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On the Structure and Ontogeny of Stomata in Some Umbellifers

By

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With 134 figures

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Key words: Stomatal types, Umbellifers, *Apiaceae*

Summary

Shah G. L. & Abraham K. 1981. On the structure of stomata in some Umbellifers. — Phyton (Austria) 21 (2): 189–202, 134 figures. — English with German summary.

A supplementary information as new data on the structure and ontogeny of stomata in the Umbelliferae is given. Anomocytic, para-, dia-, aniso- and haplocytic, transitional, tricytic, tetracytic and plagiogyria type of stomata in different combinations (20 in all) and with mesogenous, mesoperigenous and perigenous developments are reported on the vegetative and inflorescence axis of 7 species and leaves of 6 species hitherto uninvestigated. Tricytic is a new stomatal type. The number of stomatal types on the surface of an organ is (3)-5-(8). The diversity is due to differential meristematic activity of the meristemoids which is governed by inherent factors. 11 types, and each type with subtypes, of unusual stomatal forms are recorded as part of the natural phenomenon. Most of them are due to irregularities or omission of ontogenetic stages. They are rare and hence taxonomically not significant. However, in spite of the diversity, the use of the most frequent type of stomata is indicated to delineate the investigated genera to a limited extent.

Zusammenfassung

Shah G. L. & Abraham K. 1981. Bau und Ontogenie der Stomata in einigen Umbelliferen. — Phyton (Austria) 21 (2): 189–202, 134 Abb. — Englisch mit deutscher Zusammenfassung.

In den Epidermen der vegetativen Organe sowie der Infloreszenzachsen

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von 7 daraufhin noch nicht untersuchten Umbelliferen (*Apiaceae*) finden sich zahlreiche Stomatatypen in insgesamt 20 verschiedenen Kombinationen. Tricytisch ist ein neubeschriebener Stomatatyp. In der Epidermis eines Organs kommen (3)-5-(8) Stomatatypen nebeneinander vor. Die Vielfalt geht auf durch innere Faktoren gesteuerte unterschiedliche Aktivitäten der Meristoemoide zurück. Es sind zahlreiche ungewöhnliche Stomatatypen zu beobachten, die aber wegen ihres spärlichen Auftretens keinen taxonomischen Wert besitzen. Trotz der großen Vielfalt können die häufigsten Stomatatypen in beschränktem Ausmaß zur Abgrenzung der untersuchten Taxa dienen.

(Editor transl. et abbrev.)

1. Introduction

The *Umbelliferae* (*Apiaceae*) are economically important, consisting of many species whose seeds/leaves are used as condiments and spices in the culinary. For such an important family it is necessary to have as much information on its anatomy as possible as an aid to pharmacology. Epidermal studies are one such aspect.

Our knowledge about the foliar stomata in the family is through the works of METCALFE & CHALK (1950) and GUYOT (1971). However, no investigations are undertaken to study the structure and ontogeny of the stomata on the vegetative and floral organs of different species in the family except that of GUPTA *et al.* (1965) on *Bupleurum tenue*. The present study was, therefore, undertaken to bridge up the existing gap and to record supplementary information, if any, as new data. They are described on the vegetative organs and inflorescence axis of seven species and leaves of six species not investigated earlier.

2. Materials and Methods

The seeds of *Ammi majus* L., *Anethum graveolens* L., *Carum copticum* ROXB., *Coriandrum sativum* L., *Cuminum cyminum* L., *Daucus carota* L. and *Foeniculum vulgare* MILL. were grown in the departmental botanical garden. The fresh leaves, stems, petioles and inflorescence axes from mature plants and the cotyledons and hypocotyledons of twenty four days old seedlings were investigated. The dry leaves of *Bupleurum falcatum* L., *Centella asiatica* URB., *Pimpinella heyneana* WALL., *P. tomentosa* DALZ. *Seseli diffusum* S. & W. and *Trachyspermum stictocarpum* WOLFF, available in our herbarium, were studied. They were put in boiling water for about 10 min. before peeling. The peels obtained from the middle region of different organs were stained with Delafield's hematoxylin or 1% aqueous safranin in ethanol (50%) and mounted in glycerine — jelly.

The frequency (%) of different types of stomata are calculated from camera lucida drawings of five different peels of the terete organs and from each of the surface of the bilateral organs.

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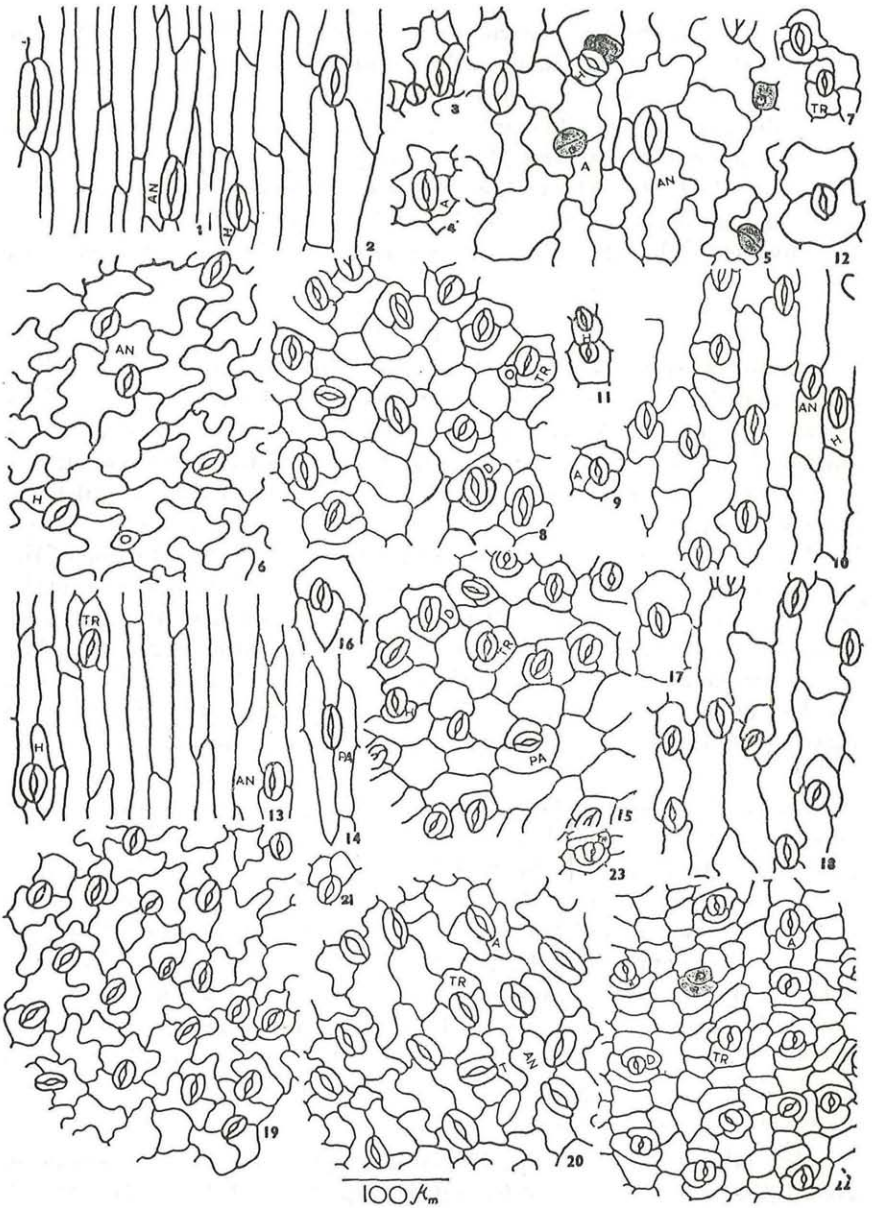

Figs. 1—23. *Daucus*: Figs. 1, 19 (H, L-ad). — *Coriandrum*: Figs. 3—5, 6—7: 13—14, 20—21 (C-ab, L-ab, Po, C-ad). — *Pimpinella tomentosa*: Figs. 8—9, 15 (L-ab, L-ad). — *Cuminum*: Figs. 10—12, 16—18 (C-ab, C-ad). — *Carum*: Figs. 2 (H), 22—23 (S). — Abbreviations: C = cotyledon, H = hypocotyledon, S = stem, L = leaf, P = petiole, I = inflorescence axis, ab = abaxial surface, ad = adaxial surface. For further details see text

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The circumscription of mature stomata is that of METCALFE & CHALK (1950), METCALFE (1961), SHAH & KOTHARI (1975) and PANT & BANERJI (1965). In some stomata the guard cells are not completely enveloped by three subsidiary cells of different sizes. They are considered here as tricytic. For the ontogeny we have adopted the terminology of PANT (1965). In the text and in the tables abbreviations are used as follows: bs = both surfaces, ad = adaxial surface, ab = abaxial surface, L = leaf, C = cotyledon, H = hypocotyledon, S = stem, P = petiole, and I = inflorescence axis.

3. Observations

Aspects of mature epidermis: The epidermal cells are of various shapes and sizes. In the surface aspect the anticlinal walls may be straight or variously sinuate. The cotyledons and leaves (except *Seseli*) are amphistomatic whereas the stomata are present all over the surface in terete organs. In general they are evenly distributed in the epidermis without any definite pattern of orientation in the leaves and cotyledons (Figs. 5, 6, 8, 15, 19, 20, 24, 25, 29, 40, 45) but their orientation is almost in the direction of the long axes of terete organs (Figs. 1, 2, 10, 13, 14, 18, 32, 39). However, in the stem and inflorescence axis of *Daucus* and *Foeniculum* and stem of *Carum* (Figs. 22, 23) the stomatal orientation is similar to that in leaves and cotyledons but the converse is true in the cotyledons and leaves of *Carum* and the last organ of *Anethum* and *Foeniculum* (Figs. 43, 44). METCALFE & CHALK (1950) also reported a similar orientation of stomata in *Eryngium* leaf.

Mature stomata: They may be anomocytic (An), hyplocytic (H), paracytic (PA), diacytic (D), transitional (Tr), anisocytic (A), tetracytic (T) and tricytic (TRI), the different types often occurring side by side even on the same surface in all the organs of the various species investigated except the hypocotyls of *Coriandrum*, *Daucus* and *Foeniculum* where they are only anomocytic (Fig. 1). In all there are twenty combinations, one with two types (Fig. 2), four with three types (Figs. 3—5, 6—7, 8—9), four with four types (Figs. 10—12, 13—14, 15, 16—18), six with five types (Figs. 19, 20—21, 22—23, 24, 25—28, 29—30), three with six types (Figs. 31—36, 37—39, 40—42), one with seven types (Figs. 43—44) and one with eight types (Figs. 45—49).

In spite of the diversity, the most frequent type is anomocytic in *Ammi* (C-bs, H, L-bs, P), *Anethum* (C-bs, H), *Carum* (C-bs, H, I), *Coriandrum* (C-bs, H, L, S, P, I), *Cuminum* (C-bs, H, L, S), *Daucus* (C-bs, H, L-ad), *Foeniculum* (C-bs, H, P), *Pimpinella heyneana* (L-ad) and *Seseli* (L-ab), but it is transistional in *Anethum* (P), *Carum* (L-bs, S, P), *Cuminum* (P, I), *Daucus* (S, P, I), *Foeniculum* (L-ab, I) and *P. tomentosa* (L-ad), diacytic in *Anethum* (L-ad, S, I), *Pimpinella heyneana* (L-ad), *P. tomentosa* (L-ab) and *Trachyspermum* (L-bs), paracytic in *Bupleurum* (L-ab), anisocytic in

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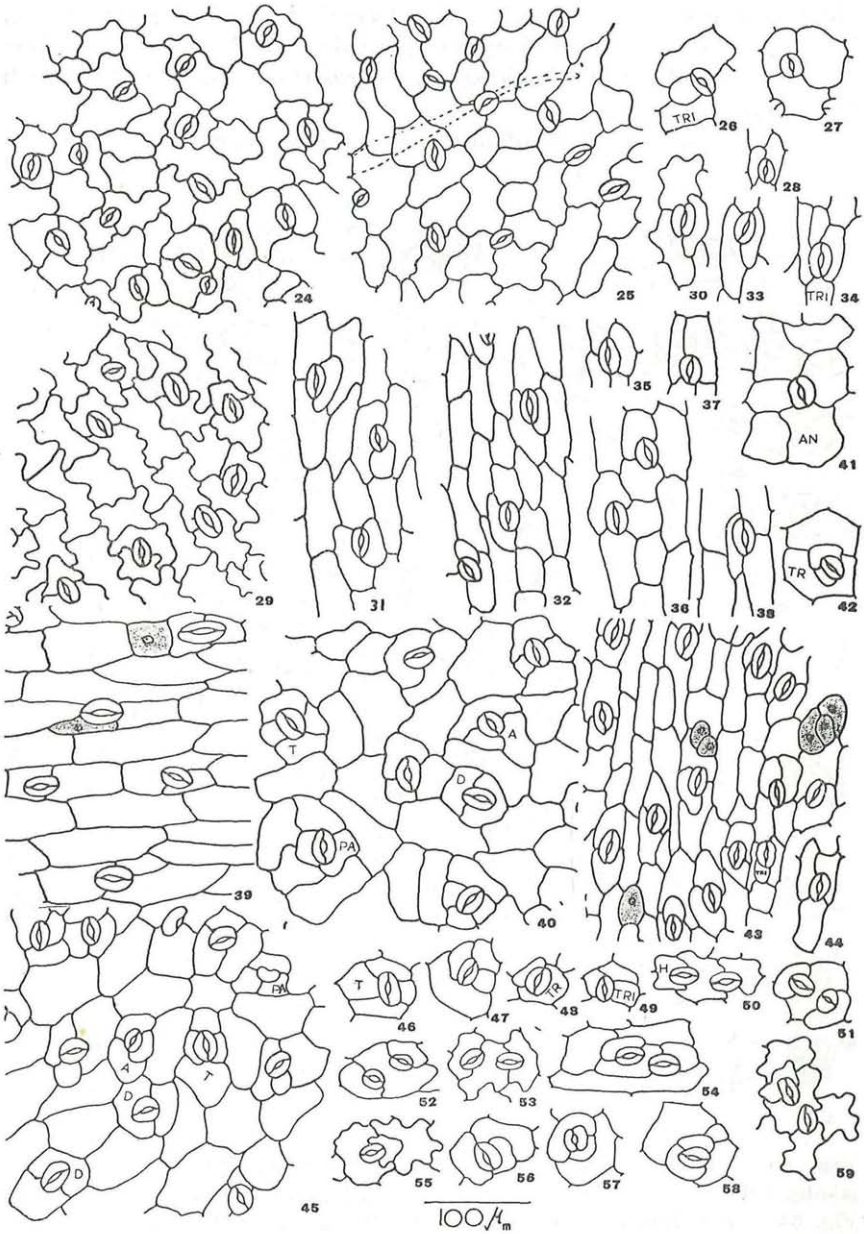

Figs. 24—59. *Bupleurum*: Fig. 24 (L-ab). *Seseli*: Figs. 25—28 (L-ab). *Anethum*: Figs. 29—30, 50, 54, 56, 58 (L-ad except 56 S). *Coriandrum*: Figs. 31—36 (S.) *Ammi*: Figs. 37—39 (P). *Centella*: Figs. 40—42 (L-ab), 45—49, 55, 57, 59 (L-ad). *Carum*: Fig. 51 (P). *Foeniculum*: Figs. 43—44, 53 (L-ab). *Trachyspermum*: Fig. 52 (L-ad). Abbreviations see Figs. 1—23

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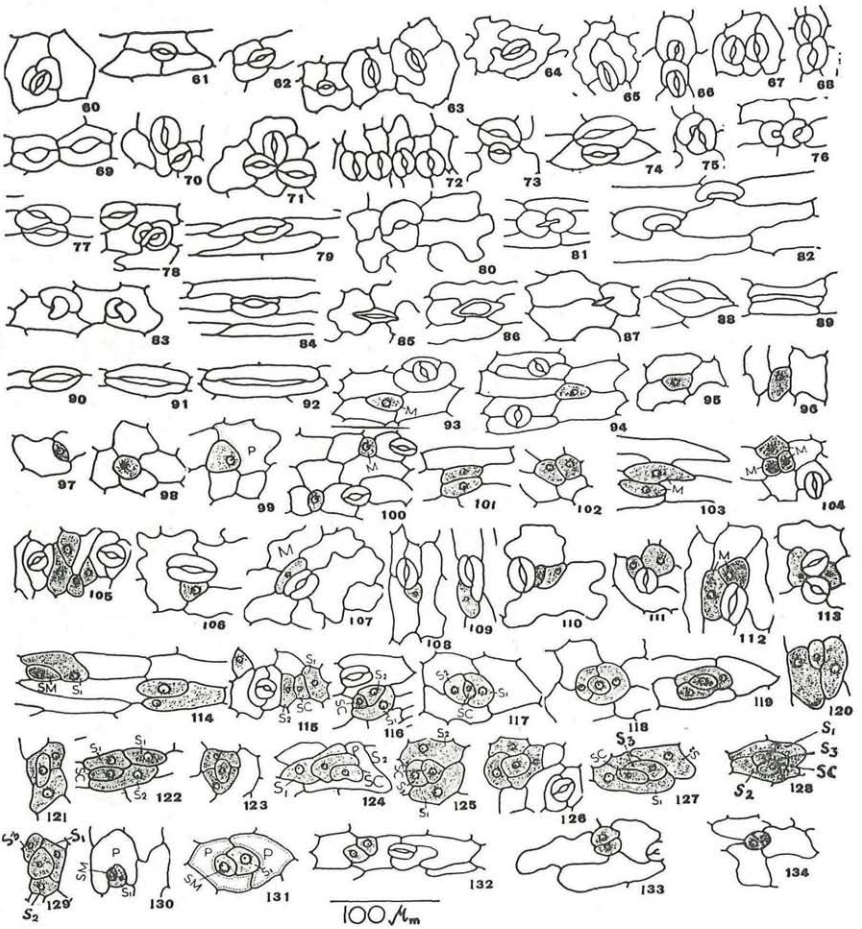
Bupleurum and *Centella* (L-ad), and tetracytic in the last genus (L-ab). Two types with nearly equal frequency percentage are dominant in *Anethum* (L-ab), *Cumin* (C-ad), *Coriandrum* (S), *Daucus* (L-ad) and *Foeniculum* (P) (Table 1).

During the present investigation several deviations from the normal



Figs. 60—134. *Cuminum*: Figs. 60—62, 66, 133 (C-ad). 81—82, 100 (H), 87 (C-ab), 101, 116, 130, 134 (L-ab). *Bupleurum*: Fig. 63 (L-ab). *Trachyspermum*: Fig. 64 (L-ad). *Daucus*: Figs. 65, 69, 74 (H) 72, 78, 98, 102, 104 (C-ab), 83, 93—95, 107, 108, 120, 128 (S), 105, 111 123, (I). *Foeniculum*: Figs. 67, 68, 70—71, 73, 75, 112, 113 (C-ab), 84 (H), 115, 126, 129 (S), 132 (L-ad). *Coriandrum*: Figs. 79, 90—92 (H), 80, 110 (C-ab), 114, 122 (S) *Anethum*: Figs. 76, 77, 85, 86, 97, 106, 109, 121 (C-ab), 103 (C-ab), 88, 89 (H), 96, 119, 124, 127 (I), 99, 117. 118, 125, 131 (S). Abbreviations see Figs. 1—23

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stomatal forms are encountered. (i) There is a common subsidiary cell between a diacytic and transitional (Figs. 50, 53), two diacytic (Fig. 51), two transitional (Figs. 52, 54) or transitional and anomocytic stomata (Fig. 59). (ii) At times a diacytic (Fig. 55), paracytic (Figs. 56, 65) or transitional stoma (Figs. 23, 57) is with an additional subsidiary cell. Such stomata are partly amphicyclic (see PANT & BANERJI 1965) and rarely they simulate an anisocytic one (Fig. 64). A transitional stoma is completely amphicyclic with an outer diacytic (Fig. 42), anisocytic (Fig. 58) or transitional ring of subsidiary cells (Fig. 60). (iii) An increase in the number of subsidiary cell takes place by a wall formation in one of them (Figs. 61, 62, 63) and a basically paracytic stoma occasionally resembles an anisocytic one (Fig. 63). (iv) The subsidiary cell of a haplocytic stoma (Figs. 11, 66) seldom completely envelopes the guard cells, simulating the *plagiogyria* type of PANT (1965) or *eupolomesoperigenous* type of FRYNS-CLAESSENS & COTTHEM (1973). (v) Two equal or unequal stomata, rarely three (Fig. 71) or four (Fig. 72) stomata, may be contiguously juxtaposed (Figs. 67, 73, 74), superposed (Figs. 68, 69) or obliquely oriented (Fig. 70). A fully developed stoma is also contiguous with a stoma with one guard cell (Figs. 75, 76). (vi) Some stomata are with unequal guard cells (Figs. 76—78) or rarely with epidermal cell-like guard cells (Figs. 79, 80) having unusual pore arrangement (Fig. 81). At times the pore between two dissimilar guard cells is not developed (Fig. 83), (vii) A stoma with one guard cell may be with a well developed pore (Fig. 82) or without a pore (Fig. 83). (viii) One or both the guard cells are very narrow indicating degeneration (Figs. 84—86). (ix) Very rarely a stoma is represented by a pore only (Fig. 87). (x) Stomata are oblong or nearly spherical in outline but a few may be rectangular (Fig. 69), lenticular (Fig. 88) or bone shaped (Fig. 89). (xi) Unusual sized stomata — the giant stomata — are observed in *Foeniculum* and *Cuminum* (C-ab) and *Anethum*, *Coriandrum* and *Daucus* (H). The average sizes (μm) are indicated as follows: length × breadth of guard cells/length of the pore, the respective values obtained from normal stomata are added in brackets. *Foeniculum* 61 × 13/44 (33 × 9/16), *Cuminum* 73 × 18/— (35 × 9/11), *Anethum* 75 × 11/53 (50 × 10/27), *Coriandrum* 82 × 11/58 (56 × 10/33), and *Daucus* 67 × 13/42 (45 × 11/24). The intermediate forms between the average sized normal stomata and the giant ones are also traced (Figs. 90—92).

Ontogeny: The stomata follow a mixed sequence of ontogeny since the ontogenetical stages are found along with the fully developed stomata often side by side or contiguously (Figs. 5, 6, 8, 22, 39, 43, 93, 94, 100, 104—113, 115, 116, 126, 132). The meristemoids (M) are scattered in the epidermis (Figs. 93—100) but at times two to four meristemoids are variously adjacently placed and they may be equal or unequal in size (Figs. 101—105). Sometimes they are contiguously cut off to a mature stoma (Figs. 106—113). They are distinguished by their smaller sizes and denser contents.

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They may be squarish (Figs. 5, 39, 104), ellipsoidal (Figs. 6, 103), ovate (Figs. 43, 93, 99, 105, 106), cylindrical (Figs. 101, 112, 113), rectangular (Figs. 98, 100, 111), trapezoidal (Figs. 94—96, 102, 104, 105, 113, 132), beakshaped (Figs. 103, 105), semilunar (Fig. 107), triangular (Figs. 39, 108, 110—112, 115) or obcylindric (Fig. 109). A meristemoid may transform into a guard cell mother cell without cutting off any subsidiary cell. Such stomata are anomocytic (cf. Figs. 133, 134). But more commonly it divides by one to three intersecting curved walls to cut off subsidiary cell segments (S_1—S_3) (Figs. 5, 22, 43, 114—123, 125—127). These organize into stomata with one subsidiary cell (hyplocytic), two subsidiary cells (paracytic, diacytic and transitional) and three subsidiary cells (anisocytic). Sometimes the S_1 and S_2 are cut off on the same side of the small central cell (SC) (Fig. 124) or S_3 is enveloped by S_1 and S_2 (Fig. 128) or S_1—S_3 do not completely envelope the central small cell (Fig. 129). These lead to irregularities in stomatal types and the last type organizes into a tricytic stoma.

The ontogeny of the anomocytic stomata is perigenous whereas the stomata with subsidiary cells are mesogenous since the guard cell, mother cell and the subsidiary cells are the derivatives of the same meristemoid. Seldom the subsidiary cell complex is partly mesogenous and partly perigenous (P) in origin. Such stomata are mesoperigenous (Figs. 124, 130, 131). The ontogeny of tetracytic stomata is not traced.

The meristemoid (M), the small segment (SM) or the central small cell (SC) transforms into a guard cell mother cell which divides by a vertical wall to form two guard cells (Figs. 5, 134) which gradually become beanshaped, developing an intervening pore.

Contiguous stomata may arise by any one of the following methods. (i) Two to three adjacently placed meristemoids develop into stomata which become variously contiguous (cf. Figs. 101, 102, 104, 105). (ii) A meristemoid or meristemoids cut off contiguously to a mature stoma (Figs. 106—112) also develop into stomata which become variously contiguous to the pre-existing mature stoma. The unequal sized contiguous stomata may be due to unequal development of the adjacent meristemoids or the meristemoids themselves are unequal (cf. Fig. 105). At times a meristemoid contiguous to a mature stoma transforms into a stoma with one guard cell. Thus one and half stomata become contiguous. A guard cell mother cell fails to divide to produce guard cells and itself becomes beanshaped, daveloping a pore on one side; at times the pore is not developed (cf. Figs. 82, 83). This is a stoma which one guard cell. The wall formation in the guard cell mother cell at times cuts off two unequal guard cells. The stoma with unequal guard cells may also be due to two unequal adjacent meristemoids each organizing into a guard cell and then developing a common pore between them (cf. Figs. 78, 79 and 103).

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Table 1

Relative frequency (% [1])) of different types of stomata and percentages of ontogenetic stages and obnormalities. An-anomocytic; H-haplocytic; PA-paracytic; D-diacytic; TR-transitional; A-anisocytic; T-tetracytic; TRI-tricytic

Species	Organ	Surface	Types of stomata							
			An	H	PA	D	TR	A	T	TRI
	1	2	3	4	5	6	7	8	9	10
Ammi majus		ad	85	15	—	—	—	—	—	—
	C	ab	88	10	2	—	—	—	—	—
	H	—	—	—	—	—	—	—	—	—
	L	ad	88	6	—	—	6	—	—	—
		ab	74	17	—	7	2	—	—	—
	S	—	—	—	—	—	—	—	—	—
	P	—	30	21	7	18	21	3	—	—
	IA	—	—	—	—	—	—	—	—	—
Anethum graveolens	C	ad	56	16	4	8	12	4	—	—
		ab	64	26	—	1	6	3	—	—
	H	—	69	31	—	—	—	—	—	—
	L	ad	24	14	—	27	27	8	—	—
		ab	35	9	—	35	19	2	—	—
	S	—	—	2	—	47	37	11	—	3
	P	—	7	8	2	30	36	15	—	2
	I	—	15	6	—	40	15	21	—	3
Bupleurum falcatum		ad	13	—	6	12	19	50	—	—
		ab	4	—	46	7	25	18	—	—
Carum copticum	C	ad	56	36	—	10	—	—	—	—
		ab	58	30	2	—	—	—	—	—
	H	—	75	25	—	33	—	—	—	—
	L	ad	24	31	2	8	10	—	—	—
		ab	8	17	—	25	42	8	—	—
	S	—	18	10	5	22	35	10	—	—
	P	—	27	24	—	6	34	9	—	—
	I	—	35	21	10	4	23	7	—	—
Centella asiatica	L	ad	5	5	5	12	9	52	7	5
		ab	6	—	12	12	18	24	28	—
Coriandrum sativum	C	ad	69	11	—	—	3	14	3	—
		ab	83	8	—	—	—	9	—	—
	H	—	100	—	—	—	—	—	—	—
	L	ad	70	10	3	7	7	3	—	—
		ab	86	8	—	—	6	—	—	—
	S	—	25	17	—	17	17	25	—	8
	P	—	70	15	10	—	5	—	—	—
	I	—	33	6	6	3	12	40	—	—

[1]) Error by rounding max. ±0,5%.

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Species	Organ	Surface	Types of stomata							
			An	H	PA	D	TR	A	T	TRI
	1	2	3	4	5	6	7	8	9	10

Table 1 (Contd.)

Cuminum cyminum	C	ad	36	36	—	26	2	—	—	—
		ab	55	37	—	8	—	—	—	—
	H	—	87	13	—	—	—	—	—	—
	L	ad	52	33	—	10	5	—	—	—
		ab	39	8	3	34	13	3	—	—
	S	—	37	12	—	27	17	5	—	2
	P	—	9	9	1	30	44	7	—	—
	I	—	26	6	1	27	35	5	—	—
Daucus carota	C	ad	52	27	—	6	9	—	6	—
		ab	52	21	1	13	12	1	—	—
	H	—	100	—	—	—	—	—	—	—
	L	ad	28	21	—	27	21	—	3	—
		ab	19	7	—	35	29	10	—	—
	S	—	—	9	3	35	46	7	—	—
	P	—	24	4	4	12	44	12	—	—
	I	—	8	6	1	27	48	9	—	1
Foeniculum vulgare	C	ad	78	10	—	2	8	2	—	—
		ab	76	12	—	—	12	—	—	—
	H	—	100	—	—	—	—	—	—	—
	L	ad	12	1	1	48	28	5	5	—
		ab	6	3	1	36	45	4	4	1
	S	—	7	5	—	47	31	10	—	—
	P	—	31	31	3	15	17	3	—	—
	I	—	15	—	—	40	42	3	—	—
Pimpinella heyneana	L	ad	22	—	—	44	30	4	—	—
		ab	39	8	3	34	13	3	—	—
P. tomentosa	L	ad	—	8	2	42	48	—	—	—
		ab	—	—	—	59	39	2	—	—
Seseli diffusum	L	ad	—	—	—	—	—	—	—	—
		ab	88	—	5	3	—	2	—	2
										Ø
Trachespermum strictocarpum	L	ad	26	2	—	52	10	10	—	—
		ab	28	12	2	32	20	6	—	—

Discussion

On the basis of his extensive study on the structure and ontogeny of stomata on the leaves of Umbelliferae, Guyot (1971) concluded: (i) In every genus all the species show more or less the same type of stomata

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though two to three stomatal types may be found on the same surface in some species. (ii) The anomocytic stomata are primitive from which other types like paracytic, diacytic, anisocytic and tetracytic are evolved. (iii) The number of divisions a meristemoid undergoes giving rise to different types of stomata, one type serving as a link with the other is important. (iv) In certain species the stomata have remained primitive in character and in others they have reached an evolved state.

Our observations provide considerable additional new information:

The structure and ontogeny of stomata on vegetative organs (except leaves) and inflorescence axis of *Ammi*, *Anethum*, *Carum*, *Coriandrum*, *Cuminum*, *Daucus*, *Foeniculum* and leaves of *Bupleurum falcatum*, *Carum copticum*, *Cuminum*, *Centella*, *Foeniculum vulgare*, *Pimpinella heyneana*, *P. tomentosa*, *Seseli diffusum* and *Trachyspermum strictocarpum* are not investigated by earlier workers.

The haplocytic, transitional, tricytic and plagiogyria are additional stomatal types for the family. In genera other than *Eryngium* and *Xanthosia* GUYOT, 1971), tetracytic stomata are also observed in *Centella* (L-ab), *Coriandrum* (C-ad), *Daucus* (L-ad) and *Foeniculum* (L-bs) and it is a dominant type in *Centella* (L-ab).

In contrast to GOYOT's (1971) observations, the diversity in stomatal types is found in almost all the organs and even on the same surface. In hypocotyls one or two stomatal types occur but in other organs they are three to eight with five as the most frequent number. The number and types of stomata are not uniform on the two surfaces of leaves and cotyledons except *Bupleurum* and *Foeniculum*.

The stomatal diversity is also associated with ontogenetical diversity which is due to the differential meristematic activity of the meristemoids to cut off subsidiary cell segments. Since it is of wide occurrence both in dicotyledons and monocotyledons, we are inclined to believe that it has something to do with some inherent factors. Experimental studies (SHARMA & DUNN 1968, 1969, SHARMA 1972, SHAH *et al.* 1974, 1976, 1977) lend some support to this inference.

In Umbelliferae, GUPTA, PALIWAL & GUPTA (1965) reported anisocytic stomata on the vegetative and floral organs of *Bupleurum tenue* and they supported the view of STEBBINS and KHUSH (1961). In spite of the diversity in stomata on different organs there are clearly two trends of ontogeny, anomocytic being perigenous and stomata with subsidiary cells being mesogenous or mesoperigenous. These observations also lend a support to the view of STEBBINS & KHUSH (1961).

Several unusual stomatal forms observed during the present study are not reported for the family by any of the earlier workers. They are the results of irregularities and omission of different stages in the ontogenetic cycle. The cause of irregularities and omissions is not known. They are considered here also as a part of the natural phenomenon of ontogeny

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because some of such forms are also observed on the leaves of untreated plants by several workers (cf. KOTHARI & SHAH 1975, SHAH & KOTHARI 1975 etc.).

Though the giant stomata are reported in *Mangifera indica* (SITHOLEY & PANDEY 1971), *Regnellidium* (RAO 1973) and *Alangium* (GUPTA *et al.* 1976), these accounts lack the data on their sizes and on the size differences between the normal and giant stomata. The present study therefore gives the first meaningful report on giant stomata, showing the size differences between the two types. Further, the average sizes of giant stomata differ in the species they occur. They are rare and their ontogeny is obscure. No meristemoidal size differences are observed even to conjucture their ontogeny.

Our observations agree with those of GUYOT (1971) for foliar stomata only in *Anethum*, *Daucus* and *Foeniculum*.

Anisocytic stomata are reported as the only type in *Coriandrum* and *Seseli* and mesoperigenous anisocytic and diacytic in *Ammi* (GUYOT 1971). However, according to METCALFE & CHALK (1950), the stomata in these genera are anomocytic. On the basis of the most frequent type, our obser vations concur with those of the last two authors.

STEBBINS & KHUSH (1961) and TAKHATAJAN (1969) consider the anomocytic stomata as a derived type, whereas GUYOT (1971) considers them as primitive. These views have to be seriously considered in light of the critical observations of TAKHATAJAN (1969) and considerable reports of diversity on the same surface including the present one.

A diagnostic value is attributed to the distribution of stomata on lower surface or both surfaces of leaves by METCALFE & CHALK (1950). In our plants, the genus *Seseli*, being hypostomatic, can be easily distinguished from other genera which are amphistomatic.

Stomatal diversity occurs not only in different organs of the same species but variability also occurs in the number of stomatal types on a surface and the most frequent one in homologous organs of the species studied. The number of stomatal types is 1—2, 2—6, 3—8, 5—6, 4—7 and 4, 6—7 in hypocotyledon, cotyledon, leaf, stem, petiole and inflorescence axis respectively. Anomocytic type is the most frequent type in hypocotyledons and cotyledons and therefore taxonomically it is of little use to delineate genera. The most frequent types are variable in petiole, stem and inflorescence axis of the different genera and it is possible to delineate them using one organ at a time. In petiole most frequent types are anomocytic (*Ammi*, *Coriandrum*, *Foeniculum*) and transitional (*Anethum*, *Carum*, *Cuminum*, *Daucus*) but they are anomocytic (*Coriandrum*, *Cuminium*), diacytic (*Anethum*) and transitional ones (*Carum*, *Daucus*). In inflorescence axis these types are found in *Carum* and *Cuminum Anethum*, and *Foeniculum* and *Daucus* respectively. But their taxonomic use in the present study is limited because of an investigation of a few genera. The

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leaf also shows much variability and distribution of the most frequent type in all the taxa investigated. An attempt is, therefore made to delineate them on this basis.

1 Leaves hypostomatic ..... *Seseli*
2 Leaves amphistomatic:
2.1 Anomocytic on both surfaces ..... *Ammi, Coriandrum, Cuminum*
2.2 Diacytic on both surfaces ..... *Trachyspermum*
2.3 Diacytic on abaxial surface:
2.3.1 Transitional on the adaxial surface ..... *Pimpinella tomentosa*
2.3.2 Anomocytic and diacytic with equal frequency percentage on the adaxial surface ..... *Daucus*
2.4 Diacytic on the adaxial surface:
2.4.1 Transitional on the abaxial surface ..... *Foeniculum*
2.4.2 Anomocytic on the abaxial surface ..... *Pimpinella heyneana*
2.4.3 Diacytic and anomocytic in equal proportions on the abaxial surface ..... *Anethum*
2.5 Anisocytic on the adaxial surface:
2.5.1 Paracytic on the abaxial surface ..... *Bupleurum*
..2.5.2 Tetracytic on the abaxial surface ..... *Centella*
2.6 Transitional on both surfaces ..... *Carum*

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