular oblique hairwith elongated apical cell,**(B,C**)Multicellular curved hair, **(D,E,F**,**G)**Multicellular hairwith base expanded cell, **(H,I**)Multicellular hair with undulate wall, **(J,K**,L,M)Multicellular hair with acuminate or acute apex, **(N,O,P,Q,R)**Papillae with different shapes**.**

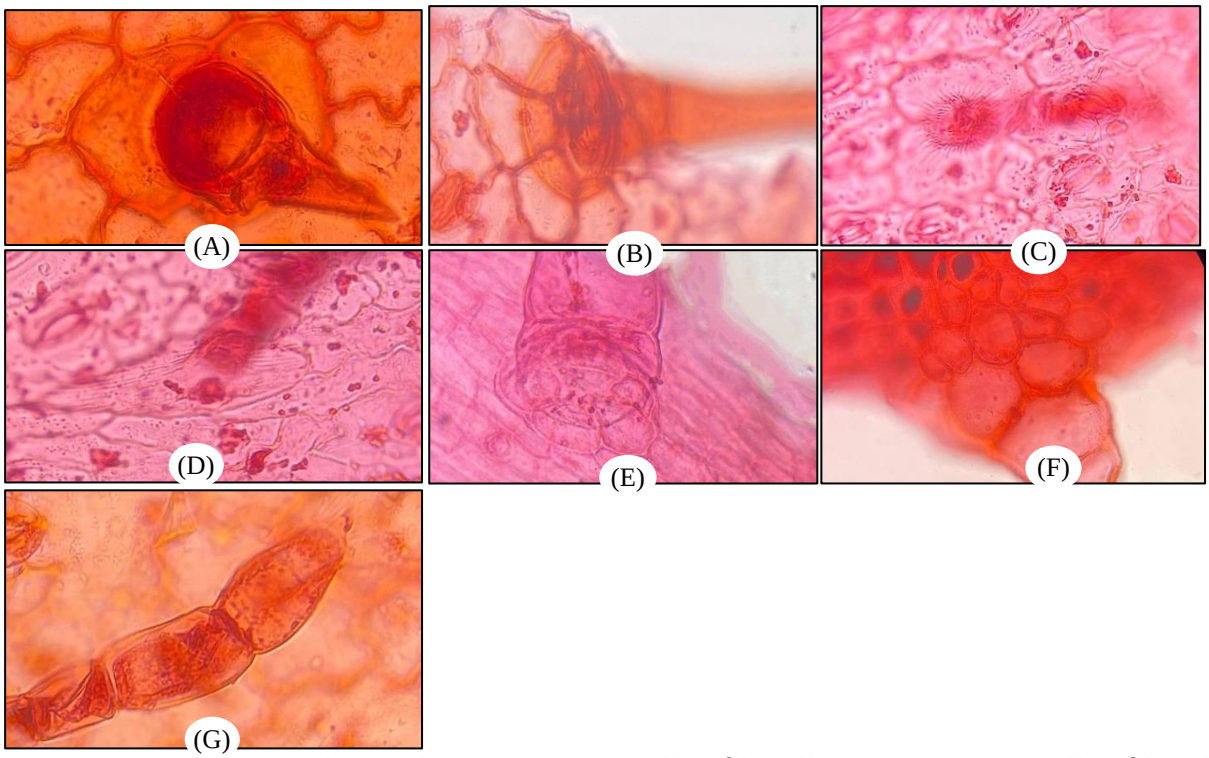

Figure 3-Asteraceae trichomes bases: (A) Two cells of baselhair,(B)Two row cells of basel hair,(C,D)Straight epidermis in basel hair,(E,F)Three rows cells of basel hair,(G)Ordinary epidermal cell of basel hair.

Table 1-Quantitative and qualitative details of Glandular and Eglandulartrichome data for species of Asteraceae

Taxon	Type	Kind	No. of cell	Shape		Length µm.	Width µm.		Wall thickness µm.	Position
				Trichome	Apex		Trichome	Base		
Bidenstrip artite	Eg	Uni	1	Obl, Cur	Obtuse	46.8-109.2 (77.8)	11.7-16.9 (15.1)	5.2-14.3 (7.6)	Thin	St
	Eg	Uni	1	Obl, Cur	Tuft	12.2-15.6 (13)	2.6-5.6 (3.8)	2.6	Thin	P,A
	Eg	Uni	1	Obl	Acute	54.2-143 (99.6)	10.4-15.6 (13)	18.2-26 (21.6)	Thin	O, C
	Eg	Mul	4-12	Obl	Obtuse	117-507 (260)	13.2-36.4 (22.1)	15.6-65 (37.7)	Thin	S,B,L, Rflo
	G	Mul	5-9	Obl	Macesha ped	26-31.2 (28.4)	13-18.2 (15.6)	/	Thin	P,O

Clarify table symbols:
An- Anther, **B**-Bract, **C**-Calyx, **CO**-Corolla,**Cur**- Curved, **Di**- Dicellular, **Dflo**- Disk floret, **Eg**-Eglandular, **G**-Glandular, **L**-Leave, **Mul**- Multicellular, **Obl**- oblique, **O**-Ovary**, P**-Palea, **Rflo**- Ray floret, **S**- Stem, **St**-Stigma, **Str**- Straight, **Uni**- Unicellular.

Table 2-Quantitative and qualitative details of Glandular and eglandulartrichome data for species of Asteraceae.

Taxon	Type	Kind	No. of cell	Shape		Length µm.	Width µm.		Wall thickness µm.	Position
				Trichome	Apex		Trichome	Base		
Cosmos bipinnatus	Eg	Uni	1	Str	obtuse	26-130 (78)	13-23.4 (18.2)	7.8-15.6 (10.4)	thin	St
	Eg	Mul.	7-18	Cur	acute	156-208 (186.3)	26-36.4 (30.3)	27.6-39 (33.8)	5.2	S
	Eg	Mul. Bise.	2-4	Str	obtuse	52-78 (65)	68-80.2 (72.8)	41.6-50 (46.8)	3.1	S
	Eg	Mul.	10	Obl, Str	obtuse	169-273 (232)	15.6-21.8 (18.6)	13-23.4	Thin	S,l B,O,Dflo
	Eg	Mul.	2-10	Obli, Cur	obtuse	143-286 (199)	10.4-18 (15.7)	26-49.4 (33.7)	4.9	L,S,B
Dahlia pinnata	Eg	Uni.	1	Str, Obl	acute	182-364 (280.2)	15.6-36.4 (30.3)	16.9-41.6 (27.7)	Thin	St
	Eg	Mul.	4-13	Str, Cur	Obtuse	83.2-572 (251.3)	15.6-20.8 (18.1)	15.4-31.2 (23.8)	Thin	S,L,C,P,O
	Eg	Mul.	7-12	Cur, Obl	Acute, flat	169-364 (267.8)	13-26 (23.9)	26.7-78 (52)	4.6	S,L
	G	Mul.	4-8	Cur	Rounded	195-210.6 (203)	17.9-20.8 (18.5)	7.8-9.2 (8.4)	Thin	Dflo
	G Ses.	Mul.	3-5	Str, Cur	Rounded	31-65 (45)	20.8-26 (23.4)	/	Thin	O, C, Rflo

Clarify table symbols:
An- anther, **B**-Bract, **Bise**- Biseriate**, C**-Calyx, **CO**-Corolla,**Cur**- Curved, **Di**- Dicellular, **Dflo**- Disk floret, **Eg**-Eglandular, **G**-Glandular, **L**-Leave, **Mul**- Multicellular, **Obl**- Oblique, **O**-Ovary**, P**-Palea, **Rflo**- Ray floret, **S**- Stem, **St**-Stigma, **Str**- Straight, **Ses**- Sessile, **Uni**- Unicellular

Table 3-Quantitative and qualitative details of Glandular and Eglandulartrichome data for species of Asteraceae.

Taxon	Type	Kind	No. of cell	Shape		Length µm.	Width µm.		Wall thickness µm.	Position
				Trichome	Apex		Trichome	Apex		
Ecliptaprostrate	Eg	Uni	1	Str, Obl	Acute	13-44.2 (28.1)	2.6-5.2 (4.3)	5.4-7.8 (6.2)	Thin	O
	large Eg	Mul	3-4	Str, Obl	Acute	182-624 (418)	18.2-39 (25.4)	28-109.2 (80.4)	6.5	S,L,B O, Co
	Eg	Mul	5-7	Obl,Cur	Obtuse	52-111.8 (79.9)	5.2-13 (9.5)	7.8-26 (14.4)	Thin	S,O,L,B
	Eg	Mul	3-4	St	Acute	46.8-65 (57.2)	11.5-15 (13)	16.5-20.1 (18.2)	Thin	C
Eupatoriumcannabinum	Eg	Uni	1	Str,Obl	Acute	13-91 (48.8)	5.2-18.2 (8.8)	7.8-20.8 (12.5)	Thin	C,P O,S
	Eg	Uni	1	Str,Obl	Obtuse	18.2-78 (44.9)	18.2-31.2 (25.3)	19.5-36.4 (26.3)	Thin	St
	Eg	Uni Bise.	1 Dendroid	Obl	Acute	540-610 (598)	13-18.2 (15.6)	23-30.2 (26)	Thin	O
	Eg	Di	2	Str	Obtuse	52-91 (73.6)	16.9-19.2 (18.4)	19.5-22.4 (21.8)	Thin	S
	Eg	Mul	2-12	Cur, Ob	Acute	78-572 (244.8)	13-27.3 (18.3)	14.3-39 (23.4)	1.3	S,L,B,O ,P
Helainthusannuus	Eg	Uni	1	Str,Obl	Acute	104-234 (132.2)	13-26 (20.2)	18.2-31.2 (25.4)	1.8	St,C, An
	Eg	Dicellular	2	Obl	Acute	75.4-127.4	20.8-31.2	26-65	2.9	L,B,O

						(88)	(26.6)	(44.2)		Dflo
	Eg	Mul	4-10	Obl, Cur	Acute	208-780 (282.7)	31.2-59.8 (45.5)	65-130 (107.2)	7.8	S,L O,B,P Dflo
	Eg	Mul	3-5	Str,Obl	Acute	156-416 (270.8)	23.4-28.6 (26.2)	22.8-29.1 (27.2)	Thin	Rflo
	G	Mul	6-11	Str,Obl	Obtuse	150.8-208 (178.7)	20.8-31.2 (25.7)	23.1-26 (24.6)	2.4	S,L,O,B
	G	Mul	5-10	Obl, Cur	Round	78-208 (127.4)	10.4-18.2 (15.6)	18.2-23.4 (20.2)	Thin	Dflo

Clarify table symbols:
An- Anther, **B**-Bract, **Bise**- Biserriate**, C**-Calyx, **CO**-Corolla,**Cur**- Curved, **Di**- Dicellular, **Dflo**- Disk floret, **Eg**-Eglandular, **G**-Glandular, **L**-Leave, **Mul**- Multicellular, **Obl**- oblique, **O**-Ovary**, P**-Palea, **Rflo**- Ray floret, **S**-Stem, **St**-Stigma, **Str**-Straight, **Ses**- Sessile, **Uni**- Unicellular

Table 4- Quantitative and qualitative details of Glandular and Eglandulartrichome data for species of Asteraceae

Taxon	type	Kind	No. of cell	Shape		Length µm.	Width µm.		Wall thickness µm.	Position
				Trichome	Apex		Trichome	Apex		
Tagetes erecta	Eg	Uni	1	Str	Obtuse	95-130.4 (117)	13.7-17.1 (15.6)	14.5-18.2 (15.8)	Thin	St
	Eg	Uni	1	Obl	Acute	78-256 (150)	78-260 (154)	14.6-26 (20.8)	2.6	C,
	Eg	Mul	2	Obl	Rounded	115-145 (134)	4-7 (5.3)	14-19 (16)	Thin	Rflo
	Eg	Mul	7-11	Str,Obl, Cur	Obtuse	182-299 (230)	13-23.4 (16.9)	10-28 (22.8)	Thin	S,L B, Dflo
	G	Mul	4-8	Cur	Round	140.4-165 (158.6)	12.1-14.8 (13)	9.2-11.7 (10.4)	Thin	Dflo
Tagetespatula	Eg	Uni	1	Str,obl,cur	Obtuse	75-100 (91)	16.5-19.5 (18.2)	16.3-19.4 (18)	Thin	St
	Eg	Uni	1	Str	Acute	230-275 (260)	15.5-17.8 (16.9)	4-5.9 (5.2)	3.2	C,O
	Eg	Mul	2	Str, Obl	Gundelia	141-275 (156)	16.1-21.4 (18.2)	8.6-11.8 (10.4)	1.3	Dflo
	Eg	Mul	4-10	Str,Cur,Obl	Obtuse	221-442 (299)	13-26 (20.2)	10.4-41.6 (31.2)	Thin	S,L,B
	G	Mul	5-6	Str	Rounded	80.4-95 (91)	10-19 (13)	13-23.4 15.6	Thin	B
Xanthium strumarium	Eg	Uni or tuft	1multi ser	Str,Obl,Cur	Flat, Obtuse	13-117 (65)	2.6	2.6-7.8 (4.9)	Thin	S,L,O, St,An
	Eg	Mul	2-8	Obl	Acute	165-416 (247)	18.6-62.4 (39)	31.2-104 (78)	4.9	S,L,B, O
	G	Mul	6-10	Str	Clavate	12.7-52.2 (30.3)	10.4-13 (11.6)	2.6	Thin	S, CO

Clarify table symbols:
An- anther, **B**-Bract, **Bise**- biseriate**, C**-Calyx, **CO**-Corolla,**Cur**- Curved, **Di**- Dicellular, **Dflo**- Disk floret, **Eg**-Eglandular, **G**-Glandular, **L**-Leave, **Mul**- Multicellular, **Obl**- Oblique, **O**-Ovary**, P**-Palea, **Rflo**- Ray floret, **S**- Stem, **St**-Stigma, **Str**- Straight, **Ses**- Sessile, **Uni**- unicellular

Table 5- Quantitative and qualitative details of Glandular and Eglandulartrichome data for species of Asteraceae

Taxon	type	Kind	No. of cell	Shape		Length µm.	Width µm.		Wall thickness µm.	Position
				Trichome	Apex		Trichome	Apex		
Zinnia elegans	Eg	Uni	1	Obl	Obtuse	26-130 (75.5)	18.2-23.4 (20.6)	10.4-14 (13.8)	thin	St
	Eg	Uni	1	Obl.	Acute	57.2-260 (164.8)	13-31.2 (19.5)	14.3-28.6 (19)	thin	C,O,Dflo
	Eg	Mul	2-5	Obl	Acute	137.8-468 (310.1)	15.6-28.6 (20.7)	26-52 (33.8)	3.5	St,O,CO, P,B,S
	Eg	Mul	7-11	Obl, Cur	Obtuse	91-143 (121.3)	13-18.2 (15.6)	10.4-15.6 (13.4)	thin	S,L
	G ses	Mul	6-8	Str,Obl	Round	20.5-38.8 (30.2)	12-18.6 (15.6)	/	thin	P, Rflo
Clarify table symbols: **An**- Anther, **B**-Bract, **Bise**- Biseriate**, C**-Calyx, **CO**-Corolla,**Cur**- Curved, **Di**- Dicellular, **Dflo**- Disk floret, **Eg**- Eglandular, **G**-Glandular, **L**-Leave, **Mul**- Multicellular, **Obl**- oblique, **O**-Ovary**, P**-Palea, **Rflo**- Ray floret, **S**- Stem, **St**-Stigma, **Str**- Straight, **Ses**- Sessile, **Uni**- unicellular										

References

[1] P.F.Stevens,"AngiospermPhylogeny"Website.Version 8, [and more or less continuously updated since].,. 2001**http://www.mobot.org/MOBOT/research/APweb/**

[2] A.C. Sobrinho, S.M. Morais, E.B. Souza, and R. Fontenelle, "The genus Eupatorium L. (Asteraceae): A review of their antimicrobial activity" *Journal of Medicinal Plants Research*, Vol. 11, no. 3, pp. 43-57, 2017. **https://academicjournals.org/journal/JMPR/article-full-text-pdf/4F30B6962396**

[3] S.A. Ghazanfar, J.R. Edmondson, and D.J. N. Hind, *Flora of Iraq: Vol.6: Compositae, Ministry of Agriculture (SBSTC/INH): Iraq and Royal botanical garde, Kew Richmond*, 2019, p 458.

[4] A.H.G. Cassini, "Aperçu des genres formés par M. Cassini dans la famille des Synantherées. Troisième fascicule," *Bulletin Scientifique, par la Société Philomatique de Paris*, Vol. 3, pp. 31–34, 1817.

[5] K**.** Krak, and P. Mráz, "Trichomes in the tribe Lactuceae (Asteraceae) - taxonomic implications" *Biologia*, Vol. 63, pp. 616-630, 2008. https://link.springer.com/article/10.2478/s11756-008-0106-z

[6] N. Kilian, B. Gemeinholzer, and H. W. Lack, *24.Cichorieae: In Systematics, Evolution and Biogeography of Compositae, Vienna: International Association for Plant Taxonomy*, 2009, p. 343.

[7] M.A. Wagner, B.F.P. Loeuille, C.M. Siniscalchi, G.F. Melo-de-Pinna, and J.R. Pirani, "Diversity of non-glandular trichomes in subtribe Lychnophorinae (Asteraceae: Vernonieae) and taxonomic implications" *Plant Systematics and Evolution*, Vol. 300, pp. 1219-1233, 2014. https://doi.org/10.1007/s00606-013-0957-9

[8] G. Khan, F. Zhang, Q. Gao, Z.U.R. Mashwami, K. Rehman, M.A. Khan, and A. Sochen, "Trichomes diversity in the tropical flora of Pakistan" *Journal of Medicinal Plants Research*, Vol. 7, no. 22, pp. 1587-1592, 2013. http://www.academicjournals.org/JMPR

[9] A**.** Perveen, M. Khan, S. Mansuri, and T. Tabassum, "Morphological studies on trichome of family Asteraceae" *International Journal of Biolgical Biotechnol*, Vol. 13, pp. 177-182, 2016. https://www.academia.edu/25078191/MORPHOLOGICAL_STUDIES_ON_TRICHOME_OF_FAMILY_ASTERACEAE

[10] L. Saha and S. Mukherjee, "Morphological variation of trichomes in some common species of Asteraceae" *International Journal of Pharmaceutical Research and Bio Sience*, vol. 1, no. 6, pp. 408-425, 2012. https://www.academia.edu/25078191/MORPHOLOGICAL_STUDIES_ON_TRICHOME_OF_FAMILY_ASTERACEAE?auto=download

[11] I. A. M**.** Al-dobaissi, Kh. Al shimmery, and A. H. Almousawy, "Cuticular indumentums of some species from Asteraceae family in Erbil province-Iraq" *Iraqi Journal of Science*, Vol. special-

issue-part-b, pp. 251-262, 2016. https://ijs.scbaghdad.edu.iq/aaaaaa/161-2016-vol-57-special-issue-part-b/2324--biology-cuticular-indumentums-of-some-species-from-asteraceae-family-in-erbil-province-iraq

[12] I. Hameed, and H. Farrukh, "Stomatal studies of selected medicinal plants of family Solanaceae "*Journal of medicinal plant research*, Vol. 5, no. 18, pp. 4525-4529, 2011. https://academicjournals.org/journal/JMPR/article-full-text-pdf/7A4C38725095

[13] M.A.H. Rahman, I.A.K.M Rafiul, and R.M. Matiur, "An anatomical investigation on Asteraceae family at Rajshahi Division" *Bangladesh International Journal of Biosciences*, Vol. 3, No. 1, PP. 13-23, 2013. https://www.innspub.net/wp-content/uploads/file/IJB-V3No1-p13-23.pdf

[14] S. E. Freire, A.M. Arambarri, N.D. Bayon, G. Sancho,E.Urtubey, C. Monti, M.C. Novoa, and M.N. Colares, "Epidermal characteristics of toxic plants for cattle from the Saldo river basin (Buenos Aires, Argentina)" *Boletín de la Sociedad Argentina de*, Vol. 40, no. 3-4, pp. 241-281, 2005. **https://botanicaargentina.org.ar/wp-content/uploads/2017/07/FREIRE-3.pdf**

[15] O. Adedeji, and O.A. Jewoola, "Importance of leaf epidermal characters in the Asteraceae family" *Notulae Botanicae Horti AgrobotaniciCluj-Napoca*, Vol. 36, no. 2, pp. 7-16, 2008. **https://www.notulaebotanicae.ro/index.php/nbha/article/view/243**

[16] S. Shafira, and A Salama, "Analysis of leaves trichomes of Eclipta prostrata, Eleuther antheraruderalis, Synedrella nodiflora, and Tridax procumbens (Asteraceae, Heliantheae*)" IOP Conf. Ser.Earth Environ. Sci*., vol. 524, pp. 012001, 2020. https://iopscience.iop.org/article/10.1088/1755-1315/524/1/012001/pdf

[17] E. Amrehn, A. Heller, and O. Spring, "Capitate glandular trichomes of Helianthus annuus (Asteraceae): ultrastructure and cytological development", *Protoplasma*, Vol. 251, pp. 161-167, 2014. https://doi.org/10.1007/s00709-013-0534-7

[18] C.A. Price, and J.S. Weitz, "Allometriccovariation: a hallmark behavior of plants and leaves", *NewPhytologist*, vol. 193, pp.882–889, 2012.

[19] A. Bano, M. Ahmad, M. Zafar, S. Sultana, and M.A. Khan, "Comparative Foliar micromorphological studies of some species of Asteraceae from Alpine Zone of Deosai plateau Western Himalayas" *The Journal of Animal & Plant Sciences*, vol. 25, no.2, pp. 422-430, 2015.