Morpho-anatomical characters of the achene in certain species of sub-family Rosoideae (Rosaceae), a comparative study

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Mourad M.M. & A. S. Al-Nowaihi 2001. Morpho-anatomical characters of the achene in certain species of sub-family Rosoideae (Rosaceae), a comparative study. ***Taeckholmia*** **21(2)**: 221-238

The morpho-anatomical characters of 18 species belonging to six genera of sub-family Rosoideae were investigated. The anatomical characters of both the pericarp and testa were found to be impracticable for species delimitation since they are consistent at the generic level. The same reason rendered the character evaluation invaluable within the species of the same genus. Of the morphological characters the mode of the achene vasculature as well as its ramification varied in the different taxa. The basic number of the achene supply is one median and two lateral strands. The behaviour of the latter, whether distinct or fused, as well as the ramification , or not, of a part or the whole of the vascular skeleton led to the suggestion of a key-like layout which shows the pathway of these character states as being primitive *vs* advanced.

Key words: Achene, anatomy, morphology, Rosaceae, Rosoideae.

Introduction

Recent studies on the phylogeny of Rosaceae through molecular systematics segmented this family into several infra-familial taxa and the number is so flactuating that no clear consensus can be cited. However, the four traditional sub-families viz. Spiraeoideae, Rosoideae, Prunoideae and Maloideae have long been accepted by Robertson (1974) and Cronquist (1981). This classification, being simple and most practical, is based mainly on the type of the fruit. In sub-family Rosoideae, the subject material, the achene develops from a perigynous flower with the ovary consisting of 1-many carpels, each with 1-2 ovules.

Many workers have shown a marked interest in studying the achene, specifically in Ranunculaceae and Rosaceae. A justification to this is that the first family is a primitive clade in the Ranalian line of evolution, and the second family retains several features that are thought to have characterized the earliest flowering plants.

As regards the Rosaceae *s.l.* morphological and anatomical studies on its achene have been carried by Pechoutre (1902), Juel (1918), Netolitzky (1926), Chute (1930), Eames (1931), Hjelmquist (1962), Sterling (1964-66) and Corner (1976).

The present work is undertaken to investigate the morphology and anatomy of the achene in 18 species of sub-family Rosoideae, for a precise species delimitation and also for the determination of the character magnitude whether primitive or advanced.

Received 20 February 2001. Revision accepted 30 October 2001.

Materials and Methods

Mature achenes of 18 species of sub-family Rosoideae are investigated (Table 1). The material was kindly supplied from Botanischer Garten, Karl–Marx University. Leipzig and processed following the method of Schobe & Lersten (1969) with some modification (Trzaski, 1999). Clearing was made by washing in 8% NaOH solution under 60 Cº. Coloured solution was removed every 24hr. and the process was repeated until the NaOH solution became clear. The cleared material was then placed in 1% alkaline fuchsine in 8% NaOH and placed in oven at 60 ºC for 24hr. The material was then thoroughly washed with water and placed onto glass slides in a drop of lactic acid. The cleared and stained material was investigated by a bright field microscope. For the study of the vascular skeleton, the closed intact achene was investigated laterally and opened later to show the vascular branching in a plane view. The plane view clarified the marginal parts of the achene which contain the ventral strands and termed the ventral edge, while the middle part contains the dorsal strand and termed the dorsal edge.

Table 1. Collection data and classification (classification cited after Willis, 1973 and Mabberly, 1997).

Sub-family	Tribe	Sub- tribe	Genus	Species
ROSOIDEAE	Ulmarieae		*Filipendula*	*F. kamtschatica,F. ulmaria, F.vulgaris*
	Kerrieae			
	Potentilleae	Rubinae		
		Potentillinae	*Fragaria*	*F. daltoniana, F.nipponica*
			*Duchesnea**	*D.indica*
		Dryadinae	*Geum*	*G.aleppicum, G. chiloese, G. heterocarpum, G. japonicum, G. magellanicum, G. parviflorum, G. rivale, G. vernum.*
			Dryas	*D. octopetala*
	sanguiorbeae		*Acaena*	*A.anserinifolia, A.nova-zelandiae, A.pinnatifida*
	Cercocarpeae			
	Roseae			

(*) not mentioned by Willis (1973).

For the anatomical investigation, the dried achenes were first softened and cleared by boiling in 10% NaOH. Customary methods of dehydration, infilteration and embedding were followed (Johansen, 1940), sections were cut at 10-16 um, stained in safranin-fast green combination and mounted in Canada Balsam. Drawings were made by the aid of Leitz Camera Lucida.

The achene vasculatures is legend as follows:
d = main dorsal strand.
d' = lateral branches arising from d.
v = main ventral strand(s).
v' = lateral branches arising from v.
xdv = point of ventral strand(s) settlement.

i = vascular strand connection joining the v and d.
i' = lateral branchlets arising from i .
f = funicular strand.
xvf = point of funicular strand settlement .

Observations

Genus*: Acaena* (Table 2&3, Figs. 1-3)

The achene in this genus is included in the hypanthium and united with it .The free parts of the sepals appear at the top of the hypanthium.

1. Morphology of the achene:

The achene in the three Acaena species is ellipticus, glabrous and terminated by short, straight, glabrous, short beaked, acute apex style and surrounded by pubescent hypanthium; the latter as well as the sepal vary in the three studied species as follows:

a- In ***A. anserinifolia***, the hypanthial spines are lacking. The four sepals become differentiated at the mouth of the hypanthium (Fig.1a). The apex of each sepal extends into a long filiform spine-like appendage which is terminated by reflexed fine hairs (Fig.1b).

b- In ***A. nova-zelandiae***, the hypanthium is provided by spine-like appendages, distributed at random. The five sepals appear as short wedge-shaped processes, the apices of which are also terminated by spine-like appendages as those on the hypanthium (Figs.2a&b).

c- In ***A. pinnatifida***, the hypanthium is provided by hooked spine-like appendages and carries two long and two short sepals devoid of any appendages (Fig.3a).

2- Achene and sepal vasculature:

The vascular supply of the achene is one (d) strand which gives two fused (v) strands within its body. Shortly above this point, an (f) strand to the seed emerges from the fused ventral strands (Fig.1d). No further ramifications are observed. Each sepal is supplied by one median and two lateral bundles (Fig.1e).

3-Anatomy of the pericarp and the testa :

The three species of ***Acaena*** have a pericarp of three layers; an exocarp of one layer of thin walled , tangentially flattened cells, a mesocarp of one layer of thin walled and radially elongated parenchymatous cells and an endocarp of one layer of thick walled, radially elongated cells (Fig.1f). The testa in the three *Acaena* species is formed of one layer of 4-5 gonal, sclerenchymatous cells, followed by a multilayered thin walled, tangentially flattened endosperm cells.

Genus*: Dryas- D. octopetala* (Table 1&2, Fig.4).
1-Morphology of the achene:

The achene is more or less spatulate, pubescent and terminated by long, filiform pubescent, straight style with acute apex (Fig.4a).

2-Achene vasculature :

The vascular supply of the achene is one (d) strand and two distinct (v) strands (Fig.4b), the whole enter the achene body as such. The (f) strand emerges from one of the two (v) strands. Near the apex of the achene two fine vascular strands connect the (d) strand with (v) strands. The (v) strands extend upward to form the stylar supply and at the summit of the latter, the (v) strand(s) become united with the (d) strand. Except for the (i) strand, no other ramifications are observed.

3-Anatomy of the pericarp and the testa (Fig.4d&e):

The pericarp layers are the same as in *Acaena* except for the exocarp which has unicellular hairs and the endosperm cells are 4-5 gonal.

Genus*: Duchesnea- D. indica* (Table 2&3, Fig.5).

1-Morphology of the achene:

The achene is kidney-shaped, glabrous with a lateral short papillate-shaped style (Fig.5a).

2-Achene vasculature:

The vascular supply of the achene is one (d) strand which gives two fused (v) strands inside its body (Fig.5b). The (f) strand emerges from the fused (v) strands. No further ramifications are observed.

3-Anatomy of the pericarp and the testa:

Similar to that of *Aceana* species except for the mesocarp has tangentiallyelogated cells and the endocarp has angular cells. (Figs.5c&d).

Genus*: Filipendula* (Table 2&3, Fig.6).

1- Morphology of the achene:

In *F. kamtschatica*, the achene is more or less dumbel-shaped with pubescent margins; twisted and glabrous in *F. ulmaria*, and ovate, pubescent in *F. vulgaris*.In all the three species, the style is terminal, short beaked with acute apex; glabrous in *F. ulmaria* , pubescent in *F. kamtschatica* and *F. vulgaris* and straight in *F.vulgaris* and curved in *F. kamtschatica*. (Figs. 6a,7a&8a).

2- Achene vasculature:

The (d), (v) and (f) strands are similar to those of *Acaena* species. Dichotomously branched ramifications are observed. The tatter originate either from both (d) and (v) strands as in *F. kamtschatica* and *F. vulgaris* or from (v) strand only as in *F. ulmaria*. The (i) strand is observed in *F. vulgaris* (Figs. 6b,7b&8b).

3- Anatomy of the pericarp and the testa:

Consistent in the three species. As for the pericarp it consists of one layer (exocarp) of radially elongated thin-walled cells, a mesocarp layer of thin-walled, tangentially elongated parenchymatous cells, and an endocarp layer of thick-walled sclerenchymatous cells. The testa consists of one layer of thick-walled cells, followed by the endosperm which consists of one layer of thin-walled tangentially flattened cells.

Genus: *Fragaria* (Table 2&3, Figs.9&10) .

1-Morphology of the achene:

The achene of the two studied species are ovate, glabrous, with short lateral papillate, glabrous style. Receptacle fleshy, achenes on the surface or sunk in pits.

2-Achene vasculature:

One main (d) strand which gives two fused (v) strands. The (f) strand originates from the fused (v) strands inside the body of the achene. Dichotomously branched ramifications originate either from both (d) and (v) strands as in *F. daltoniana* or from the base of the (d) strand as in *F. nipponica*. The (i) strand is lacking.

3-Anatomy of the pericarp and the testa:

Similar to genus *Filipendula* except for the multilayered endosperm.

Genus*: Geum* (Table 2&3, Figs. 11-18).

1-Morphology of the achene:

The achene of the eight studied species is ovate, pubescent with long filiform, terminal, glabrous, hooked style. The style is either straight in *G. aleppicum*, *G. heterocarpum* and *G. parviflorum* or forming a knee in the remainder five species (Figs.11a-18a).

2-Achene vasculature:

One (d) strand which gives two distinct (v) strands and the whole enter the body of the achene. The (f) strand emerges from one of the two (v) strands. The (i) strand is observed in *G. chiloense* and *G. heterocarpum*. The (i) strands are observed in *G. chiloense*. Other ramifications emerging either from (d) and (v) strands or from one of them are observed in all the remainder species. Three types of ramifications are observed (Figs.11b&c-18b&c).

a- Pinnate (v) ramification where a few number of secondary or tertiary strands are more or less parallel as in *G. alippicum* and *G. vernum* (Figs. 11c&18c).
b- Reticulate (v) ramifications with relatively large number of secondary or tertiary strands which become dichotomously branched as in *G. japonicum* (Fig.14c).
c- Reticulate ramifications originate from (d) and (v) strands where a dichotomously branched (d) and (v) strands are observed as in the remainder species.

3-Anatomy of the pericarp and the testa:

The pericarp anatomy is on the ground plan of *Filipendula* species. Contrary to the other species studied, the testa consists of two layers of thin-walled cells. The cells of the outer layer are small, tangentially flattened and those of the inner one are large and radially elongated (Fig.11d&e).

Discussion

In the studied species of sub-family Rosoideae, the hypanthium was found to be fleshy (*Duchesnea* and *Fragaria*) or dry in the remainder species. In the latter case it is either flat (*Filipendula*) or concave to various degrees (*Acaena, Dryas* and *Geum*).

The shape of the achene is consistent in *Acaena* species where it is elliptic with the style appearing as short beak. In *Fragaria* species it is ovate with a lateral papillate style. In *Geum* species the achene is ovate with a long filiform style. However in this latter genus minor variations in the straightness of the style were observed; being either straight or kneed. Bailey (1949) stated that the style characters can be used to distinguish between the different taxa. So far as the available material is concerned, the shape of the achene seems to be consistent at the generic level except in *Filipendula*. The anatomical characters of both the pericarp and testa are also invaluable for both the species delimitation (within the same genus) and the character evaluation.

Two types of achene vasculature are observed. The first type was observed in *Acaena, Duchesnea, Filipendula* and *Fragaria* In these genera, a single median strand (dorsal strand) enters the achene and later branches into two lateral strands which may become fused (ventral strands). Trzaski (1999) stated that all the other vascular branches originate from the median (dorsal) strand. The second type was observed in *Dryas* and *Geum* where three strands viz. One dorsal and two ventrals enter the achene from the very beginning. This latter type of vasculature is easily understood relying on the concept that the achene is of foliar nature, and hence supplied by one median (dorsal) and two lateral (ventral) strands just as the leaf from which it originated (Fraser,1937, Fahn, 1969 and Pandey, 1993).

Taking into consideration the point from which the ventral strands arise from the dorsal strand (xdv-point); the studied species can be classified into two groups. A first group in which the xdv-point is located inside the body of the achene (*Acaena, Duchesnea, Filipendula* and *Fragaria*). In this case the ventral strands arise fused, and a second group in which this point is located elsewhere (in the receptacle) outside the achene (*Dryas* and *Geum*). In the latter case they remain distinct. Mourad et al (2000) working on Ranunculaceae stated that the fusion of the ventral strands is an advanced character.

As to the source of the funicular strand, two opinions were claimed. Brouland (1935) & Gregoire (1938) considered it as a continuation from the main axial vascular

elements which gives all other strands as lateral ramifications. Tepfer (1953), Melville (1962) and Trzaski (1999) stated that the funicular strand can be derived from either of the ventral strands. In the present study, our observation is in accord with the second view. Trzaski (1999) claimed that the rise of the funicular strand from the ventral(s) strand is a further proof to the classical carpel theory.

Ramification of the dorsal / and or the ventral(s) strand may be either absent altogether (*Acaena* species and *Duchesnea indica*) or present (in the remainder taxa). Where present three ramification types are observed viz. either from the dorsal strand (*Filipendula ulmaria* and *Fragaria nipponica*), from the ventral strand(s) (*Dryas octopetala* ,*Geum aleppicum, G. chiloense, G. heterocarpum, G. japonicum* and *G. vernum*), or from both (*Filipendula kamtschatica, F. vulgaris, Fragaria daltoniana, Geum magellanicum, G. parviflorum* and *G. rivale*). The ramification, in turn, assumes two configurations; either pinnate where branchelts are few in number and more or less parallel (*Geum aleppicum* and *G. vernum*), or reticulate where the branches are relatively numerous and dichotomously forked (*Filipendula* species, *Fragaria* species, *Geum chiloense, G. japonicum, G. magellanicum, G. parviflorum* and *G. rivale*). In Ranunculaceae, Trzaski (1999) discussed the ramification from the phylogenetic view point, where he suggested a hypothetical pathway in which a reduction occurs in the pinnate-reticulate configuration. In other words, the ramification is an indicator to complexity.

In the present work, and convinced that reduction is an evolutionary criterion, it could be claimed that the total absence or rarity of ramification will point to an advanced character status. Accepting this, together with the fusion or not of the ventral strands, the subsequent key-like layout is suggested to show the magnitude of these characters as being primitive vs advanced.

Key-like layout for the character states(arrows indicate the line of evolution; primitive (p) vs advanced (a).

A. Ventral strands distinct

B. Amplified ramification (*Geum* species)

p vs a

p vs a

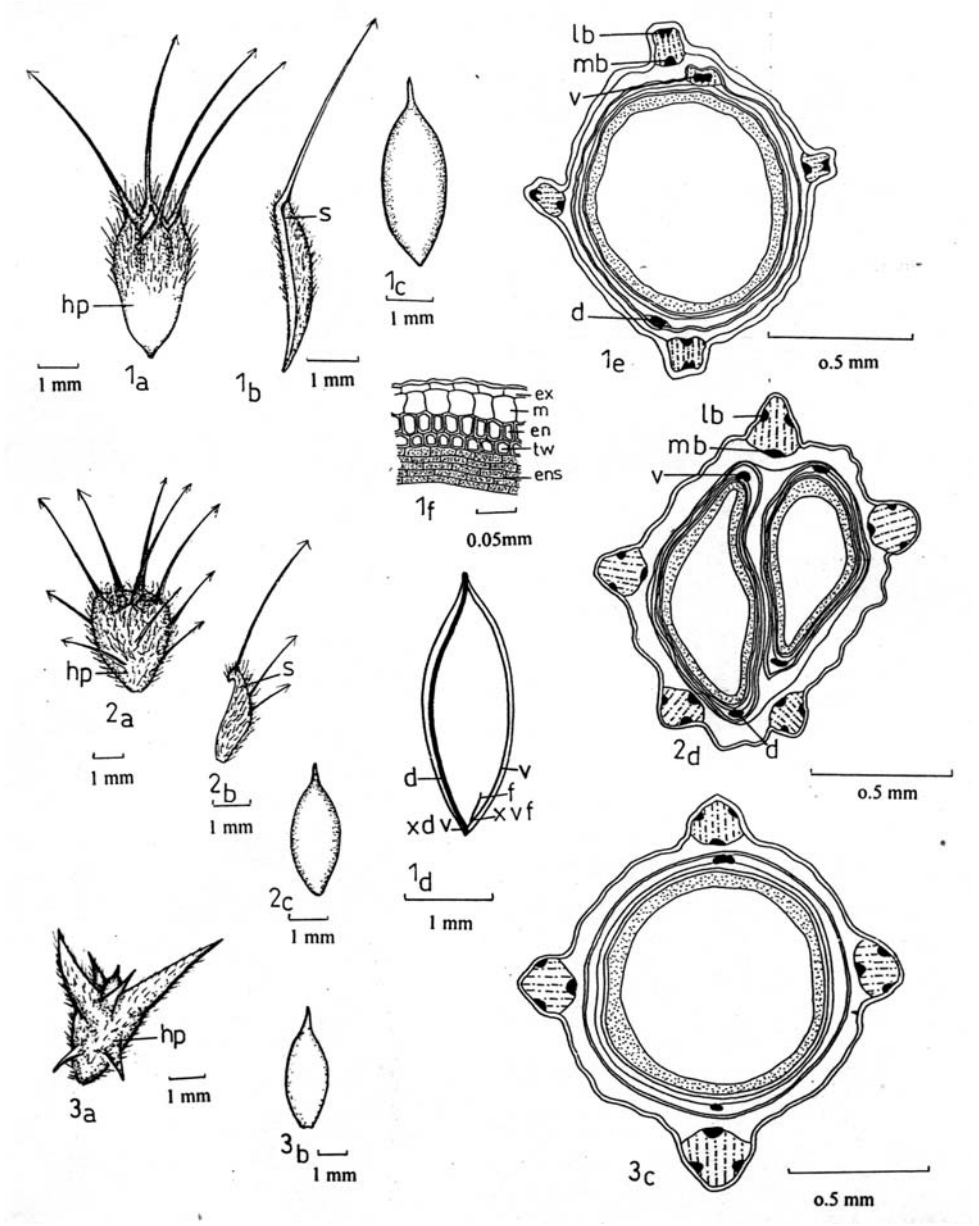
BB. Few ramification (*Dryas octopetala*)

AA. Ventral strands fused

C. Amplified ramification (*Filipendula* species and *Fragaria* species)

p vs a

CC. Ramification lacking altogether (*Acaena* species and *Duchesnea indica*)

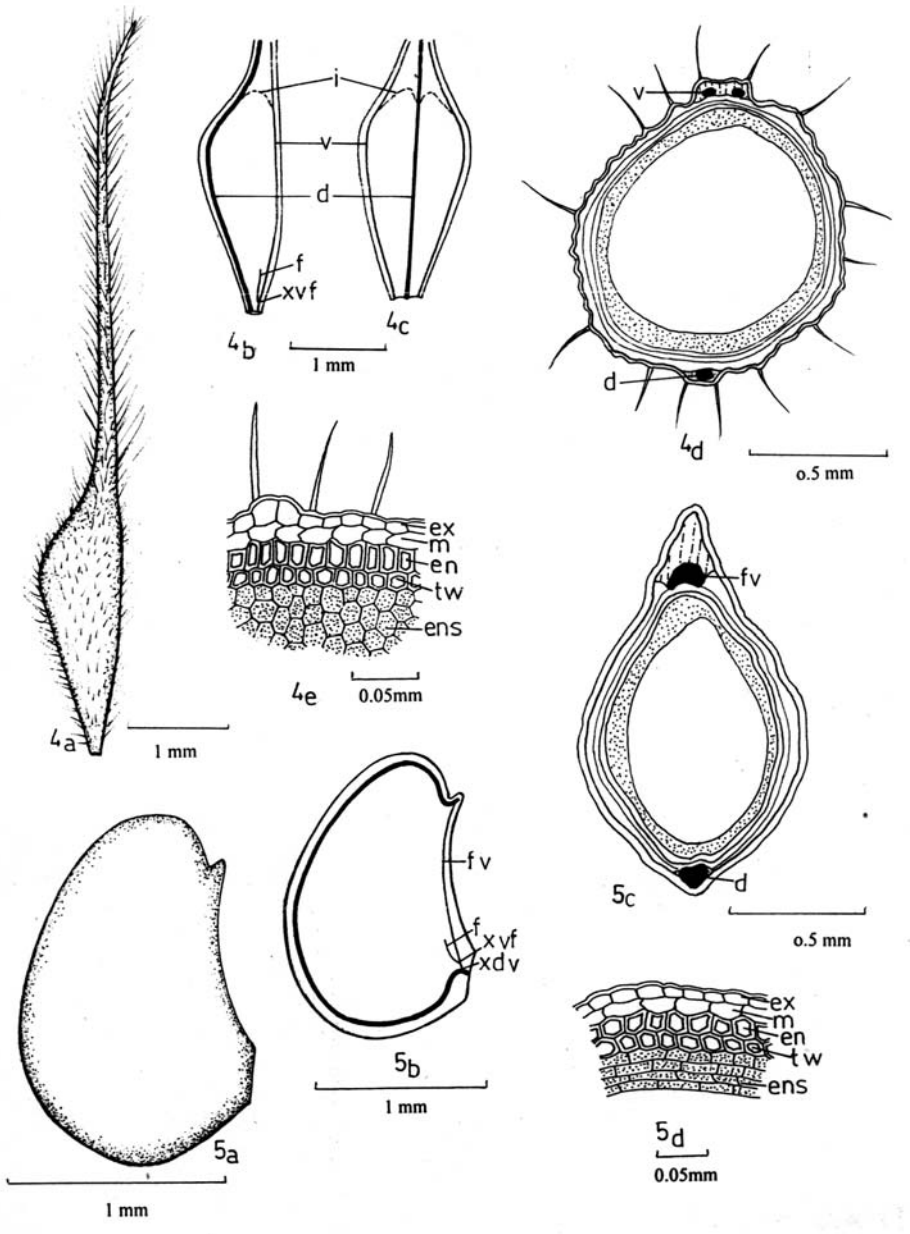


Achene morphology, vasculature and anatomy.

Figure 1, *Acaena anserinifolia*; 1a= whole flower; 1b= sepal; 1c= achene; 1d= lateral view of cleared achene; 1e&f= achene anatomy.

Figure 2, *A. nova-zelandiae*; 2a= whole flower; 2b= sepal; 2c= achene; 2d= achene anatomy.

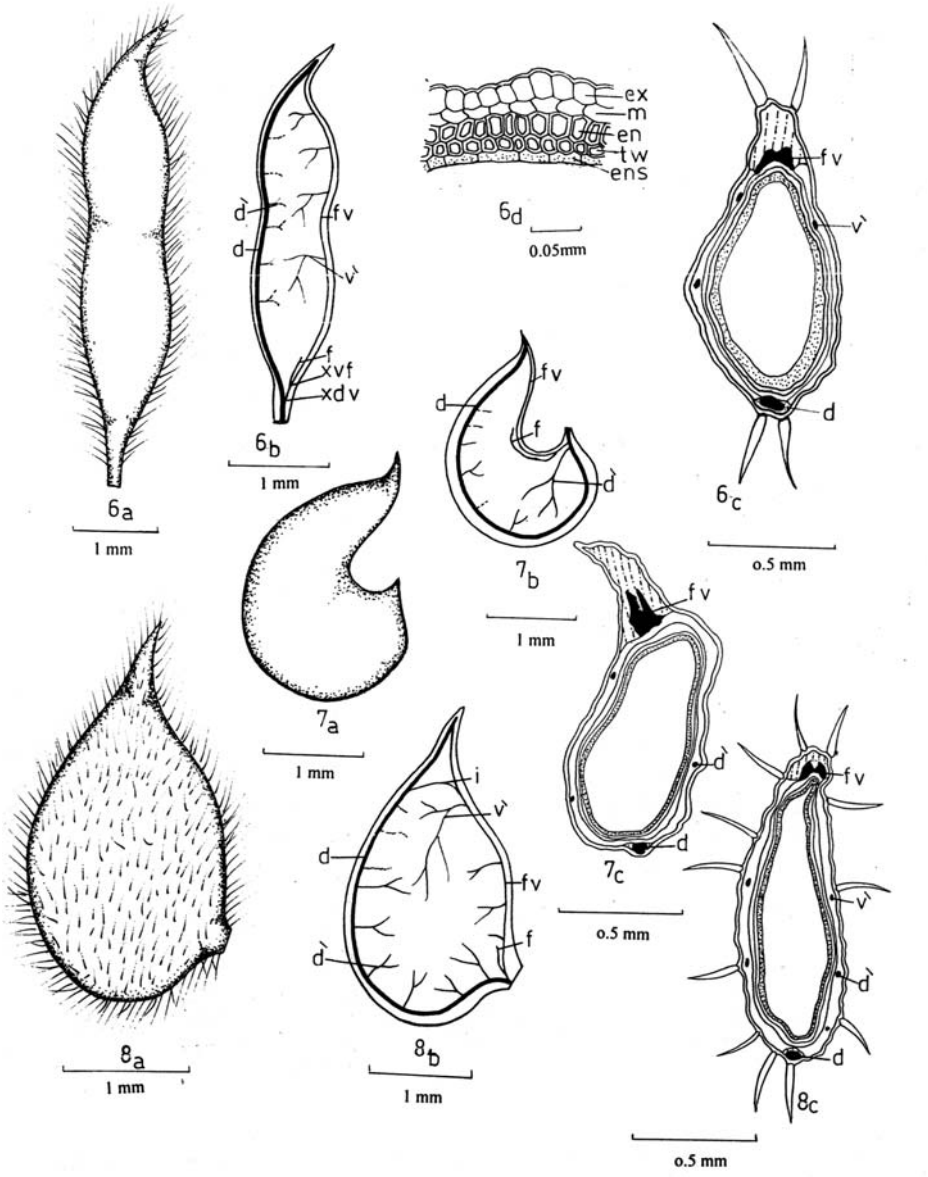
Figure 3, *A. pinnatifida*; 3a= whole flower; 3b= achene; 3c= achene anatomy. d= dorsal strand; en= endocarp; ens= endosperm; ex= exocarp; f= funicular strand; hp= hypanthium; lb=lateral bundle(s); m= mesocarp; mb= median bundle; s= sepal; tw= testal wall; v= ventral strand; xdv=point of ventral strand settlement; xvf= point of funicular strand settlement



Achene morphology, vasculature and anatomy (continued)

Figure 4, *Dryas octopetala*; 4a= achene; 4b= lateral view of cleared achene; 4c= plane view of cleared achene; 4d&e,=achene anatomy.

Figure 5, *Duchesnea indica*; 5a= achene; 5b= lateral view ; 5c&d= achene anatomy. d= dorsal strand; en= endocarp; ens= endosperm; ex= exocarp; f= funicular strand; fv= fused ventral strands; i= vascular strand connection joining the v and d; m= mesocarp; tw= testal wall; v= ventral strand(s); xdv= point of ventral strand settlement; xvf= point of funicular strand settlement.

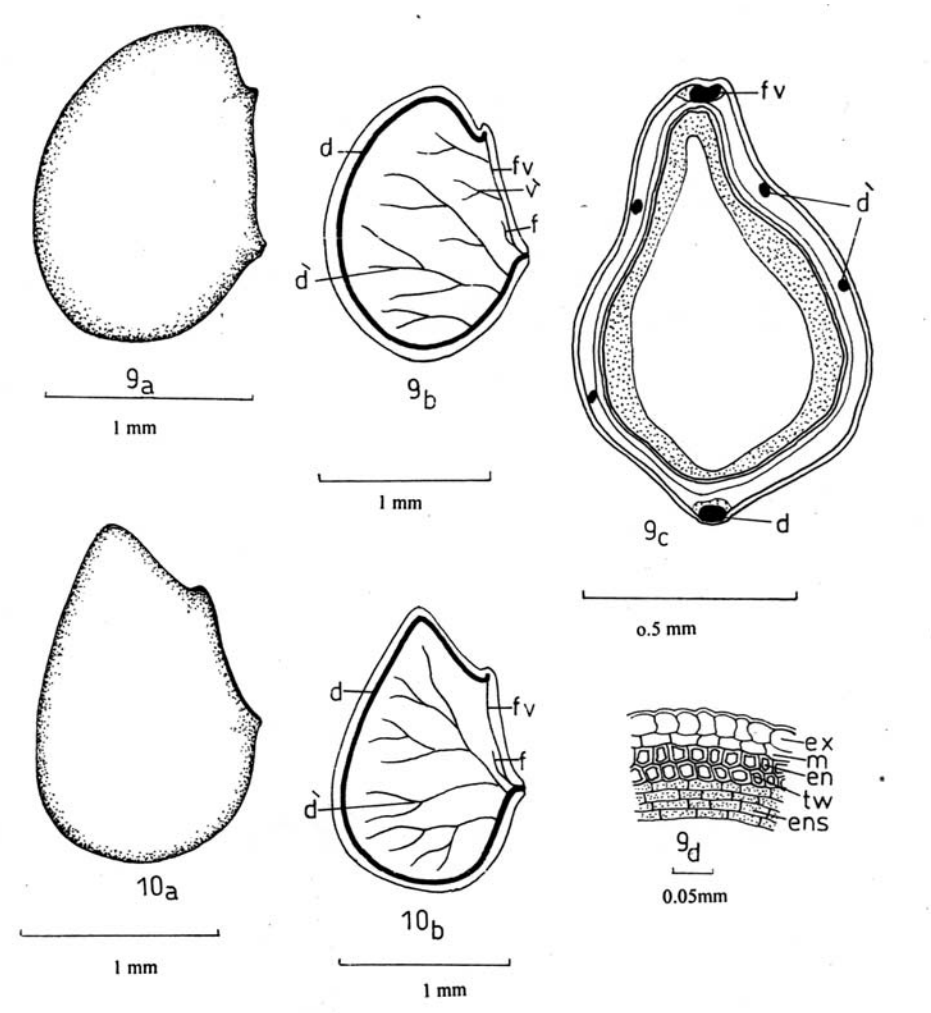


Achene morphology, vasculature and anatomy (continued).

Figure 6, *Filipendula kamtschatica*; 6a=achene; 6b= lateral view; 6c&d= achene anatomy

Figure 7, *F. ulmaria*; 7a= achene; 7b= lateral view; 7c= achene anatomy.

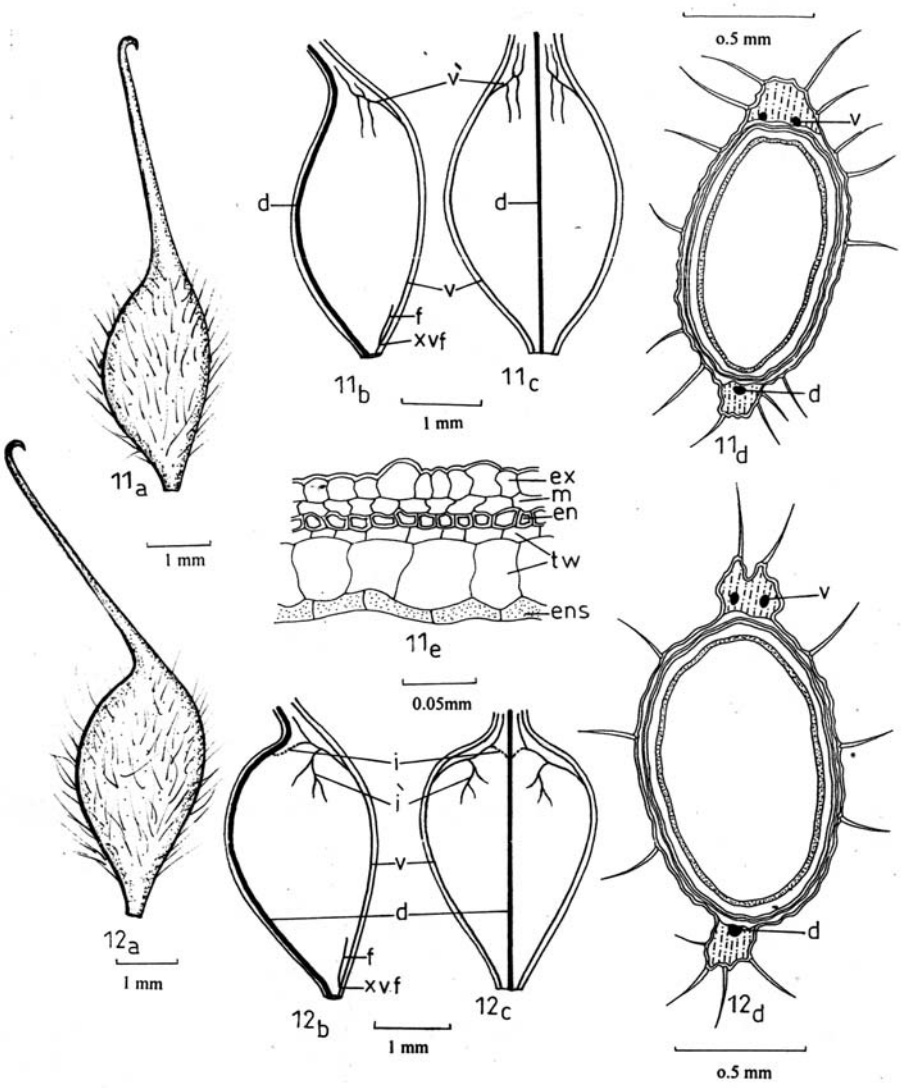
Figure 8, *F. vulgaris*; 8a= achene; 8b= lateral view; 8c= achene anatomy. d=dorsal strand; d'= lateral branches arising from d; en= endocarp; ens= endosperm; ex= exocarp; f= funicular strand; fv= fused ventral strands; i= vascular strand connection joining the v and d; m= mesocarp; tw= testal wall; v=ventral strand(s); v'= lateral branching arising from v; xdv= point of ventral strand(s) settlement; xvf= point of funicular strand settlement.



Achene morphology, vasculature and anatomy (continued).

Figure 9, *Fragaria* daltoniana, 9a= achene; 9b= lateral view; 9c&d= achene anatomy.

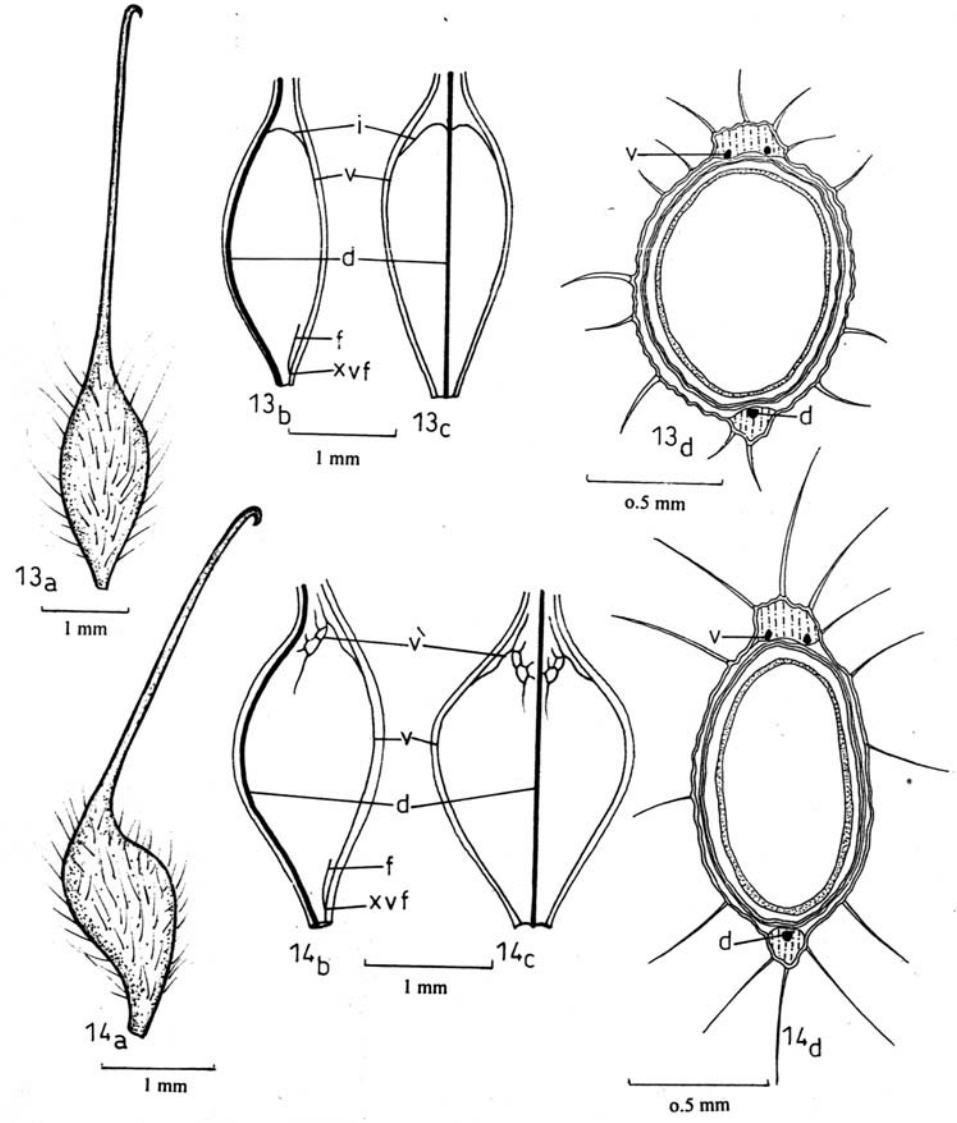
Figure 10, *F. nipponica*; 10a= achene; 10b= lateral view; 10c= achene anatomy. d= dorsal strand; d'= lateral branching arising from d; en= endocarp; ens= endosperm; ex= exocarp; f= funicular strand; fv= fused ventral strands; m= mesocarp; tw= testal wall; v= ventral strand(s); v'= Lateral branching arising from v.



Figs. 11&12 Achene morphology, vasculature and anatomy (continued).

Figure 11, *Geum aleppicum*; 11a= achene; 11b= lateral view; 11c= plane view; 11d&e= achene anatomy.

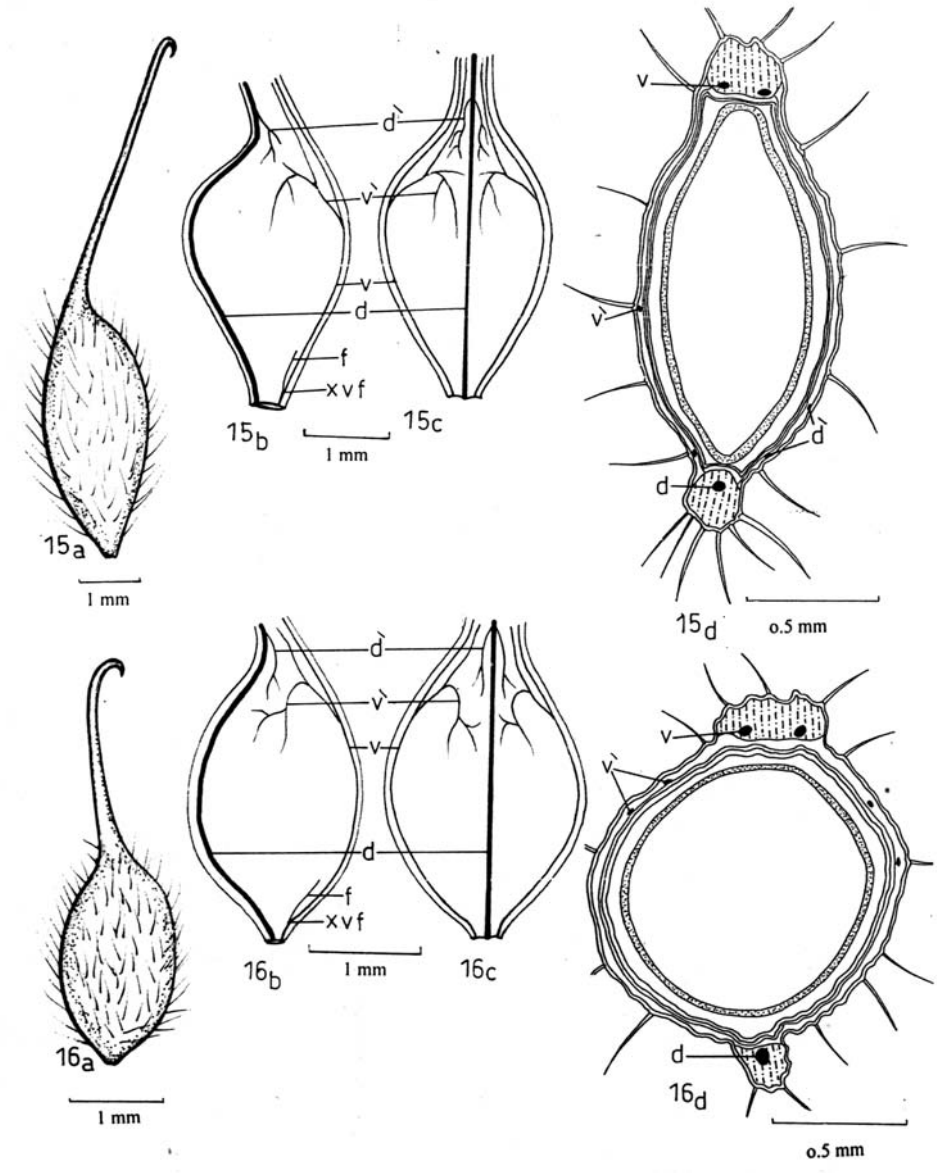
Figure12, *G. chiloense*; 12a= achene; 12b= lateral view; 12c= plane view; 12d= achene anatomy. d=dorsal strand; ; en= endocarp; ens= endosperm; ex= exocarp; f= funicular strand ; i= vascular strand connection joining the v and d; i'= lateral branchlets arising form i; m= mesocarp; tw= testal wall; v= ventral strand(s); v'= lateral branching arising from v; xvf= point of funicular strand settleme.



Achene morphology, vasculature and anatomy (continued).

Figure 13, *Geum heterocarpum*; 13a= achene; 13b= lateral view; 13 c= plane view; 13d= achene anatomy.

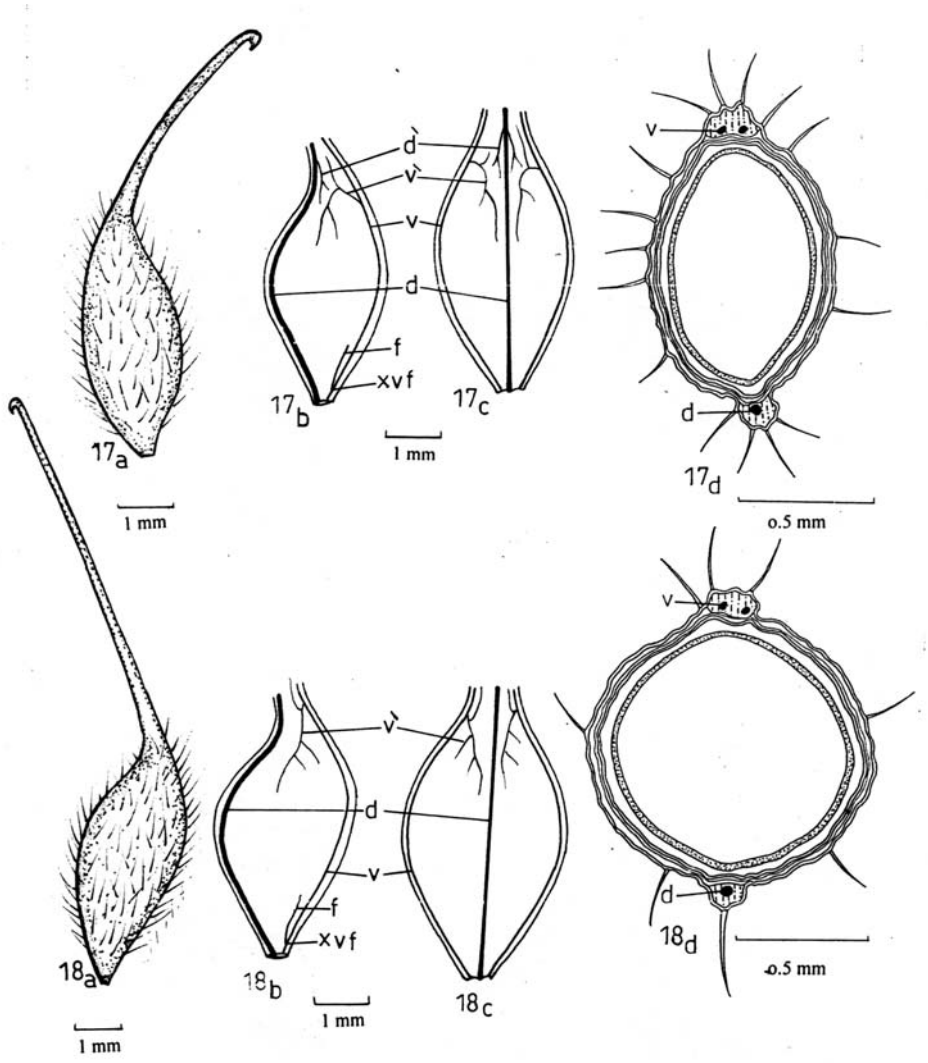
Figure 14, *G. japonicum*; 14a= achene; 14b= lateral view; 14c= plane view; 14d= achene anatomy. d=dorsal strand; f= funicular strand ; i= vascular strand connection joining the v and d; v= ventral strand(s); v'= lateral branching arising from v; xvf= point of funicular strand settlement.



Figs. 15&16 Achene morphology, vasculature and anatomy (continued).

Figure 15, *Geum magellanicum*; 15a= achene; 15b= lateral view; 15c= plane view; 15d = achene anatomy.

Figure 16, *G. parviflorum*; 16a= achene; 16b= lateral view; 16c= plane view; 16d= achene anatomy. d=dorsal strand; d'= lateral branching arising from d; f= funicular strand; v= ventral strand(s); v'= lateral branching arising from v; xvf= point of funicular strand settlement.



Achene morphology, vasculature and anatomy (continued).

Figure 17, *Geum rivale*; 17a= achene; 17b= lateral view; 17c= plane view; 17d = achene anatomy.

Figure 18, *G. vernum*; 18a= achene; 18b= lateral view; 18c= plane view; 18d= achene anatomy. Dd=dorsal strand; d'= lateral branching arising from d; f= funicular strand; v= ventral strand(s); v'= lateral branching arising from v; xvf= point of funicular strand settlement.

Table 2. The Morphological Aspects of the Achene of the Studied Taxa of Rosoideae (Rosaceae)

Aspects / Taxa	Achene	Achene	Style				
	Shape	Texture	aspect	Insertion	Straightness	Apex	Texture
1-*Acaena anserinifolia* (J.R.&G.Forster)Druce	Ellipticus	Glabrous	Short beaked	Terminal	Straight	Acute	Glabrous
2-*A.nova-zelandiae* T.Kirk	Ellipticus	Glabrous	Short beaked	Terminal	Straight	Acute	Glabrous
3-*A.pinnatifida* Hort .ex Steud	Ellipticus	Glabrous	Short beaked	Terminal	Straight	Acute	Glabrous
4-*Dryas actopetala* L.	Spatulate	Pubescent	Long filiform	Terminal	Straight	Acute	pubescent
5-*Duchesnea indica* (Andrews)Focke	Kidney-shapes	Glabrous	shortpapilla	Lateral	*	*	Glabrous
6-*Filipendula kamtschatica* Maxim.	Dumbel-shaped	Edges hairy	Short beaked	Terminal	Curved	Acute	pubescent
7-*F. ulmaria* (L.)Maxim.	Twisted	Glabrous	Short beaked	Terminal	Straight	Acute	Glabrous
8-*F. vulgaris* Moench	Ovate	Pubescent	Short beaked	Terminal	Straight	Acute	pubescent
9-*Fragaria daltoniana* F. Gay	Ovate	Glabrous	Short papilla	Lateral	*	*	Glabrous
10-*F.nipponica* Makino	Ovate	Glabrous	Short papilla	Lateral	*	*	Glabrous
11-*Geum aleppicun* Jacq	Ovate	Pubescent	Long filiform	Terminal	Straight	Hooked	Glabrous
12*G.chiloense* Balbis	Ovate	Pubescent	Long filiform	Terminal	kneed	Hooked	Glabrous
13-*G.hetero carpum* Boiss.	Ovate	Pubescent	Long filiform	Terminal	Straight	Hooked	Glabrous
14-*G.japonicum* Hort.&Scheutz	Ovate	Pubescent	Long filiform	Terminal	kneed	Hooked	Glabrous
15-*G.magellanicum* Comm.ex Pers	Ovate	Pubescent	Long filiform	Terminal	kneed	Hooked	Glabrous
16-*G. parviflorum* Steud .&Hochst ex steud	Ovate	Pubescent	Long filiform	Terminal	Straight	Hooked	Glabrous
17-*G.* rivale L.	Ovate	Pubescent	Long filiform	Terminal	kneed	Hooked	Glabrous
18-*G.vernum* Torr .ex Gray	Ovate	Pubescent	Long filiform	Terminal	kneed	Hooked	Glabrous

***style is in the form of short papilla**

Table 3. Achene vascular supply and anatomy of the pericarp and seed of the taxa studied

No	Aspects	Achene vascular strands						Pericarp anatomy			Seed anatomy		Endosperm	
	Taxa	No of main strands	origin of (v) strand	Ramification				Exo.	Meso.	Endo.	No of layers	thickess	No of layers	Arrangement
				d'	v'	l	l'							
1	*Acaena anserinifolia* (J.R.&G.Forster)Druce	1+(2)	ip	-	-	-	-	T.	R.	R.	1	K	mult	T
2	*A.nova-zelandiae* T.Kirk	1+(2)	ip	-	-	-	-	T.	R.	R.	1	K	mult	T
3	A.pinnatifida Hort .ex Steud.	1+(2)	ip	-	-	-	-	T.	R.	R.	1	K	mult	T
4	*Dryas octopetala* L.	1+2	op	-	-	+	-	T.R	T	R.	1	K	mult.	5-6 gonal
5	*Duchesnea indica* (Andrews)Focke	1+(2)	ip	-	-	-	-	T	T	ang	1	K	mult.	T
6	*Filipendula kamtschatica* Maxim.	1+(2)	ip	+	+	-	-	R	T	ang	1	K	1	T
7	*F. ulmaria* (L.) Maxim.	1+(2)	ip	+	-	-	-	R	T	ang	1	K	1	T
8	*F. vulgaris* Moench	1+(2)	ip	+	+	+	-	R	T	ang	1	K	1	T
9	*Fragaria daltoniana* F. Gay	1+(2)	ip	+	+	-	-	R	T	ang	1	K	mult	T
10	*F.nipponica* Makino	1+(2)	ip	+	-	-	-	R	T	ang	1	K	mult	T
11	*Geum aleppicun* Jacq.	1+2	op	-	+	-	-	R	ang	ang	2	N	1	T
12	*G.chiloense* Balbis	1+2	op	-	-	+	+	R	ang	ang	2	N	1	T
13	*G.heterocarpum* Boiss.	1+2	op	-	-	+	-	R	ang	ang	2	N	1	T
14	*G.japonicum* Hort.&Scheutz	1+2	op	-	+	-	-	R	ang	ang	2	N	1	T
15	*G.magellanicum* Comm.ex Pers.	1+2	op	+	+	-	-	R	ang	ang	2	N	1	T
16	*G. parviflorum* Steud .&Hochst ex steud.	1+2	op	+	+	-	-	R	ang	ang	2	N	1	T
17	*G.* rivale L.	1+2	op	+	+	-	-	R	ang	ang	2	N	1	T
18	*G.vernum* Torr .ex Gray	1+2	op	-	+	-	-	R	ang	ang	2	N	1	T

( ), fused; ang.,angular; ip, inside the pericarp; muti.,multilayered;N, thin; op, outside the pericarp; R, Radially elongated; T, Tangentially elongated; +, present;-, absent.

Acknowledgement

The authors are grateful to Botanischer Garten, Karl–Marx University. Leipzig for the loan of the seeds.

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