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A Contribution to the Achene Knowledge of Rosoideae (Rosaceae) LM and SEM

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ABSTRACT

Macro– and micromorphological characters of the achene of 29 taxa belonging to four tribes and 10 genera of Rosoideae were carried out using light and scanning electron microscopy. Results by LM showed that the macro- and micromorphological characters of achene such as shape, colour, surface, dimensions, pericarp and testa anatomy are all parameters that are unreliable either for identification or differentiation between the species of the same genus. A proposed presentation was constructed on the basis of the number of dorsal and ventral vascular bundles of the achene and their behaviour to show the line of evolution in the taxa under investigation. SEM study of the pericarp showed nine types of achene surface pattern, six of the them comprise sub-types. The achene surface pattern has great taxonomic value for species delimitation and represents a significant contribution to the knowledge of Rosoideae.

Key Words: Achene morphology; Achene anatomy; SEM; Rosoideae (Rosaceae)

INTRODUCTION

The scanning electron microscopic studies on seeds and fruits surface pattern have been used in elucidating taxonomic and genetic relationships (Heywood, 1971; Brisson & Peterson, 1976; Gopinathan & Babu, 1985; Rajdali, 1990; Sulaiman, 1995; Balkwill & Young, 1999).

Lersten (1979) indicated that the exomorphic pattern of the seed and fruit surface have been done to solve many of classificatory problems, establish evolutionary relationships or to show the weight of these characters in segregating the conflicting groups within various plant families. For example, Vosa (1983) indicated species-specific testa surface pattern of *Tulbaghia* L. (Alliaceae). Axelius (1992) on *Physalis* L. and other genera of Solanaceae revealed useful differences that considered new characters. Numerous studies on Fabaceae have reached to an important character (Lersten, 1981; Bragg & Bridges, 1984; Van Staden *et al*., 1989).

As regards the Rosaceae, the morphological and anatomical studies on its achene have been done earlier (Eames, 1931; Hjelnquist, 1962; Sterling, 1964, 1966; Corner, 1976). However, the four sub-families of Rosaceae (Spiraeoideae, Rosoideae, Prunoideae & Maloideae) have long been accepted by Robertson (1974) and Cronquist (1981).

The updating studies were carried out on the phylogeny of Rosaceae, specifically Rosoideae to assess the usefulness of a combined molecular and morphological approach to test some previously proposed hypotheses on taxonomic delimitation and relationships (Sojack, 1985, 1986, 1989; Eleven & Elvebakk, 1996; Eriksen, 1996; Kranitz, 1997; Hansen *et al*., 2000, Eriksen & Fredrikson, 2000; Amsellen *et al.*, 2001).

The specific objective of this study was to assess the usefulness of the macro- and micromorphological characters of the achene using light microscopy (LM) and scanning electron microscopy (SEM) at the infra-generic level between the taxa of Rosoideae under this investigation. The aim was also to obtain comparative information on the achene surface pattern and whether achene patterns are constant within species and can be used to differentiate between species recognized on gross morphological ground.

MATERIALS AND METHODS

Mature achenes of 29 foreign taxa were studied. Table I shows the collection data, source of collection and classification of Rosoideae cited after Willis (1973) and Mabberly (1997).

For macromorphological investigation, 10 achenes from each taxon were examined by stereomicroscope to determine, the shape, colour, surface, dimensions and style appearance. The differences between these parameters were drawn at bench level at similar magnification.

The micromorphological study begin by fixing the achenes in F.A.A., then thoroughly washed with water, dehydrated in series of ethyl alcohol and finally embedded in paraffin wax. Serial cross sections of achene were cut using rotary microtome according to the traditional method of Johansen (1940). Drawing of achene T.S. was made at bench level by the aid of (Ken- A- vision Microprojector" Model X–1000–1) at nearly similar magnifications.

Table I. Collection data, source of collection and classification of data cited after Willis (1973) and Mabberly (1997)

Tribe	Sub-tribe	Genus	Species
Kerrieae		*Rhodotypos*	**R. scandens* Mak.
Potentilleae	Rubinae		
	Potentillinae	*Coluria*	****C. geoides* Ledeb.
		Duchesnea	**D. indica* Andrews.
		Fragaria	****F.vesca* var. vesca L.
		Potentilla	*** P.argenta* var. *calabra* L.
			**P. arnavatensis* L.
			***P. calycina* B. et. R.
			**P. cinerea* Chaix et. Vill.
			**P. delphinensis* Gren & Godron
			**P. dissecta* Purch.
			***P. dombeyi* Nestl.
			**P. fulgens* Wall.
			P. recta* L. *
			***P. rupestris* var. *asperula* L.
	Dryadinae	*Dryas*	* *D. drummondii* Richard e.x Hook.
			* *D. octopetala* L.
		Geum	*** G. bulgaricum* Pancie
			*** G. rhodopium* Stoj.et. Stef.
			***G. rivale* L.
			* *G. urbanum* L.
		Waldestinia	*** W. fragaroides* Tratt.
Cercocarpeae			
Ulmarieae			
Sanguisorbeae		*Sanguisorba*	****S. canadensis* L.
			* *S. officinalis* L.
			****S. minor* Scop.
Roseae		*Rosa*	* *R. glauca* Pourr.
			*** R. hugonis* Hemsl.
			*** R. pendulina* L.
			**** R. sempervirens* L.
			* *R. spinosissima* L.

*** Source of collection:** * = The Curator Botanic Gardens – MTCoot – The Road – Toowong Queensland 4066 – Australia; ** =Bundesgarten Wien – A – Alpengarten IM Bel. Austeria; *** = Museum National D'histoirc Naturelle Service des Cultures 43, Rue De Buffon – 75005. Paris. France

For SEM examination, the achenes were mounted on brass-stubs and then coated with gold palladium in sputter coating unit. The scanning was carried out by a Joel JSM 100 SEM at accelerating voltage of 25 Kv. The terminology of surface pattern was adopted after Stearn (1978). The comparative evaluations were made at the same magnification level X = 2000.

RESULTS AND DISCUSSION

The cumulative macromorphological features of the achene as clarified by LM was shown in Table II and Plate I. As regards, the achene shape, colour, dimensions, surface and style appearance are all parameters that are more or less consistent at the generic level in the taxa of *Dryas*, *Geum*, *Potentilla*, *Rosa* and *Sanguisorba* under investigation except some minor variations in the surface and style appearance.

In *Coluria geoides* and *Rhodotypos scandens*, the shape and texture of achenes are unique. In *Duchesnea indica*, *Fragaria vesca* and *Waldestinia fragaroides* (each genus represented by one species in this study, the shape and surface of the achenes are similar to that of *Potentilla* (Table II & Plate I).

The style in the studied taxa shows a range of variation in its appearance between feather-like, filiform, papillate or shortly hooked (Table II). The insertion of the style range between terminal or lateral, straight or curved. The surface may be glabrous, hairy or pubescent (Table II & Plate I).

From the data in Table II and plate I, it is concluded that, the achene macromorphological characters as clarified by LM seem to be consistent at the generic level. Rendle (1925) stated that the long feathery style on the achene play an important role in the fruit dispersal by wind whereas, the hooked style help in fruit dispersal by animals. Bailey (1949) indicated that the style macromorphological aspects can be used to distinguish between the different taxa. So far as the criteria obtained from the current study seem to be unreliable either in the delimitation between the species of the same genus or in characters evaluation. This conclusion has been also reached by Husian *et al*. (1990) and Mourad and Al-Nowaihi (2001).

II-SEM investigation of the studied taxa show nine types of achene surface pattern. These are colliculate, tuberculate, alveolate, favulariate, reticulate, rugose pusticulate, undulate and areolate. The former six types only comprise sub-types (Table III & Plate II). The types and sub-types of the achene surface pattern are arranged in the following key:

1- The colliculate surface pattern comprises four subtypes:
- 1a. Colliculate pattern with smooth ruminate appearance as in *Fragaria vesca* var. *vesca* Fig. 1.
- 1b.Colliculate surface pattern with granulate appearance as in *Sanguisorba canadensis* Fig. 2.
- 1c. Colliculate surface pattern with striate elevations as in *Sanguisorba officinalis* Fig. 3.
- 1d. Irregularly colliculate surface pattern with smooth elevations as in *Sanguisorba minor* Fig. 4.

2. The tuberculate achene surface pattern comprises three sub-types:
- 2a. Tuberculate surface pattern with rugose - striate bases and lateral sides of the tubercles and smooth tops as in *Potentilla delphinensis* Fig. 5.
- 2b. Tuberculate surface with rugose - favulariate bases and lateral sides of the tubercles and ruminate tops as in *Potentilla rupestris* var. *asperula* Fig. 6.
- 2c. Tuberculate surface with irregularly striated bases and lateral sides of the tubercles and irregularly striate-ruminate appearance of the tubercles tops as in *Waldestinia fragaroides* Fig. 7.

3. The alveolate surface pattern comprises two sub-types:
- 3a. Alveolate surface with finelly granulated elevations and depressions as in *Geum rivale* Fig. 8.
- 3b. Alveolate surface pattern with smooth elevations and depressions as in *Rosa hugonis* Fig. 9.

Table II. Achene macromorphological characters of the studied taxa of Rosoideae

Taxa	Macromorphological characters of achene (LM)						
	Shape	Colour	Surface	Dimensions (L x W) mm	Style		
					Appearance	Insertion	Surface
Coluria geoides	Elliptic	Dark brown	Papillate	3 × 1. 2	Short beaked	Treminal curved	Hairy
Dryas drummondii	Spathulate	Brown	Hairy	4 × 1	Feather–like	Trminal straight	Pubescent
D. octoptala	Spathulate	Dark brown	Pubescent	3.5 × 1.1	Feather–like	Trminal straight	Pubescent
Duchesnea indica	Kidney-shaped	Dark brown	Glabrous	1 × 1.1	Aristed point	Lateral curved	Glabrous
Fragaria vesca	Ovate	Dark brown	Glabrous	1.1 × 1	Aristed point	Lateral striaght	Glabrous
Geum bulgaricum	Elliptic	Dark brown	Glabrous	2.5 × 1.2	Filiform	Terminal straight	Glabrous
G. rhodopeum	Long ovate	Dark brown	Pubescent	3.4 × 1.3	Filiform	Terminal straight	Pubescent
G. rivale	Long ovate	Dark brown	Hairy	4 × 1.1	Filiform	Terminal hooked	Pubescent
G. urbanum	Long ovate	Dark brown	Hairy	3.5 × 1.5	Filiform	Terminal hooked	Pubescent
Potentilla argenta	Ovate	Dark Brown	Glabrous	1.2 × 1	Papillate	Lateral straight	Glabrous
P. arnavatensis	Ovate	Brown	Glabrous	2 × 1.2	Papillate	Lateral curved	Glabrous
P. calycina	Ovate	Brown	Glabrous	1.5 × 1	Aristed point	Terminal curved	Glabrous
P. cinerea	Ovate	Dark brown	Glabrous	1.2 × 1	Aristed point	Lateral straight	Glabrous
P. delphinensis	Ovate + wing	Dark brown	Glabrous	2 × 1.3	Aristed point	Terminal straight	Glabrous
P. dissecta	Ovate	Dark brown	Glabrous	1.5 × 1	Aristed point	Lateral curved	Glabrous
P. dombeyi	Ovate	Dark brown	Glabrous	1.5 × 1	Short beaked	Lateral straight	Glabrous
P. fulgens	Ovate	Dark brown	Glabrous	2 × 1.2	Aristed point	Lateral curved	Glabrous
P. recta	Ovate	Dark brown	Glabrous	1.9 × 1.1	Aristed point	Terminal straight	Glabrous
P. rupestris	Ovate	Dark brown	Glabrous	1.5 × 1	Aristed point	Terminal straight	Glabrous
Rhodotypos scandens	Ovate	Shiny brown	Pubescent	2.5 × 2.4	Aristed point	Terminal straight	Glabrous
Rosa gluca	Ovate	Straw yellow	Pubescent	4.9 × 3	Aristed point	Lateral straight	Glabrous
R. hugonis	Ovate	Dark brown	Pubescent	5 × 4	Aristed point	Lateral curved	Glabrous
R. pendulina	Ovate	Straw yellow	Glabrous	5.4 × 3.2	Aristed point	Terminal straight	Glabrous
R. sempervirens	Ovate	Dark brown	Pubescent	5 × 3	Aristed point	Terminal curved	Pubescent
R. spinosissima	Ovate	Dark brown	Glabrous	5 × 4.2	Aristed point	Terminal straight	Glabrous
Sanguisorba canadensis	Ovate	Dark brown	Glabrous	2.2 × 2	Papilliate	Terminal swollen	Glabrous
S. officinalis	Ovate	Black	Glabrous	3.1 × 2.1	Papilliate	Terminal swollen	Glabrous
S. minor	Ovate	Brown	Spiny	3.9 × 3	Papilliate	Terminal swollen	Glabrous
Waledestinia fragar oides	Ovate	Straw Yellow	Glabrous	2 × 1.2	Short beaked	Terminal straight	Glabrous

4. The favulariate surface pattern comprises two sub-types:

4a. Favulariate surface with smooth undulate elevations as in *Geum bulgaricum* Fig. 10.

4b. Favulariate surface with smooth lineate elevations

Fig. 1. Proposed presentation for the taxa under investigation

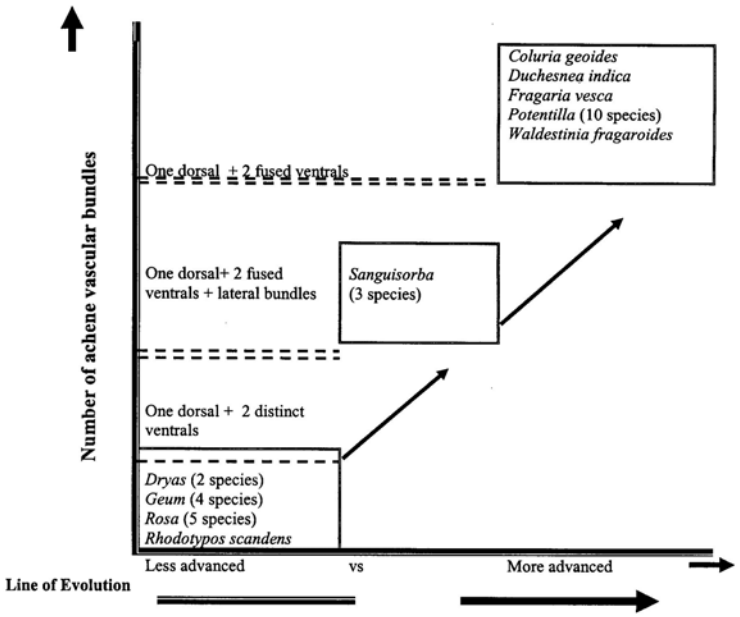


Table III. Achene surface morphology (SEM) and micro-anatomy (LM) of the studied taxa of Rosoideae

Taxa	(SEM) Achene surface pattern	Number of vascular bundles	Achene micromorphological characters						
			Pericarp anatomy			Seed coat		Endosperm	
			Exocarp	Mesocarp	Endocarp	No - of layers	Thickness	No – of layers	Arrangement
Coluria geoides	Rugose – striate	1 dorsal + 2 fused ventrals	Radially	Tangentially	Tangentially	1	Thick	1	Tangentially
Dryas drummondii	Rugose – striate	1 dorsal + 2 distinct vs.	T. R.	T.	T.	1	Thick	Multi	
D. octoptala	Rugose – striate	1 dorsal + 2 distinct vs.	T. R.	T.	T.	1	Thick	Multi	
Duchesnea indica	Reticulate – striate	One dorsal + 2 fused vs.	T.	T.	Angular	1	Thick	Multi	T.
Fragaria vesca	Colliculate	1 dorsal + 2 fused vs.	R.	T.	Angular	1	Thick	1	T.
Geum bulgaricum	Favulariate – undulate	One dorsal + 2 distinct vs.	R.	Angular	Angular	2	Thin	1	T.
G. rhodopeum	Rugose	One dorsal + 2 distinct vs.	R.	Angular	Angular	2	Thin	1	T.
G. rivale	Alveolate – granulate	One dorsal + 2 distinct vs.	R.	Angular	Angular	2	Thin	1	T.
G. urbanum	Reticulate – lineate – granulate	One dorsal + 2 distinct vs.	R.	Angular	Angular	2	Thin	1	T.
Potentilla argenta	Reticulate – Papillate	One dorsal + 2 fused vs.	R.	T.	T.	1	Thick	Multi	T.
P. arnavatensis	Favulariate – Lineate	One dorsal + 2 fused vs.	R.	T.	T.	1	Thick	Multi	T.
P. calycina	Rugose	One dorsal + 2 fused vs.	R.	T.	T.	1	Thick	Multi	T.
P. cinerea	Reticulate – granulate	One dorsal + 2 fused vs.	R.	T.	T.	1	Thick	Multi	T.
P. delphinensis	Tuberculate	One dorsal + 2 fused vs.	R.	T.	T.	1	Thick	Multi	T.
P. dissecta	Reticulate – tuberculate	One dorsal + 2 fused vs.	R.	T.	T.	1	Thick	Multi	T.
P. dombeyi	Rugose	One dorsal + 2 fused vs.	R.	T.	T.	1	Thick	Multi	T.
P. fulgens	Reticulate ±Pentagonal cells	One dorsal + 2 fused vs.	R.	T.	T.	1	Thick	Multi	T.
P. recta	Reticulate – lineate	One dorsal + 2 fused vs.	R.	T.	T.	1	Thick	Multi	T.
P. rupestris	Tuberculate	One dorsal + 2 distinct vs.	R.	T.	T.	1	Thick	Multi	T.
Rhodotypos scandens	Reticulate	One dorsal + 2 distinct vs.	R.	Ang.	Ang.	2	Thick	1	T.
Rosa gluca	Undulate – granulate	One dorsal + 2 distinct vs.	T.	T.	Rod-shaped	1	Thin	Multi	T.
R. hugonis	Alveolate	One dorsal + 2 distinct vs.	T.	T.	Palisade	1	Thin	Multi	Angular
R. pendulina	Areolate – glebulate	One dorsal + 2 distinct vs.	T. + R.	R.	Angular	1	Thin	Multi	Palisade
R. sempervirens	Reticulate	One dorsal + 2 distinct vs.	R.	Angular	Angular	1	Thin	Multi	T.
R. spinosissima	Reticulate – alveolate	One dorsal + 2 distinct vs.	T. + R.	Angular	Angular	1	Thin	Multi	T.
Sanguisorba canadensis	Colliculate – granulate	1 dorsal + 2 fused vs. + Lateral bundles	R. + T.	T.	T.	2	Thin	Multi	T.
S. officinalis	Colliculate – striate	1 dorsal + 2 fused vs. + Lateral bundles	R. + T.	T.	T.	2	Thin	Multi	T.
S. minor	Colliculate – slightly striate	1 dorsal + 2 fused vs. + Lateral bundles	R. + T.	T.	T.	2	Thin	Multi	T.
Waledestinia fragar oides	Tuberculate	one dorsal + 2 fused vs.	T.	T.	T.	1	Thick	Multi.	T.

Mult. = Multilayered; R = Radially elongated; T. = Tangentially elongated ; vs. = Ventrals

and depressions as in *Potentilla arnavatensis* Fig. 11.

5. The reticulate surface pattern comprises ten sub-types:

5a. Reticulate surface with smooth elevations and rugose-striate depressions as in *Duchesnea indica* Fig. 12.

5b. Reticulate with smooth-granulated elevations and lineate – granulate depressions as in *Geum urbanum* Fig. 13.

5c. Reticulate surface with smooth elevations and papillate depressions as in *Potentilla argenta* var. *calabra* Fig 14.

5d. Reticulate surface with smooth elevations and tuberculate depressions as in *Potentilla dissecta* Fig. 15.

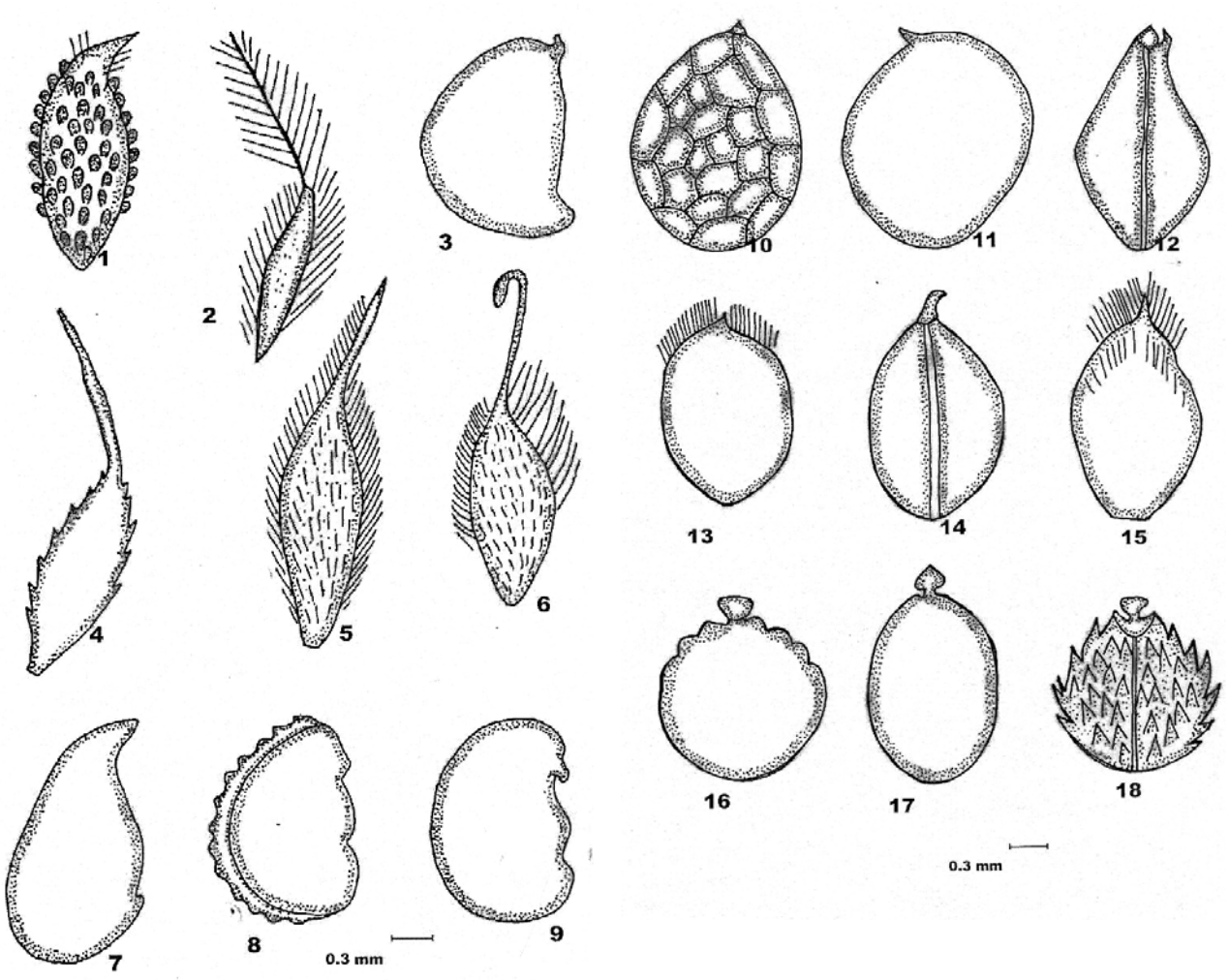
5e. Reticulate surface with slightly rugose–smooth elevations and granulate depressions as in *Potentilla cinerea* Fig. 16.

5f. Reticulate surface with more or less pentagonal cells. The elevations are smooth and the depressions are smooth with large central pores as in *Potentilla fulgens* Fig. 17.

5g. Reticulate surface pattern with lineate surface of elevations and depressions as in *Potentilla recta* Fig. 18.

5h. Reticulate surface pattern with more or less pentagonal cells. The elevations are smooth while the

Plate I (Achene morphology). Figs. (1) *Coluria geoides*, (2) *Dryas drummondii* and *D. octoptala*, (3) *Duchesnea indica*, *Fragaria vesca*, *Potentilla argenta, P. cinerea, P. recta*, (4) *Geum bulgaricum*, (5) *G. rhodopeum*, (6) *G. rivale* & *G. urbanum*, (7) *Potentilla calycina, P. dombeyi, P. rupestris, Waldestenia fragaroides*, (8) *P. delphinensis*, (9) *P. arnavatensis, P. dissecta, P. fulgens*; (10) *Rhodotypos scandens*, (11) *Rosa spinosissima*, (12) *R. gluca*, (13) *R. hugonis*, (14) *R. pendulina*, (15) *R. sempervirens*, (16) *Sanguisorba canadensis*, (17) *S. officinalis*, (18) *S. minor*



depressions are lobed – granulated as in *Rhodotypes scandens* Fig. 19.

5i. Reticulate surface pattern with smooth elevations and alveolate depressions as in *Rosa spinosissima* Fig. 20.

5j. Reticulate surface pattern with more or less pentagonal cells. The elevations are smooth whereas the depressions are with ruminate–glebulate appearance as in *Rosa sempervirens* Fig. 21.

6. The rugose surface pattern comprises three sub-types:

6a. Rugose surface with smooth elevations and depressions. The surface is densly hairy with short glandular hairs as in *Coluria geoides* Fig. 22 or long eglandular hairs as in *Dryas drummondii* and *D. octopetala* Fig. 23.

6b. Rugose surface with smooth elevations and slightly lineate depressions as in *Potentilla calycina* Fig. 24.

6c. Rugose surface with smooth elevations which are widely separated and smooth depressions with fine bands as in *Potentilla dombeyi* Fig. 25.

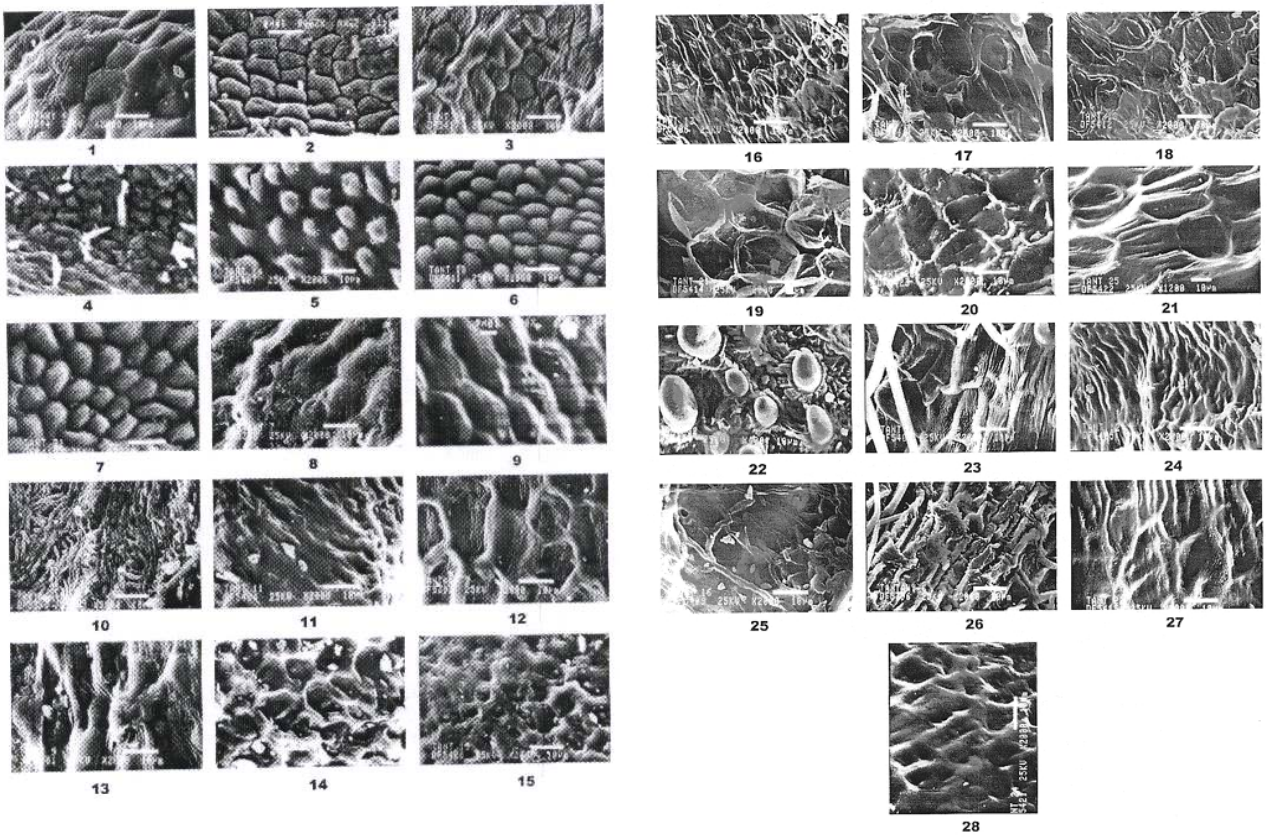
7. Pusticulate surface with smooth elevations and ruminate – glebulate depressions as in *Geum rhodopeum* Fig 26.

8- Undulate with smooth elevations and granulate depressions as in *Rosa glauca* Fig. 27.

9- Areolate surface pattern with smooth elevation and lineate – glebulate depressions as in *Rosa pendulina* Fig. 28.

As regards, the achene surface pattern shows more or less consistency at the generic level in species belonging to *Drays* and *Sanguisorba*. The delimitation between the species of each genus depends on minor variations in the anticlinal and periclinal walls appearance. In the remainder

Plate II (Achene surface morphology SEM). Figs. 1- *Fragaria vesca* var. *vesca*, 2- *Sanguisorba canadensis*, 3- *S. officinalis*, 4- *S. minor*, 5- *Potentilla delphinensis*, 6- *P. rupestris*, 7- *Waldestenia fragaroides*, 8- *Geum rivale*, 9- *Rosa hugonis*,10- *Geum bulgaricum*,11- *Potentilla arnavatensis*,12- *Duchesnea indica*,13- *Geum urbanum*,14- *Potentilla argenta* var. *calabra*, 15- *P. dissecta*.16- *P. cinerea*,17- *P. fulgens*, 18- *P. recta*, 19- *Rhodotypos scandens*, 20- *Rosa spinosissima*, 21- *R. sempervirens*, 22- *Coluria geoides*, 23- *Dryas drummondii* and *D. octoptala*, 24- *Potentilla calycina*, 25- *P. dombeyi*, 26- *Geum rhodopeum*, 27- *Rosa gluca*, 28- *R. pendulina*



studied taxa the surface pattern varying among the species of the same genus and among the species of another studied taxa as shown in the above key.

From morphological view point, the criteria from the achene surface pattern seem to be with taxonomic value at the generic and infra-generic level of the taxa under investigation which help in the species delimitation with great reservedly. Retief and Reyneke (1984) and Balkwill and Young (1999) on *Thunbergia* indicated that the macromorphological surface features of seed alone are not sufficient for discrimination between species. In accordance with this conclusion more morphological and molecular studies are required for sharp species delimitation and characters evaluation between the taxa of Rosoideae under investigation.

III- The achene microanatomical characters as clarified by LM show that the pericarp, seed coat and endosperm aspects in the taxa under investigation are consistent at the generic level except some minor variations such as the presence or absence of hairs on the exocarp or the variations in the number of endocarp or testal wall layers (Table III & Plate III). Mourad and Al- Nowaihi (2001) concluded that the anatomical characters of the achene of other taxa of Rosoideae were found to be impracticable for species delimitation. This is in accordance with the attitude in the present study.

As regards the number of vascular bundles supplied the achene in the taxa under investigation, the subsequent aspects of the achene vascular pathway are recorded:

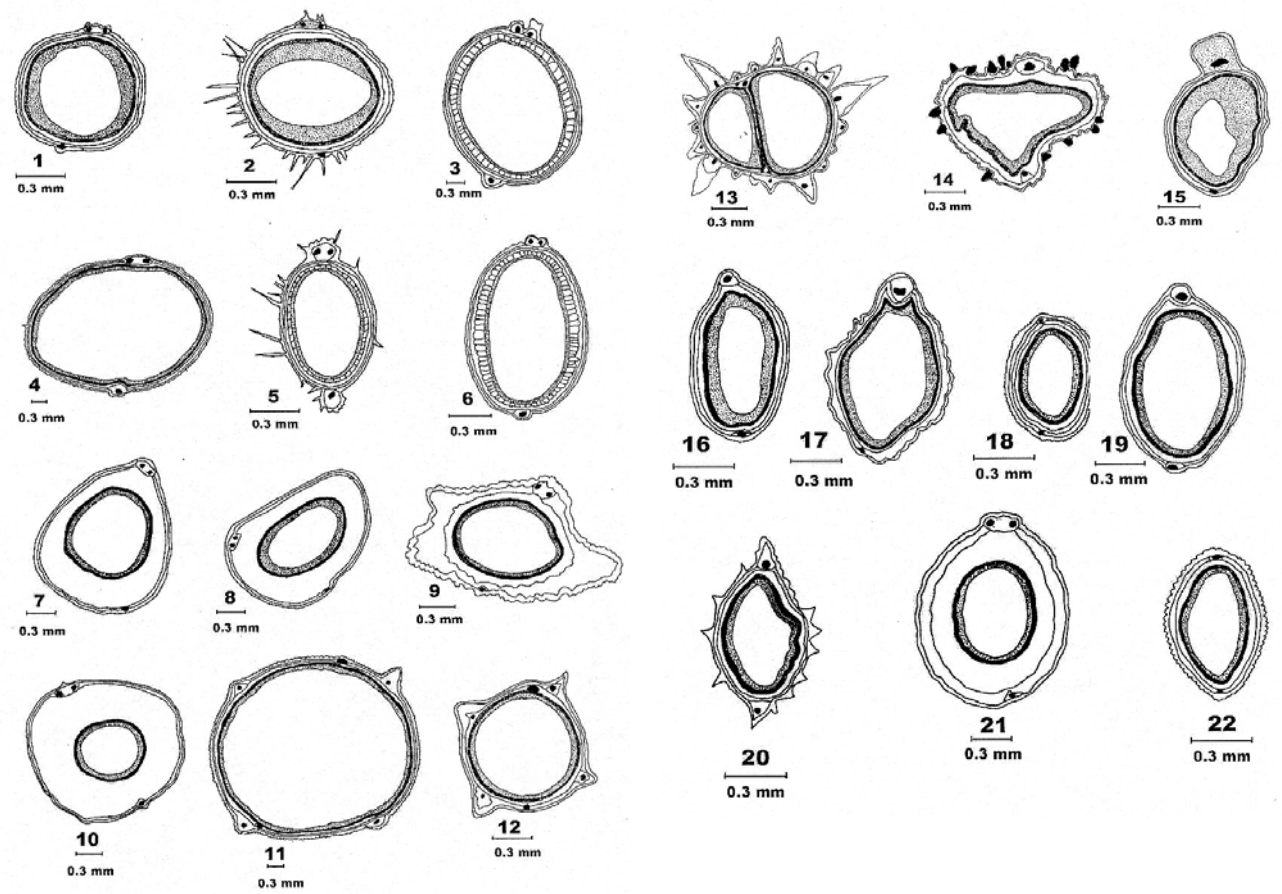
a. One dorsal bundle and two separate ventrals (the classical number of vascular bundles of each carpel as mentioned before by Pandey, 1993) as recorded in species of *Dryas*, *Geum*, *Rosa* and *Rhodotypos* (Plate III, Figs. 1-10 & 21).

b. One dorsal and two fused ventral vascular bundles in addition to few lateral bundles as recorded in species of *Sanguisorba* (Plate III, Figs. 11-13). The source of the latter bundles is ill-defined at the level of T.S. whether from dorsal or ventral strands.

C- One dorsal and two fused ventral vascular bundles as recorded in the remained studied taxa (14 taxa) as shown in Plate III, Figs.14-20 & 22).

Bessey (1915) set earlier that the reduction or fusion in

Plate III (Achene anatomy LM). Figs. 1- *Dryas drummondii*, 2- *D. octoptala*,3- *Geum bulgaricum*, 4- *G. rhodopeum*, 5- *G. rivale* 6- *G. urbanum*, 7- *Rosa gluca*, 8- *R. pendulina*, 9- *R. sempervirens*, 10- *R. hugonis*, *R. spinosissima*, 11- *Sanguisorba canadensis*, 12- *S. officinalis*, 13- *S. minor*, 14- *Coluria geoides*, 15- *Duchesnea indica*, 16- *Fragaria vesca*, 17- *Potentilla argenta*, *P. arnavatensis*, *P. calycina*, *P. cinerea*, *P. delphinensis*, 18- *P. dombeyi*, *P. dissecta*, 19- *P. fulgens*, *P. rupestris*, 20- *P. recta*, 21- *Rhodotypos scandens*, 22- *Waldestenia fragaroides*



number are two phylogenetic dicta that determine the evolution line. In accordance with this line of evolution, the achene vascular supply and its behaviour here help in constructing phylogenetic status to show the value of these characters as less advanced to more advanced (Fig. 1).

CONCLUSION

From taxonomic view point, the exomorphic characters of the achene of the taxa under investigation as revealed by LM seem to be unreliable either in the separation of the species of the same genus or characters evaluation at the infra-generic level.

As regards, the achene surface pattern as clarified by SEM shows more or less consistency at the generic level in some taxa and varying in the majority among the species of the same genus or among the species of the different genera. The achene surface patterns are taxonomically effective in species delimitation.

The anatomical investigation of the pericarp and testal walls shows a great homogenity between the species of the same genus. The micromorphological characters are consistent at the generic level. Relying on the number of achene vascular bundles and their behaviour, it could be claimed that the altogether absence of the bundles or the reduction of ramification with the fusion of ventrals will consider an advanced character status.

However, from the sum of exo- and endomorphic characters of achene in this study, the final conclosion is that these characters are not sufficient alone for delimitation between species and we recommend for doing more morphological and molecular studies.

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