

## Taxonomic characters of fruit and seed in brazilian species of *Pavonia* Cav. (Malvaceae)

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**ABSTRACT** - (Taxonomic characters of the fruit and seed in brazilian species of *Pavonia* Cav. (Malvaceae)). This study was based on the analysis of fruit and seed morphology of species of *Pavonia* (Malvaceae) from northeastern and southeastern Brazil. The importance of characters in the infrageneric taxonomy is discussed. In general, the variability in fruit and seed characters is useful to separate closely related species subgenera. The seed characters can be used to separate the sections of the subgenera *Pavonia*. A key to the subgenera and sections is provided.

**Key words:** fruit, seed, morphology, taxonomy

**RESUMO** - (Caracteres taxonômicos do fruto e semente das espécies brasileiras de *Pavonia* Cav. (Malvaceae)). Este estudo trata da morfologia do fruto e semente das espécies de *Pavonia* (Malvaceae) das regiões nordeste e sudeste do Brasil. É discutida a importância das características morfológicas para a taxonomia infragenérica. A variabilidade das características do fruto e da semente é útil para a separação de espécies afins e dos subgêneros. Os caracteres da semente podem ser usados na separação das seções e dos subgêneros. É apresentada uma chave para as seções e subgêneros.

**Palavras-chave:** fruto, semente, morfologia, taxonomia

### Introduction

*Pavonia* Cav. is represented by 224 species in the Americas, from the southern United States, Central America, West Antilles, and South America. It also occurs in the Old World, especially in Africa (Ulbrich 1921, Fryxell 1999). In Brazil 134 species have been recorded (Fryxel 1999), 78 of which are found in the northeastern and southeastern regions (Esteves 1998a).

The genus is a member of the tribe Malvaceae K. Presl, which is characterized by having the number of styles corresponding to twice the number of carpels. *Pavonia* is characterized by petals without basal auricles, absence of foliar nectaries, epicalyx bracteoles not differentiated into foot and lamina, schizocarpic fruits, and by the mericarps without glochidiate spines.

This work is part of a larger study on the systematic of *Pavonia*, that focused on the species found in northeastern and southeastern Brazil (Esteves 1996). The main objective of this paper is to describe the morphology of the fruit and seed in the genus as well as present a new set of characters relevant to the classification at the infrageneric level.

### Material and methods

Morphological and taxonomic studies were based on the specimens collected by the author in northeastern and southeastern Brazil, especially in the type localities as well as in the localities where the genus was least collected and on collections borrowed from the 47 herbaria cited in Esteves (1996, 1998b, 2001). The illustrations were made using a camera lucida attached to a microscope. The photographs were taken from herbarium material using a Zeiss 940A scanning electron microscope.

The terminology follows Hochreutiner (1920), Heel (1978), Krapovickas & Cristóbal (1962), Krapovickas (1982) and Fryxell (1988). The species studied (Table 1) are classified according to Esteves' (1998a, b; 2000, 2001) infrageneric classification system.

### Results and Discussion

**Fruit** - The fruit in Malvaceae presents wide morphological variation that is a great source of useful characters from the tribe down to species. The fruit in *Pavonia* is a schizocarp formed by five trigonal mericarps (figure 1, 6) attached to a central columella

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Table 1. Species of *Pavonia* (Malvaceae) from northeastern and southeastern Brazil examined for fruit and seed characters. The numbers refer to the details of the mericarps of fruit (figures 1-32) and seeds (figures 33, 34).

Rank and taxa	Illustration	Rank and taxa	Illustration
Subg. <i>Pavonia</i>			
Sect. <i>Pavonia</i>			
<i>P. laxifolia</i> A. St.-Hil.	figure 29	<i>P. grazielae</i> Krapov.	—
<i>P. gracilis</i> R.E. Fr.	—	<i>P. almasana</i> Ulbr.	—
<i>P. corymbosa</i> (Sw.) Willd.	figure 25	<i>P. humifusa</i> A. St.-Hil.	—
Sect. <i>Lebretonia</i> (Schrank) Endl.		<i>P. repens</i> Fryxell	—
<i>P. kleinii</i> Krapov. & Cristóbal	figure 23	<i>P. cancellata</i> (L.) Cav.	—
<i>P. guerkeana</i> R.E. Fr.	figure 21	<i>P. piauyensis</i> Ulbr.	figure 12
<i>P. sagittata</i> A. St.-Hil.	figures 28, 33	<i>P. angustifolia</i> Benth.	—
<i>P. distinguenda</i> A. St.-Hil. & Naudin	figure 32	<i>P. malacophylla</i> (Link & Otto) Garcke	—
<i>P. hastata</i> Cav.	—	<i>P. varians</i> Moric.	figure 14
<i>P. reticulata</i> Garcke	—	<i>P. pterocarpa</i> R.E. Fr.	figure 19
<i>P. viscidula</i> A. St.-Hil. & Naudin	—	<i>P. aschersoniana</i> Gürke	—
<i>P. schranckii</i> Spreng.	—	Subg. <i>Goetheoides</i> (Gürke) Ulbr.	
<i>P. dusenii</i> Krapov.	—	Sect. <i>Goetheoides</i> Gürke	
Sect. <i>Asterochlaena</i> (Garcke) Ulbr.		<i>P. goetheoides</i> (Hassl.) Fryxell	—
<i>P. sidifolia</i> Kunth	figure 31	<i>P. alnifolia</i> A. St.-Hil.	figure 17
<i>P. garckeana</i> Gürke	—	<i>P. crassipedicellata</i> Krapov.	—
<i>P. vinosa</i> G.L. Esteves	—	<i>P. calyculosa</i> A. St.-Hil & Naudin	figures 6, 7
<i>P. biflora</i> Fryxell	—	<i>P. ducke-limae</i> Monteiro	—
<i>P. geminiflora</i> Moric.	figure 18	<i>P. makoyana</i> E. Morren	figure 20
<i>P. hexaphylla</i> (S. Moore) Krapov.	figure 34	Sect. <i>Tricalycaris</i> Gürke	
Sect. <i>Lopimia</i> (Mart.) Endl.		<i>P. tricalycaris</i> A. St.-Hil.	figure 27
<i>P. erythrolema</i> Gürke	—	<i>P. multiflora</i> A. St.-Hil.	—
<i>P. blanchetiana</i> Miq.	figure 16	Subg. <i>Typhalea</i> (DC.) Ulbr.	
<i>P. serrana</i> G.L. Esteves	—	Sect. <i>Typhalea</i> DC.	
<i>P. rosa-campestris</i> A. St.-Hil.	figure 13	<i>P. fruticosa</i> (Mill.) Fawc. & Rendle	figures 3-5, 26
<i>P. luetzelburgii</i> Ulbr.	—	<i>P. stellata</i> (Spreng.) Spreng.	figure 9
<i>P. macrostyla</i> Gürke	figure 15	<i>P. nemoralis</i> A. St.-Hil.	figure 1, 2
<i>P. harleyi</i> Krapov.	—	<i>P. peruviana</i> Gürke	—
<i>P. malvaviscoides</i> A. St.-Hil.	—	<i>P. castaneifolia</i> A. St.-Hil. & Naudin	—
<i>P. viscosa</i> A. St.-Hil.	—	Sect. <i>Urenoidea</i> A. St.-Hil.	
<i>P. montana</i> Garcke ex Gürke	figure 22	<i>P. communis</i> A. St.-Hil.	figure 8
		<i>P. flavispina</i> Miq.	figure 11
		<i>P. sepium</i> A. St.-Hil.	figure 10

(figure 2). The mericarps separate themselves from the central columella and split into five one-seeded segments, resulting in the dispersal unit. Each mericarp has a dorsal face which corresponds to the fruit external surface (figure 3), a ventral surface which is the area where the mericarp is attached to the central columella (figure 4) and the lateral surface, contrasting with dorsal surface for there is contact between two adjacent mericarps (figures 5, 7, 8-25).

The analysis of mericarp morphology in *Pavonia* revealed diagnostic characters useful in separating the infrageneric taxa. The presence or absence of an awn on the mericarps is an important character used to separate the subgenera (see key). In the species of subgenera *Pavonia* and *Goetheoides* the mericarps are awnless (figures 22-25) or 1-3-rostrate at the apex

(figures 12-21); the central rostrum is formed by the junction of the extended median nerve of the carpel with its ventral suture. In the species of subg. *Typhalea* the mericarps are 3(-1)-awned (figures 8-11), the central awn is straight and subapical, formed by the extended median nerve of the carpel (figure 8).

The two lateral awns may be straight, for most species in the subgenus, almost horizontal, as in *P. flavispina* (figure 11) or reflexed as in certain species that do not occur in the study areas. The occurrence of aristate mericarps is common in other genera of Malvaceae such as *Sida*, *Bastardiopsis* and *Tarasa*, in which the awns are entire at the beginning of their development but they split later when the carpel is mature (Hochreutiner 1920). In *Urocarpidium*, however, the awns remain entire and

the mericarps are uniaristate. This pattern of development probably also occurs in *P. stellata* (figure 9). The awns display spines, retrorse trichomes (figure 26) that probably play an important role in fruit dispersal.

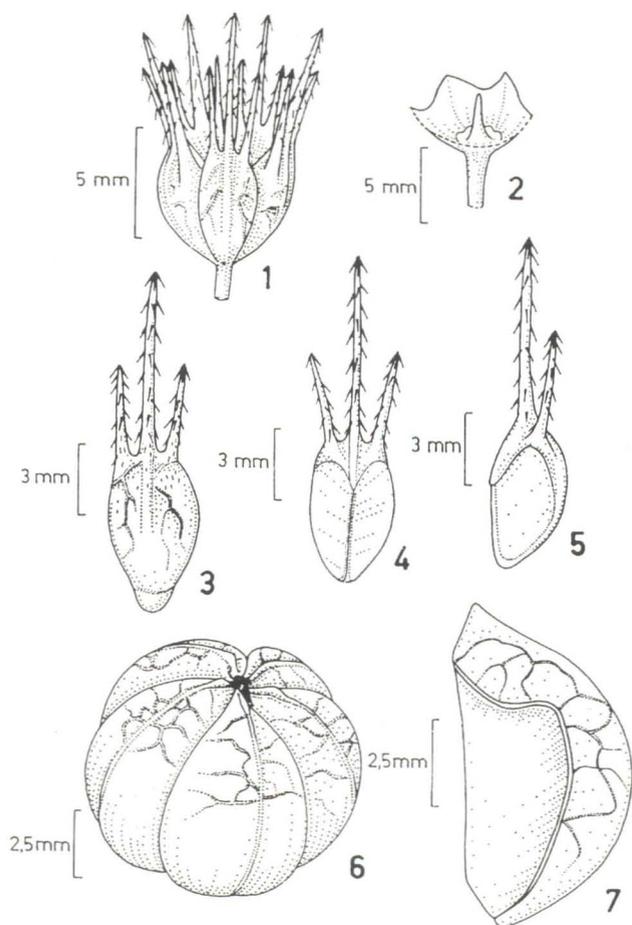
The mericarps are obovoid in almost the entire genus (figure 31), but subovoid mericarps occur in sections *Lebretonia* and *Lopimia* (figure 28). The lateral faces of the mericarps are flat in the majority of the species, slightly convex in the species of sect. *Lebretonia* (figures 21, 23-24) and in some species of sect. *Lopimia* and slightly compressed in the species of subg. *Goetheoides* (figures 19, 20). Furthermore, in most of the species of the genus, the contact area between two adjacent mericarps is extense and totally smooth (figures 11-17, 19-20, 22) or with discrete nerves, such as in *P. gracilis*, *P. laxifolia*, *P. geminiflora* and *P. corymbosa* (figure 18, 25). In *P. piauyensis*, *P. rosa-campestris* and *P. varians*

(figure 12-14), among others, this area is comparatively smaller and the lateral faces show prominent nerves. All these patterns are consistent at both the infra and interspecific levels.

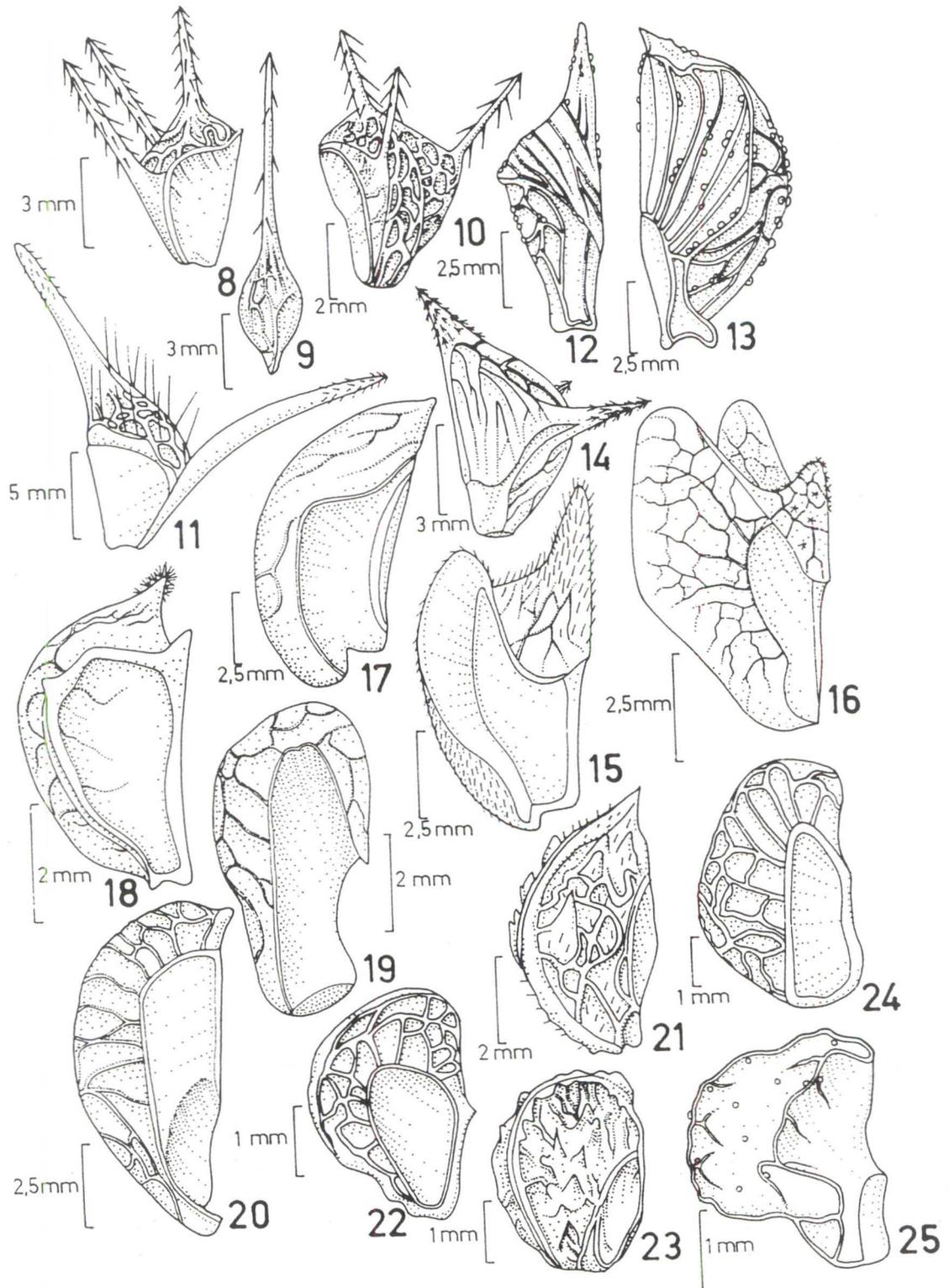
The external surfaces of mericarps display several features that can be used to separate species, especially in the subg. *Pavonia*, as is the case in *P. guerkeana*, *P. kleinii*, *P. laxifolia* and *P. distinguenda* that have tuberculate mericarps (figures 21, 23, 29, 32) and *P. sagittata*, *P. hastata*, *P. reticulata*, *P. viscidula*, *P. malvaviscoides*, *P. viscosa*, *P. serrana*, *P. grazielae*, *P. almasana*, *P. harleyi* and *P. montana* that have mericarps with reticulate, dense and prominent nervation, except in areas where contact between two adjacent mericarps occurs (figures 22, 24). On the other hand, in sections *Asterochlaena* and *Lopimia*, several species are distinguishable by their verrucose mericarps, such as *P. piauyensis*, *P. biflora*, *P. vinosa*, *P. cancellata*, *P. humifusa*, *P. garckeana*, *P. repens*, *P. rosa-campestris* and *P. sidifolia* (figures 12-13, 31). Mericarps almost entirely smooth appear in species that are not found in forest habitats, especially in subg. *Goetheoides* (Ulbrich 1921) (figures 17, 27).

The median nerve of the mericarps also has relevant taxonomic characters. In sect. *Lebretonia*, *P. hastata*, *P. viscidula*, *P. reticulata*, *P. guerkeana* and *P. sagittata* the nerve median carpelar is carinate and smooth (figures 21, 28), whereas in *P. dusenii*, *P. schranckii*, *P. kleinii* and *P. distinguenda* the nerve is costate and wavy or, occasionally, longitudinally sulcate (figures 23, 32). In subg. *Typhalea* the group formed by *P. communis*, *P. flavispina*, *P. castaneifolia* and *P. peruviana* the median nerve is strongly prominent. However, in several species of the subgenera *Goetheoides* and *Pavonia* the median nerve of mericarps is almost inconspicuous (figures 27, 29-31).

Winged mericarps appear in several species of open habitats. The wings are wider in *P. luetzelburgii*, *P. macrostyla* and *P. blanchetiana* (figures 15-16), and gradually narrower in *P. cancellata* and *P. humifusa* (sect. *Lopimia*) and *P. sidifolia* and *P. vinosa* (sect. *Asterochlaena*). The wings are originated by the expansion of mericarp's lateral walls. They are commonly found in the genera *Bakeridesia*, *Cristaria* and *Horsfordia* (Hochreutiner 1920). The wings have clear adaptative value related to mericarp dispersal in species that occur in aquatic or open habitats (Ulbrich 1921).



Figures 1-7. Fruits and mericarps in *Pavonia*: *P. nemoralis* (Duarte 10489): 1. Fruit. 2. Columella. *P. fruticosa* (Esteves & Kameyama 2582): 3. Mericarp, dorsal view. 4. Mericarp, ventral view. 5. Mericarp, lateral-dorsal view. *P. calyculosa* (Esteves et al. 2399): 6. Fruit. 7. Mericarp, lateral-dorsal view.

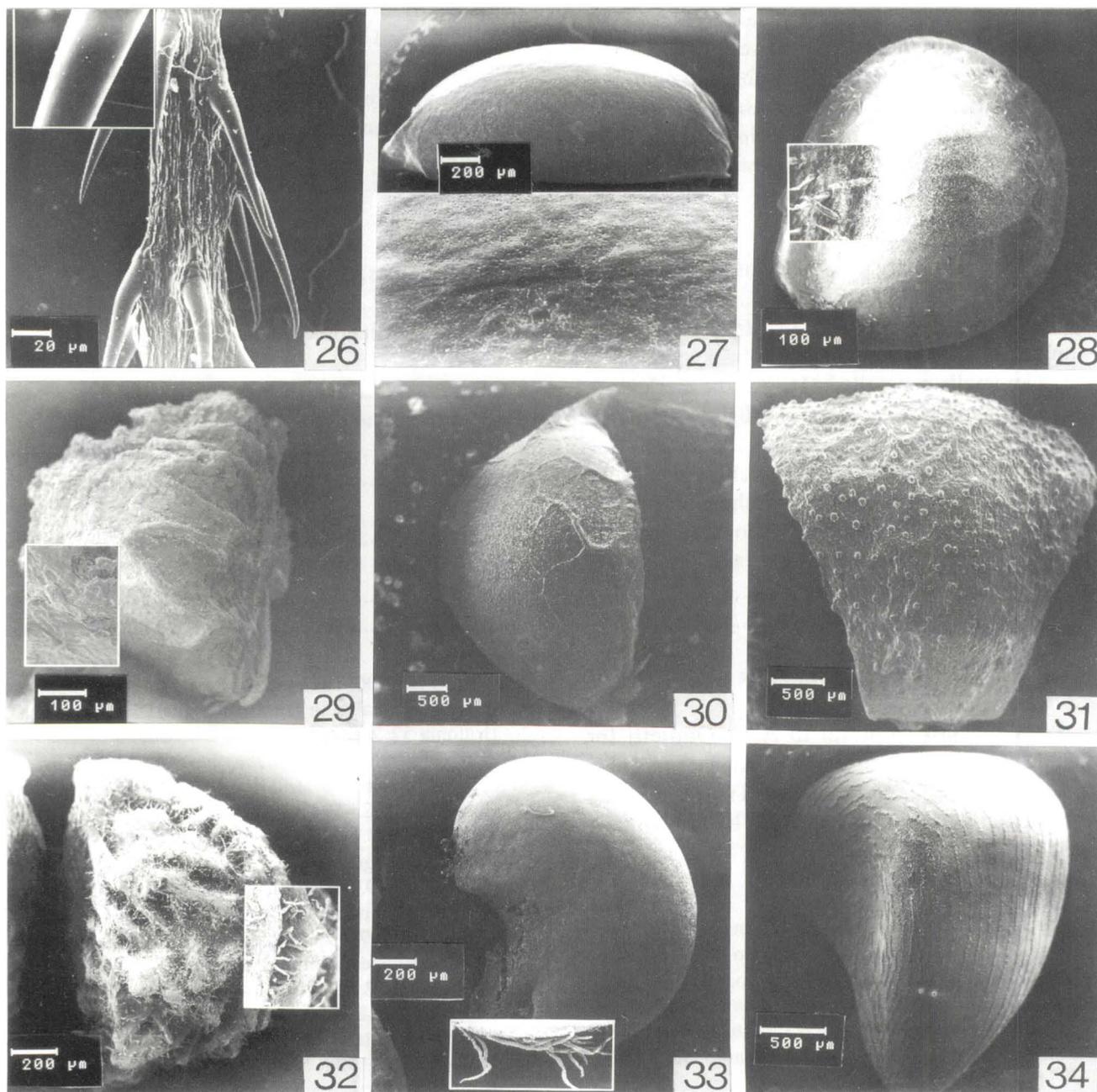


Figures 8-25. Types of mericarps in *Pavonia*, lateral view: 8. *P. communis* (Esteves & Kameyama 2450). 9. *P. stellata* (Esteves & Rossi 2621). 10. *P. sepium* (Trigo s.n., UEC15981). 11. *P. flavispina* (Esteves et al. 2703). 12. *P. piauyensis* (Luetzelburgii 1242). 13. *P. rosa-campestris* (Harley et al. CFCR 6647). 14. *P. varians* (Esteves & Lyra-Lemos 2220). 15. *P. macrostyla* (Harley et al. 19947). 16. *P. blanchetiana* (Viana 1428). 17. *P. alnifolia* (Esteves & Kameyama 2612). 18. *P. geminiflora* (Pinto 50-44). 19. *P. pterocarpa* (Magalhães Gomes 2950). 20. *P. makoyana* (Brade 19441). 21. *P. guerkeana* (Viegas et al. s.n., SP48779). 22. *P. harleyi* (Esteves & Lyra-Lemos 2541). 23. *P. kleinii* (Leitão-Filho et al. 1834). 24. *P. montana* (Esteves & Kameyama 2453). 25. *P. corymbosa* (Andrade-Lima 48-109).

The mericarps also vary in colour. The species from the forest habitats are predominately chestnut-coloured, grading into vinaceous to blackish in species from the open habitats. The external walls of the mericarps are generally thick and hard, but in a few of the species sect. *Lopimia* they are thin and almost

transparent. The columella is slightly shorter than the mericarps in the subg. *Typhalea*, about twice smaller in the subg. *Pavonia* and generally the same the length in the subg. *Goetheoides*.

It is noteworthy that some species have other distinctive mericarp characters, such as



Figures 26-34. Photomicrographs of fruits and seeds in *Pavonia*. 26. *P. fruticosa*, portion of the awn of the mericarp (Esteves et al. 1680). 27. *P. tricalycaris*, mericarp, dorsal face and detail of the external surface (Pereira et al. 2471). 28. *P. sagittata*, mericarp, lateral face (Esteves 2405). 29. *P. laxifolia*, mericarp, dorsal-lateral view, detail of the surface (Hoehne s.n., SP20058). 30. *P. geminiflora*, mericarp, dorsal face (Pinto 50-44). 31. *P. sidifolia*, mericarp, dorsal face (Esteves 2570). 32. *P. distinguenda*, mericarp lateral face (Hashimoto 594). 33. *P. sagittata*, seed, lateral-dorsal view (Hashimoto 594). 34. *P. hexaphylla*, seed, dorsal-lateral view (Esteves & Kameyama 2477).

*P. malacophylla* that has a mucilaginous, whitish substance on the external surface of the fruit; *P. ducke-limae* that has the apical portion of the mericarps strongly convex and *P. goetheoides*, *P. crassipedicellata* and *P. makoyana* (figure 20) that have a small basal depression on the lateral walls.

Seed - The seeds have a series of important taxonomic characters especially at the sectional level (see key). The sculpturing of the seed coat is very important for the separation of the sections of subg. *Pavonia*. It is longitudinally striate in sections *Asterochlaena* and *Pavonia* (figure 34) but smooth in the remaining sections (figure 33). In sect. *Lebretonia* the seeds

have two tufts of trichomes in the ventral face of both ends of the hilum (figure 33). This character is found only in this section and is quite distinct from the common pattern found in the rest of the genus, where the majority of the seeds are pubescent to glabrous. The seeds are reniform in the majority of the species (figure 33), but in sect. *Asterochlaena* and also occasionally in sect. *Lopimia* they are obovoid (figure 34). The seed colour is the same as that of the mericarps, i.e., they are generally chestnut-coloured in the species of subgenera *Typhalea* and *Goetheoides* and vinaceous to blackish in subg. *Pavonia*.

#### Key to subgenera and sections

1. Mericarps 1 or 3-ristate, the awns hard, with spines, retrorse trichomes; central awn subapical, straight ..... Subg. *Typhalea*
- 1'. Mericarps awnless or (1)-2-3-rostrate, rostrum without spines, retrorse trichomes; central rostrum apical, straight or slightly turned backward.
  2. Columella generally as long as the mericarp ..... Subg. *Goetheoides*
  - 2'. Columella size varying from slightly shorter to two twice as short as the length of the mericarp ..... Subg. *Pavonia*
3. Seeds with one tufts of trichomes at each end ..... Sect. *Lebretonia*
- 3'. Seeds without tufts of trichomes at the ends.
  4. Seeds smooth, without longitudinal grooves ..... Sect. *Lopimia*
  - 4'. Seeds longitudinally striate.
    5. Seeds obovoid ..... Sect. *Asterochlaena*
    - 5'. Seeds reniform ..... Sect. *Pavonia*

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