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Contributions to the Pollen morphology of the family Compositae

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Abstract: The pollen morphology of 24 species of Compositae belonging to 18 genera was examined by light and scanning microscopy. The present data confirms the eurypalynous nature of the family. Delimitation of the genera on the basis of pollen characters is less marked. Pollen grains usually radially symmetrical, isopolar rarely apolar; tricolporate, often porate. Shape commonly oblate-spheroidal to prolate-spheroidal, with some suboblate to subprolate types. Tectum echinate to echinolphate, often non-echinate. Tectum in-between the spines or spinules is sub-psilate, or perforated to striate. On the basis of the exine pattern, 4 distinct pollen types are recognized viz., Pollen type-I: *Dicoma tomentosa*, Pollen type-II: *Eclipta prostrata*, Pollen type-III: *Echinops echinatus* and Pollen type-IV: *Launaea nudicaulis*.

Within the pollen types, pollen characters are significantly sufficient for characterization of the species. An interesting correlation observed is that the taxa having spiny capitula have a mostly non-echinate or spinulose tectum with very thick exine (7-25 μm).

Key Words: Pollen morphology, Compositae, Eurypalynous

Compositae Familyasının Pollen Morfolojisine Katkılar

Özet: Compositae familyasının 18 sınıfına ait 24 türünde pollen morfolojisi ışık ve scanning elektron mikroskopik olarak incelendi. Elde edilen veriler bu familyanın *eurypalynous* tabiatında olduğunu destekliyor. Pollen karakterlerine göre bu sınıfın (grubun) sınırları tam olarak belirlenmemiş değil. Pollen tanecikleri genellikle radial olarak simetrik, izopolar, ender olarak da apolar; tricolporate ya da daha sıklıkla porate olduğu görüldü. Formu (yapısı) çoğunlukla oblate-spheroidal'den prolate-spheroidal'e kadar değişmekte olup bazen sub-oblate'den sub-prolate tiplere kadar değişen tiplere rastlanmıştır. Tektum'un ise echinate, echinolphate, çoğunlukla non-echinate olarak gözlenmiştir. Tektum'un ise echinate olarak gözlenmiştir. Tektum spine'ler ve spinule'ler arasında sub-psilate, ya da perfore ve striate görünümündedir.

Exine yapısına göre 4 belirgin pollen tipi tespit edildi: Tip I. *Dicoma tomentose*, tip II *Eclipta prostrata*, tip III *Echinops echinatus*, tip IV *Launaea nudicaulis*.

Pollen tipleri içinde türlerin karakterize edilmesi oldukça iyi bulundu. Ayrıca, spiny capitula'ya sahip grupların (taxon'ların), kalın exine taşıyan non-echinate ya da spinulose tektum taşıması arasında ilginç bir kolerasyonun varlığı gözlemlendi (17-25 μm).

Anahtar Sözcükler: Pollen morfolojisi-compositae-Eurypalynous.

Introduction

Compositae is a well-defined and easily field recognized family. It is the largest family of dicotyledons, with more than 1100 genera and 20.000 species [1, 2]. It has a number of distinctive characters, viz. capitulum inflorescence, rayflorets or disklorets. However, the family shows a wide range of variation in floral and reproductive characters, and a number of researchers, including Cronquist (3) and Dahlgren (5), have divided the family into 13-15 tribes. Like its floral morphology, the palynology of the family is also unique.

The internal structure of the Compositae pollen wall was first studied by Stix (6). Skvarla & Turner (7), Skvarla & Larsen (8) and Skvarla et al. (9) employed transmission electron microscopy to elucidate the detailed internal structure of the pollen walls. They utilized these characters in determining tribal affinities and phyletic relationships in the Compositae. The palynology of Hypochoeridinae and Scolyminae has been described by El-Ghazaly (10). Blackmore (11) examined pollen grains of Northwest European species of the tribe Lactuceae. Robinson & Marticorena [12] described the palynology of the tribes of Liabeae (Compositae). Bolick (13, 14) also studied the various tribes of the family Compositae. The purpose of the present study was to provide palynological information about 24 species representing 18 genera of the family Compositae, which would be helpful for finding generic and tribal relationships.

Materials and Methods

Pollen samples were obtained from the Karchi University Herbarium (KUH) or collected from the field (the list of voucher specimens is deposited in KUH). The pollen grains were prepared for light and scanning electron microscopy by the standard methods described by Erdtman (15). For light microscopy, the pollen grains were mounted in unstained glycerine jelly, and observations were made with a Nikon Type 2 microscope, under (E40, 0.65) and oil immersion (E100, 1.25) using a 10x eye piece. For SEM studies, pollen grains suspended in a drop of distilled water were transferred onto a metallic stub using double-sided cello tape and coated with gold in a sputtering chamber (Ion-sputter JFC-1100). Coating was restricted to 150A. The S.E.M examination was carried out on a Jeol microscope JSM-T200. The measurements were based on 15-20 readings from each specimen. Polar axis (P) and equatorial diameter (E), colpi length, apocolpium, mesocolpium, spine length and exine thickness were measured (Table 1).

The terminology used is in accordance with Wodehouse [16]; Erdtman [15]; Faegri & Iversen [17] and Walker & Doyle [18].

Results and observations

General Pollen characters of the family Compositae

Pollen grains are usually radially symmetrical, isopolar rarely apolar, oblate-spheroidal to prolate-spheroidal, with some suboblate to subprolate types; triangular in polar view, lophate grains hexagonal to octagonal in polar view, few±spheroidal in shape; tricolporate, rarely tetracolporate or porate; clopal membrane sub-psilate. In lophate grains, colpus with mural

Table 1. General pollen characters found in the family Compositae

Name of taxa	Shape	Length in μm	Breadth in μm	Colpus length in μm	Mesocolpium in μm
<i>Amberboa ramosa</i> (Roxb.) Jafri	sub-pr	28.7 (33.76) 35.91	25.13 (28.59) 32.31	21.50 (24.70) 26.91	17.91 (20.10) 21.51
<i>Blainvillea latifolia</i> (L.F.) DC.	pr-sp	19.7 (22.36) 25.13	19.70 (21.90) 25.13	14.13 (15.70) 17.91	12.56 (4.93) 17.91
<i>Blumea lacera</i> (Burm. f.) DC.	ob-sp	15.41 (16.61) 18.21	16.81 (17.70) 18.21	10.91 (11.40) 12.61	11.21 (12.70) 12.70
<i>Blumea obliqua</i> (L.) Druce	ob-sp	18.2 (19.70) 21.21	19.61 (11.40) 23.81	11.21 (12.70) 18.21	5.61 (6.16) 18.21
<i>Conyza canadensis</i> (L.) Cronquist	pr-sp	18.21 (20.3) 21.72	43.08 (48.61) 53.81	14.11 (15.49) 16.61	12.61 (13.81) 14.11 5.61
<i>Dicoma tomentosa</i> Cass.	ob-sp	32.31 (35.50) 39.51	28.70 (36.94) 39.51	25.11 (29.61) 32.32	21.50 (23.61) 28.72
<i>Eclipta prostrata</i> (L.) L.	ob-sp	18.21 (19.20) 23.81	18.21 (20.70) 23.81	9.80 (11.90) 14.21	12.61 (14.32) 15.41
<i>Echinopsis echinatus</i> DC.	pr	71.8 (78.81) 96.91	50.26 (57.81) 59.23	46.67 (54.04) 57.44	25.11 (31.77) 39.41
<i>Enhydra fluctuans</i> Lour.	ob-sp	13.21 (19.32) 21.11	19.61 (21.61) 25.21	14.31 (14.90) 15.41	15.4 (16.50) 18.21
<i>Gnaphalium americanum</i> L.	ob-sp	15.41 (16.28) 18.21	16.80 (17.81) 18.21	11.21 (12.46) 12.61	11.21 (13.40) 14.11
<i>Hochstetteria schimperi</i> DC	sub-pr	43.08 (49.70) 53.81	39.41 (41.70) 43.08	23.31 (25.41) 28.72	21.41 (25.11) 28.72
<i>Iphonia grantioides</i> (Boiss.) A. Andenberg	ob-sp	21.50 (24.81) 25.13	25.13 (26.42) 28.72	17.95 (19.34) 21.54	14.31 (16.35) 17.95
<i>Launaea nudicaulis</i> (L.) Hk. J.	ob-sp	25.13 (32.21) 36.21	32.21 (35.90) 39.91	c. 21.51	14.36 (16.95) 17.91
<i>Launaea residifolia</i> (L.)	ob-sp	35.91 (39.01) 39.51	35.91 (39.10) 36.12	21.50 (22.61) 25.12	14.31 (19.50) 21.51
<i>Lactuca remotiflora</i> DC.	sub-ob	20.11 (21.62) 23.32	21.50 (25.30) 26.12	12.50 (14.50) 23.32	14.31 (17.90) 21.50
<i>Pluchea arguta</i> Boiss.	sub-pr	19.61 (21.81) 24.51	23.81 (25.11) 28.11	15.41 (16.30) 18.21	15.41 (17.90) 21.43
<i>Pluchea lanceolata</i> (DC.) Oliv.	pr-sp	18.21 (20.6) 21.11	18.21 (19.36) 21.11	14.11 (14.81) 16.81	12.61 (13.50) 15.41
<i>Pulicaria angustifolia</i> DC.	pr-sp	18.11 (19.11) 21.11	18.21 (19.67) 22.41	11.21 (12.61) 15.41	14.18 (15.05) 16.81
<i>Pulicaria boissieri</i> DC. Hook. f.	ob-sp	20.31 (21.11) 21.11	21.01 (23.11) 22.41	14.21 (15.12) 15.41	14.2 (15.0) 16.81
<i>Sonchus asper</i> L.	sub-ob	25.11 (27.61) 30.51	32.31 (33.50) 35.91	17.9 (19.30) 21.01	17.91 (20.02) 21.51
<i>Sonchus oleraceus</i> L.	sub-ob	28.7 (36.21) 43.08	39.50 (41.64) 46.61	21.50 (23.11) 25.12	14.50 (17.70) 19.70
<i>Tridax procumbens</i> L.	ob-sp	21.01 (23.40) 25.21	21.01 (23.81) 26.61	12.61 (15.40) 18.21	12.61 (14.14) 16.81
<i>Vernonia cineria</i> (L.) Less.	sp	--	10.50 (11.59) 1.61	--	--
<i>Vernonia cinerascens</i> Schultz-Bip	ob-sp	28.70 (33.02) 35.91	32.31 (36.40) 41.32	17.91 (23.50) 28.72	21.50 (23.30) 25.12

Table 1 Contunie

Name of taxa	Shape	Apocolpium in pm	Exine thickness in	Spines length in μm	interspinal distance μm	Tectum
<i>Amberboa ramosa</i> (Roxb.) Jafri	sub-pr	5.38 (7.51) 10.72	3.61 (4.12) 6.82	c. 0.60	-	spinulose
<i>Blainvillea latifolia</i> (L.) DC.	pr-sp	3.61 (4.93) 7.01	1.79 (2.40) 3.23	2.32 (3.58) 3.46	c. 4.33	echinate/sub-ps
<i>Blumea lacera</i> (Burm. f) DC.	ob-sp	5.61 (6.16) 7.01	0.56 (1.21) 1.14	1.41 (2.41) 2.60	c. 3.85	echinate/sub-ps
<i>Blumea obliqua</i> (L.) Druce	ob-sp	c. 3.71 μm	1.41 (1.49)	2.81 (3.81) 4.21	c. 4	echinate/Fr
<i>Conyza canadensis</i> (L.) Cronquist	pr-sp	1.54 (3.76) 5.61	2.11 (2.36) 2.66	2.11 (2.36) 2.66	c. 2.11	echinate/sup-ps
<i>Dicoma tomentosa</i> Cass.	ob-sp	7.18 (9.57) 10.72	7.18 (7.93) 8.92	-	-	Densely verrucate
<i>Eclipta prostrata</i> (L.) L.	ob-sp	5.61 (16.86) 7.21	2.80 (3.08) 4.20	2.80 (3.70) 4.21	c. 4.6	echinate/st
<i>Echinopsis echinatus</i> DC.	pr	syncolpate	10.77 (12.20) 13.32	0.51-1.01	-	spinulose/Fp
<i>Enhydra fluctuans</i> Lour.	ob-sp	2.80 (4.02) 7.11	1.68 (1.72) 2.12	3.50 (4.06) 4.21	c. 4.16	echinate/sup-ps-sc
<i>Gnaphalium americanum</i> L.	ob-sp	2.80 (5.18) 5.61	2.52 (2.61) 2.66	1.26 (1.30) 1.41	c. 2.36	spinulose/sub-ps
<i>Hochstetteria schimperi</i> DC	sub-pr	7.18 (9.14) 10.72	8.91 (10.21) 10.72	1.41-1.71	c. 4.21	spinulose/sub-ps-sp
<i>Iphonia grantioides</i> (Boiss.) A. Andenberg	ob-sp	5.38 (7.71) 10.72	1.07 (1.08) 2.15	3.23 (3.43) 3.61	c. 6.05	echinate/sub-ps
<i>Launaea nudicaulis</i> (L.) Hk. J.	ob-sp	7.18 (9.21) 10.72	5.38 (6.82)	-	-	echinolophate
<i>Launaea residifolia</i> (L.) O. Kuntze	ob-sp	7.18 (7.78) 8.95	6.82 (7.73) 10.41	-	-	echinolophate
<i>Lactuca remotiflora</i> DC.	sub-ob	3.61 (4.78) 5.38	3.61 (4.30) 6.81	-	-	echinolophate
<i>Pluchea arguta</i> Boiss.	sub-pr	4.21 (6.12) 7.11	1.41 (1.86) 2.66	4.21 (5.21) 5.61	c. 5.71	echinate/sub-ps
<i>Pluchea lanceolata</i> (DC.) Oliv.	pr-sp	5.61 (6.30) 7.11	1.54 (2.05) 2.66	2.90 (2.99) 3.51	c. 4.61	echinate/sup-ps
<i>Pulicaria angustifolia</i> DC.	pr-sp	5.61 (5.94) 6.31	2.11 (2.71) 2.81	2.11 (2.71) 2.81	c. 4.33	echinate/sub-ps
<i>Pulicaria boissieri</i> DC. Hook. f.	ob-sp	Syncolpate 6.31	2.11 (2.47) 2.81	2.11 (2.55) 2.81	c. 4.02	echinate/sp
<i>Sonchus asper</i> L.	sub-ob	c. 7.18	4.31 (5.60) 7.18	-	-	echinolophate
<i>Sonchus oleraceus</i> L.	sub-ob	10.70 (11.61) 14.32	6.82 (7.49) 7.18	-	-	echinolophate
<i>Tridax procumbens</i> L.	ob-sp	8.41 (9.16) 11.21	1.41 (1.76) 2.21	2.80 (4.13) 7.21	c. 4.03	echinate/sup-ps
<i>Vernonia cineria</i> (L.) Less.	sp	--	1.54 (1.80) 2.66	1.51-2.11 4.21	c. 2.08	echinolophate
<i>Vernonia cinerascens</i> Schultz-Bip	ob-sp	c. 1.43	3.91 (5.59) 7.18	2.51-3.75	c. 5.01	echinolophate

Abbreviations

Pr-sp= Prolate-spheroidal, Ob-sp= Oblate-spheroidal, Sub-pr= Sub-prolate, Sub-ob= Sub-oblate, sub-ps= subsillate in between spines, sp= sparsely punctate in between spines; St= striate in between spines; Fp= finely punctate in between spines; Fr= finely reticulate in between spines.

projections, rectangular or transversely elliptic. Sexine slightly thinner or thicker than nexine, often as thick as nexine. Tectum echinate or echinolophate, tectum inbetween spines and spinules is sub-psilate to sparsely perforated, rarely striate, spines or spinules have punctate base with acute or sharp-pointed tips; echinolophate grains perforated both on the ridges as well as on the depressions, spinules 6-12 on equatorial ridges, few to many on polar area.

Key to the Pollen types

- | | |
|---|-------------------|
| 1. + Pollen grains non-echinate | Pollen - I |
| - Pollen grains echinate or echino-lophate. | 2 |
| 2. + Pollen grains echinate or spinulose | 3 |
| - Pollen grains echinolophate | Pollen type - IV |
| 3. + Pollen grains spinulose, spinules | |
| 0.2 - 1.71 μm long. | Pollen type - III |
| - Pollen grains spiny, spines | Pollen types - II |
| 1.82 - 7.21 μm | |

Pollen type-I: *Dicoma tomentosa* (Fig. 1 A-C; Fig. 4A & B).

Pollen grains radially symmetrical, isopolar, usually oblate-spheroidal, tricolporate. Triangular in polar view, elliptic in equatorial view, P/E ratio; 0.99. Polar axis P(32.31-) 35.91 \pm 0.84 (-39.51) μm , and equatorial diameter E(28.70-) 34.10 \pm 0.89 (-39.51) μm . Colpi (25.11-) 28.71 \pm 0.97 (-32.32) μm long with costae; colpal membrane sub-psilate, ora distinct in S.E.M. Mesocolpium (21.50-) 25.11 \pm 0.79 (-28.72) μm . Apocolpium (7.18-) 7.91 \pm 0.75 (-10.72) μm . Exine (7.18-) 8.01 \pm 0.23 (-8.97) μm thick, sexine baculate, thinner at the polar region than at the equator. Tectum areolate.

Species included:

Dicoma tomentosa Cass.

Pollen type-II: *Eclipta prostrata* (Fig. 1D-I; Fig. 2A-E; Fig 4C & D).

Pollen grains radially symmetrical, isopolar, usually oblate-spheroidal to prolate-spheroidal, or prolate to subprolate, rarely suboblate, tricolporate, occasionally tetracolporate.

Triangular in polar view; elliptic to oval in equatorial view. Polar axis P(13.21-) 19.15 \pm 1.05 (-25.1) μm , and equatorial diameter E(16.81-) 24.23 \pm 1.23 (-28.71) μm . Colpi (9.81-) 15.76 \pm 0.09 (-21.71) μm long, with costae; colpal membrane sub-psilate, rarely granulated. Ora circular or transversely elliptic, slightly lalongate. Mesocolpium (11.51-) 16.31 \pm 0.21 (-21.11) μm . Apocolpium (1.20-) 5.96 \pm 0.59 (-10.72) μm . Exine (0.5-) 3.94 \pm 0.10 (-4.21) μm thick, sexine thicker or thinner than or as thick as nexine. Tectum echinate, spines sharp-pointed (1.11-) 2.36 \pm 0.12 (-5.66) μm long; tectum between spines is perforated to sub-psilate, rarely reticulate-perforated.

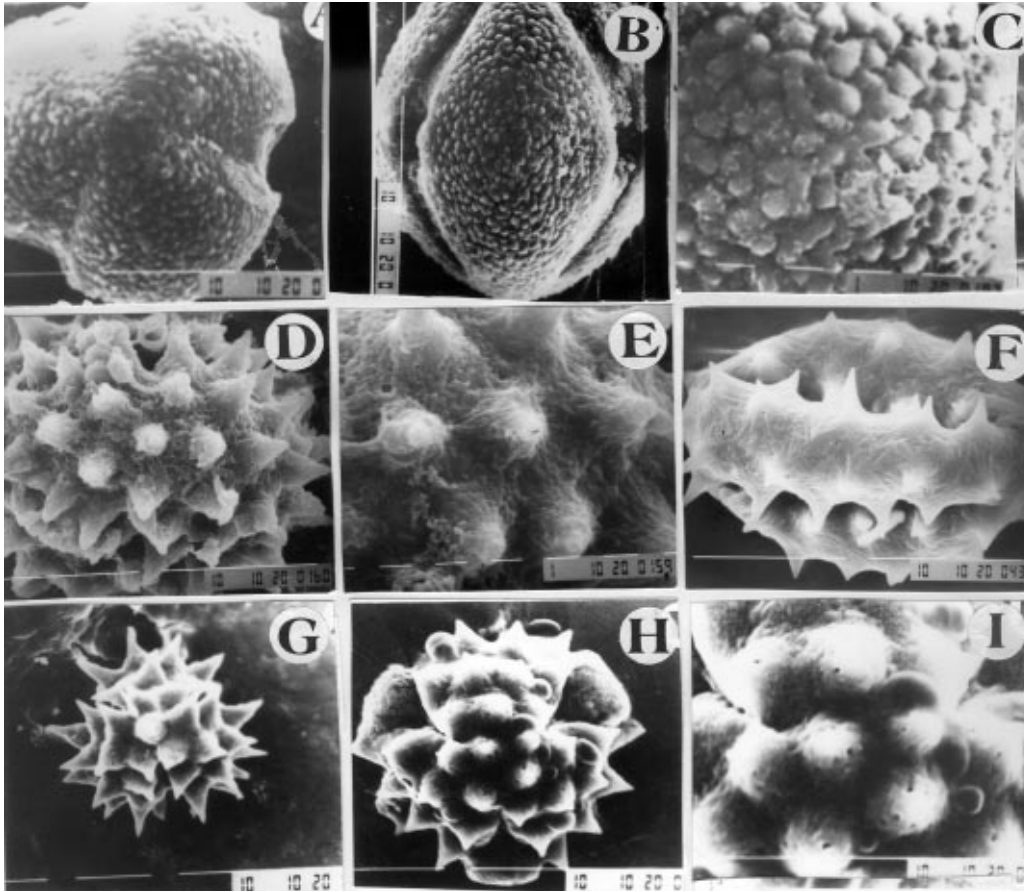


Figure 1. Scanning Electron micrographs of pollen grains. *Dicoma tomentosa*: A. Polar view; B. Equatorial view; C. Exine pattern. *Blainvillia latifolia*: D. Equatorial view; E. Exine pattern. *Eclipta prostrata*: F. Equatorial view. *Pluchea arguta*: G. Polar view. *Pulicaria angustifolia*: H. polar view; I. Exine pattern. Scale bar=A, B, D, F-I=10 μ m; C, E=1 μ m.

Species included

Blainvillea latifolia (L. f.) DC., *Blumea obliqua* (L.) Druce, *Blumea lacera* (Burm. f.) DC., *Conyza canadensis* (L.) Cronquist, *Eclipta prostrata* (L.) L., *Enhydra fluctuans* Lour., *Iphonia grantioides* (Boiss.) A. Anderberg, *Pluchea lanceolata* (DC.) Oliv., *Pluchea arguta* Boiss., *Pulicaria angustifolia* DC. *Pulicaria boissieri* Hook. f., *Tridax procumbens* L.

Key to the species

1. + Pollen grains tetra-colporate. *Tridax procumbens*
 - Pollen grains tricolporate very rarely tetracolporate.
2. + Tectum \pm striate in between spines. *Eclipta prostrata*

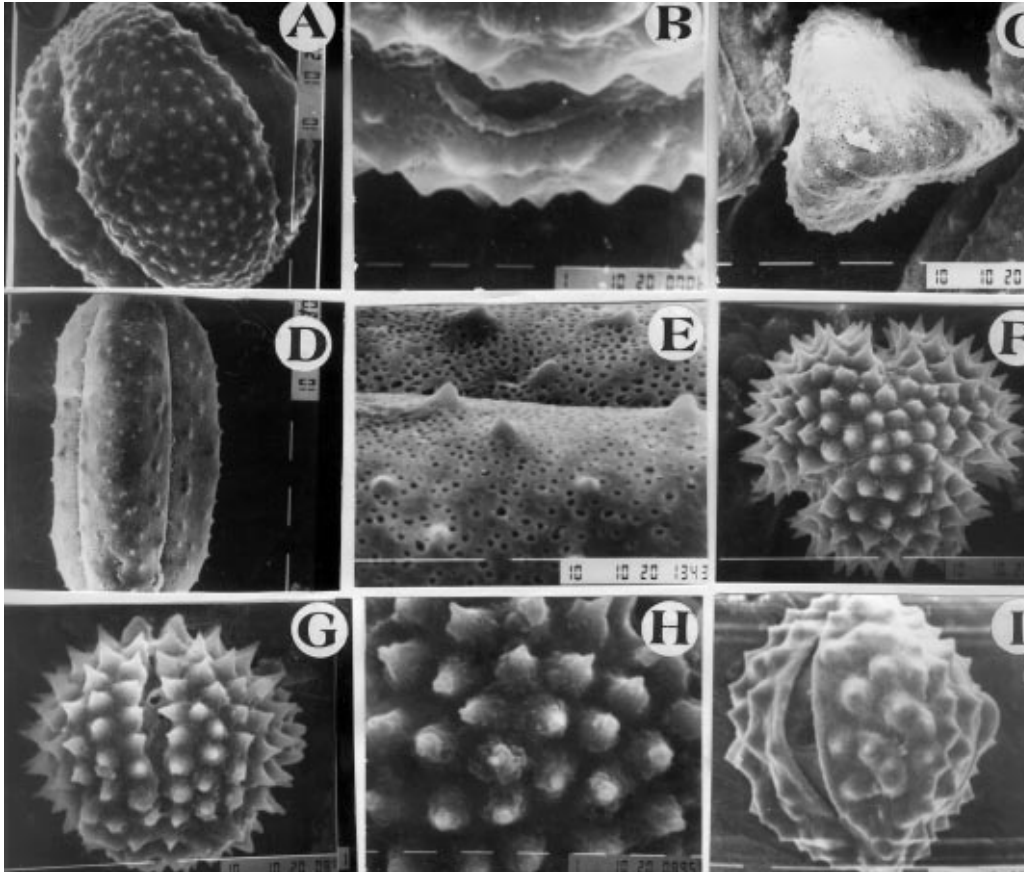


Figure 2. Scanning Electron micrographs of pollen grains. *Amberboa ramosa*: A, Equatorial view; B, Exine pattern. *Echinops echinatus*: C, Polar view; D, Equatorial view; E, Exine pattern. *Gnaphalium americanum*: F, Polar view; G, Equatorial view. H, Exine Pattern. *Hochstetteri schimperi*: I, Equatorial view. Scale bar= A, C-G & I=10 μm ; B & H=1 μm .

- Tectum sub-psilate or broadly punctate between spines.
- 3. + Tectum finely reticulate-perforated *Blumea obliqua*
 - Tectum sub-psilate to sparsely scabrate 4
- 4. + Spines 1.41-2.81 μm long 5
 - Spines 2.80-7.21 μm long 7
- 5. + Interspinal distance c. 2. 12 μm .
 - Mesocolpium 12.61-14.11 μm
 - Interspinal distance 3.85-4.33 μm .

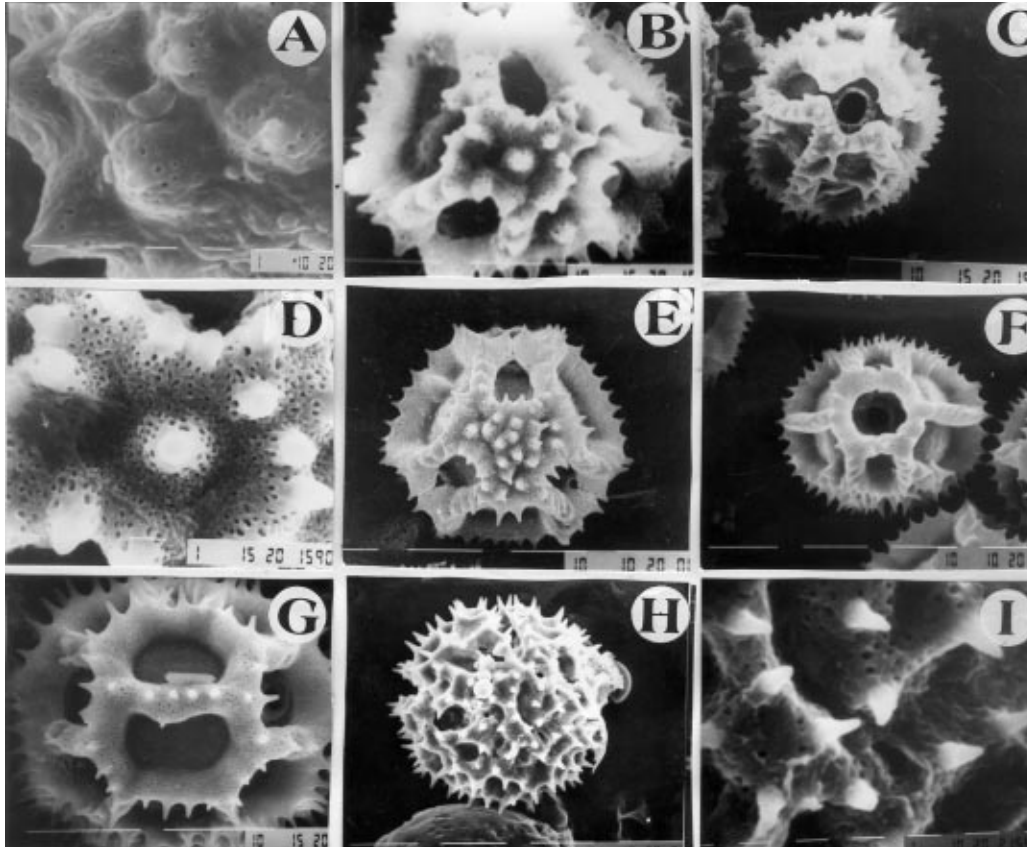


Figure 3. Scanning Electron micrographs of pollen grains. *Hochstetteri schimperi*: A, Exine pattern. *Lactuca remotiflora*: B, Polar view; C, Equatorial view; D, Exine pattern; *Launaea residifolia*: E, Polar View; F, Equatorial view. *sonchus oleraceus*: G, Equatorial view. *Vernonia cinerascens*: H, Polar view; I, Exine pattern. Scale bar= B, C, E-H=10 μ m; A, D & I=1 μ m.

Mesocolpium 14.21-16.91 μ m.

6

6. + Exine 2.11-2.66 μ m thick.

Pluicaria boissieri

- Exine 0.50-1.14 μ m thick

Blumea lacera

7. + Grains prolate-spheroidal

Pulicaria angustifolia

- Grains oblate-spheroidal to suboblate

8

8. + Colpi 14.31-15.41 μ m, polar area

index C.1.30.

Enhydra flucatus

- Colpi 17.95-21.54 μ m long, polar area

index c.1.46.

Iphonia grantioides

9. + Interspinal distance C.4.33 μm . *Blainvillea latifolia*

- Interspinal distance 4.61-5.71 μm . 10

10. + Pollen grains prolate-spheroidal,
spines 2.80-3.51 μm long. *Pluchea lanceolata*

- Pollen grains sub-oblate, spines
4.21-5.61 μm long. *Pluchea arguta*

Pollen type-III: *Echinops echinatus* (Fig. 2 C-I; Fig 3A; Fig 4 E-I).

Pollen grains radially symmetrical, isopolar, usually prolate to subprolate, rarely oblate-spheroidal, tricolporate. Triangular in polar view, elliptic to oval in equatorial view. Polar axis

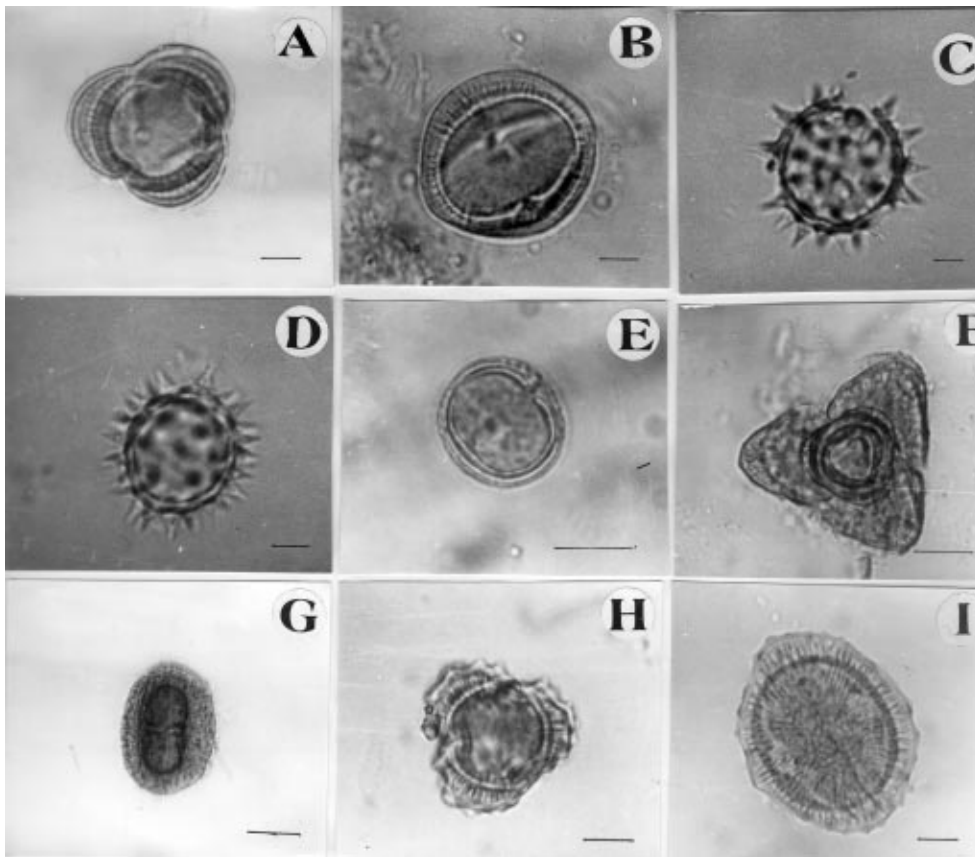


Figure 4. Light micrographs of pollen grains. *Dicoma tomentosa*: A, Polar view; B, Equatorial view; *Blumea obliqua*: C, polar view; D, Equatorial view. *Amberboa ramosa*: E, Equatorial view. *Echinops echinatus*: F, Polar view; G, Equatorial view. *Hochstetteri schimperi*: H, Polar view; I, Equatorial view. Scale bar= A-I=10 μm

P(15.41-) 56.16 ± 1.05 (-96.91) μm , and equatorial diameter E(16.81-) 38.02 ± 1.23 (-59.23) μm . Colpi (11.21-) 34.21 ± 0.09 (-57.21) μm long; with costae, colpal membrane sup-psilate. Ora circular or transversely elliptic, slightly lalongate Mesocolpium (11.61-) 25.51 ± 0.21 (-39.41) μm . Apocolpium (2.80-) 6.76 ± 0.59 (-10.72) μm . Exine distinctly stratified, (2.52-) 12.85 ± 0.10 (-23.21) μm thick, sexine thinner at the polar region than at the equator. Tectum spinulose, tectum between the spinules is perforated to sub-psilate, 0.6-1.71 μm .

Species included:

Amberboa ramosa (Roxb.) Jafri, *Echinops echinatus* DC., *Gnaphalium americanum* L., *Hochstetteria schimperi* DC.

Key to the species

1. + Tectum finely perforated, spinules widely distributed. *Echinops echinatus*
- Tectum sup-psilate to sparsely punctate, spinules not widely distributed.
2. + Pollen grains oblate-spheroidal *Gnaphalium americanum*
- Pollen grains sub-prolate
3. + Polar length 43.08-53.81 μm , Exine 8.91-10.72 μm thick. *Hochstetteria schimperi*
- Polar length 28.70-35.91 μm , Exine 3.61-6.82 μm thick. *Amberboa ramosa*

Pollen type-IV: *Launaea nudicaulis* (Fig. 3 B-I).

Pollen grains radially symmetrical, isopolar, suboblate to oblate-spheroidal, tricolporate, occasionally tetracolporate, rarely porate, hexagonal in polar view, elliptic to oval in equatorial view. Polar axis P(21.50-) 33.80 ± 1.05 (-46.1) μm , and equatorial diameter E(16.81-) 22.76 ± 1.23 (-28.71) μm . Colpi (9.81-) 15.76 ± 0.09 (-21.71) μm long, colpi short 21.5-22.6 μm long. Ora distinct, c. 3.26 μm in diameter. Mural projection partially or completely enclosing the ora. Mesocolpium (14.51-) 17.81 ± 0.21 (-21.11) μm . Apocolpium (3.61-) 9.16 ± 0.59 (-14.72) μm . Exine (3.61-) 5.39 ± 0.10 (-7.18) μm thick, sexine thicker or thinner than or as thick as nexine Tectum echinolophate, perforated both on the ridges and on the lacunae, perforations indistinct on the depression; spinules 6-8 on equatorial ridges, but few to many at polar area, 1.2-1.7 μm long, with acute tips and distinct perforated base.

Species included:

Lactuca remotiflora DC., *Launaea residifolia* (L.) O. Kuntze, *Launaea nudicaulis* (L.) HK. f., *sonchus asper* (L.) Hill, *Sonchus oleraceus* L., *Vernonia cinerea* (L.) Less., *Vernonia cinerascens* Schultz-Bipz.

Key to the species and species group

1. + Pollen grains porate. *Vernonia cinerea*
 - Pollen grains colporate 2.
 2. + Pollen grains ± spheroidal
 in polar view *Vernonia cinerascens*
 - Pollen grains hexagonal or octagonal
 in polar view *Sonchus oleraceus*-group

(*Lactuca remotiflora*, *Launaea residifolia*, *Launaea nudicaulis* *Sonchus asper*, *sonchus oleraceus*)

Discussion

Pollen morphology of 24 species distributed in 18 genera has revealed that Compositae is a eurypalynous family (15). Striking variation is found in shape, size and exine pattern. However, on the basis of exine sculpturing, 4 distinct pollen types are recognized viz., Pollen type I: *Dicoma tomentosa*, Pollen type II: *Eclipta prostrata*- Pollen type III: *Echinops echinatus* and Pollen type IV: *Launaea nudicaulis*.

Type I is characterized by non-echinate (areolate) pollen. A single species, *Dicoma tomentosa* (L.) Vatke (Mutisieae), comprises this type.

Type II is easily recognized by its echinate tectum. The majority of the genera fall in this pollen type, viz., *Tridax* L., *Eclipta* L., *Blainvillea* Cass, *Enhydra* Lour (Heliantheae), *Pluchea* Cass, *Pulicaria* Gaertn., *Blumea* DC. (Inuleae) and *Conyza* L. (Astereae).

The pollen morphology is significant at the specific level, and all the species included in this pollen type are easily delimited on the basis of pollen characters (see the key to the species, Table 1). Although these genera belong to 3 different tribes (difference occur in style, anthers and involucral bracts), the palynology suggests close affinities of these tribes within the subfamily Asteroideae.

Pollen type III is characterized by a spinulose tectum in which spinules are less than 1.7 µm long. This pollen type is comprised of 4 genera, viz., *Hochstetteria* DC. (Mutisieae), *Echinops* L., *Amberboa* Less. (Cynareae) and *Gnaphalium* (Inuleae). However, the spinulosa correlation is found in genera which have spiny capitula, with the exception of *Gnaphalium*, which has non-spiny capitula but spinulose pollen. Pollen type IV is readily recognized by its characteristic echinolophate tectum. Four genera are included in this type, namely, *Launaea* Cass, *Lactuca* L., *Sonchus* L. (Lactuceae) and *Vernonia* Schreb. (Vernonieae). However, the genera of the tribe Lactuceae are mostly characterized by an elaborate system of echinate ridges, which enclose a number of Lacunae. Similar types of grains in the subtribe Stephanomeriinae lophate and Hypochoeridiinae have also been reported by Tome et al. [19] and El-Ghazaly [10]. In *Vernonia* Schreb. (Vernonieae), lophate type forms with regular or irregular mural pattern. The exine

structures of the tribe Vernonieae in the two closely related species are quite distinct from each other [16]. In the genus *Vernonia* Schreb., both the species are significantly distinct in their pollen characters. In *Vernonia cinerea* (L.) Less, porate grains are found, while in *V. cinerascens* Schult.-Bip., tetracolporate grains are observed. Kingnam (20) clearly divided the tribe Vernonieae into 6 well-marked types. Similar to exine sculpturing, the shape and size of the grains also vary within the family. Almost all grain shapes are found in this family.

Apart from this, within Compositae *Lactuca* L., *Sonchus* L., *Launaea* Cass and *Vernonia* Schreb. seem to be relatively specialized genera, having an echinolophate tectum. The echinolophate and psilolophate types are widely regarded as a derived condition, as compared to echinate and sub-echinolophate types [16, 21-23].

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