

## TAXONOMIC SIGNIFICANCE OF LEAF CHARACTERS IN SOME SPECIES OF APIACEAE

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Amaal H. Mohammed<sup>1</sup>; Azza A.F. Khafagi<sup>1</sup> and Dalia G.E. Gabr<sup>1</sup>

<sup>1</sup>- Botany Dept., Faculty of Science (Girls Branch), AL Azhar University, Nasr City, Cairo, Egypt.

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### ABSTRACT

Leaf surface morphology of 13 species belonging to 10 genera of family Apiaceae is examined with Light microscope (LM) and Scanning electron microscope (SEM). Trichome type, epidermal cells, stomata, and cuticular ornamentation revealed several interesting epidermal features that have not previously been reported in the family. Three types of cuticular ornamentation are recorded: favulariate, striate and wrinkled. Stomata are mostly diacytic. Trichome type has been found to be of great diagnostic value in the studied species. The study of the leaf epidermal surface of the studied species of Apiaceae exposed a number of important micro-morphological characters, and these characters show evidence of interesting specific variations that are significance for identification.

### INTRODUCTION

Literature on the cuticular ornamentation, stomata and trichomes types of family Apiaceae is relatively rare although the taxonomic value of the epidermal morphology and trichomes is well documented in botanical review for some other groups of Angiosperms (Stace, 1965; Theobald *et al* 1979 and Batterman & Lammers, 2004).

Stomata and associated epidermal cells are providing an increasingly important source of taxonomic characters. The taxonomic significance of stomata distribution and morphology in the Epacridaceae was surveyed by Watson, (1962). He found that trichomes and hydathodes are other characters present on the epidermis and other organs of plants that can serve as good taxonomic tool. Hallam and Chambers, (1970) on SEM studies of the leaf of *Eucalyptus* demonstrated the potential of epicuticular wax studies to aid the classification of a complex genus. Also there are various reports were published on the epidermal structure and stomata ontogeny (Karatela & Gill, 1984, 1985; Aboel-Atta, 2004; Kamel, 2004 and Sonibare and Jayeola, 2005).

The main objective of this work was to study the cuticular ornamentation, stomata and trichomes types of some species of Apiaceae in search of taxonomic characters that might assist in identification and delimitation of these species.

### MATERIALS AND METHODS

Plant specimens were collected fresh from different localities in Egypt and also obtained dried from herbarium of Cairo University (CAI) (Table 1).

Studied species were identified by means of comparison with specimens in the herbarium of Cairo University. In addition, keys of Tackholm (1974) and Boulos (2000) were consulted. Reference herbarium specimens of studied species were

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Table 1. List of the studied species and their locality

Species	Locality and date
1. <i>Pycnocycla tomentosa</i> Decne.	-Saint Catharine, 5/2003 -Wadi Feiran, 8/ 1982 (CAI) -Hag Eid Abu Mosaid, 5/ 1982(CAI)
2. <i>Pseudorlaya pumila</i> (L.) Grande.	-West of Alexandria – Sidi krir, 4/1989 (CAI) -Alexandria-Burg El Arab, 4/2001
3. <i>Coriandrum sativum</i> L.	-Kom ombo, 3/1961 (CAI) -Cairo–Alexandria Road, 4/2003
4. <i>Pimpinella ethaica</i> Schweinf.	- Cairo – Alexandria Road, 4/2003
5. <i>Deverra tortuosa</i> (Desf.) DC.	-Alexandria-Burg El Arab, 4/2001 -Cairo- Suez road, 4/ 2003 -Faiyum Sennuris, 12/1967(CAI)
6. <i>Ammi majus</i> L.	-Al Sharkia, 1/2000 -Near Tanta road, 3/ 2003
7. <i>Ammi visnaga</i> (L.) Lam.	-Al Sharkia, 2/2003 - Near Tanta road, 3/ 2003
8. <i>Ridolfia segetum</i> (L.)Moris.	-Nasr City-Cairo, 3/2000 - Nasr City-Cairo, 4/2002
9. <i>Foeniculum vulgare</i> Mill.	-Cairo–Alexandria road, 4/2003 -Near Tanta road, 3/ 2003
10. <i>Anethum graveolens</i> L.	-Cairo-Bahariya Road(Km. 157 & Rest House), 5/1979(CAI). (Cultivated) -Alexandria-Burg El Arab, 4/2001
11. <i>Eryngium campestre</i> L.	-Cairo-Alex. Desert road, 5/ 1958 (CAI) -Ras El Hekma, 5/ 1966 (CAI) -Nobaria, 6/ 1969 (CAI) -BurgEl Arab 23 /3/1977
12. <i>Eryngium creticum</i> . Lam.	-El Dabaa, Mariut 16/4/1977 -Dekhella, 1/5/1959 -Wadi El Daiga. Isthmic desert 15/8/1951
13. <i>Eryngium glomeratum</i> . Lam.	-Wadi El Maghara, N. Sinai 1/7/1959 -Burg El Arab 24/9/1971

prepared and kept in the herbarium of Botany Department, Faculty of Science (Girls Branch) Al-Azhar University.

The stomata types were determined by stripping and fixing the lower leaf epidermis in 70 % ethanol and cleared in 1% warm lactic acid before examination by light microscope (Nassar and El-sahhar, 1998). For the study of leaf surface (cuticular ornamentation, stomata, and trichomes types) using SEM, three leaves were mounted on metal stubs, coated, golden, examined and photographed by JEOL scanning electron microscope at the accelerating voltage of 7 and 10 Kv. The terminology of Metcalfe & Chalk (1979) Stearn (1992), Barthlott (1981) and Munson (1995) was followed to describe the leaf surface stomata, and trichomes.

## RESULTS AND DISCUSSION

Microcharacters of taxonomic significance obtained from selected features of the leaf surfaces, using scanning electron microscope (SEM) are presented in Tables (2 and 3).

### Trichomes

The taxonomic value of trichomes in angiosperm is well recognized in botanical literature (Theobald *et al* 1979; Batterman and Lammers, 2004).

As stated by Metcalfe and Chalk (1979), the trichomes are likely to be of considerable value in the differentiation between most of the studied Apiaceae species. The types of trichomes are recorded on the leaves of studied species: glandular, nonglandular, scales, stellate, dendritic and trichomes with special structure (Plate 1, 2 & 3 and Table 3). The following types of trichomes are recorded on the leaves of studied taxa:

#### A- Glandular

1. Glandular with unicellular stalk and unicellular head. *e.g. Ammi visnaga* (Plate 1, Fig. a).
2. Glandular with bicellular-uniseriate stalk and unicellular head.
3. Glandular with unicellular stalk and bicellular head. *e.g. Coriandrum sativum*
4. Glandular with unicellular stalk and tetracellular head. *e.g. Anethum graveolens*
5. Glandular with unicellular stalk and multicellular head. *e.g. Ammi majus*.
6. Glandular with multicellular-uniseriate stalk and multicellular head.
7. Glandular with bicellular-biseriate stalk and multicellular head.

8. Glandular with multicellular-multiseriate stalk and multicellular head. *e.g. Foeniculum vulgare* (Plate 1, Fig. b)
9. Glandular with tuberculated multicellular-multiseriate stalk and multicellular head. *e.g. Pseudorlaya pumila* (Plate 1, Fig. c).

#### B- Non-glandular.

10. Unicellular papillose *e.g. Eryngium campestre*
11. Unicellular papillose with thick tuberculated cell wall. *e.g. Pycnocycla tomentosa* (Plate 2, Fig. a).
12. Unicellular papillose with striated cell wall. *e.g. Eryngium glomeratum*.
13. Bicellular papillose. *e.g. Eryngium campestre*
14. Non-glandular unicellular with long broad, acute cell. *e.g. Pycnocycla tomentosa* (Plate 2, Fig. b).
15. Non-glandular with short basal cell and long fusiform acute apical cell. *e.g. Pycnocycla tomentosa*
16. Non-glandular with short basal cell and long blunt apical cell. *e.g. Coriandrum sativum* (Plate 2, Fig. d).
17. Non-glandular with short basal cell and long acute apical cell. *e.g. Pimpinella etbaica*.
18. Non-glandular with broad short basal cell and tuberculated long bicellular curved apical cell. *e.g. Pseudorlaya pumila* (Plate 2, Fig. c).
19. Non-glandular with short basal cell and multicellular-uniseriate narrow apical cell. *e.g. Coriandrum sativum*.
20. Non-glandular with two basal cell and long acute apical cell.

#### C- Scales trichomes

21. Glandular scale. *e.g. Eryngium creticum* (Plate 3, Fig. a).

#### D- Stellate trichomes

22. Stellate with four arms. *e.g. Eryngium campestre* (Plate 3, Fig. b).

#### E- Dendritic trichomes

23. Unicellular, branching medially. *e.g. Foeniculum vulgare* (Plate 3, Fig. c).

#### F- Special structure

24. Papillae structure. *e.g. Pycnocycla tomentosa* (Plate 4, Fig. a).
25. Scales structure. *e.g. Pycnocycla tomentosa* (Plate 4, Fig. b).

Table 2. Leaf surface characters of the studied species

Species	Characters		Epidermal cells		Cuticle layer		stomata		
	Type	Shape	Type	Shape	Thickness	Warty	Type	Leveling	Rim
1- <i>Pycnocycla tomentosa</i>	mixed	polygonal	mixed	polygonal	very thick	warty	anomocytic	semi-depressed	Flat
2- <i>Pseudorlaya pumila</i>	radially elongated	polygonal	radially elongated	polygonal	very thick	striated	diacytic	superficial	Flat
3- <i>Coriandrum sativum</i>	mixed	polygonal	mixed	polygonal	thick	warty	anomocytic	superficial	Flat
4- <i>Pimpinella etabica</i>	mixed	polygonal	mixed	polygonal	thick	warty	diacytic	superficial	Flat
5- <i>Deverra tortuosa</i>	tangentially elongated	± angular	tangentially elongated	± angular	thick	warty	diacytic	semi-depressed	Flat
6- <i>Ammi majus</i>	mixed	irregular	mixed	irregular	very thick	smooth	anisocytic	semi-depressed	Flat
7- <i>Ammi visnaga</i>	mixed	polygonal	mixed	polygonal	very thick	smooth	diacytic	semi-depressed	Flat
8- <i>Ridolfia segetum</i>	mixed	polygonal	mixed	polygonal	thick	warty	diacytic	superficial	Flat
9- <i>Foeniculum vulgare</i>	mixed	polygonal	mixed	polygonal	thick	warty	diacytic	semi-depressed	Flat
10- <i>Anethum graveolens</i>	tangentially elongated	polygonal	tangentially elongated	polygonal	very thick	smooth	diacytic	superficial	Flat
11- <i>Eryngium campestre</i>	radially elongated	± angular	radially elongated	± angular	thick	striated	diacytic	superficial	Raised
12- <i>Eryngium creticum</i>	radially elongated	± angular	radially elongated	± angular	thick	striated	diacytic	superficial	Raised
13- <i>Eryngium glomeratum</i>	tangentially	± angular	tangentially	± angular	thick	striated	diacytic	superficial	Raised

Table 3 . Foliar trichomes types and cuticular ornamentation of the studied species

Species	Trichomes																							Cuticular ornamentation		
	Glandular											Eglandular											Dendritic		Trichome ornamentations	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22		23		
1	+	-	+	-	-	-	-	-	-	-	+	-	-	+	+	-	+	-	-	-	-	-	-	-	Warty	Irregularly striated
2	+	-	-	-	+	-	-	-	+	-	-	-	+	+	-	-	+	-	-	-	-	-	-	-	Smooth	Parallel striated
3	+	+	+	-	+	-	+	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	Warty	Favulariate
4	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Smooth	Favulariate
5	+	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	Smooth	Favulariate plane
6	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Smooth	Slightly striated
7	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Smooth	Favulariate
8	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	Smooth	Wrinkled
9	+	-	-	-	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	Smooth	Favulariate plane
10	+	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	Smooth	Wrinkled
11	+	-	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	+	-	-	Smooth	Favulariate
12	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	Smooth	Favulariate
13	+	-	-	-	-	+	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	Striate	Striate

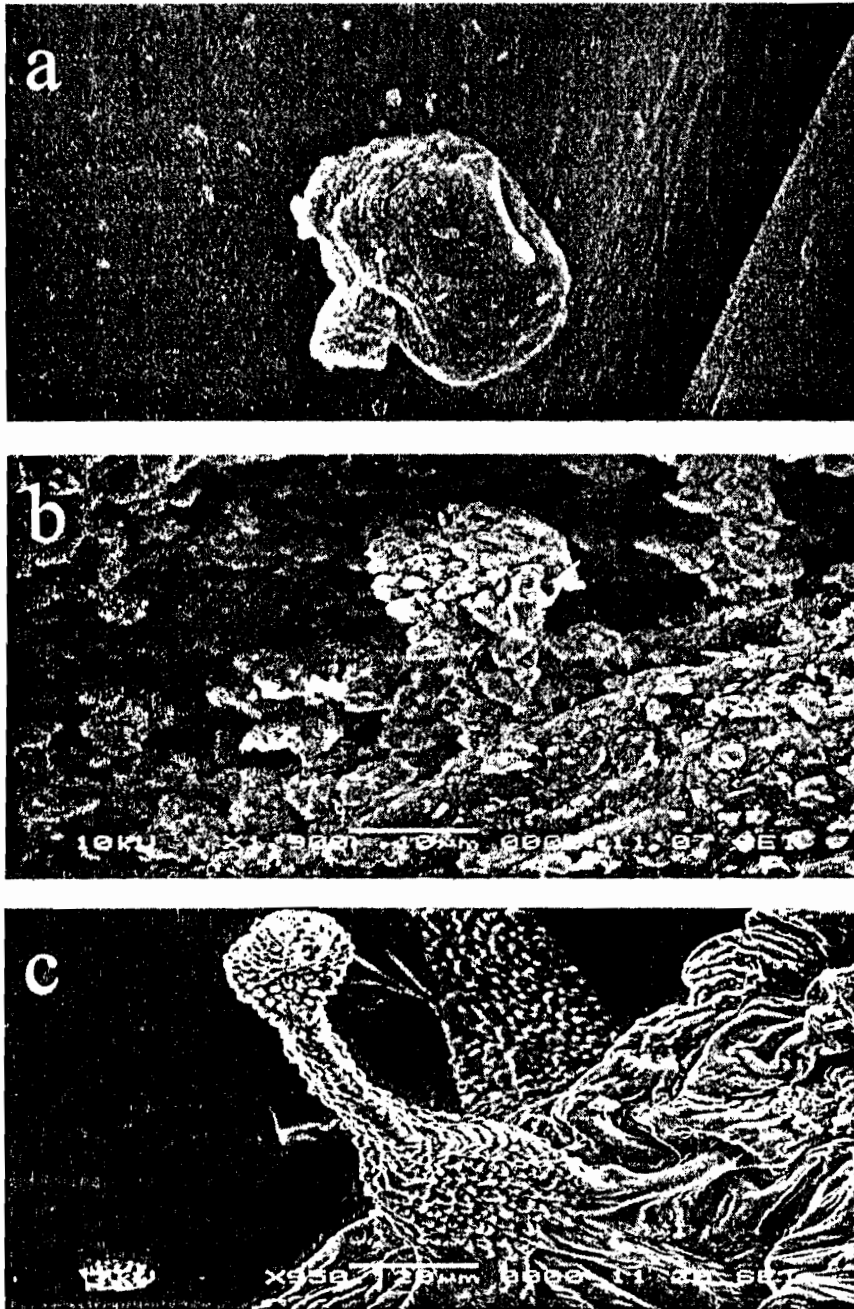


Plate I (Figs. a-c): Glandular trichomes.

Fig. a: unicellular stalk and unicellular head. *e.g. Ammi visnaga*.

Fig. b: multicellular-multiseriate stalk and multicellular head. *e.g. Foeniculum vulgare*

Fig. c: tuberculated multicellular-multiseriate stalk and multicellular head. *e.g. Pseudorlaya pumila*

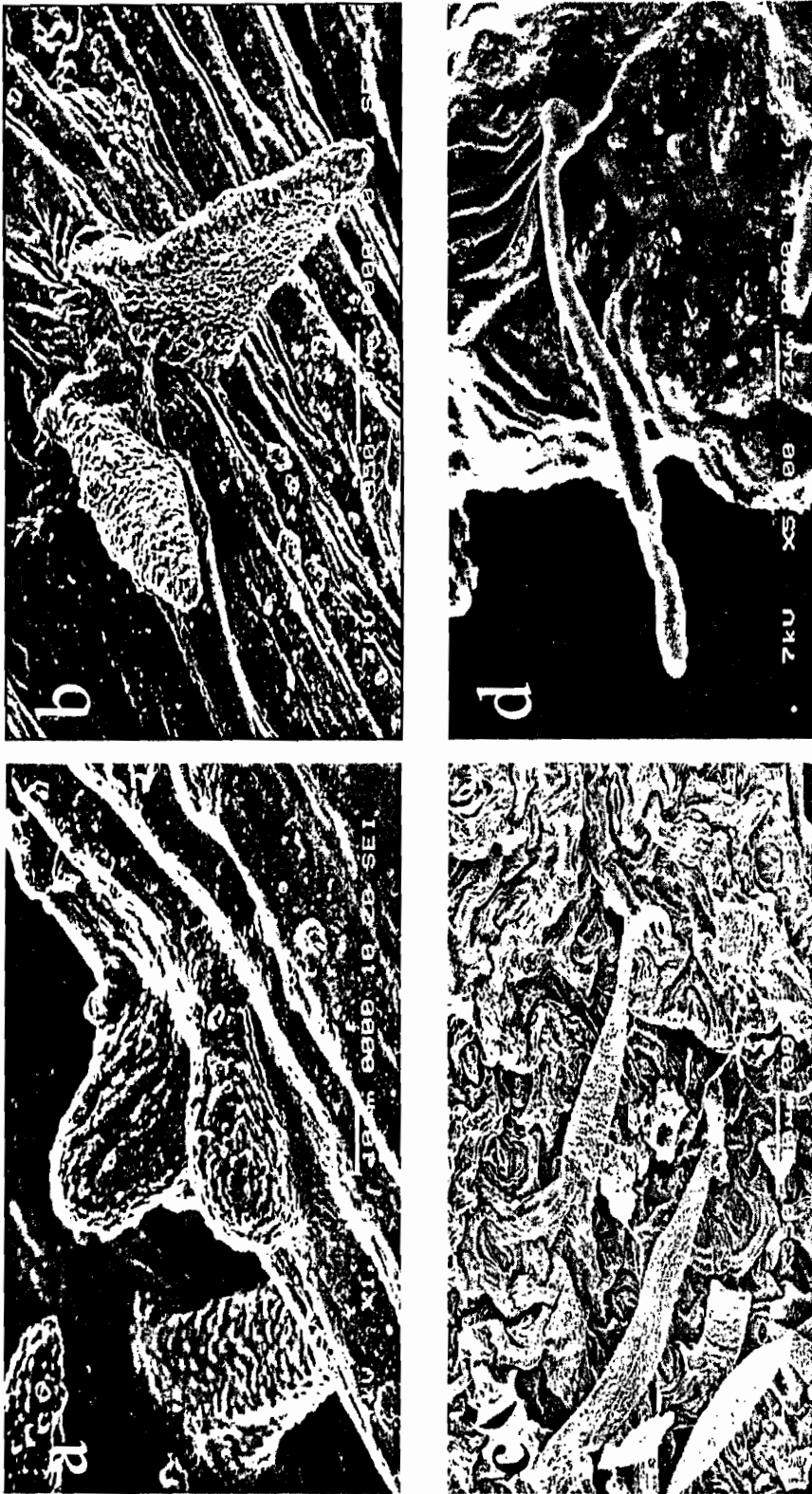


Plate 2. (Fig. a-d): Non-glandular trichomes.

Fig. a: unicellular papillose with thick tuberculated cell wall. e.g. *Pycnocycla tomentosa*

Fig. b: short basal cell and long fusiform acute apical cell. e.g. *Pycnocycla tomentosa*

Fig. c: broad short basal cell and tuberculated long bicellular curved apical cell. e.g. *Pseudorlaya pumila*

Fig. d: short basal cell and long blunt apical cell. e.g. *Coriandrum sativum*.

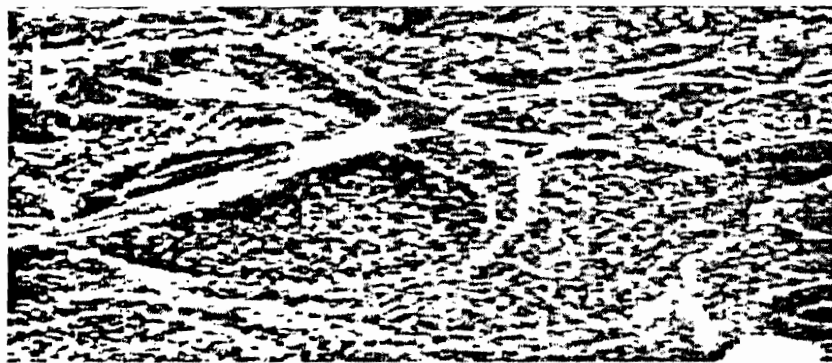
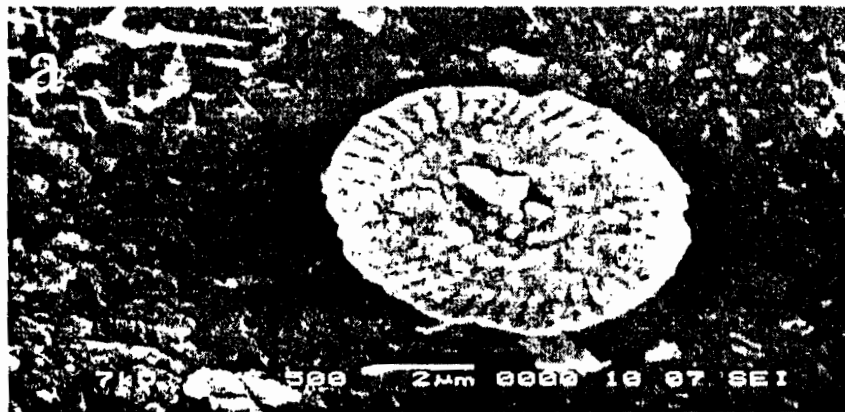


Plate 3

Fig. a: Glandular scale. e.g. *Eryngium creticum*

Fig. b: Stellate with four arms e.g. *Eryngium campestre*.

Fig. c: Unicellular, branching medially e.g. *Foeniculum vulgare*.



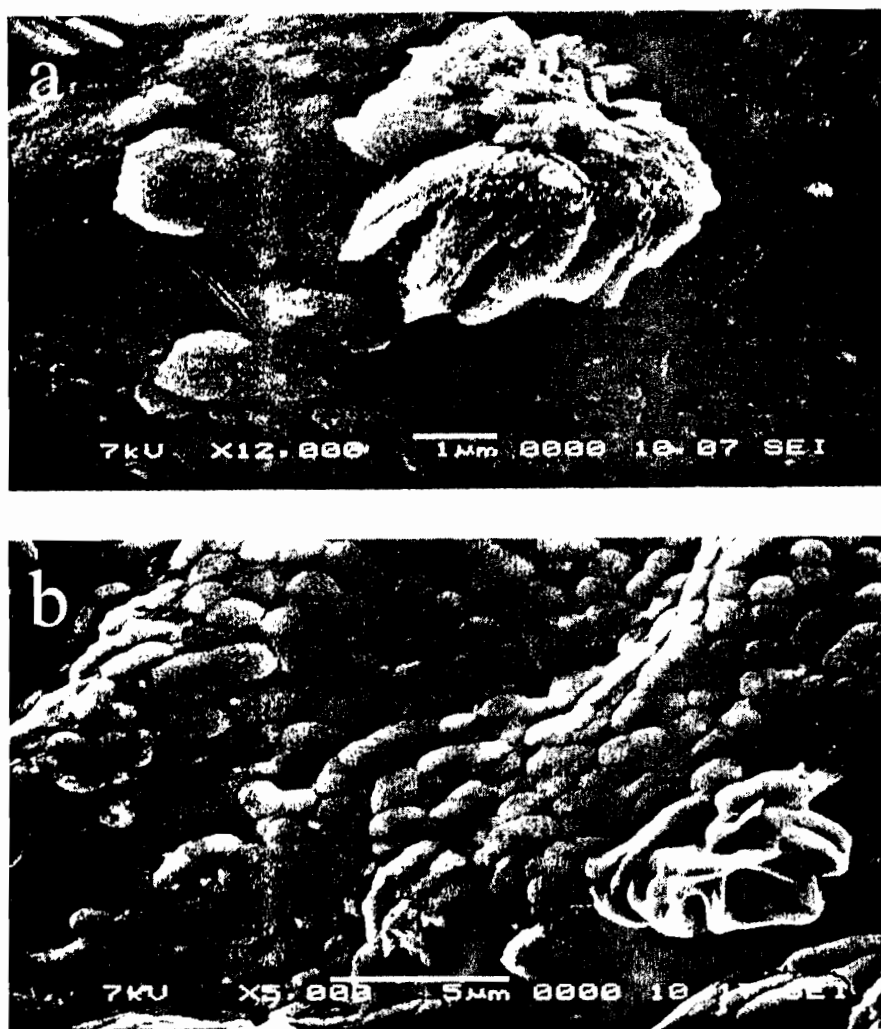


Plate 4 (Figs. a,b)

Fig. a: Papillae structure. e.g. *Pycnocycla tomentosa*.

Fig. b: Scales structure. e.g. *Pycnocycla tomentosa*.

### Trichome Ornamentation

There are three types of trichomes ornamentation in the studied species; warty in *Pycnocycla tomentosa*, *Pseudorhiza pumila* and *Pimpinella etbaica*, striate in *Eryngium glomeratum* and smooth in the remainder.

### Epidermal cells

The epidermal cells are tangentially elongated in *Deverra tortuosa*, *Anethum graveolens* and *Eryngium glomeratum*, radially in *Pseudorhiza*

*pumila*, *Eryngium canpestre* and *Eryngium creticum*, and mixed (tangential and radial) in the rest studied species. Cell shape is irregular in *Ammi majus*, while polygonal in other species, except in *Eryngium* species which they are  $\pm$  angular.

### Stomatal Apparatus

Stomata leveling ranged between superficial and semi-depressed (Table 2). Stomata are mostly of a diacytic. The outlines of the pair of guard cells are usually suborbiculate to elliptical.

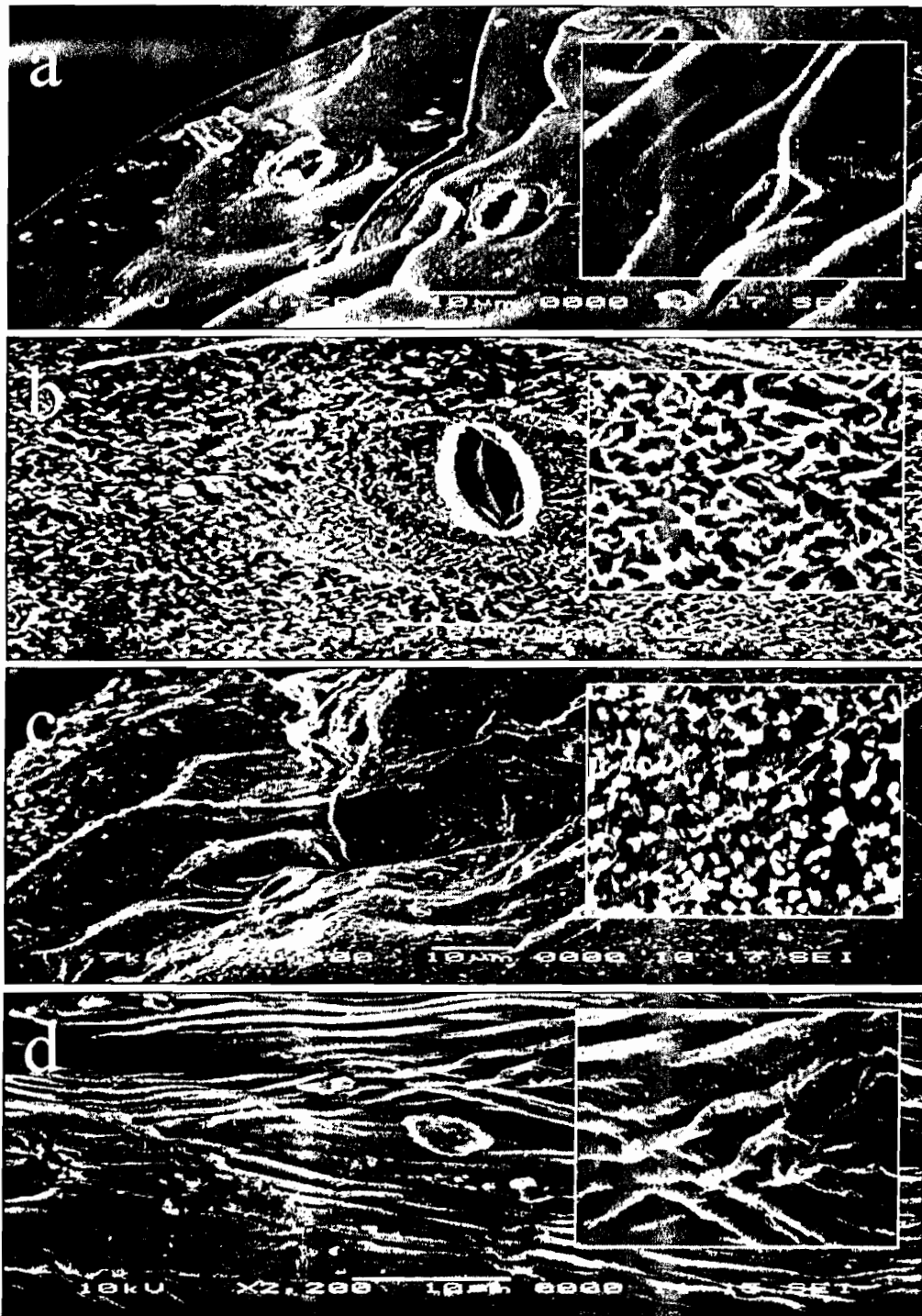


Plate 5 (Figs. a-d): Cuticular ornamentation

- Fig. a: Favulariate covered with smooth glossy wax. *e.g.* *Ammi visnaga*, *Pimpinella etbaica*.  
 Fig. b: Favulariate covered with loose curled scales of wax. *e.g.* *Eryngium campestre*  
 Fig. c: Wrinkled with warty-crustose wax particles. *e.g.* *Anethum graveolens*, *Ridolfia segetum*.  
 Fig. d: Irregularly striated  $\pm$  parallel covered with finely warty wax. *e.g.* *Eryngium glomeratum*.

**Cuticular and wax ornamentation**

According to Metcalfe and Chalk (1979), Barthlott (1981) and Kamel (2004) stated that the variation in the striation of the leaf cuticle might be of taxonomic value. The cuticular patterns on the adaxial surface of the leaf are recorded (Plate 4 and Table 2).

**A. Favulariate**

1. Favulariate covered with smooth glossy wax. e.g. *Ammi visnaga*, *Coriandrum sativum*, *Pimpinella etbaica* (Plate 5, Fig. a).
2. Favulariate plane covered with finely warty wax. e.g. *Deverra tortuosa*, *Foeniculum vulgare*.
3. Favulariate covered with upright filaments of wax. e.g. *Eryngium creticum*
4. Favulariate covered with loose curled scales of wax. e.g. *Eryngium campestre* (Plate 5, Fig. b).

**B. Wrinkled**

5. Wrinkled with warty-crustose wax particles. e.g. *Anethum graveolens*, *Ridolfia segetum* (Plate 5, Fig. c).

**C. striate**

6. Slightly striated covered with finely warty wax. e.g. *Ammi majus*
7. Parallel striated covered with finely warty wax. e.g. *Pseudorlaya pumila*
8. Irregularly striated covered with tuberculate wax. e.g. *Pycnocycla tomentosa*
9. Irregularly striated  $\pm$  parallel covered with finely warty wax. e.g. *Eryngium glomeratum* (Plate 5, Fig. d).

From the observations presented, the subsequent key is suggested for distinguish between the investigated species.

- A- Stomata anomocytic; trichome ornamentation warty.
- B- Cuticular ornamentation irregularly striate; special papillae structures present ..... *Pycnocycla tomentosa*
- BB- Cuticular ornamentation favulariate; special papillae structures absent ..... *Coriandrum sativum*
- AA- Stomata diacytic, trichome ornamentation smooth or striate
- C- Rim of stomata raised.
- D- Cuticular ornamentation favulariate, trichome ornamentation smooth.
- E- E glandular trichome absent ..... *Eryngium creticum*
- EE- E glandular trichome present ..... *Eryngium campestre*
- DD- Cuticular ornamentation striate, trichome ornamentation striate ..... *Eryngium glomeratum*
- CC- Rim of stomata flat.
- F- Cuticular ornamentation favulariate or striate; E glandular trichome absent
- G- Cuticular ornamentation slightly striate ..... *Ammi majus*
- GG- Cuticular ornamentation favulariate ..... *Ammi visnaga*
- FF- Cuticular ornamentation wrinkled; E glandular trichome present.
- H- glandular with unicellular stalk and tetracellular head present ..... *Anethum graveolens*
- HH- glandular with unicellular stalk and tetracellular head absent ..... *Ridolfia segetum*

- I- Cuticular ornamentation parallel striate ..... *Pseudorlaya pumila*  
 II- Cuticular ornamentation favulariate  
 J- Cuticular ornamentation favulariate, covered with smooth glossy wax; trichome ornamentation warty..... *Pimpinella etbaica*  
 JJ- Cuticular ornamentation favulariate plane covered with finely warty wax; trichome ornamentation smooth.  
 K- Epidermal cells mixed; dendritic trichomes present ..... *Foeniculum vulgare*  
 KK- Epidermal cells tangentially elongated, unicellular papillose present .. ..... *Deverra tortuosa*

### DISCUSSION

The taxonomic value of trichomes in this work was boundless. Trichome type has been found to be of diagnostic value in the studied study.

There are 23 types of trichomes recorded in the studied species, some of these trichomes about twelve are specific for some genera for example: Glandular with bicellular-uniseriate stalk and unicellular head present in *Coriandrum sativum*; glandular with multicellular-uniseriate stalk and multicellular head are present in *Eryngium glomeratum*; glandular with tuberculated multicellular-multiseriate stalk and multicellular head recorded in *Pseudorlaya pumila*; unicellular papillose with thick tuberculated cell wall present in *Pycnocycla tomentosa*; unicellular papillose with striated cell wall recorded in *Eryngium glomeratum*; non-glandular unicellular with long broad, acute cell present in *Pycnocycla tomentosa*; non-glandular with broad short basal cell and tuberculated long bicellular curved apical cell present in *Pseudorlaya pumila*; non-glandular with short basal cell and multicellular-uniseriate apical cell found in *Coriandrum sativum*; non-glandular with two basal cell and long acute apical cell found in *Foeniculum vulgare* only. Scales trichomes recorded in *Eryngium creticum* only. Stellate trichomes recorded in *Eryngium campestre* and absent in the remainders. Dendritic trichomes present in *Foeniculum vulgare* and absent in the remainder studied species.

There are three main types of cuticular ornamentation: Favulariate, present in *Ammi visnaga*, *Deverra tortuosa*, *Eryngium creticum* and *Eryngium campestre*; Wrinkled recorded in *Anethum graveolens* and striate, in *Ammi majus*,

*Pseudorlaya pumila*, *Pycnocycla tomentosa* and *Eryngium glomeratum*.

Leaf surface characters are generally regarded as fairly specific and might therefore be important in assessing relationships and also provided information on specific and sectional levels.

Trichome ornamentation is rarely used in leaf anatomical diagnoses, but is well worth consideration for diagnostic value between families or genera (Metcalf and Chalk, 1979).

The study of the leaf epidermal surface of the studied species of Apiaceae exposed a number of important micro-morphological characters, and these characters show evidence of interesting specific variations that are significant for identification.

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## الاهمية التصنيفية لصفات الورقة في بعض أنواع الفصيلة الخيمية

[٢١]

آمال حسن محمد<sup>١</sup> - عزة احمد فهمي خفاجي<sup>١</sup> - داليا جودة جبر<sup>١</sup>

١- قسم النبات-كلية العلوم -جامعة الأزهر (فرع البنات)-مدينة نصر-القاهرة

ونقرى (Favularite) . والثغورفي الغالب من النوع المتعامد Diacytic .  
كما وجد أن أنواع وسطح الشعيرات ذات قيمة تصنيفية معنوية بالأنواع تحت الدراسة . وأظهرت نتائج الدراسة أن سطح الورقة بأنواع الفصيلة الخيمية الجاري دراستها عددا من الصفات التشريحية المهمة ذات قيمة اعتبارية بين الأنواع وقد استخدمت هذه الصفات في بناء مفتاح اصطناعي للتمييز بين الأنواع قيد الدراسة.

قد تم في هذه الدراسة فحص و دراسة السطح الخارجي لأوراق ثلاثة عشر نوعا تتبع عشرة أجناس من الفصيلة الخيمية باستخدام المجهر الضوئي والمجهر الإلكتروني الماسح .  
وأظهرت أنواع الشعيرات وخلايا البشرة والثغور وزخارف السطح العديد من سمات البشرة المهمة والتي لم تسجل من قبل بهذه الفصيلة.  
وقد تحقق من وجود ثلاثة طرز من زخارف السطح هي : مجعد (Wrinkled) ومخطط (Striate)