

Leaf Anatomy and Systematics of New World Velloziaceae

Edward S. Ayensu



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ABSTRACT

Edward S. Ayensu. Leaf Anatomy and Systematics of New World Velloziaceae. *Smithsonian Contributions to Botany*, number 15, 125 pages, frontispiece, 24 figures, 51 plates, 1974.—The leaf anatomy of 106 species of New World Velloziaceae has been studied with the purpose of providing important character-states in assessing the systematics of the family. Transverse section of the leaves have shown the type of sclerenchyma and mesophyll patterns that are assignable either to the genus *Vellozia* or *Barbacenia* (sensu lato). In addition to the light microscope, the scanning electron microscope was used to examine epidermal surfaces of the leaves as well as their internal structures. The SEM has served as a remarkable tool in allowing us to examine the topography of the leaf surface in three-dimension. Details of the structure of the stomata, the furrows in the leaf, and the types of hairs, including coalescent hairs, have been observed for the first time. The application of leaf anatomy in the taxonomy of the family has been stressed. Light and scanning electron micrographs are presented as an aid in the identification of each species.

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Contents

	Page
Introduction	1
Material Examined	1
Methods	5
Characters Used in the Descriptions	5
Classification of the Species	5
Acknowledgments	9
<i>Vellozia</i>	10
Section I: <i>Vellozia</i>	
<i>Vellozia abietina</i> Martius	10
<i>Vellozia alata</i> L. B. Smith	10
<i>Vellozia aloifolia</i> Martius	12
<i>Vellozia angustifolia</i> Goethart & Henrard	12
<i>Vellozia asperula</i> Martius	12
<i>Vellozia bicolor</i> L. B. Smith	13
<i>Vellozia brachypoda</i> L. B. Smith & Ayensu	13
<i>Vellozia burle-marxii</i> L. B. Smith	14
<i>Vellozia caruncularis</i> Martius & Seubert	15
<i>Vellozia ciliata</i> L. B. Smith	15
<i>Vellozia cinerascens</i> Martius ex Schultes f.	16
<i>Vellozia compacta</i> Martius ex Schultes f.	16
<i>Vellozia costata</i> L. B. Smith & Ayensu	17
<i>Vellozia crassicaulis</i> Martius ex Schultes f.	18
<i>Vellozia crinita</i> Goethart & Henrard	18
<i>Vellozia dasypus</i> Seubert	20
<i>Vellozia declinans</i> Goethart & Henrard	20
<i>Vellozia echinata</i> Goethart & Henrard	21
<i>Vellozia epidendroides</i> Martius ex Schultes f.	21
<i>Vellozia exilis</i> Goethart & Henrard	23
<i>Vellozia fibrosa</i> Goethart & Henrard	23
<i>Vellozia flavicans</i> Martius ex Schultes f.	23
<i>Vellozia glabra</i> Mikan	24
<i>Vellozia glandulifera</i> Goethart & Henrard	24
<i>Vellozia glauca</i> Pohl	25
<i>Vellozia glochidea</i> Pohl-Heringer	25
<i>Vellozia granulata</i> Goethart & Henrard	26
<i>Vellozia grisea</i> Goethart & Henrard	26
<i>Vellozia hatschbachii</i> L. B. Smith & Ayensu	26
<i>Vellozia hemisphaerica</i> Seubert in Martius	28
<i>Vellozia hypoxoides</i> L. B. Smith	28
<i>Vellozia incurvata</i> Martius ex Schultes f.	29
<i>Vellozia intermedia</i> Seubert in Martius	29
<i>Vellozia irwinii</i> L. B. Smith	29
<i>Vellozia lappa</i> L. B. Smith & Ayensu	30

	Page
<i>Vellozia leptopetala</i> Goethart & Henrard	30
<i>Vellozia magdalenae</i> L. B. Smith & Ayensu	31
<i>Vellozia metzgerae</i> L. B. Smith	31
<i>Vellozia minima</i> Pohl	33
<i>Vellozia modesta</i> L. B. Smith & Ayensu	33
<i>Vellozia nuda</i> L. B. Smith & Ayensu	33
<i>Vellozia ornata</i> Martius ex Schultes f.	34
<i>Vellozia phalocarpa</i> Pohl	34
<i>Vellozia pilosa</i> Goethart & Henrard	35
<i>Vellozia piresiana</i> L. B. Smith	35
<i>Vellozia plicata</i> Martius	35
<i>Vellozia pumila</i> Goethart & Henrard	37
<i>Vellozia punctulata</i> Seubert in Martius	37
<i>Vellozia resinosa</i> Martius ex Schultes f.	37
<i>Vellozia sellovii</i> Seubert in Martius	38
<i>Vellozia squalida</i> Martius ex Seubert f.	38
<i>Vellozia swollenii</i> L. B. Smith	39
<i>Vellozia taxifolia</i> Martius ex Schultes f.	39
<i>Vellozia tenella</i> Martius ex Schultes f.	39
<i>Vellozia teres</i> L. B. Smith & Ayensu	42
<i>Vellozia tragacantha</i> Martius ex Seubert	42
<i>Vellozia triquetra</i> Pohl	42
<i>Vellozia variabilis</i> Martius ex Schultes f.	44
<i>Vellozia verruculosa</i> Martius ex Schultes f.	44
<i>Vellozia virgata</i> Goethart & Henrard	45
<i>Vellozia wasshausenii</i> L. B. Smith	45
Section II: Radia	45
<i>Vellozia cachimbensis</i> L. B. Smith	45
<i>Vellozia cana</i> Goethart & Henrard	46
<i>Vellozia candida</i> Mikan	46
<i>Vellozia caput-ardeae</i> L. B. Smith & Ayensu	46
<i>Vellozia dawsonii</i> L. B. Smith	48
<i>Vellozia dumittiana</i> Schultes	48
<i>Vellozia hirsuta</i> Goethart & Henrard	49
<i>Vellozia lanata</i> Pohl	49
<i>Vellozia lithophila</i> Schultes	49
<i>Vellozia machrisiana</i> L. B. Smith	50
<i>Vellozia maculata</i> Goethart & Henrard	50
<i>Vellozia riedeliana</i> Goethart & Henrard	51
<i>Vellozia tubiflora</i> A. Richard	51
<i>Barbacenia</i>	53
Subkey I.	53
<i>Barbacenia delicatula</i> L. B. Smith & Ayensu	53
<i>Barbacenia gaveensis</i> Goethart & Henrard	53
<i>Barbacenia gounelleana</i> Beauverd	53
<i>Barbacenia hatschbachii</i> L. B. Smith & Ayensu	54
<i>Barbacenia irwiniana</i> L. B. Smith	55
<i>Barbacenia longiscapa</i> Goethart & Henrard	55
<i>Barbacenia purpurea</i> Hooker	55

	<i>Page</i>
<i>Barbacenia seubertiana</i> Goethart & Henrard	56
<i>Barbacenia stenophylla</i> Goethart & Henrard	57
Subkey II.	57
<i>Barbacenia celiae</i> Maguire	57
<i>Barbacenia flava</i> Martius ex Schultes f.	57
<i>Barbacenia ignea</i> Martius ex Schultes f.	58
<i>Barbacenia involucrata</i> L. B. Smith	58
<i>Barbacenia schwackei</i> Goethart & Henrard	58
<i>Barbacenia sellovii</i> Goethart & Henrard	60
<i>Barbacenia vandellii</i> Pohl ex Seubert in Martius	61
<i>Barbacenia williamsii</i> L. B. Smith	61
Subkey III.	61
<i>Barbacenia blackii</i> L. B. Smith	61
<i>Barbacenia conicostigma</i> Goethart & Henrard	63
<i>Barbacenia exscapa</i> Martius	63
<i>Barbacenia fragrans</i> Goethart & Henrard	63
<i>Barbacenia gardneri</i> Seubert in Martius	64
<i>Barbacenia gentianoides</i> Goethart & Henrard	64
<i>Barbacenia longiflora</i> Martius	64
<i>Barbacenia luzulifolia</i> Martius ex Schultes f.	65
<i>Barbacenia macrantha</i> Lem	65
<i>Barbacenia nana</i> L. B. Smith & Ayensu	65
<i>Barbacenia paranaensis</i> L. B. Smith	66
<i>Barbacenia riedeliana</i> Goethart & Henrard	67
<i>Barbacenia rubro-virens</i> Martius	67
<i>Barbacenia tomentosa</i> Martius	67
<i>Barbacenia viscosissima</i> Goethart & Henrard	69
Observations	69
Light Microscopic Observations	69
Scanning Electron Microscopic Observations	71
Literature Cited	72
Plates	75



Dr. Lyman B. Smith collecting Velloziaceae in Diamantina, Minas Gerais, Brazil
(photograph by author).

Leaf Anatomy and Systematics of New World Velloziaceae

Edward S. Ayensu

Introduction

This study is a sequel to an earlier anatomical treatment of the Old World Velloziaceae (Ayensu 1969a) prepared primarily to help solve taxonomic problems in this family. Unlike the Old World species, the New World members have been largely brought up to date taxonomically by Smith (1962), including his subsequent publications. Except for the publication by Warming (1893) on the biology and anatomy of the leaf of Velloziaceae, the work of Menezes (1971a) and my studies of *Barbaceniopsis* (Ayensu, 1968), and *Vellozia uaipianensis* (Ayensu, 1969b), no systematic attempt has been made to bring together the anatomical data of the New World species.

As I have indicated in other publications (Ayensu 1969a, 1973), features of the vegetative anatomy of the leaves in this family provide very important character-states in separating the genera. The most important anatomical characters are the sclerenchyma patterns in the leaves. In species of *Vellozia* the vascular bundles are partially surrounded by sclerenchyma on the adaxial side in the form of an inverted crescentiform or V-shaped cap. The abaxial sclerenchyma is either U- or Y-shaped. In *Barbacenia* the vascular bundles are partially surrounded on both the adaxial and abaxial sides by Y-shaped sclerenchyma, the adaxial one being inverted.

Apart from these broad sclerenchyma patterns that separate the genera, each species exhibits dis-

tinct mesophyll and epidermal features that permit their individual identification. The descriptions of the leaf anatomy of the New World Velloziaceae, as well as the accompanying line drawings and photomicrographs of the anatomical features, will hopefully provide additional clarification for the interpretation of the relationships of taxa in this family. This study will also serve as an atlas of the leaf anatomy of the New World species.

MATERIAL EXAMINED.—The following 241 specimens (106 species of two genera) were examined for this study. The herbarium vouchers are deposited either in the United States National Herbarium, National Museum of Natural History, Smithsonian Institution (US) or the New York Botanical Garden (NY).

Vellozia abietina Martius.—Maguire, Magalhaes & Maguire 49115, (1960) Concepcão, Minas Gerais, Brazil, NY & US.

Vellozia alata L. B. Smith.—Maguire, Magalhaes & Maguire 49049, (1960) Serra do Cipó, 1200 m, Minas Gerais, Brazil, NY & US.

Vellozia aloifolia Martius.—Y. Mexia 5870 (1931) Serra do Capão, 1240 m, Minas Gerais, Brazil, US.

Vellozia angustifolia Goethart & Henrard.—Riedel (1824) Serra da Lapa, Brazil, US; W. A. Archer 4092 (1936) highway between Diamantina and Guinda, Minas Gerais, Brazil, US; Centro Pesq. (R) 1411, Brazil, NY.

Vellozia asperula Martius.—G. Gardner 5228, Minas Gerais, Brazil, US; Occhioui s.n., Brazil, NY.

Vellozia bicolor L. B. Smith.—B. Maguire et al. 49047 (1960) Serra Cipó, 1200 m, Minas Gerais, Brazil, NY & US.

Vellozia brachypoda L. B. Smith & Ayensu.—Irwin 23534, Brazil, NY.

Vellozia burle-marxii L. B. Smith.—R. Burle-marx s.n., Brazil, US; Irwin et al. 32520 (1971) Rio Ferra Doido, 18 km E of Morro do Chapéu, ca. 1100 m, Bahia, Brazil, US.

Vellozia cachimbensis L. B. Smith.—Pires, Black, Wurdack & Silva 6235 (1956) Serra do Chachimbo, Pará, Brazil, US;

Edward S. Ayensu, Department of Botany, Smithsonian Institution, Washington, D.C. 20560.

- Pires 6111 (1956) Serra do Chachimbo, Pará, Brazil, NY & US.
- Vellozia cana* Goethart & Henrard.—H. S. Irwin, R. Souza & R. Reis dos Santos 11734, Brazil, NY & US; H. S. Irwin et al. 12556, Brazil, NY & US.
- Vellozia candida* Mikan.—Kuhlmann s.n. (1922) Brazil, NY; J. P. P. Carauta 160 (1963) Pedra da Gavea, Guanabara, Brazil, US; Porto 91195, Brazil, NY; Jardim Bot., Rio de Janeiro 2485, Brazil, NY; J. N. Rose & P. G. Russell 20669 (1915) Corcovado, Rio de Janeiro, Brazil, US.
- Vellozia caput-ardeae* L. B. Smith.—L. B. Smith, Ayensu & Hatschbach 15989, (1972) Giunda, Diamantina, Minas Gerais, Brazil, US.
- Vellozia caruncularis* Martius & Seubert.—B. Maguire, J. M. Magalhaes, C. K. Maguire 49013 (1960) Serro do Cipó, 1200 m, Minas Gerais, Brazil, NY & US; E. P. Heringer 5265 (1956) Serra do Cipó, Riacho da Serra, Minas Gerais, Brazil, US; J. M. Pires & G. A. Black 2721 (1951) Serra do Cipó, Minas Gerais, Brazil, US; L. B. Smith 6855 (1952) Serra do Cipó, 1200 m, Minas Gerais, Brazil, US; A. Macedo 2959 (1951) Serra do Cipó, Minas Gerais, Brazil, US; L. B. Smith & Ayensu 15988 (1972) 9 km W of Serro, Datas, Minas Gerais, Brazil, US.
- Vellozia ciliata* L. B. Smith.—L. B. Smith & Ayensu 15995 (1972) 20 km from Diamantina, Minas Gerais, Brazil, US.
- Vellozia cinerascens* Martius ex Schultes f.—Lehnkner 323 (1912) Serra de Tinga, Bahia, Brazil, NY.
- Vellozia compacta* Martius ex Schultes f.—B. Maguire, G. M. Magalhaes, C. K. Maguire 49132 (1960) 3–5 km E of Serra on road to Diamantina, Minas Gerais, Brazil, NY & US; H. S. Irwin 2407 (1959) Serra da Piedade, 5500 ft, Minas Gerais, Brazil, NY & US; L. B. Smith 7005, Brazil, US; Segadas-Vianna & Loredó 1085, Brazil, US.
- Vellozia costata* L. B. Smith & Ayensu.—H. S. Irwin et al. 20999, Brazil, NY.
- Vellozia crassicaulis* Martius ex Schultes f.—W. A. Archer 4076 (1936) Mendanha, Minas Gerais, Brazil, US; W. A. Archer 4079 (1936) Mendanha, Minas Gerais, Brazil, NY & US; H. S. Irwin, R. Souza, & R. Reis dos Santos 9975 (1965) 5 km S of Cristalina, 1175 m, Goiás, Brazil, NY & US; H. S. Irwin, R. Souza, & R. Reis dos Santos 9744 (1965) 5 km S of Cristalina, Goiás, Brazil, NY & US; H. S. Irwin, R. Souza, & R. Reis dos Santos 11699 (1966) Serra Dourada, 20 km SE of Goiás Velho, Goiás, Brazil, NY & US; H. S. Irwin, J. W. Grear, Jr., R. Souza, & R. Reis dos Santos 13377 (1966) ca. 3 km S of Cristalina, 1200 m, Goiás, Brazil, NY & US; L. B. Smith & Ayensu 15965 (1972) 1 km N of Palacios, Minas Gerais, Brazil, US.
- Vellozia crinita* Goethart & Henrard.—Glaziou 16388, Brazil, NY.
- Vellozia dasyphyllum* Seubert.—Blanchet 3538, Brazil, NY; R. de Lemos Fróes 20246 (1943) Serra de Sincorá, Baiá, Brazil, US; J. N. Rose & P. G. Russell 19697 (1915) Bahia, Brazil, US.
- Vellozia dawsonii* L. B. Smith.—H. S. Irwin, J. W. Grear, R. Souza & R. Reis dos Santos 12648 (1966) Chapada dos Veadeiros, 1000 m, Goiás, Brazil, NY & US; H. S. Irwin, J. W. Grear, Jr., R. Souza, R. Reis dos Santos 12622 (1966) Chapada dos Veadeiros, Goiás, Brazil, US.
- Vellozia declinans* Goethart & Henrard.—Hatschbach 27842, Brazil, NY.
- Vellozia dumitiana* Schultes.—Schultes & Cabrera 15050A (1952) Cerro Isibukuri, Rio Kananari, Vaupes, Colombia, US; H. Garcia-Barriga 13804 (1951) Rio Kananari y Cerro Isibukuri, Vaupes, Colombia, US.
- Vellozia echinata* Goethart & Henrard.—Riedel 1780 (1824) near Paranna, Minas Gerais, Brazil, US.
- Vellozia epidendroides* Martius ex Schultes f.—E. Pereira 2229 (1956) Espirito Santo, Forno Grande, 1700 m, Brazil, US; A. P. Duarte 4519 (1958) Serra do Cipó, Minas Gerais, Brazil, NY; B. Maguire, G. M. Magalhaes, C. K. Maguire 49060 (1960) Serra do Cipó, 1200–1300 m, Minas Gerais, Brazil, US; A. Macedo 2993 (1951) Cipó, Minas Gerais, Brazil, US; L. B. Smith 6762 (1952) Serra do Cipó, 1200 m, Minas Gerais, Brazil, US; Duarte 6537, Brazil, NY; Brade 19136, Brazil, NY; Schwacke 10321, Brazil, NY; Lima & Brade 13297A, Brazil, NY; Schwacke 8354, Brazil, NY.
- Vellozia exilis* Goethart & Henrard.—H. S. Irwin, J. W. Grear, Jr., R. Souza, & R. Reis dos Santos 12696 (1966) Chapada dos Veadeiros, 1000 m, Goiás, Brazil, US; H. S. Irwin 12692, Brazil, US; H. S. Irwin et al. 9507, Brazil, NY & US.
- Vellozia fibrosa* Goethart & Henrard.—D. Azevedo 5592 (1943) Serra do Jatobá, Minas Gerais, Brazil, US.
- Vellozia flavicans* Martius ex Schultes f.—H. S. Irwin, J. W. Grear, Jr., R. Souza, R. Reis dos Santos 12938 (1966) Chapada dos Veadeiros, Goiás, Brazil, NY & US; J. M. Pires, N. T. Silva, & R. Souza 9052 (1963) Parque do Gama, Brasília, Brazil, US; L. B. Smith 4670 (1956) Anapolis, Goiás, Brazil, US; E. P. Heringer 8162–256 (1961) Plano Piloto, Brasília, Brazil, US; A. Andrade 356—M. Emmerich 348 (1960) Cabeça do Veado, Brasília, Brazil, US; H. S. Irwin, R. Souza, R. Reis dos Santos 9379 (1965) ca. 12 km NW of Veadeiros, 1200 m, Goiás, Brazil, NY & US; H. S. Irwin, J. W. Grear, Jr., R. Souza, & R. Reis dos Santos 15520 (1966) ca. 3 km S of Sobradinho, Federal District, Brazil, NY & US; G. Gardner 4370, Brazil, US; H. S. Irwin, R. Souza, & R. Reis dos Santos 8073 (1965) Chapada da Contagem, ca. 25 km NE of Brasília, 1000 m, Federal District, Brazil, NY & US; H. S. Irwin & T. R. Soderstrom 5100 (1964) Chapada da Contagem, ca. 20 km E of Brasília, Federal District, Brazil, NY & US; H. S. Irwin, J. W. Grear, Jr., R. Souza, & R. Reis dos Santos 12574 (1966) Chapada dos Veadeiros, Goiás, Brazil, NY & US; H. S. Irwin et al. 11399, Brazil, NY & US.
- Vellozia glabra* Mikan.—B. Maguire, G. M. Magalhaes, C. K. Maguire 49048 (1960) Serra Cipó, 1200 m, Minas Gerais, Brazil, NY & US; B. Maguire, C. K. Maguire, J. M. Pires 44622 (1959) Serra Rola Moca, 4400 ft, Minas Gerais, Brazil, US; Duarte 8355—Mathos 464, Brazil, NY.
- Vellozia glandulifera* Goethart & Henrard.—L. B. Smith & Ayensu 15998, Brazil, NY.
- Vellozia glauca* Pohl.—Maguire, Maguire & Pires 44793 (1959) 6 mi before Cristalina, Goiás, Brazil, NY & US; Irwin et al. 21395 (1968) 10 km S of Guara, Goiás, Brazil, NY.
- Vellozia glochidea* Pohl.—A. P. Duarte 8340—A. Mathos 677 (1964) Goiania, Goiás, Brazil, NY; H. S. Irwin, J. W.

- Grear, Jr., R. Souza & R. Reis dos Santos 14584 (1966) Posse, Serra Geral de Goiás, Goiás, Brazil, NY & US; E. P. Heringer 10923 (1966) Serra Dourada, Goiás, Brazil, US.
- Vellozia granulata* Goethart & Henrard.—Riedel s.n. (1824) Serra da Lapa, Brazil, K; Glaziou 19934 (1892) Diamantina, Minas Gerais, Brazil, NY.
- Vellozia grisea* Goethart & Henrard.—Weddell 3006, Goyaz & Cujabo, Brazil, NY.
- Vellozia hatschbachii* L. B. Smith & Ayensu.—L. B. Smith, Ayensu & Hatschbach 16002 (1972) 33 km NE Diamantina, Minas Gerais, Brazil, US.
- Vellozia hemisphaerica* Seubert in Martius.—Blanchet 2544 (1838) Jacobina, Bahia, Brazil, NY.
- Vellozia hirsuta* Goethart & Henrard.—Hatschbach 28093, Brazil, NY; L. B. Smith, Ayensu & Hatschbach 15999 (1972) Serra do Espinhaco, Diamantina, Minas Gerais, Brazil, US.
- Vellozia hypoxoides* L. B. Smith.—Irwin et al. 34120 (1972) Serra dos Pirineus, Goiás, Brazil, US & NY.
- Vellozia incurvata* Martius ex Schultes f.—Maguire, Maguire & Pires 44752, (1959) 49 mi from Diamantina, Minas Gerais, Brazil, NY & US; Pereira 2959—Pabst 3795 (1963) Serra de Ouro Branco, Minas Gerais, Brazil, US.
- Vellozia intermedia* Seubert in Martius.—L. B. Smith 6854 (1952) Serra do Cipó, Minas Gerais, Brazil, NY & US.
- Vellozia irwinii* L. B. Smith.—Irwin, Maxwell & Wasshausen 20998, Brazil, NY.
- Vellozia lanata* Pohl.—Pires 9895 (1963) Parque do Gama, Federal District, Brazil, NY & US; Veralucia & Graziella s.n. (1968) Serra Dourado, Goiás, Brazil, NY.
- Vellozia lappa* L. B. Smith & Ayensu.—L. B. Smith & Ayensu 15988 (1972) Guinda, Diamantina, Minas Gerais, Brazil, US.
- Vellozia leptopetala* Goethart & Henrard.—Maguire et al. 49184 (1960) road between Diamantina and Gouveia, Minas Gerais, Brazil, NY & US.
- Vellozia lithophila* Schultes.—R. E. Schultes & I. Cabrera 18317 (1952) Rio Kubiýú, Cerro Kañendá, Vaupes, Colombia, US; J. Cuatrecasas 7700 (1939) San Jone del Guaviare, Rio Guaviare, Colombia, US.
- Vellozia machrisiana* L. B. Smith.—Irwin, Grear, Souza & Reis dos Santos 12454 (1966) Chapada dos Veadeiros, Goiás, Brazil, NY & US; Irwin 12697 (1966) Chapada dos Veadeiros, Goiás, Brazil, NY; Prance & Silva 58275, Brazil, NY.
- Vellozia maculata* Goethart & Henrard.—Glaziou 22218—a (1895) Cachoeiras da Vargem, Brazil, NY.
- Vellozia magdalenae* L. B. Smith & Ayensu.—Lima & Brade 13298 (1934) Alto do Desengano, 2000 m, Rio de Janeiro, Brazil, NY; Lima & Brade 14288 (1935) Serra da Furquilha, Rio de Janeiro, Brazil, NY.
- Vellozia metzgerae* L. B. Smith.—W. Egler s.n. (1947) Diamantina, Minas Gerais, Brazil, NY.
- Vellozia minima* Pohl.—Duarte 2379 (1945) Serro do Cipó, Conceição, 1250 m, Brazil, US; Maguire et al. 49099 (1960) Serra de Cipó, 1200–1300 m, Minas Gerais, Brazil, US; H. S. Irwin, H. Maxwell & D. C. Wasshausen 20630 (1968) Serro do Cipó, Minas Gerais, 1500 m, Brazil, US.
- Vellozia modesta* L. B. Smith & Ayensu.—L. B. Smith, Ayensu & Hatschbach 15997 (1972) Serra de Espinhaço, Diamantina, Minas Gerais, Brazil, US.
- Vellozia nuda* L. B. Smith & Ayensu.—Hatschbach & Pelanda 28029, Brazil, NY.
- Vellozia ornata* Martius ex Schultes f.—L. B. Smith, Ayensu & Hatschbach 16001 (1972) 33 km NE of Diamantina, Minas Gerais, Brazil, US.
- Vellozia phalocarpa* Pohl.—Anderson et al. 35855 (1972) Serra do Espinhaco, Minas Gerais, Brazil, NY & US.
- Vellozia pilosa* Goethart & Henrard.—Glaziou 19933, (1892) Diamantina, Minas Gerais, Brazil, NY.
- Vellozia piresiana* L. B. Smith.—Duarte 2068, Brazil, NY.
- Vellozia plicata* Martius.—Porto 29572, Brazil, NY; Frazão s.n., Brazil, NY; Duarte 3635—Gomes 420 (1953) Minas Gerais, Brazil, US; Lima 192, Brazil, NY; Brade 15947, Brazil, NY.
- Vellozia pumila* Goethart & Henrard.—Glaziou 22215 (1894) Goiás, Brazil, NY; H. S. Irwin, R. Souza, & R. Reis dos Santos 9428 (1965) ca. 12 km NW of Veadeiros, 1200 m, Goiás, Brazil, NY & US; H. S. Irwin, R. Souza, R. Reis dos Santos 10922 (1965) Serra dos Pirineus, 1100 m, Goiás, Brazil, NY & US; H. S. Irwin et al. 9230, Brazil, NY & US.
- Vellozia punctulata* Seubert in Martius.—Blanchet 2561, Serra Gardina, Brazil, NY.
- Vellozia resinosa* Martius ex Schultes f.—B. & C. K. Maguire & J. M. Pires 44694 (1959) Serra Cipó, 3800 ft, Minas Gerais, Brazil, NY & US.
- Vellozia riedeliana* Goethart & Henrard.—L. B. Smith & Ayensu 15983, (1972) 27 km W of Serro, Minas Gerais, Brazil, NY.
- Vellozia sellovii* Seubert in Martius.—Pereira 2677—Pabst 3513 (1957) Serra da Piedade, Minas Gerais, Brazil, US.
- Vellozia squalida* Martius ex Seubert f.—W. A. Archer & M. Barreto 4937 (1936) Serra do Cipó, Minas Gerais, Brazil, US; Duarte 6401 (1961) Serra do Cipó, Minas Gerais, Brazil, NY.
- Vellozia suallenii* L. B. Smith.—J. M. Pires, N. T. Silva, R. Souza 9712 (1936) Brasília, Brazil, US; J. M. Pires, N. T. Silva, R. Souza 9655 (1963) Brasília, Brazil, US; G. Fonjecs 11, Brazil, NY.
- Vellozia taxifolia* Martius ex Schultes f.—Ynes Mexia 4289, Brazil, US; Pereira 1290 (1955) Sta. Maria Madalena, Pedra Dubois, 1200 m, Rio de Janeiro, Brazil, NY.
- Vellozia tenella* Martius ex Schultes f.—Schwacke 6470, 6749, Brazil, NY; Pereira 2549—Pabst 3385 (1957) Caraça, Minas Gerais, Brazil, US; Damazio 91192, Brazil, NY; Damazio 91185, Brazil, NY.
- Vellozia teres* L. B. Smith & Ayensu.—Irwin, Maxwell & Wasshausen 21000, Brazil, NY.
- Vellozia tragacantha* Martius ex Schultes f.—Claussen 13, Brazil, NY; Claussen 1794, Brazil, NY; Irwin 2495 (1959) 72 km SW of Diamantina, Minas Gerais, Brazil, US.
- Vellozia triquetra* Pohl.—G. Gardner 2735, Formigas, near Minas Novas, Brazil, US.
- Vellozia tubiflora* A. Richard.—Maguire et al. 30835, Amazonas, Guayana, NY; Maguire et al. 29159, Amazonas, Guayana, NY; Maguire et al. 30941, Amazonas, Guayana, NY; Maguire et al. 29245, Amazonas, Guayana, NY; Maguire et al. 30955, Amazonas, Guayana, NY; Maguire et al. 30703, Amazonas, Guayana, NY; Maguire et al. 31003, Amazonas, Guayana, NY; Maguire et al. 31679, Amazonas,

- Guayana, NY; Maguire et al. 31777, Amazonas, Guayana, NY; Maguire et al. 32307, Amazonas, Guayana, NY; Maguire et al. 33532, Amazonas, Guayana, NY; Maguire et al. 35131, Amazonas, Guayana, NY; Maguire et al. 35136, Amazonas, Guayana, NY; Maguire et al. 35248, Amazonas, Guayana, NY; Maguire et al. 36051, Amazonas, Guayana, NY; Maguire et al. 43855, Amazonas, Guayana, NY; Maguire et al. 45918, Amazonas, Guayana, NY; E. Foldats 3526 (1960) Cerca del Puerto Ayacucho, Terr. Fed. Amazonas, Venezuela, US; L. Williams 13459 (1940) Pto. Ayacucho, Terr. Amazonas, 150 m, Venezuela, US; L. Williams 12974 (1940) Pto. Ayacucho, Terr. Fed. Amazonas, 100 m, Venezuela, US; L. Williams 16022 (1942) Sanariapo, 150 m, Venezuela, US; J. A. Steyermark & L. Aristeguieta 54 (1962) NE of Luepa, 1200 m, Venezuela, NY & US; J. A. Steyermark & S. Nilsson 554 (1960) NE of Luepa, 1200 m, Venezuela, NY & US; J. A. Steyermark 60326 (1944) forest of Rio Karuai, 1220 m, Bolivar, Venezuela, US; Tamayo 3105 (1946) Gran Sabana, Bolivar, Venezuela, US; G. H. H. Tate 1196 (1938) Mount Auyan-tepui, 1100 m, Venezuela, US; T. Lasser 1777 (1946) Guayana venezolana, Venezuela, US; J. A. Steyermark 93208 (1964) Auyan-tepui, Bolivar, Venezuela, US.
- Vellozia variabilis* Martius ex Schultes f.—B. Maguire, G. M. Magalhaes & C. K. Maguire 49262 (1960) Serro Grao Mogul, 900–1100 m, Minas Gerais, Brazil, US; H. S. Irwin, R. Souza, & R. Reis dos Santos 9809 (1965) Serra dos Cristais, Goiás, 1125 m, Brazil; L. B. Smith & Ayensu 15981 (1972) 23 km from Serro, Minas Gerais, Brazil, US; H. S. Irwin, R. Souza & R. Reis dos Santos 9915 (1965) Serra dos Cristais, Goiás, 1250 m, Brazil, US; H. S. Irwin, R. Souza & R. Reis dos Santos 11709 (1966) Serra Dourado, Goiás, 800 m, Brazil, US; H. S. Irwin, R. Souza & R. Reis dos Santos 9726 (1965) Serra dos Cristais, Goiás, 1175 m, Brazil, US; E. Pereira 2857–Pabst 3693 (1957) Minas Gerais, Brazil, US; Brade 13893, Brazil, NY; Lima 58–3003, Brazil, NY; Irwin et al. 9867, Brazil, NY.
- Vellozia verruculosa* Martius ex Schultes f.—L. O. Williams 8112 (1943) Casa Branca, 1200 m, Minas Gerais, Brazil, US.
- Vellozia virgata* Goethart & Henrard.—Schwacke 5889, Brazil, NY; Porto 543 (1915) Minas Gerais, Brazil, NY.
- Vellozia wasshausenii* L. B. Smith.—Irwin et al. 20318, Brazil, NY.
- Barbacenia blackii* L. B. Smith.—Macedo 2962 (1951) Cipó, 1600 m, Minas Gerais, Brazil, US.
- Barbacenia celiae* Maguire.—Maguire et al. 40025, Guayana, NY; Maguire et al. 40154, Guayana, NY; Maguire et al. 40298, Guayana, NY.
- Barbacenia conicostigma* Goethart & Henrard.—L. B. Smith, Ayensu & Hatschbach 15982 (1972) 27 km W of Serra, Datas, Minas Gerais, Brazil, US.
- Barbacenia delicatula*, L. B. Smith & Ayensu.—L. B. Smith, Ayensu & Hatschbach 15975 [1972] Conceição do Mato Dentro, Rio Santo Antônio, Minas Gerais, Brazil, US.
- Barbacenia exscapa* Martius.—Anderson et al. 35831 (1972) Serra do Espinheiro, Minas Gerais, Brazil, NY.
- Barbacenia flava* Martius ex Schultes f.—L. B. Smith 6856 (1959) Serra do Cipó, 1200 m, Minas Gerais, Brazil, US; B. Maguire, G. M. Magalhaes, C. K. Maguire 49116 (1960) 20 km from Conceição on road to Diamantina, Minas Gerais, Brazil, US; L. B. Smith 6695 (1952) Serra do Cipó, 1100 m, Minas Gerais, Brazil, US; R. M. & A. F. Tryon 6836 (1965) Serra do Cipó, 1120 m, Minas Gerais, Brazil, US; B. Maguire, G. M. Magalhaes & C. K. Maguire 49011 (1960) Serra do Cipó, 1200 m, Minas Gerais, Brazil, US; A. Macedo 3747 (1952) Serra do Cipó, Minas Gerais, Brazil, US; B. & C. K. Maguire & J. M. Pires 44691 (1959) Serra Cipó, 3700 ft, Minas Gerais, Brazil, US; Segadas-Vianna & Loredó 110 (1953) Serra do Cipó, Minas Gerais, Brazil, US.
- Barbacenia fragrans* Goethart & Henrard.—Dueke s.n. (1929), Brazil, NY; Widgren 1267 (1845) Minas Gerais, Brazil, US; A. F. Regnell 1239 (1867) Minas Gerais, Brazil, US.
- Barbacenia gardneri* Seubert in Martius.—Pereira 2849–Pabst 3685 (1957) Minas Gerais, Brazil, US.
- Barbacenia gaveensis* Goethart & Henrard.—L. B. Smith 6445 (1954) Pedra da Gávea, Federal District, 850 m, Brazil, US.
- Barbacenia gentianoides* Goethart & Henrard.—Segadas-Vianna & Loredó 1066 (1953) Serra do Cipó, Minas Gerais, Brazil, US.
- Barbacenia gounelleana* Beauverd.—L. Emygdio 1428 (1957) Itatisia, Rio de Janeiro, Brazil, US; E. Pereira 7050 (1962) Itatisia, Rio de Janeiro, Brazil, US.
- Barbacenia hatschbachii* L. B. Smith & Ayensu.—Hatschbach 24284, Brazil, NY.
- Barbacenia ignea* Martius ex Schultes f.—L. O. Williams & V. Assis 6817 [1945] Serro de Monjolo, Minas Gerais, Brazil, US.
- Barbacenia involucrata* L. B. Smith.—Irwin et al. 20973, Brazil, NY.
- Barbacenia irwiniana* L. B. Smith.—Porto 1140, Brazil, NY.
- Barbacenia longiflora* Martius.—H. S. Irwin 2486 (1959) 10 km N of Guida, Minas Gerais, Brazil, US; W. A. Archer 4089 (1936) between Diamantina and Guinda, Minas Gerais, Brazil, US.
- Barbacenia longiscapa* Goethart & Henrard.—Irwin et al. 22186 (1969) Serra do Espinheiro, 1370 m, Minas Gerais, Brazil, NY.
- Barbacenia luzulifolia* Martius ex Schultes f.—Pereira 2664–Pabst 3500 (1957) Serra da Piedade, 1800 m, Minas Gerais, Brazil, NY.
- Barbacenia macrantha* Lem.—Irwin, Maxwell & Wasshausen 20071, Brazil, NY.
- Barbacenia nana* L. B. Smith & Ayensu.—Smith, Ayensu & Hatschbach 15973 (1972) Conceição do Mato Dentro, Rio Santo Antônio, Minas Gerais, Brazil, US.
- Barbacenia paranaensis* L. B. Smith.—G. Hatschbach 15715 (1967) Serra dos Mulatos, Brazil, US; G. Hatschbach 29212, Brazil, US.
- Barbacenia purpurea* Hook.—A. L. Schott 151098, Brazil, US.
- Barbacenia riedeliana* Goethart & Henrard.—Anderson et al. 35123 (1972) Serra do Espinheiro, Minas Gerais, Brazil, NY; G. Hatschbach & P. Pelanda 27806 (1971) Serra do Espinheiro, Gouveia, Minas Gerais, Brazil, US.
- Barbacenia rubro-virens* Martius.—B. Maguire et al. 49177 (1960) between Diamantina and Gouveia, Minas Gerais, Brazil, US; B. Maguire et al. 49260 (1960) Serra Grao Mogul, 900–1100 m, Minas Gerais, Brazil, US.

- Barbacenia schwachei* Goethart & Henrard.—E. P. Heringer 5263 (1956) Serra do Cipó, Minas Gerais, Brazil, US.
- Barbacenia sellovii* Goethart & Henrard.—Menezes & Continho 5, Brazil, NY.
- Barbacenia seubertiana* Goethart & Henrard.—J. P. Lanna Sobro 4488 (1956) Guanabera, Tijuca, Rio de Janeiro, Brazil, US; Strang 239, Brazil, NY; Strang 523, Brazil, NY; Goethart & Henrard 4332, Brazil, NY.
- Barbacenia stenophylla* Goethart & Henrard.—Irwin, Souza & Reis dos Santos 9901 (1965) 6 km S of Cristalina, 1175 m, Serra dos Cristais, Goiás, Brazil, US.
- Barbacenia tomentosa* Martius.—H. S. Irwin, R. M. Harley & E. Onishi 29559 (1971) Serra do Espinhaço, Minas Gerais, 1650 m, Brazil, US; N. L. Menezes 1, Jardim Botânico do Rio de Janeiro, Brazil, NY.
- Barbacenia vandellii* Pohl ex Seubert in Martius.—Gardner 5224, Minas Gerais, Brazil, US.
- Barbacenia viscosissima* Goethart & Henrard.—A. Macedo 2826 (1950) 1500 m, Minas Gerais, Brazil, US.
- Barbacenia williamsii* L. B. Smith.—Pereira 2460—Pabst 3296 (1957) Serro do Curral, Minas Gerais, Brazil, US; L. W. Williams & V. Assis 6386 (1945) Serra do Curral, 1300 m, Minas Gerais, Brazil, US; Dueke s.n. (1929) Brazil, NY.

METHODS.—Apart from the few pickled materials, most of the leaf fragments upon which this study was based were obtained from herbarium specimens. The specimens were soaked in a mixture of Aerosol OT solution and distilled water (cf. Ayensu, 1967) until maximum expansion was attained. After a quick wash in tap water, free hand sections were prepared. Microscopic details were studied in glycerine mounted unstained sections as well as sections stained in safranin and Delafield's Haematoxylin. Line drawings and photomicrographs were prepared, using a Wild M20 microscope with camera lucida and photographic attachments. The scanning electron micrographs were obtained with a Cambridge Steroscan Mark 2A. The specimens were mounted on cover glass, and the stub holding the cover glass was rotated under pressure in high vacuum and coated with gold plating approximately 200–400 angstroms thick. Maximum pictorial effect was obtained by tilting the samples at a 45° angle.

CHARACTERS USED IN THE DESCRIPTIONS.—The following characters were found to be significant in the diagnosis of the species examined. (a) The epidermal cells are generally somewhat rectangular. Others are almost square shaped. (b) The stomata are generally paracytic and tend to be in longitudinal rows. They occur mostly on the abaxial surface, and in the furrows when these are present. (c) The cuticle is thin layered but often it is thicker

around stomata and on the abaxial epidermis. (d) Trichomes occur in the form of hairs which may be unicellular or multicellular; often they appear in tufts. The kinds of hair may differ in the same species either on both surfaces or on the same surface. Protrusions in furrows may be in the form of hairs or epidermal extensions. The taxonomic importance of hairs in Velloziaceae must be assessed very critically since changes in the kinds of hairs occur with age. (e) The vascular bundles are of fairly equal size in each species except those at the margins and in the midvein that tend to be small. The number of bundles varies from species to species. It is important to note that leaf sections are always taken at the same level in each case (i.e., from the midportion). (f) The number of phloem units lying along the arms of the abaxial U- or Y-shaped sclerenchyma girder is usually two in a mature leaf. In juvenile leaves the phloem units are often united. (g) The vascular bundles are surrounded by distinct bundle sheaths which extend to the abaxial and adaxial epidermis in the case of *Barbacenia* species or the sheath is connected to the translucent layers radially arranged adaxially on vascular bundles of *Vellozia* species. (h) The central and marginal bundles are associated with distinct sclerenchyma. (k) Commissural bundles are often present. The absence of them in any particular species does not necessarily mean that they are totally lacking within the leaf, for this may merely reflect their absence at the midportion of the leaf from which sections are taken for examination.

The descriptive terms which I have employed are essentially those published by Metcalfe and Gregory (1964), Ayensu (1969a), and Metcalfe (1971). In these publications several diagrammatic representations of sclerenchyma patterns in leaves of Cyperaceae and Velloziaceae were given.

CLASSIFICATION OF THE SPECIES.—In the synopsis of the American species of *Vellozia* by Smith (1962), the species were placed into two sections on the basis of the following characters:

Tepals free or obscurely short-connate above the ovary.....
Section I: *Vellozia*
 Tepals forming a distinct tube above the ovary.....
Section II: *Radia*

The species of *Barbacenia* were classified further as follows:

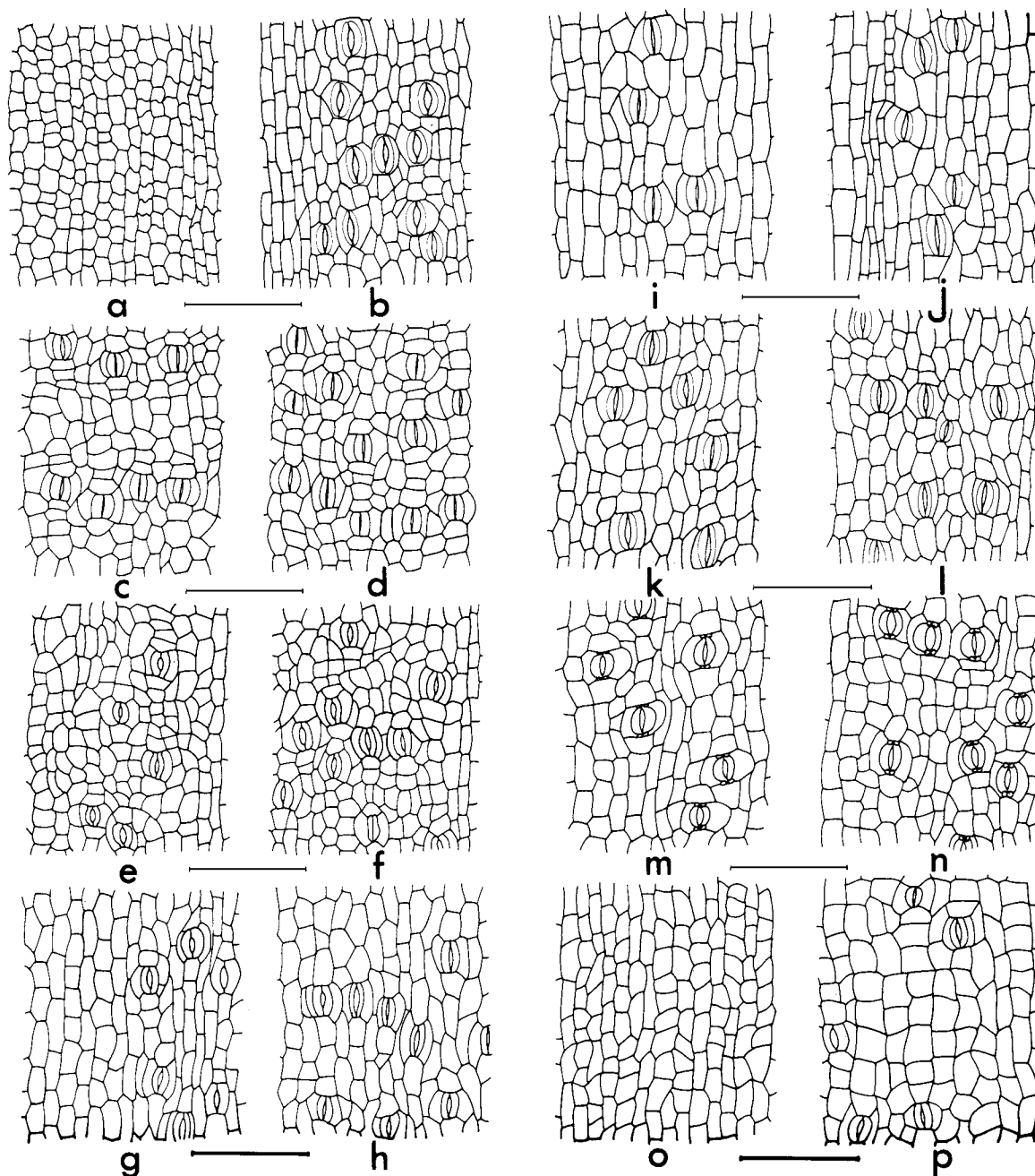


FIGURE 1.—Diagrams showing the presence of paracytic type of stomata on adaxial and abaxial surfaces of leaf epidermis: a, *Barbacenia gounelleana*, adaxial surface; b, *B. gounelleana*, abaxial surface (Pereira 7050); c, *B. flava*, adaxial surface; d, *B. flava*, abaxial surface (Maguire 49116); e, *B. vandellii*, adaxial surface; f, *B. vandellii*, abaxial surface (Gardner 5224); g, *B. conicostigma*, adaxial surface; h, *B. conicostigma*, abaxial surface (L. B. Smith and Ayensu 15982); i, *B. stenophylla*, adaxial surface; j, *B. stenophylla*, abaxial surface (Irwin et al. 9901); k, *B. involucrata*, adaxial surface; l, *B. involucrata*, abaxial surface (Irwin et al. 20973); m, *B. rubro-virens*, adaxial surface; n, *B. rubro-virens*, abaxial surface (Maguire 49177); o, *B. luzulifolia*, adaxial surface; p, *B. luzulifolia*, abaxial surface (C Pereira 2664-Pabst 3500).

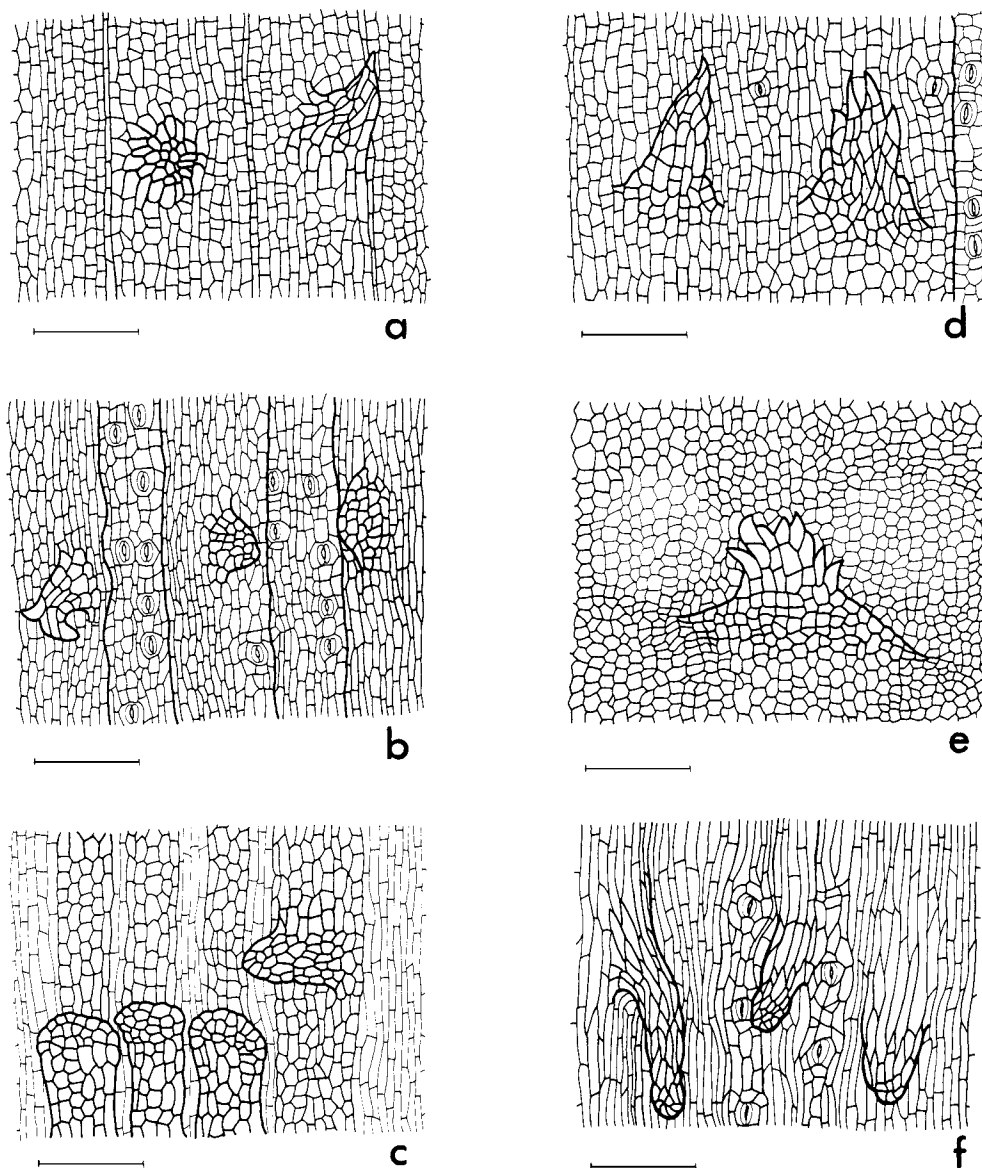


FIGURE 2.—Diagrams showing type and distribution of hairs and stomata on epidermis: a, *Vellozia bicolor* (Maguire 49047); b, *V. lithophila* (Schultes and Cabrera 18317); c, *V. glandulifera* (L. B. Smith & Ayensu 15998); d, *Barbacenia fragrans* (Dueke s.n.); e, *B. nana* (L. B. Smith and Ayensu 15973); f, *B. macrantha* (Irwin et al. 20017).

1. Perianth-tube not more than twice as long as the ovary
 2. Ovary section of the perianth partially or wholly glabrous, the costae evident (lacking in *B. beauverdii*).....Subkey I
 2. Ovary section of the perianth wholly vestite.....Subkey II
1. Perianth-tube more than twice as long as the ovary.....Subkey III

Menezes (1971b) recently proposed new combinations in Velloziaceae, including the recognition

of a new genus, *Aylthonia*. The characters upon which she based her judgment agree with those of the section *Radia* of *Vellozia* established by Smith (1962). Furthermore there seems to be some confusion regarding the meaning of the term "corona." In his description of *Vellozia* flower, Maguire (1969) used the term "staminal corona" to refer to the structure between the ovary and the anthers. Menezes on the other hand considered

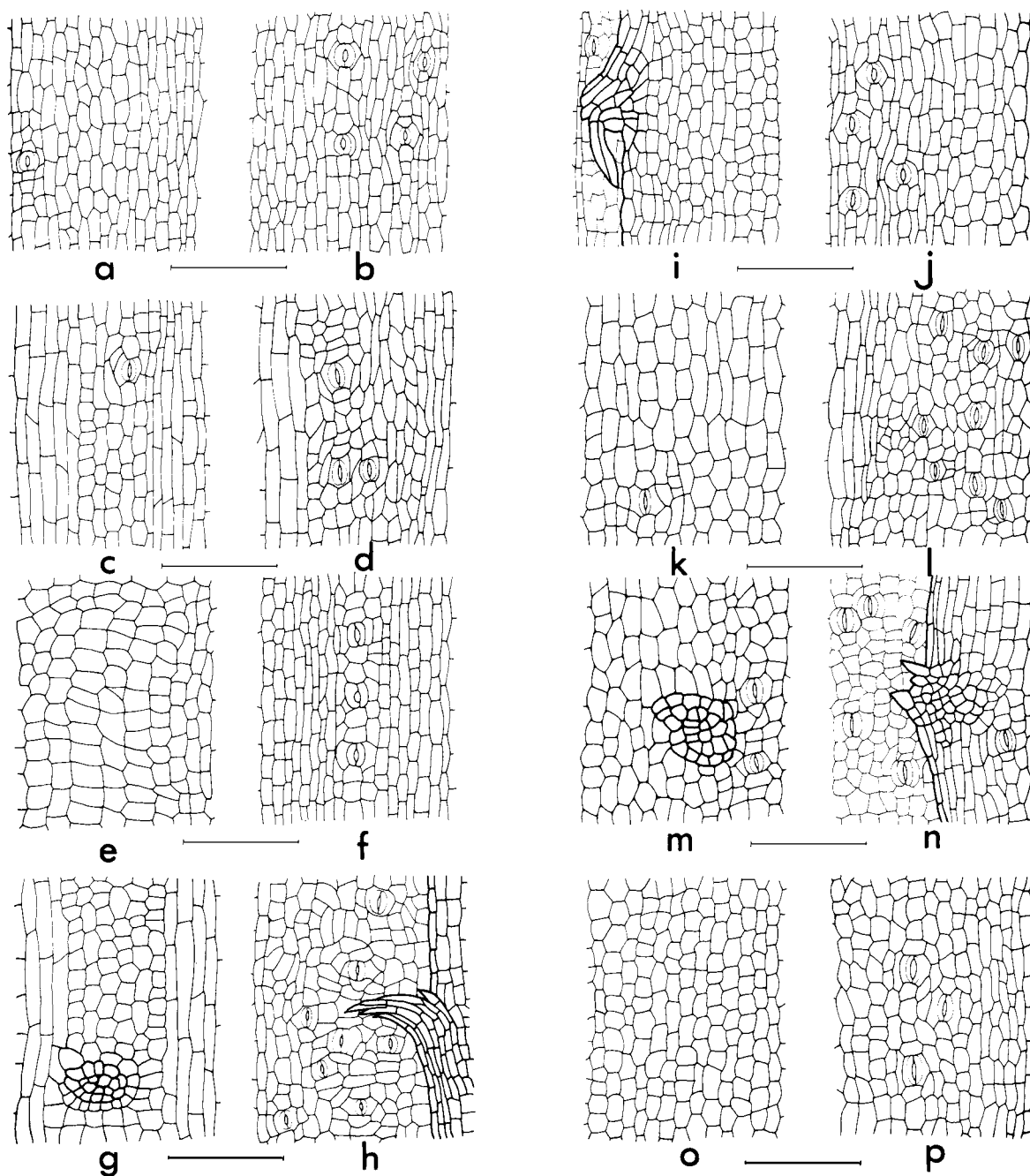


FIGURE 3.—Diagrams showing stomata, types of epidermal cells and hairs: a, *Vellozia virgata*, adaxial surface; b, *V. virgata*, abaxial surface (Porto 543); c, *V. cinerascens*, adaxial surface; d, *V. cinerascens*, abaxial surface (Lehnkner 323); e, *V. glauca*, adaxial surface; f, *V. glauca*, abaxial surface (Maguire et al. 44793); g, *V. dawsonii*, adaxial surface; h, *V. dawsonii*, abaxial surface (Irwin et al. 12622); i, *V. grisea*, adaxial surface; j, *V. grisea*, abaxial surface (Weddell 3006); k, *V. flavicans*, adaxial surface; l, *V. flavicans*, abaxial surface (Andrade 356—Emmerich 348); m, *V. cachimbensis*, adaxial surface; n, *V. cachimbensis*, abaxial surface (Pires et al. 6111); o, *V. maculata*, adaxial surface; p, *V. maculata*, abaxial surface (Glaziou 222—18A).

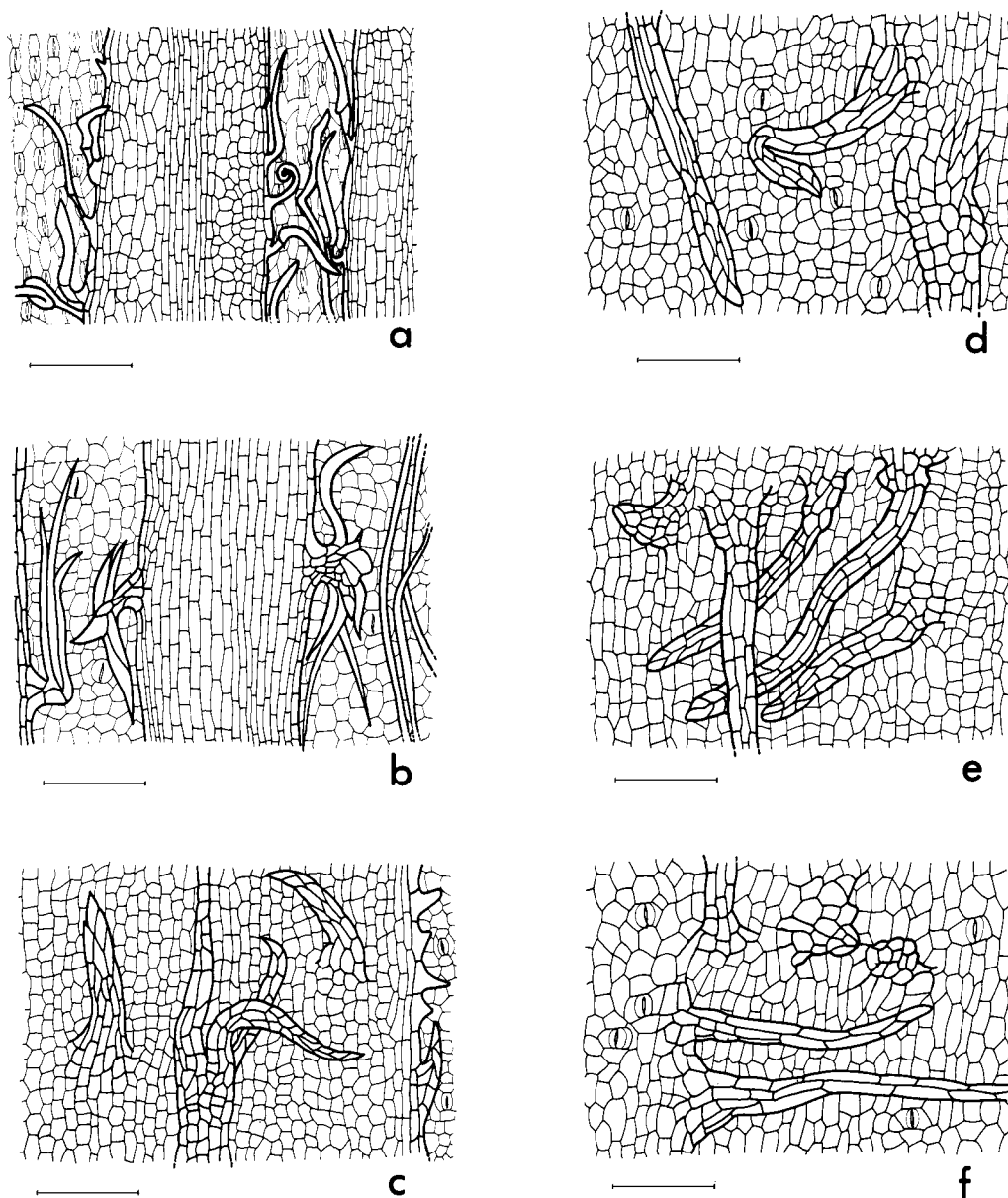


FIGURE 4.—Diagrams showing variation in hair types on epidermis: a, *Vellozia punctata* (Blanchet 2561); b, *V. grisea* (Weddell 3006); c, *V. nuda* (Hatschbach & Pelanda 2829); d, *V. hirsuta* (Hatschbach 2803); e, *V. riedeliana* (L. B. Smith and Ayensu 15983); f, *V. plicata* (Duarte 3635).

the same structure as a tissue of the perianth which mimicks dilated filaments. The study of Noher de Halac and Cococci (1971) stressed the staminal origin of this "corona" with the lateral lobes being essentially staminodes. These differences of opinion will naturally have to await detailed studies of floral morphology in the family.

For the present I have subdivided the species of the New World members according to Smith's classification. The descriptions of the species are arranged alphabetically within each section and subkey.

ACKNOWLEDGMENTS.—I wish to dedicate this contribution to Dr. Lyman B. Smith, Senior Botanist,

Smithsonian Institution, and the foremost authority on the taxonomy of Velloziaceae, on the occasion of his seventieth birthday.

I am most grateful to Ms. Cynthia Bailey, Research Assistant, for her continuous assistance in the preparation of the manuscript. Her interest and enthusiasm are much appreciated. Mr. Eduardo Barros was very helpful in the preparation of the anatomical slides upon which this work was based. Ms. Diane Robertson prepared the camera lucida drawings for which I am most grateful. My thanks are also extended to the Scanning Electron Microscope staff of the National Museum of Natural History for helping with the production of the SEM photos. I wish to thank Dr. Basset Maguire for making available to me several leaf samples from his collections and for his continuous interest in my work. I also wish to thank Dr. Thomas R. Soderstrom for reading portions of the manuscript and for making helpful comments. This study was supported in part by the Smithsonian Research Foundation.

Vellozia

Section I: *Vellozia*

Vellozia abietina Martius

FIGURE 5a-b; PLATE 24a-b

SPECIMENS EXAMINED.—Maguire et al. 49115.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial and abaxial cells rectangular, thin walled. Stomata: tetracytic, $18 \times 12 \mu\text{m}$; observed on both surfaces.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; thickly V-shaped with significant median adaxial groove. Adaxial and abaxial surfaces evenly undulating. Epidermis: cells more or less square, rounded, or rectangular; cells thin walled with thicker inner tangential walls; few individual thick-walled fibers observed subjacent to adaxial epidermis. Cuticle: uniformly thickened, slightly thinner on cells forming median adaxial groove. Stomata: walls of guard cells generally thickened; slight development of inner ledges; substomatal chamber present. Mesophyll: palisade cells almost nonexistent except for one to three layers of cells on either side of adaxial median groove; spongy

tissue making up nearly all of mesophyll. Vascular bundles: 12; commissural bundles not observed. Large veins each with a single wide vessel. Two phloem units lying laterally in short flanges of abaxial girder. Each vascular bundle always accompanied by partial adaxial girder or cap and abaxial girder. Vascular bundle completely surrounded by a distinct bundle sheath with extensions of two to four cells toward adaxial epidermis only. Crystals and tannin: not observed.

NOTE: Although this specimen has all the *Vellozia* distinguishing characters, there is a close resemblance of it to *Barbacenia* because the partial adaxial girder is almost becoming a full girder except for the adaxial bundle sheath extensions. The mesophyll is nearly all spongy.

Vellozia alata L. B. Smith

FIGURE 5c-e; PLATE 24c-e

SPECIMENS EXAMINED.—Maguire et al. 49049.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial and abaxial cells rectangular. Stomata: tetracytic, $18 \times 24 \mu\text{m}$; observed on both surfaces, especially on adaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; thinly crescentiform with upturned margins and median abaxial groove. Adaxial surface evenly ridged, especially in areas between vascular bundles; abaxial surface conspicuously furrowed about one-fourth thickness of blade. Epidermis: adaxial and abaxial cells square or rectangular, walls uniformly thickened; short rows of thick-walled fibers found subjacent to epidermis. Cuticle: thick, conspicuously ridged along entire length of lamina on both surfaces. Stomata: slightly sunken, walls of guard cells thickened with short outer ledges; substantial chamber present. Most of abaxial stomata confined to furrows. Mesophyll: adaxial palisade four to six layered, occupying about half of mesophyll and changes abruptly into abaxial spongy tissue. Cells between veins unlike rest of mesophyll, thick walled, somewhat rounded, and conspicuously translucent, resembling bundle sheath extensions. Vascular bundles: 42; commissural bundles few. Large veins each with one to three wide vessels. Two phloem units lying laterally in flanges of abaxial Y-shaped girder. Each vascular bundle always accompanied by partial ad-

FIGURES 5-24

Transverse sections of leaves of Velloziaceae showing the distribution, types of sclerenchyma girders and strands, as well as the arrangement of mesophyll tissue. The measuring unit for each species represents 100 μ m.

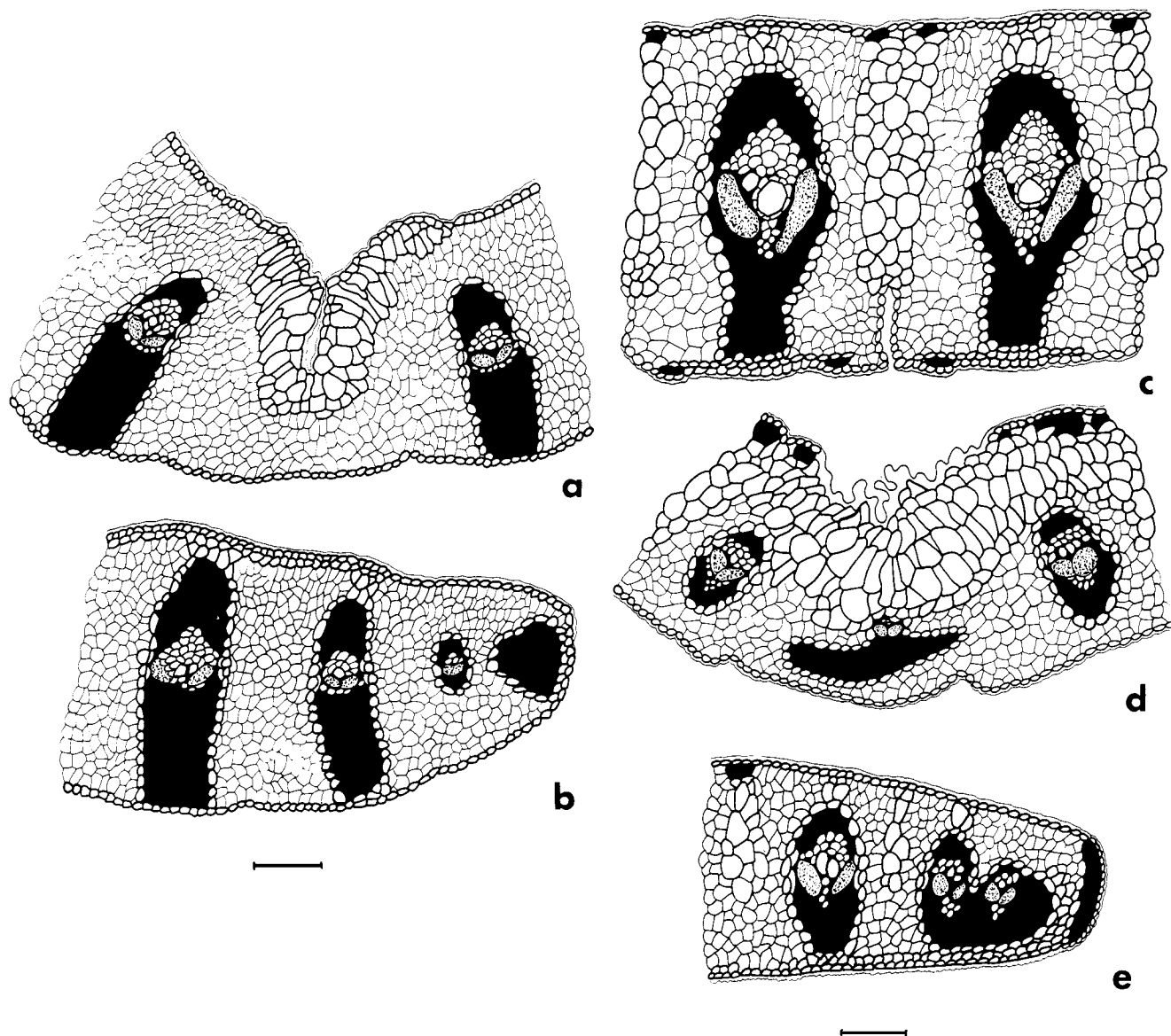


FIGURE 5.—a-b, *Vellozia abietina* (Maguire et al. 49115); c-e, *V. alata* (Maguire et al. 49049).

axial girder or cap. Abaxial girders of vascular bundles on either side of midvein and at margins often partial. Vascular bundle completely surrounded by a distinct bundle sheath with extensions of three to four cells toward adaxial epidermis only.

Crystals: not observed. Tannin: few in mesophyll.

NOTE: The distinguishing features of this species are (a) the rather wide blade with over 40 veins; (b) the two to four wide translucent cells running radially from the tip of the abaxial fur-

row to the adaxial epidermis; and (c) the raised corrugated midsection of the leaf. The furrows are conspicuously narrow, almost touching at the ends.

Vellozia aloifolia Martius

FIGURE 10a-c; PLATE 29d-f

SPECIMENS EXAMINED.—Y. Mexia 5870.

SURFACE VIEW.—Hairs: unicellular, fingerlike or club shaped. Present on abaxial surface only. Epidermis: adaxial cells uniformly cuboidal, abaxial cuboidal to rectangular and distinctly thick walled. Stomata: paracytic, $18 \times 12 \mu\text{m}$; observed on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; shallowly corrugate, and with a distinct adaxial median groove. Adaxial surface evenly to unevenly ridged; abaxial surface conspicuously furrowed about one-third to half thickness of blade. Epidermis: two to three rows of adaxial cells square to rectangular of thin walls; abaxial cells consisting of fibrous sclerenchyma except where stomata occur. Cuticle: thick, undulating, but conspicuously ridged near adaxial and abaxial median region. Stomata: present in furrows; guard cells generally thickened; substomatal chamber inconspicuous; short strands of thick-walled fibers observed subjacent to epidermis. Mesophyll: adaxial palisade four to six layered, occupying slightly more than half of mesophyll and abruptly changing into spongy tissue; upper two to three rows of palisade and those arranged radially above vascular bundles, furrows, and above midvein distinctly translucent and large; rest of palisade cells compactly arranged and filled with chloroplast. Vascular bundles: 52 commissural bundles present. Large veins each with one to two wide vessels, mostly one. Two phloem units lying laterally in flanges of abaxial Y-shaped girder. Each vascular bundle always accompanied by adaxial cap. Vascular bundle completely surrounded by a distinct bundle sheath with short extensions of two to three cells toward abaxial epidermis. Crystals and tannin: not observed.

NOTE: The fingerlike and club-shaped hairs in the abaxial furrows of this species recall a similar feature in the Old World species of *Vellozia dasyliroides* and its varieties (cf. Ayensu, 1969). The thick blade (15 mm), with over 50 veins, has a shallowly corrugate shape.

Vellozia angustifolia Goethart & Henrard

FIGURE 7d-f; PLATE 28a-e

SPECIMENS EXAMINED.—W. A. Archer, 4092; Centro Pesq. (R)01411; Riedel s.n.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial and abaxial cells mostly rectangular, thin walled. Stomata: tetracytic, $30 \times 15 \mu\text{m}$; observed on both surfaces.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; shallowly V-shaped with downturned margins and median adaxial groove. Adaxial surface evenly undulating; abaxial surface furrowed about half of blade thickness. Epidermis: cells more or less rounded or square. One or two rows of thick-walled fibers forming almost a continuous strand subjacent to epidermis. Below strand is a layer of large translucent cells separating it from mesophyll. Cuticle: thin on both surfaces. Stomata: in line with epidermis; mostly confined to abaxial surface, especially in fibrous walls; guard cells thickened with short inner and outer ledges; substomatal chamber present. Mesophyll: adaxial palisade two to four layered, occupying about half of mesophyll and gradually changing into spongy tissue; palisade cells arranged radially above vascular bundles furrows and above midvein distinctly translucent and large; rest of palisade compactly arranged and filled with chloroplast. Vascular bundles: 16–27; commissural bundles present. Large veins each with one to three wide vessels, mostly two. Two phloem units almost coalescing into one lying laterally in abaxial or slightly partial V-shaped girder. Each vascular bundle always accompanied by adaxial cap. Vascular bundle completely surrounded by a distinct bundle sheath with extensions toward adaxial epidermis and short extensions toward abaxial epidermis. Crystals and tannin: not observed.

NOTE: The one row translucent rectangular cells separating the adaxial strands of thick-walled fibers from the palisade cells is very distinctive.

Vellozia asperula Martius

FIGURE 9d-f

SPECIMENS EXAMINED.—G. Gardner 5228; Ochiouni s.n.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial and abaxial cells rectangular, thin walled. Sto-

mata: Mainly paracytic, some tetracytic, $15 \times 18 \mu\text{m}$; present mainly on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with median adaxial groove. Adaxial surface unevenly ridged; abaxial surface conspicuously furrowed, slightly more than one-third thickness of blade. Epidermis: cells more or less rectangular, some triangular, others almost rounded; intermittent rows of thick-walled fibers observed subjacent to epidermis, especially toward leaf margin. Cuticle: uniformly thickened on adaxial and abaxial surfaces but not observed in furrows. Stomata: present in furrows; guard cells thick walled; substomatal chamber inconspicuous. Mesophyll: adaxial palisade four to six layered, occupying about one-third of mesophyll and gradually changing into spongy tissue; two to four rows of distinctly translucent cells arranged radially above vascular bundles and furrows; rest of palisade compactly arranged and filled with chloroplast. Vascular bundles: 24, commissural bundles not observed. Large veins each with one to two, occasionally three, wide vessels. Two phloem units lying laterally in flanges of partial abaxial U-shaped girder. Each vascular bundle always accompanied by adaxial cap. Vascular bundles completely surrounded by a distinct thin-walled bundle sheath. Crystals and tannin: not observed.

NOTE: The partial abaxial U-shaped girder recalls those of the *Xerophyta* type described for some of the Old World species (cf. Ayensu, 1969).

Vellozia bicolor L. B. Smith

FIGURE 2a; PLATE 42a

SPECIMENS EXAMINED.—Maguire et al. 49047.

SURFACE VIEW.—Hairs: long and narrow, mostly unicellular but bicellular ones observed. Present on abaxial surface only. Epidermis: adaxial cells uniformly rectangular; abaxial cells even more rectangular, thin walled. Stomata: mainly paracytic, few tetracytic, $24 \times 18 \mu\text{m}$; observed on abaxial surface only.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with median adaxial groove. Adaxial surface unevenly undulating; abaxial surface furrowed, about one-fourth thickness of blade. Epidermis: adaxial and abaxial cells more or less rectangularly flattened, especially of adaxial cells,

walls uniformly thin walled. Discrete strands of fibers occur subjacent to adaxial epidermis, often two strands opposite each adaxial furrow, occasionally three strands observed. Directly below fiber strands and subepidermal cells is a layer of large somewhat translucent parenchyma cells separating epidermal and subepidermal cells from rest of mesophyll. Cuticle: distinctly thickened on both surfaces. Stomata: confined to furrows, almost flush with epidermis. Mesophyll: adaxial palisade three to four layered, occupying about half of mesophyll, and abruptly changing into spongy tissue; two layers of palisade cells arranged radially above vascular bundles distinctly translucent and large; rest of palisade cells compactly arranged and filled with chloroplast. Vascular bundles: 46; commissural bundles few. Large veins each with one to three wide vessels, mostly one. Two phloem units lying laterally in flanges of abaxial Y-shaped girder. Each vascular bundle always accompanied by adaxial inverted V-shaped sclerenchyma cap, both in turn completely surrounded by a distinct bundle sheath. Crystals: rhomboidal, square, and diamond-shaped present in subepidermal cells. Tannin: not observed.

NOTE: The almost woolly-like hairs and the adaxial fiber strands subjacent to the epidermis are very distinctive to this species.

Vellozia brachypoda L. B. Smith & Ayensu

PLATE 42b

SPECIMENS EXAMINED.—Irwin 23534.

SURFACE VIEW.—Hairs: absent. Epidermis: cells mostly square to rectangular on adaxial and abaxial surfaces; thin walled. Stomata: paracytic, $15 \times 9 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove. Adaxial surface ridged; abaxial surface slightly undulating; furrowed one-third to one-half thickness of blade. Epidermis: adaxial cells dome shaped to conical; abaxial cells rounded to dome shaped; walls uniformly thin on both surfaces. Layer of parenchyma cells subjacent to adaxial epidermis. Cuticle: slightly thickened and ridged on both surfaces. Stomata: present on abaxial surface; almost flush with epidermis; substomatal chamber present. Mesophyll: three- to four-layered palisade with

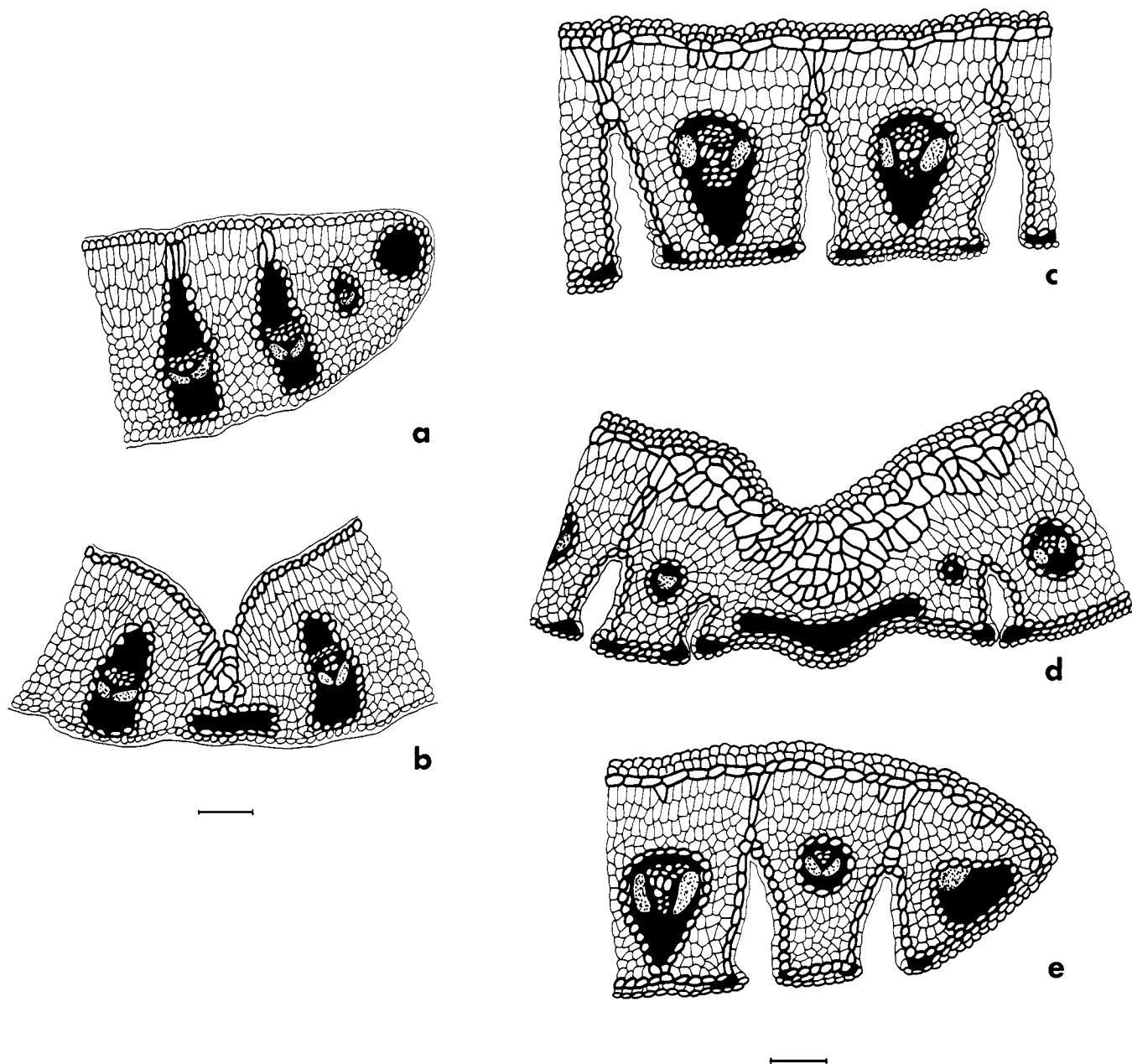


FIGURE 6.—a-b, *Vellozia tragacantha* (Irwin 2495); c-e, *V. granulata* (Riedel s.n.).

tissue grading into compactly arranged spongy tissue. Few rectangular translucent palisade cells arranged radially above vascular bundles and furrows. Vascular bundles: 27; commissural bundles not observed. Veins with one to two large vessels, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Adaxial inverted sclerenchyma cap present on each vascular bundle.

Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

Vellozia burle-marxii L. B. Smith

FIGURE 16a-c

SPECIMENS EXAMINED.—R. Burle-marx, s.n.; Irwin et al. 32520.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial and abaxial cells, rectangular, thin walled. Stomata: paracytic, $24 \times 15 \mu\text{m}$; observed on abaxial surface only.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with median adaxial groove. Adaxial surface conspicuously ridged and more or less slightly furrowed; abaxial surface distinctly furrowed. Epidermis: cells more or less rectangular; thin walled. Cuticle: uniformly thin, slightly thicker on abaxial side of median groove. Stomata: present in abaxial furrows only; slightly sunken; somewhat protected by epidermal protuberances in furrows; substomatal chamber present. Mesophyll: adaxial palisade three to four layered, occupying half of mesophyll and abruptly changing into spongy tissue; palisade cells radially arranged above vascular bundles, translucent and slightly larger than rest of cells; other palisade cells compactly arranged and filled with chloroplast. Vascular bundles: of two types, major and minor veins; major veins 19; minor veins 18. Major veins each with one to two wide vessels, mostly one; two phloem units lying laterally in flanges of abaxial Y-shaped girder; each vascular bundle always accompanied by adaxial cap; vascular bundle completely surrounded by a distinct bundle sheath. Minor veins observed at adaxial side of abaxial furrows; both adaxial and abaxial sides of vascular bundle accompanied by sclerenchyma caps. Minor veins also surrounded by a distinct bundle sheath. Crystals and tannin: not observed.

NOTE: The presence of major and minor veins in this species coupled with the bifurcations of the abaxial surfaces, especially with respect to the lateral epidermal projections, recalls the same conditions in *Vellozia hemisphaerica*.

Vellozia caruncularis Martius & Seubert

FIGURE 14a-c; PLATES 18b, 34b-d

SPECIMENS EXAMINED.—Maguire et al. 49013; Pires et al. 2721; L. B. Smith 6855; Heringer 5265; Macedo 2959.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial and abaxial cells mostly rectangular, some square cells as observed on main veins; thick walled. Stomata: paracytic, $21 \times 12 \mu\text{m}$; observed on furrows of abaxial surface only.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; inversely W-shaped with slight median adaxial groove. Adaxial surface slightly undulating; abaxial surface distinctly furrowed. Epidermis: cells more or less rectangular; abaxial cells much smaller than adaxial ones; short strands of fibers observed subadjacent to epidermis; tangentially oriented translucent parenchyma cells separating the palisade cells from subepidermal cells. Cuticle: uniformly thin but significantly thicker in the midrib region. Stomata: present on both the abaxial surface and furrows; almost flush with epidermis; those in furrows are somewhat protected by epidermal protuberances; substomatal chamber present. Mesophyll: adaxial palisade three to four layered, occupying about half of mesophyll and abruptly changing into spongy tissue; two to three large radially oriented translucent cells arranged adaxially on vascular bundles and inner limits of furrows connecting three conspicuous parenchyma cells. Palisade cells compactly arranged and filled with chloroplast. Vascular bundles: 17–20; commissural bundles few. Large veins with one to three large vessels, mostly one. Two phloem units lying laterally in flanges of abaxial Y-shaped girder. Each vascular bundle always accompanied by adaxial inverted V-shaped sclerenchyma cap; both in turn completely surrounded by a distinct bundle sheath. Crystals: not observed. Tannin: present in mesophyll.

NOTE: The five collections studied show a remarkable uniformity in leaf shape as well as in histology. This is indicative of the stability of this species.

Vellozia ciliata L. B. Smith

PLATES 5c, 36b, 49a-c

SPECIMENS EXAMINED.—L. B. Smith and Ayensu 15995.

SURFACE VIEW.—Hairs: small papillae on adaxial surface. Epidermis: adaxial cells square to rectangular; thin walled. Stomata: paracytic, $18 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove. Adaxial surface almost smooth; abaxial surface furrowed about one-third thickness of blade. Epidermis: adaxial cells square; few papillae observed on

adaxial surface. Abaxial epidermis mostly composed of sclerenchyma strands with few dome-shaped cells. Subjacent to adaxial epidermis are one to two rows sclerenchyma strands interspersed with parenchyma cells. Below sclerenchyma strands is distinct layer of parenchyma cells. Cuticle: very thin on adaxial and abaxial surfaces. Stomata: present in abaxial furrows; small substomatal chamber present. Somewhat protected by small papillae present in furrows. Mesophyll: five to six layers distinct palisade tissue changing abruptly into compact spongy tissue. Three to five layers large translucent palisade cells arranged radially above vascular bundle and furrows. Three to four layers large translucent palisade cells arranged radially above midvein; no small palisade tissue here. Vascular bundle: 37; few commissural bundles present. One large vessel present in each vascular bundle. Two phloem units laterally arranged in flanges of Y-shaped abaxial girder. Adaxial cap present on each vascular bundle. Abaxial sclerenchyma strands only present on epidermal layer. Bundle sheath completely surrounding vascular bundle. Crystals and tannins: none observed.

Vellozia cinerascens Martius ex Schultes f.

FIGURE 3c-d; PLATES 4c-d, 42c

SPECIMENS EXAMINED.—Lehnkner 323.

SURFACE VIEW.—Hairs: present in clusters. Epidermis: adaxial cells rectangular; abaxial cells mostly square, few rounded or rectangular; cell walls thin on both surfaces. Stomata: paracytic, $18 \times 6 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; flanged V-shaped. Adaxial surface deeply ridged; abaxial surface furrowed about one-third the thickness of blade. Epidermis: adaxial cells dome shaped to conical; interspersed with large strands of sclerenchyma positioned above vascular bundles and furrows. Abaxial cells rounded to dome shaped, thin walled; inner to cells lined with rectangular strands of sclerenchyma, leaving about one-half of furrows uncovered. Cuticle: thin and ridged on both adaxial and abaxial surfaces. Stomata: present in abaxial furrows and spaces between sclerenchyma strands; substomatal chamber present. Mesophyll: two to three layers palisade, grading into loosely compact spongy tissue. Translucent palisade

radially arranged above vascular bundles. Vascular bundle: 39; commissural bundles not observed. One to two large vessels present in vascular bundles. Two phloem units laterally arranged in flanges of U-shaped abaxial girder. Each bundle always accompanied by an adaxial cap and an abaxial U-shaped sclerenchyma vascular bundle completely surrounded by a bundle sheath. Crystals and tannins: none observed.

NOTE: The arrangement and disposition of adaxial and abaxial sclerenchyma strands are very distinctive for this species.

Vellozia compacta Martius ex Schultes f.

FIGURE 7a-c; PLATE 25b-f

SPECIMEN EXAMINED.—Irwin 2407; Maguire et al. 49132; Segades-Vianna & Loredó 1085; L. B. Smith 7005.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial and abaxial cells mostly rectangular but often square shaped, thin walled. Stomata: tetracytic, $24 \times 15 \mu\text{m}$; present on both surfaces but highly concentrated on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; shallowly V-shaped with slight median adaxial groove. Adaxial surface undulating; abaxial surface furrowed about half blade thickness. Epidermis: cells more or less rounded, abaxial cells square shaped. Subjacent to adaxial epidermis occur one to three layers of parenchyma cells accentuated by short strands of sclerenchyma. Below sclerenchyma strands and subjacent parenchyma cells are one to two layers of large translucent cells separating it from mesophyll. Cuticle: thickened on both surfaces. Stomata: mostly confined to furrows in abaxial surface; substomatal chamber inconspicuous. Mesophyll: adaxial palisade three to four layered, occupying about one-third of mesophyll and gradually changing into spongy tissue; three to four rows of large translucent cells arranged radially above vascular bundles and furrows. Palisade cells and spongy mesophyll compactly arranged and filled with chloroplast. Vascular bundles: 49–59; commissural bundles present. Large veins each with three or more wide vessels. Two phloem units lying laterally in flanges of abaxial Y-shaped girder. Each vascular bundle always accompanied by adaxial inverted V-shaped scleren-

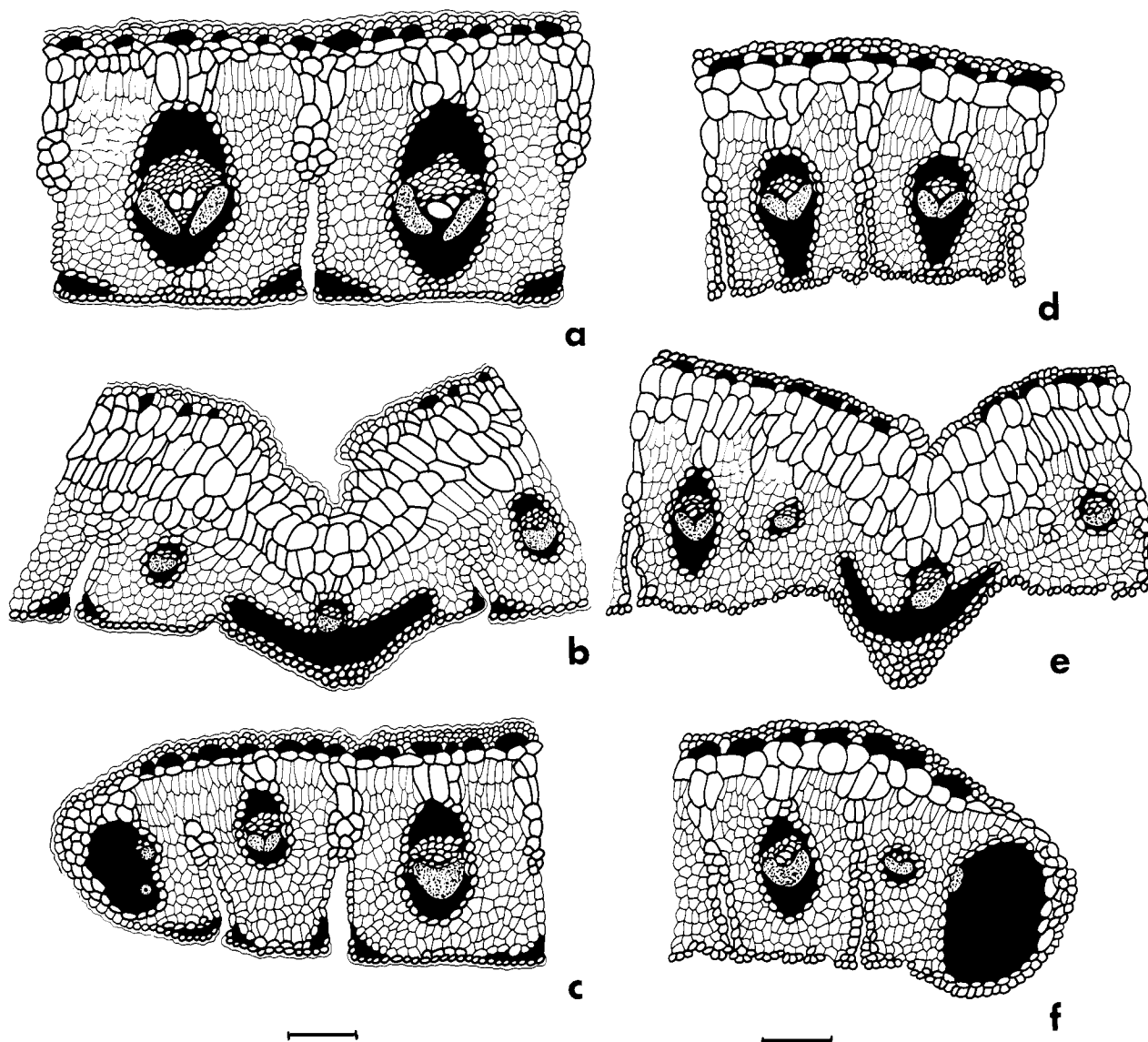


FIGURE 7.—a-c, *Vellozia compacta* (Irwin 2407); d-f, *V. angustifolia* (Riedel s.n.).

chyma cap; both in turn completely surrounded by a distinct bundle sheath. Crystals not observed. Tannin: few in mesophyll.

NOTE: There are clear variations in the sclerenchyma patterns in the species examined. The adaxial sclerenchyma shapes range from strictly cap shaped to partial girder. The same is true of abaxial sclerenchyma where some are distinctly Y-shaped and others are somewhat partial.

Vellozia costata L. B. Smith & Ayensu

PLATE 36c

SPECIMEN EXAMINED.—Irwin et al. 20999.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial and abaxial cells rectangular, thick walled; occasional rows of square cells observed. Stomata: paracytic, $30 \times 9 \mu\text{m}$; present mainly on abaxial surface, few on adaxial side.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with slight median adaxial groove. Adaxial surface undulated, especially that of the right flange of V. Abaxial surface with deep furrows in which stomata are present. Epidermis: consisting of very thick outer walls except where stomata occur. Cuticle: uniformly thickened, slightly thicker around stomata. Almost continuous row of fibrous sclerenchyma occur immediately below the abaxial epidermis. Discrete clusters of fibers observed subjacent to adaxial epidermis. A single row of large cells of unequal shape, containing tanniferous deposits, occurs subjacent to adaxial and abaxial rows of fibers. Mesophyll: adaxial palisade five to seven layered, occupying half of mesophyll and gradually changing into spongy tissue. Abaxial palisade two to three layered, not highly differentiated from spongy mesophyll. One to three layers of thin-walled parenchymatous cells devoid of chloroplast occur in radial rows on adaxial side of vascular bundles and furrows. Vascular bundles: 22–24; connected commissural bundles occasionally observed. Main veins each with one to three wide vessels, mostly two. Two phloem units lying laterally in flanges of abaxial partial girder. Each vascular bundle always accompanied by an adaxial cap and an abaxial V-shaped partial girder. Crystals and tannins: not observed.

***Vellozia crassicaulis* Martius ex Schultes f.**

FIGURE 12d–f; PLATES 11a–b, 32c–g, 33a

SPECIMENS EXAMINED.—Archer 4079, 4076; Irwin 9591, 9744, 9975, 10906, 11699, 13377.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial and abaxial cells mostly rectangular. Stomata: paracytic, $18 \times 12 \mu\text{m}$; observed on both surfaces.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with median adaxial groove; occasionally abaxially two grooved. Adaxial surface evenly undulating; abaxial surface furrowed about one-half to two-thirds thickness of blade. Epidermis: cells more or less rectangularly flattened, especially adaxial cells; abaxial slightly larger than adaxial cells; walls uniformly thin walled. Distinct baculiform sclerenchyma strands, separated from each other by one radial row of parenchyma, occur subjacent to adaxial epidermis. Cuticle: uniformly thin, slightly thicker around margins and median

abaxial surface. Stomata: present in abaxial furrows, few on adaxial surface. Mesophyll: adaxial palisade three layered, occupying about half of mesophyll; palisade separated from adaxial sclerenchyma strands by one layer of distinct translucent parenchyma cells; two to three radially oriented large translucent cells arranged adaxially on vascular bundles. Palisade cells compactly arranged and filled with chloroplast; spongy mesophyll loosely arranged. Vascular bundles: 24–40; 17 in Archer 4076; commissural bundles few. Large veins each with one large vessel, occasionally two. Two phloem units lying laterally in flanges of abaxial V- or Y-shaped girder. Each vascular bundle always accompanied by adaxial inverted V-shaped sclerenchyma cap; both in turn completely surrounded by a distinct bundle sheath. Crystals: not observed. Tannin: few in mesophyll.

NOTE: All the specimens investigated share anatomical and histological characteristics except for size of leaf blade. However, one specimen (Archer 4079) differs slightly from the others in that, whereas the furrows are almost 90° from the abaxial surface, Dr. Archer's specimen is thinly crescentiform on the abaxial surface from one furrow to the other. Furthermore, the specimen exhibits almost solid subjacent sclerenchyma band under the abaxial epidermis. Dr. Archer's specimen has sclerenchyma strands confined to the corners of the furrow gates. Another specimen (Irwin et al. 10906) lacks the distinctive abaxial furrows and the sclerenchyma strands which seems to distinguish this species.

***Vellozia crinita* Goethart & Henrard**

PLATE 42d

SPECIMENS EXAMINED.—Glaziou 16388.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial cells square to rectangular, few rounded; thin walled. Abaxial cells rectangular; thin walled. Stomata: paracytic, $21 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with margins curved slightly inversely but not flanged; small median adaxial groove. Adaxial surface slightly undulating; abaxial surface furrowed about one-half thickness of blade. Epidermis: adaxial cells rounded to rectangular;

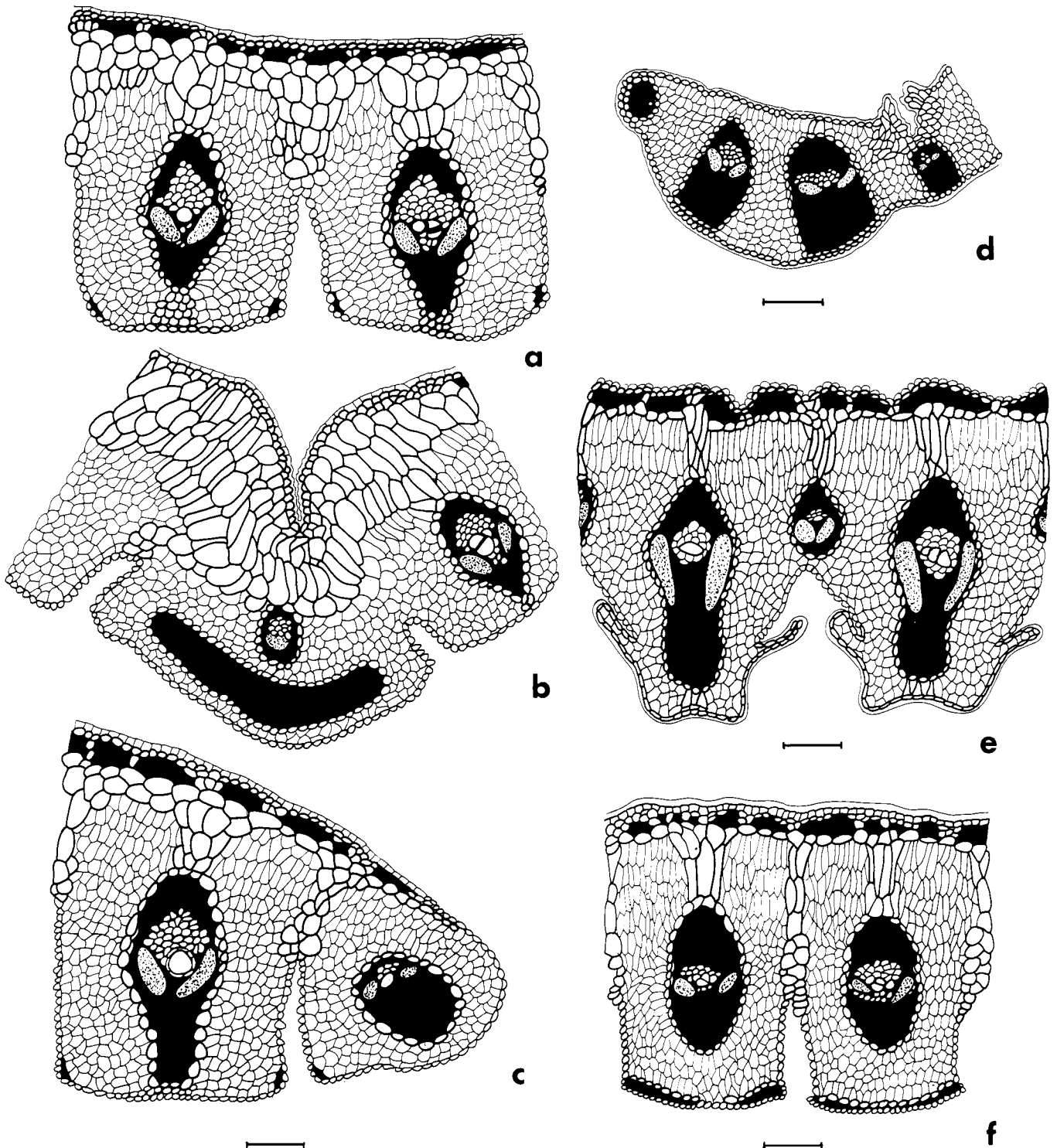


FIGURE 8.—a-c, *Vellozia resinosa* (Maguire et al. 44694); d, *V. minima* (Maguire et al. 49099); e, *V. hemisphaerica* (Blanchet 2544); f, *V. taxifolia* (Mexia 4289).

abaxial cells more rounded to conical; thin walled on both surfaces. Two to three layers parenchyma cells subjacent to adaxial epidermis and interspersed with sclerenchyma strands. Cuticle: very thin on adaxial and abaxial surfaces. Stomata: present on abaxial surface and in abaxial furrows. Substomatal chamber present: stomata almost flush with surface. Mesophyll: three to four layers palisade cells; not distinctive; blending right into compact spongy tissue. Row of large translucent palisade cells arranged radially above vascular bundles and furrows. Vascular bundle: 34; no commissural bundles observed. Veins with a single large vessel. Two phloem units lying in flanges of Y-shaped abaxial girder; girder extends almost to abaxial epidermis. Cap or partial adaxial girder occurs on each vascular bundle. Bundle sheath completely surrounding each vascular bundle; adjacent to epidermis on abaxial surface. Epidermal extensions present in furrows. Few abaxial sclerenchyma strands observed on lower edge of furrows. Crystals: none observed. Tannins: few present.

Vellozia dasypus Seubert

FIGURE 13c-e; PLATES 16a, 33d-h, 34a

SPECIMENS EXAMINED.—Belém and Pinheiro 3179; R. de Lemos Froes 20246; Rose and Russell 19697; Blanchet 3558.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial and abaxial cells mostly of square cells, occasionally rectangular cells are observed. Stomata: paracytic, $24 \times 12 \mu\text{m}$; occur on both surfaces especially in furrows of abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped to nearly inversely W-shaped with median adaxial groove. Adaxial surface ridged; abaxial surface furrowed about one-fifth to one-seventh of blade thickness. Epidermis: cells more or less square; abaxial cells almost replaced by fibers except in furrows. Distinct cuboidal sclerenchyma strands, separated from each other by three to four radial rows of parenchyma, occur subjacent to adaxial epidermis. Cuticle: uniformly thickened. Stomata: present on both surfaces, particularly in abaxial furrows. Mesophyll: adaxial palisade two to three layered; palisade separated from adaxial sclerenchyma strands by one layer of distinct trans-

lucent parenchyma cells; two to five radially oriented large translucent cells arranged adaxially on vascular bundles. Palisade cells compactly arranged and filled with chloroplast; palisade occupying about one-third of mesophyll and abruptly changing into almost tiered spongy cells. Vascular bundles: 27–33; commissural bundles present. Large veins each with one to two large vessels, mostly one. Two phloem units lying laterally in flanges of abaxial Y-shaped girder. Each vascular bundle always accompanied by adaxial inverted V-shaped sclerenchyma cap; both in turn completely surrounded by a distinct bundle sheath. Crystals: not observed. Tannin: present but few in mesophyll.

NOTE: The four specimens under study share similar histological details except that the median abaxial surface in one (R. de Lemos Froes 20246) is much broader than the others, and the adaxial inverted V-shaped sclerenchyma in one of the four specimens (Russell 19697) is much more pronounced, especially at the middle of the intercostal region.

Vellozia declinans Goethart & Henrard

PLATE 36d

SPECIMENS EXAMINED.—Hatschbach 27842.

SURFACE VIEW.—Hairs: few small papillae, appearing in tufts on adaxial surface. Epidermis: adaxial and abaxial cells square to rectangular; thin walled. Stomata: $18 \times 6 \mu\text{m}$; tetracytic; mostly present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped, with median adaxial groove; turned slightly inversely at margins. Adaxial surface almost smooth; abaxial surface furrowed one-half thickness of blade. Epidermis: adaxial cells square; abaxial cells dome shaped to conical. Walls thin on abaxial and adaxial surfaces. Subjacent to adaxial epidermis occur two to three layers of sclerenchyma strands interspersed with rows of parenchyma cells of two to three layers. Below sclerenchyma strands is a distinct layer of parenchyma cells. Cuticle: very thin and ridged on both surfaces. Stomata: present mainly in abaxial furrows; small substomatal chamber present. Mesophyll: four to five layers of palisade tissue grading into compact spongy tissue. Two to four layers of

large translucent palisade cells arranged radially above vascular bundle and on furrows. Vascular bundle: 16; few commissural bundles present. Two to three large vessels present in each vascular bundle. Two phloem units lying laterally in flanges of U-shaped partial abaxial girder. Adaxial cap present on each vascular bundle. Distinct bundle sheath completely surrounding each vascular bundle. Two to three layers of sclerenchyma cells subjacent to abaxial epidermis; some sclerenchyma present in furrowed area. Crystals: none observed. Tannins: few present.

NOTE: The partial abaxial girder recalls the *Xerophyta* type of sclerenchyma pattern.

Vellozia echinata Goethart & Henrard

PLATE 36e

SPECIMENS EXAMINED.—Riedel 1780.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial cells rounded, square to rectangular; abaxial cells rounded. Walls thin on both surfaces. Stomata: paracytic, $15 \times 3 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped. Adaxial surface slightly undulating; abaxial surface furrowed almost three-fourths thickness of blade. Epidermis: cells on adaxial surface mostly rectangular, some rounded and crescent shaped; thin walled. Cells on abaxial surface rounded to conical, few rectangular; thin walled. Cells in furrows with fingerlike projections, subjacent to adaxial epidermis is a layer of parenchyma cells interspersed with sclerenchyma strands. Below parenchyma cells and sclerenchyma strands is distinct layer of large parenchyma cells. Cuticle: very thin and slightly ridged on adaxial and abaxial surfaces. Stomata: present in abaxial furrows, substomatal chamber virtually absent. Mesophyll: three distinct layers palisade tissue present; three layers of large translucent cells positioned radially above furrows and vascular bundles. Large palisade cells also arranged above midvein. Palisade changing abruptly into loosely spongy tissue; some large spongy tissue present. Vascular bundles: 25; commissural bundles not observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder; sometimes partial girders observed. Small adaxial cap present on each vascular

bundle. Bundle sheath completely surrounding each vascular bundle. No abaxial sclerenchyma strands or layers observed. Crystals: none observed. Tannins: present.

NOTE: This species is distinct in that the abaxial furrows are exceptionally deep with its upper limit even higher than the adaxial sclerenchyma cap.

Vellozia epidendroides Martius ex Schultes f.

FIGURE 9a-c; PLATE 31b-d

SPECIMENS EXAMINED.—Achwake 19321; Brade 19136; Duarte 6537; Lima and Brade 13297A; Macedo 2993; Pereira 2229; Maguire et al. 49060; Schwake 8354; L. B. Smith 6762; Duarte 4519.

SURFACE VIEW.—Hairs: few present. Epidermis: adaxial and abaxial cells mainly cuboidal with few rows of rectangular cells; cell walls thin. Stomata: paracytic, $21 \times 14 \mu\text{m}$; observed on abaxial side only.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with shallow median adaxial groove; margins of lamina turned inversely. Adaxial surface slightly undulating; occasionally somewhat ridged; abaxial surface furrowed one-fifth to one-half thickness of blade. Epidermis: adaxial cells more or less dome shaped, interspersed with conical cells; abaxial cells mainly rounded; cells thin walled. Subjacent to adaxial epidermis occur one to three layers of sclerenchyma bands interspersed with parenchyma cells. Below is one conspicuous layer of parenchyma cells. Subjacent to abaxial epidermis occurs a layer or two, sometimes strands of sclerenchyma. Cuticle: thick on abaxial and adaxial surfaces; smooth. Stomata: present in abaxial furrows; somewhat associated with epidermal protuberances. Mesophyll: adaxial palisade cells one to two layers, gradually changing into spongy tissue; spongy tissue compactly arranged. One to two layers of large translucent palisade cells arranged radially above vascular bundles and furrows; of some specimens quite numerous in midvein region. Vascular bundles: 10 to 27; no commissural bundles observed. Each vein large with one to three wide vessels. Two phloem units lying laterally in flanges of abaxial Y-shaped partial girder. Each vascular bundle accompanied by adaxial cap, sometimes much larger than abaxial girder. Vascular bundle

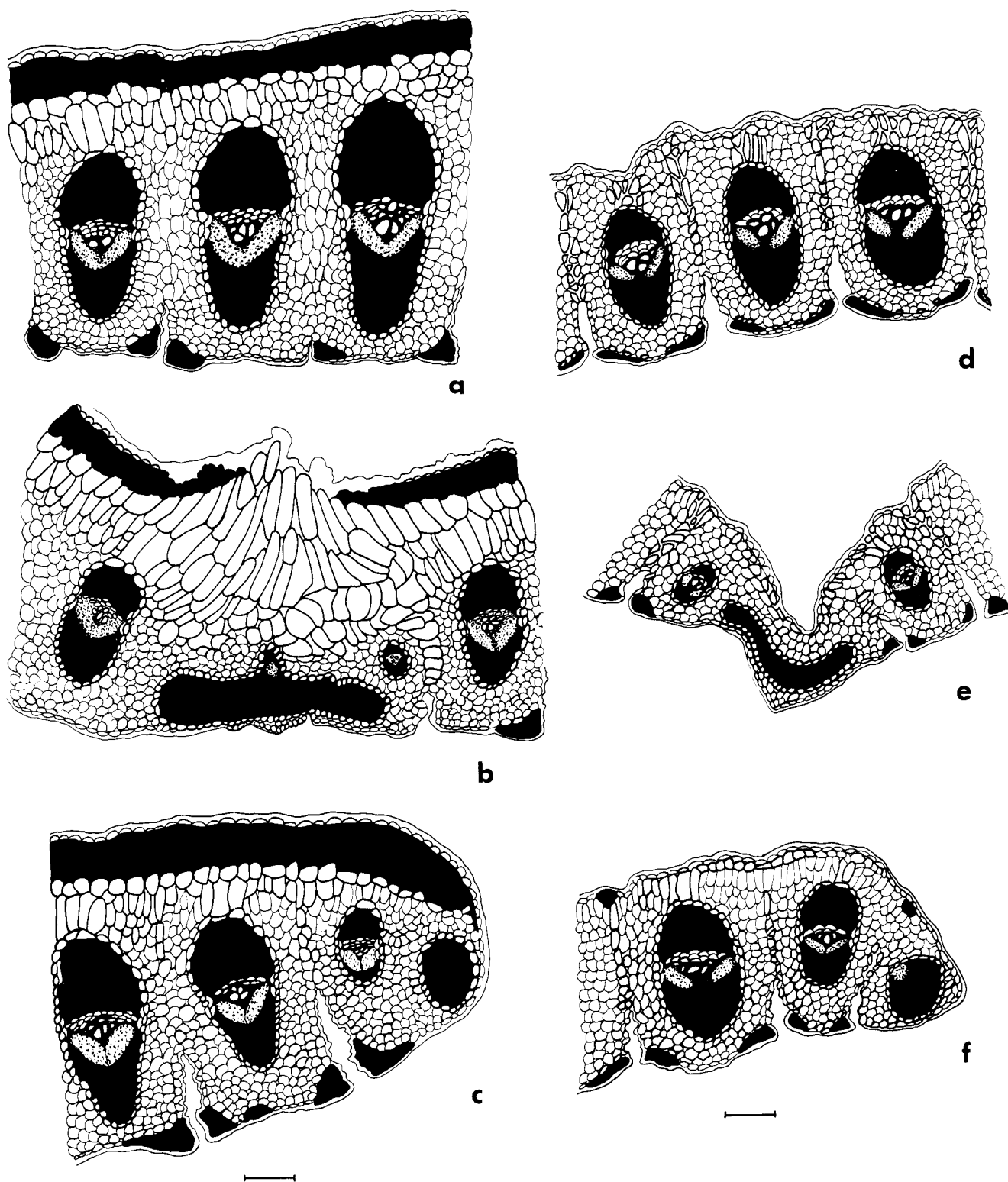


FIGURE 9.—a-c, *Vellozia epidendroides* (L. B. Smith 6762); d-f, *V. asperula* (Gardner 5228).

completely surrounded by distinct bundle sheath. Crystals and tannins: not observed.

NOTE: Notwithstanding the general uniformity of the specimens examined, there are certain variations in the depth of the furrows, the shape of the abaxial portions of the midveins (some are pointed, others are flattened), and the shape of the margins. These modifications may constitute varietal characteristics.

Vellozia exilis Goethart & Henrard

FIGURE 14d-e; PLATE 34e-f

SPECIMENS EXAMINED.—Goethart and Henrard 12696; Irwin 12692; Irwin et al. 9507.

SURFACE VIEW.—Hairs: few and in tufts. Epidermis: cells rectangular on abaxial and adaxial surfaces; walls thin on both surfaces. Stomata: paracytic, $18 \times 3 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with flanges inversely inrolled; abaxial median section laterally extended on both sides. Adaxial surface slightly undulating, occasionally ridged toward median of lamina; abaxial surface furrowed about one-fourth thickness of blade. Epidermis: adaxial cells more or less dome shaped; abaxial cells dome shaped to conical; cells thin walled. Subjacent to adaxial epidermis occur three to six layers of sclerenchyma cells interspersed with radial rows of two to four parenchyma cells; subjacent to sclerenchyma and radial rows of parenchyma cells is one layer of distinct parenchyma cells. Cuticle: thick on adaxial surface; thin on abaxial surface; slightly ridged. Stomata: present in abaxial furrows; small substomatal chamber present; associated with short epidermal projections in furrows. Mesophyll: two to three distinct layers of palisade tissue abruptly changing into compactly arranged spongy tissue. One to two layers of large translucent cells arranged radially above vascular bundles. Vascular bundles: 9; no commissural bundles observed. One to two large vessels present, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Adaxial cap more or less inverted V shaped. Lateral extensions formed on either side of median abaxial vein have compactly arranged spongy mesophyll and a broad band of sclerenchyma cells. Bundle sheath completely surrounding vascular

bundles. Abaxial strands present. Crystals and tannins: not observed.

NOTE: The leaf shape of this species is very distinctive in the Velloziaceae, thus rendering its identification simple.

Vellozia fibrosa Goethart & Henrard

PLATES 17b, 26d-f

SPECIMENS EXAMINED.—Azevedo 5592.

SURFACE VIEW.—Hairs: few papillae present. Epidermis: cells square to rectangular, thin walled. Stomata: tetracytic, $12 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove; margins turned inversely, flanged. Adaxial surface very slightly undulating; abaxial surface furrowed one-half thickness of blade. Epidermis: cells more or less square, rounded or rectangular; walls slightly thick, especially on inner tangential wall. Subjacent to adaxial epidermis is one to two layers of thick-walled parenchyma cells interspersed with sclerenchyma strands; below parenchyma and sclerenchyma is a layer of translucent parenchyma cells. Cuticle: adaxial surface thicker than abaxial; both slightly ridged. Stomata: present in furrows and on abaxial surface. Substomatal chamber virtually absent. Mesophyll: one to three layers of distinct palisade tissue changing into compact spongy tissue; one to three layers of large translucent palisade cells arranged radially above vascular bundles and furrows. Vascular bundles: 16; commissural bundles not observed. Veins with one to two large vessels, mostly one. Two phloem units lying laterally in flanges of U-shaped partial abaxial girder. Each vascular bundle accompanied by an adaxial cap. Vascular bundle completely surrounded by bundle sheath. Abaxial strands present at open ends of furrows. Crystals: not observed. Tannins: few present.

NOTE: The presence of partial abaxial girders recalls the *Xerophyta* type of sclerenchyma encountered in Madagascar species of this family.

Vellozia flavicans Martius ex Schultes f.

FIGURES 3k-l, 11a-c; PLATE 31e-g

SPECIMENS EXAMINED.—Andrade 356-Emmerich 348; Heringer 8126-256; Irwin et al. 8073, 9379,

12574; Irwin et al. 11399; Gardner 4370; L. B. Smith 4670; Irwin et al. 12938; Irwin et al. 15520; Irwin and Soderstrom 5100; Pires et al. 9052.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial and abaxial cells rectangular; thin walled. Stomata: paracytic, $21 \times 18 \mu\text{m}$; present mainly on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove. Adaxial surface undulating; abaxial surface furrowed about one-fourth to one-third thickness of blade, occasionally up to one-half (c.f. Irwin et al. 15520). Epidermis: adaxial and abaxial cells rounded to rectangular; walls uniformly thickened. Subjacent to epidermis occur three to four layers of sclerenchyma strands interspersed with three to four rows of translucent parenchyma. Below sclerenchyma strands and parenchyma cells is a distinct layer of translucent cells. Cuticle: thick on abaxial and adaxial surfaces; extends partially into furrows; ridged on abaxial surface. Stomata: present mainly in abaxial furrows, occasionally few occur on adaxial surface; almost flush with surface; small substomatal chamber present. Mesophyll: palisade cells of four to five layers; large translucent cells arranged radially above vascular bundles. Spongy tissue compactly arranged, some cells somewhat translucent. Vascular bundles: 18 to 42; few commissural bundles observed and occasional fused bundles seen (c.f. Gardner 4370). One to two large vessels in each vein, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Adaxial cap occurs on each vascular bundle. Abaxial strands or layers present. Distinct bundle sheath completely surrounds vascular bundles. Crystals: none observed. Tannins: some present.

NOTE: All the specimens studied show that the large translucent cells occur only on vascular bundles, only and not above the furrows as well. This species is quite distinct, even at different stages of leaf development.

Vellozia glabra Mikan

PLATES 24f–g, 25a

SPECIMENS EXAMINED.—Maguire et al. 44622; Maguire et al. 49048; Duarte 8355—Mathos 464.

SURFACE VIEW.—Hairs: on abaxial furrows. Epidermis: cells square to rectangular; thin walled.

Stomata: paracytic, $21 \times 12 \mu\text{m}$; present mainly on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with very small median adaxial groove; very slight inversion at margins. Adaxial surface almost smooth; abaxial surface furrowed about one-half thickness of blade. Epidermis: adaxial and abaxial cells square to rectangular; walls thicker on inner tangential side. Subjacent to epidermis occur two to three layers of parenchyma cells interspersed with one to two layers of sclerenchyma strands. Below parenchyma and sclerenchyma layers is a distinct layer of large translucent parenchyma cells. Cuticle: slightly thicker on adaxial side; slightly ridged on both surfaces. Stomata: present in furrows and on abaxial surface; small substomatal chamber present; protected by hairs in furrows. Mesophyll: definite palisade tissue of three layers abruptly changing into compact spongy tissue; two to three layers of translucent palisade cells arranged radially above vascular bundles and furrows. Three distinct layers of large translucent palisade cells in midvein region. Vascular bundles: 16–46; no commissural bundles observed. One to two large vessels in each vascular bundle, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Each vascular bundle has an adaxial cap. Some sclerenchyma strands occur between abaxial epidermis and abaxial parenchyma layer. Bundle sheath completely surrounds each vascular bundle; few large translucent cells may appear at abaxial end of vascular bundle. Abaxial furrows contain many epidermal extensions. Crystals: none observed. Tannins: few present.

Vellozia glandulifera Goethart & Henrard

FIGURE 2c; PLATES 1c–d, 36f

SPECIMENS EXAMINED.—L. B. Smith and Ayensu 15998.

SURFACE VIEW.—Hairs: multiseriate, present on adaxial surface in clumps, consisting of small fingerlike projections; abaxial surface hairs long and fairly thin. Epidermis: adaxial cells mostly square; thin walled. Abaxial cells square to rectangular, few almost rounded; thin walled. Stomata: paracytic, $24 \times 15 \mu\text{m}$; present on abaxial surface, few on adaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove; turned slightly inversely at margins. Very slightly undulating on adaxial surface; abaxial surface furrowed one-half thickness of blade. Epidermis: adaxial cells square; abaxial cells slightly rounded. Walls thin on abaxial and adaxial surfaces. Two to three layers of parenchyma cells subjacent to adaxial epidermis and interspersed with sclerenchyma strands. Below is a layer of parenchyma cells. Cuticle: very thin and slightly ridged on both surfaces. Stomata: present in abaxial furrows in association with fingerlike projections. Mesophyll: three to four layers palisade tissue changing abruptly into compact spongy tissue. Three to four layers of large translucent palisade cells radially arranged above vascular bundles and furrows. Vascular bundles: 22; commissural bundles not observed. One to three large vessels present in each vascular bundle. Two phloem units laterally arranged in flanges of Y-shaped abaxial girder. Adaxial cap present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Some abaxial sclerenchyma strands present at entrances of furrows. Crystals: none observed. Tannins: present.

Vellozia glauca Pohl

FIGURES 3e-f, 11d-f

SPECIMENS EXAMINED.—Irwin et al. 21395; Maguire et al. 44793.

SURFACE VIEW.—Hairs: absent. Epidermis: cells square to rectangular; thin walled. Stomata: paracytic, $21 \times 18 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; open V-shaped with margins turned slightly inversely. Adaxial surface slightly undulating; abaxial surface furrowed one-fourth thickness of blade. Epidermis: adaxial and abaxial cells rounded and thin walled. Subjacent to epidermis occur four to five layers of sclerenchyma strands interspersed with two to four layered rows of parenchyma. A distinct layer of large parenchyma cells subjacent to sclerenchyma and parenchyma cells. Cuticle: evenly thickened on adaxial surface; thick and quite ridged on abaxial surface. Stomata: present in furrows; small substomatal chamber present. Mesophyll: three to five layers palisade tissue

grading into spongy tissue. One to two layers large translucent palisade cells arranged radially above vascular bundles. Vascular bundles: 38–58; commissural bundles not observed. Veins have one to three large vessels, mostly one, rarely three. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Each vascular bundle has an adaxial cap. Abaxial strands near openings of furrows present between abaxial epidermis and a distinct layer of parenchyma cells. Bundle sheath extends completely around vascular bundle. Crystals: observed. Tannins: present.

Vellozia glochidea Pohl-Heringer

FIGURE 12a-c; PLATES 5a, 31h, 32a-b

SPECIMENS EXAMINED.—Irwin et al. 14584; Duarte 8340–Mattos 677; Heringer 10923.

SURFACE VIEW.—Hairs: absent. Epidermis: cells square to rectangular in shape; walls thin. Stomata: paracytic, $21 \times 18 \mu\text{m}$; and present on abaxial surface only in Irwin et al. 14584.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove; turned slightly inversely at margins. Adaxial surface slightly undulating; abaxial surface furrowed up to one-third the thickness of blade in Irwin 14584, one-fourth in Heringer 10923 and Duarte 8340–Mattos 677. Epidermis: cells rounded to dome shaped on abaxial and adaxial surfaces; thin walled. Subjacent are three to four layers sclerenchyma strands interspersed with rows of parenchyma. Sclerenchyma layers very distinct and interspersed with single parenchyma rows in Irwin et al. 14584. Below sclerenchyma is a distinct layer of parenchyma cells. Cuticle: thick and smooth on adaxial surface; bumpy on abaxial surface; very thick and ridged in Irwin et al. 14584. Stomata: present on adaxial and abaxial surfaces and in abaxial furrows; substomatal chamber present; seen only in abaxial furrows in Irwin et al. 14584. Mesophyll: definite palisade tissue present in two to four layers grading into compact spongy tissue. Three to four layers translucent palisade cells arranged radially above vascular bundles. Vascular bundles: 27; 43 in Irwin et al. 14584; few commissural bundles observed. Usually one large vessel in each vein. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Each vascular bundle

accompanied by an adaxial cap. Abaxial sclerenchyma strands or layers present (three to four layered in Irwin et al. 14584); parenchyma layer may be between sclerenchyma and mesophyll. Vascular bundles completely surrounded by bundle sheath; cells at abaxial end of sheath may be enlarged. Crystals: none observed. Tannins: few present.

NOTE: The specimen by Irwin et al. 14584 does not seem to be the same as the other two specimens.

***Vellozia granulata* Goethart & Henrard**

FIGURE 6c-e

SPECIMENS EXAMINED.—Glaziou 19934; Riedel s.n.

SURFACE VIEW.—Hairs: few papillae present. Epidermis: cells square to rectangular, thin walled. Stomata: tetracytic, $18 \times 12 \mu\text{m}$; present on abaxial surface; seen on both surfaces in Glaziou 19934.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with margins turned very slightly inversely; small median adaxial groove; groove large in Glaziou 19934. Adaxial surface slightly undulating, ridged in Glaziou 19934. Abaxial furrows one-half thickness of blade, furrows almost absent in Glaziou 19934. Epidermis: cells on both surfaces dome shaped to conical. Two to three layers thick-walled parenchyma cells subjacent to epidermis and interspersed with sclerenchyma strands. One to two layers thin-walled parenchyma in Glaziou 19934; few sclerenchyma strands. Another layer of large parenchyma cells above palisade tissue. Cuticle: slightly ridged on both surfaces; cuticle fairly thick. Stomata: present in furrows; substomatal chamber virtually absent. Mesophyll: three layered palisade grading into spongy tissue; cells near abaxial surface more compactly arranged; spongy tissue in Glaziou 19934 completely obliterated in most sections. Large translucent palisade tissue radially oriented above vascular bundles and on furrows. Vascular bundles: 19 in Riedel s.n.; 29 in Glaziou 19934; commissural bundles not observed. One to two vessels larger than others. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Adaxial cap usually small, rather large in Glaziou 19934. Sclerenchyma strands and isolated fibers forming a layer between abaxial epidermis and a distinct layer of parenchyma cells.

Bundle sheath completely surrounding vascular bundles. Crystals and tannins: not observed.

NOTE: The two specimens examined are not identical—a clear indication of misidentification.

***Vellozia grisea* Goethart & Henrard**

FIGURES 3i-j, 4b; PLATES 16b, 42e, 50c

SPECIMENS EXAMINED.—Weddell 3006.

SURFACE VIEW.—Hairs: present in clumps on adaxial and abaxial surfaces. Epidermis: cells square to rectangular, thin walled. Stomata: paracytic, $15 \times 9 \mu\text{m}$; present on abaxial and few on adaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with deep median adaxial groove. Adaxial surface conspicuously ridged; adaxial furrows almost one-half thickness of blade. Epidermis: cells rounded to dome shaped on both surfaces; few conical on adaxial surface. Two to three layers of sclerenchyma cells subjacent to epidermis and interspersed with parenchyma cells. Below sclerenchyma is a layer of parenchyma cells. Cuticle: uniformly ridged and thick on both surfaces. Stomata: present in furrows; substomatal chamber virtually absent. Mesophyll: three to four layers indistinct palisade cells grading into compact spongy tissue; few translucent palisade cells radially arranged above vascular bundles. Vascular bundles: 20; commissural bundles not observed. Veins having one to two large vessels, mostly one. Two phloem units lying laterally in flanges of Y-shaped girder. Each vascular bundle has in addition to Y-shaped abaxial girder an adaxial cap. Vascular bundle completely surrounded by bundle sheath. Few strands of abaxial sclerenchyma observed. Crystals: not observed. Tannins: present.

NOTE: The adaxial surface is very heavily ridged. In some areas the ridges are deep enough to qualify as small furrows.

***Vellozia hatschbachii* L. B. Smith & Ayensu**

PLATES 10a-b, 37a

SPECIMENS EXAMINED.—L. B. Smith and Ayensu 16002.

SURFACE VIEW.—Hairs: none present. Epidermis: adaxial cells mostly square, few rectangular; thin

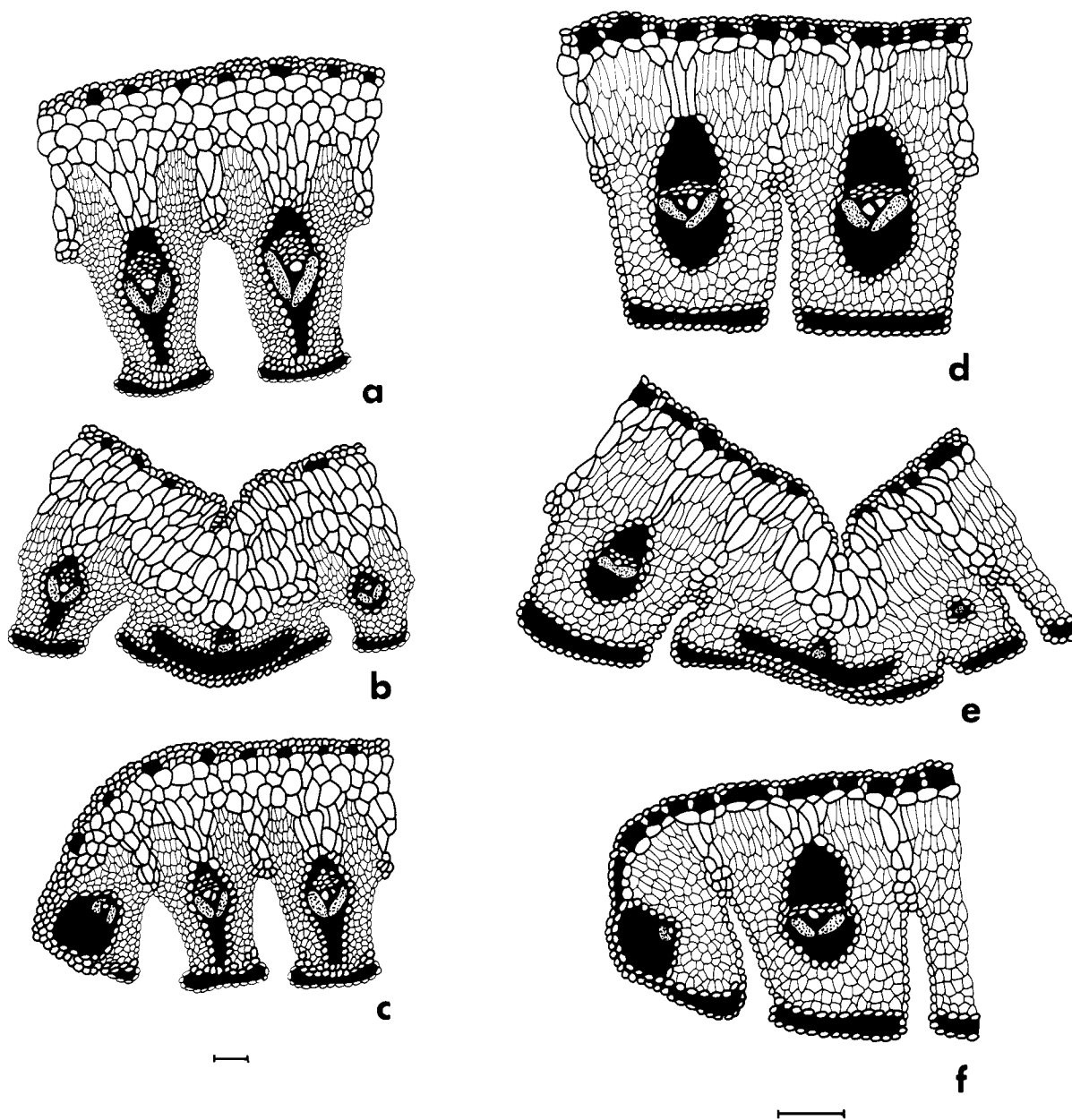


FIGURE 10.—a-c, *Vellozia aloifolia* (Mexia 5870); d-f, *V. leptopetala* (Maguire et al. 49184).

walled. Abaxial cells rectangular; thin walled. Stomata: paracytic, $21 \times 9 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove. Adaxial surface very slightly undulating; abaxial surface furrowed one-half to three-fourths thickness of blade. Epidermis: adaxial cells rounded; few rec-

tangular; thin walled. Abaxial cells rounded; interspersed with small sclerenchyma strands. Subjacent to adaxial epidermis occur two to three layers of sclerenchyma strands interspersed with radially arranged rows of two to three parenchyma cells. Below sclerenchyma strands is a distinct layer of parenchyma cells. Cuticle: fairly thick and ridged on adaxial and abaxial surfaces. Stomata: present

in abaxial furrows; substomatal chamber present; some epidermal furrow projections covering stomata. Mesophyll: three to four, mostly three, layers of compactly arranged small palisade tissue changing abruptly into spongy tissue. Two to three layers of large translucent cells radially arranged above vascular bundles and furrows. Vascular bundles: 46; few commissural bundles present. Two to three large vessels present in each vascular bundle. Two phloem units arranged laterally in flanges of partial Y-shaped abaxial girder. Small adaxial cap present on each vascular bundle. Abaxial sclerenchyma strands present between abaxial epidermis followed by a layer of parenchyma cells. Each vascular bundle completely surrounded by a bundle sheath. Crystals: none observed. Tannins: some present.

NOTE: This species resembles *Vellozia lappa* in its general anatomy. The leaf blade is smaller than *V. lappa*. Furthermore the translucent cells above the vascular bundles are mostly two, whereas those in *V. lappa* are mostly four.

Vellozia hemisphaerica Seubert in Martius

FIGURE 8c

SPECIMENS EXAMINED.—Blanchet 2544.

SURFACE VIEW.—Hairs: absent. Epidermis: cells square to rectangular, thin walled. Stomata: paracytic, $18 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped. Adaxial surface conspicuously ridged; abaxial surface distinctly furrowed about one-half thickness of blade. Epidermis: adaxial cells rounded to dome shaped, some conical; abaxial cells more rectangular; cells on both surfaces thin walled. Subjacent to the epidermis are one to two layers of sclerenchyma strands interspersed with parenchyma cells. Below sclerenchyma strands is a distinct layer of parenchyma cells. Cuticle: thin and ridged on adaxial surface; not as ridged but thicker on abaxial surface. Stomata: present in abaxial furrows; covered by epidermal projections; large, distinct hooklike protuberances in furrows overarch some of the stomata; substomatal chamber present. Mesophyll: two to three layers of palisade grading into compactly arranged spongy tissue to abaxial side; one to two layers of large translucent palisade cells radially arranged above major and

minor vascular bundles. Vascular bundle: two types present, major and minor veins; major veins 18 to 22; minor veins 16 to 24 arranged radially above furrows. Major veins contain one to two large vessels, mostly one; two phloem units lying laterally in flanges of Y-shaped abaxial girder; each vascular bundle accompanied by an adaxial cap; vascular bundles completely surrounded by a distinct bundle sheath. Minor veins usually with one large vessel; abaxial and adaxial ends accompanied by sclerenchyma caps; minor veins with adaxial cap and abaxial U- or V-shaped girder completely surrounded by a bundle sheath. Crystals and tannins: not observed.

NOTE: This species and *Vellozia burle-marxii* share the following common characters: (a) major and minor vascular bundles and (b) distinct hooklike protuberances in furrows which overarch the lower stomata.

Vellozia hypoxoides L. B. Smith

PLATES 37c, 50a

SPECIMENS EXAMINED.—Irwin et al. 34120.

SURFACE VIEW.—Hairs: few tufts of multicellular hairs. Epidermis: adaxial cells square to rectangular; thin walled. Abaxial cells square to rectangular, few rounded; thin walled. Stomata: paracytic, $18 \times 9 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with median adaxial groove. Margins turned very slightly inversely. Abaxial surface furrowed about one-half thickness of blade. Epidermis: adaxial cells square to rectangular, few rounded; cell walls slightly thickened. Abaxial cells rounded to dome shaped; walls slightly thickened. Subjacent to adaxial epidermis occur two layers of small parenchyma cells followed by a layer of large parenchyma cells. Few sclerenchyma strands found in parenchyma cell layers. Cuticle: thick and slightly ridged on adaxial surface; thin on abaxial surface. Stomata: present in abaxial furrows, small substomatal chamber observed, flush with epidermis. Mesophyll: two to three layers of palisade tissue subjacent to adaxial epidermis, rather indistinct in places. Two- to three-layered large and almost rounded translucent cells arranged radially above vascular bundles and furrows. Palisade cells grading into compact spongy tissue of small round

cells. Vascular bundles: 23; few commissural bundles observed. One to two vessels present in each vascular bundle, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Small adaxial cap present on each vascular bundle. Bundle sheath completely surrounds each vascular bundle. One layer of parenchyma cells subjacent to abaxial epidermis. Crystals: none observed. Tannins: some present.

Vellozia incurvata Martius ex Schultes f.

PLATE 42f

SPECIMENS EXAMINED.—Maguire et al. 44752; Pereira 2959–Pabst 3795.

SURFACE VIEW.—Hairs: absent. Epidermis: cells rectangular to cubelike on both surfaces; thin walled. Stomata: tetracytic, $21 \times 17 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove in Pereira 2959, Pabst 3795; margins turned slightly inversely and pointed. Adaxial surface slightly undulating; abaxial surface furrowed about one-half the thickness of blade. Epidermis: adaxial and abaxial cells rounded to rectangular; cell walls thin on both surfaces. One layer of sclerenchyma cells subjacent to epidermis and interspersed by parenchyma cells. Below sclerenchyma cells are two to three layers of parenchyma cells. Cuticle: thick on both surfaces; only slightly ridged on both surfaces. Stomata: present in abaxial furrows; substomatal chamber present. Mesophyll: two to three layers of indistinct palisade tissue grading into compactly arranged spongy tissue. Two to three layers of large translucent cells arranged radially above vascular bundles and furrows, poorly differentiated in Maguire et al. 44752. Vascular bundles: 25–34; few commissural bundles observed. One to two large vessels present in each vascular bundle, usually one. Two phloem units lying laterally in flanges of Y-shaped partial abaxial girder. Adaxial cap present on each vascular bundle. Two to three layers of sclerenchyma cells separating abaxial epidermis and a distinct layer of parenchyma cells. Bundle sheath completely surrounding vascular bundles. Some epidermal projections present in furrows. Crystals: none observed. Tannins: some present.

NOTE: The two specimens studied are quite similar; however, the abaxial median portion is pointed in Pereira 2959, Pabst 3795, while that of Maguire et al. 44752 is flattened.

Vellozia intermedia Seubert in Martius

PLATE 28f–g

SPECIMENS EXAMINED.—L. B. Smith 6854.

SURFACE VIEW.—Hairs: present. Epidermis: cells square to rectangular; thin walled. Stomata: paracytic, $21 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped; small adaxial groove present. Adaxial surface slightly undulating; abaxial surface furrowed about one-half thickness of blade. Epidermis: adaxial cells rounded to dome shaped; abaxial cells rounded. One to two layers parenchyma subjacent to epidermis; below parenchyma cells are two to three layers of sclerenchyma strands interspersed with radial rows of two- to three-layered parenchyma cells. Subjacent to sclerenchyma is a distinct layer of parenchyma cells. Cuticle: thick and slightly ridged on adaxial surface; thin on abaxial surface. Stomata: present in abaxial furrows; associated with large numbers of epidermal projections; small substomatal chamber. Mesophyll: three to four layers of translucent tissue changing abruptly into compact spongy tissue. Four to five layers of large translucent palisade cells arranged radially above vascular bundles and furrows. Vascular bundles: 55; few commissural bundles observed. One to two large vessels, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Adaxial cap present on each vascular bundle. One to two layers sclerenchyma cells between abaxial epidermis and a distinct parenchyma layer. Vascular bundle completely surrounded by bundle sheath. Crystals: none observed. Tannins: present.

Vellozia irwinii L. B. Smith

PLATE 43a

SPECIMENS EXAMINED.—Irwin, Maxwell, Waschausen 20998.

SURFACE VIEW.—Hairs: multicellular, present on adaxial surface. Epidermis: cells circular to rec-

tangular, thin walled. Some crystals present. Stomata: paracytic, $24 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped; turned slightly inversely at margins; small adaxial grooves present. Adaxial surface slightly undulating; abaxial surface deeply furrowed over one-half the thickness of blade. Epidermis: adaxial cells rounded to dome shaped; abaxial cells dome shaped to conical. Cells on both surfaces thin walled. Subjacent to epidermis is a layer of parenchyma cells; below parenchyma are sclerenchyma strands interspersed with parenchyma cells; subjacent is another layer of parenchyma cells. Cuticle: very thin on both surfaces. Stomata: present in furrows, and on surface; substomatal chamber present. Mesophyll: three to four layers of palisade cells grading into compactly arranged spongy tissue; cells near abaxial side less compact. Two to three layers large translucent palisade cells arranged radially above vascular bundles and furrows. Vascular bundles: 55; commissural bundles not observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units arranged laterally in flanges of Y-shaped abaxial girder. Adaxial cap present on each vascular bundle. Vascular bundles completely surrounded by bundle sheath. Crystals: present. Tannins: some present.

Vellozia lappa L. B. Smith & Ayensu

PLATE 37d

SPECIMENS EXAMINED.—L. B. Smith and Ayensu 15988.

SURFACE VIEW.—Hairs: short hairs present in clumps on adaxial surface; none on abaxial. Epidermis: cells on adaxial and abaxial surfaces square to rectangular; thin walled. Stomata: paracytic, $21 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove; turned slightly inversely at margins. Adaxial surface almost smooth; abaxial surface furrowed about one-half thickness of blade. Epidermis: adaxial cells square to rectangular in shape; thin walled. Abaxial cells rounded to square; thick walled; abaxial epidermal cells replaced by sclerenchyma cells in a number of places. Subjacent to adaxial epidermis

occur two to three layers of parenchyma cells interspersed with sclerenchyma strands. Below is a distinct layer of parenchyma cells, sometimes two. Cuticle: very thin on abaxial and adaxial surfaces. Stomata: present in abaxial furrows; small substomatal chamber present. Numerous furrow projections present. Mesophyll: three to four layers palisade tissue grading into compactly arranged spongy tissue. Three to four layers of large translucent cells radially arranged above vascular bundles and furrows. Vascular bundles: 30; few commissural bundles observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units lying laterally in flanges of Y-shaped or partially Y-shaped abaxial girder. Small adaxial cap present on each vascular bundle. Abaxial sclerenchyma strands replacing some of abaxial epidermal cells. Row of parenchyma cells between abaxial epidermis and spongy tissue. Bundle sheath completely surrounding vascular bundle; occasionally two bundle sheaths around one bundle are observed. Crystals and tannins: none observed.

NOTE: The presence of two bundle sheaths around one vascular bundle is quite distinctive.

Vellozia leptopetala Goethart & Henrard

FIGURE 10d-f; PLATE 30d-f

SPECIMENS EXAMINED.—Maguire et al. 49184.

SURFACE VIEW.—Hairs: absent. Epidermis: cells square to rectangular; thin walled. Stomata: paracytic, $15 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove. Adaxial surface very slightly undulating; abaxial surface furrowed about one-half thickness of blade. Epidermis: cells rounded to dome shaped on adaxial surface; rounded on abaxial surface; thin walled. Subjacent to adaxial epidermis occur one to two layers of sclerenchyma strands interspersed with rows of parenchyma tissue of two to three cells thick. Below sclerenchyma is a distinct layer of parenchyma cells. Cuticle: thin and slightly ridged on both surfaces. Stomata: present in furrows; substomatal chamber virtually absent. Mesophyll: three- to four-layered palisade tissue changing abruptly into compact spongy tissue. One to two layers of large translucent cells arranged radially

above vascular bundles and furrows. Vascular bundles: 18; no commissural bundles observed. One to two large vessels, mostly one. Two phloem units lying laterally in flanges of U- or V-shaped partial abaxial girder. Adaxial cap present on all vascular bundles. Distinct layer of parenchyma cells separating abaxial epidermis and one to two layers abaxial sclerenchyma. Bundle sheath completely surrounding vascular bundle. Crystals and tannins: none observed.

NOTE: The partial abaxial sclerenchyma recalls the *Xerophyta* type of sclerenchyma girders found in some Old World Velloziaceae species. The flattened abaxial portion of the median vein is also distinctive.

Vellozia magdalenae L. B. Smith & Ayensu

PLATES 14a, 43b

SPECIMENS EXAMINED.—Lima and Brade 13298, 14288.

SURFACE VIEW.—Hairs: absent. Epidermis: cells rounded, square to rectangular on both surfaces; thin walled. Stomata: paracytic, $18 \times 15 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove. Adaxial surface slightly undulating; abaxial surface furrowed about one-third the thickness of blade. Epidermis: adaxial cells dome shaped to square and rectangular; walls slightly thickened. Abaxial cells rounded to dome shaped; thin walled. Subjacent to adaxial epidermis occur one to two layers of parenchyma cells interspersed with sclerenchyma strands. Below parenchyma layers is a distinct layer of parenchyma cells. Cuticle: fairly thick on both adaxial and abaxial surfaces; slightly ridged on abaxial. Stomata: present in abaxial furrows; surrounded with epidermal projections in furrows, small substomatal chamber observed. Mesophyll: distinct two- to three-layered palisade tissue grading into fairly compact spongy tissue; cells less compact toward abaxial surface. One to two layers of large translucent cells arranged radially above vascular bundles and on furrows. Vascular bundles: 18 to 19; no commissural bundles observed. One to two large vessels present in vascular bundles, mostly one. Two phloem units arranged laterally in flanges of Y-shaped, sometimes partial abaxial

girder. Adaxial caps present on all vascular bundles. Abaxial sclerenchyma strands present between abaxial epidermis and a layer of parenchyma cells. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

NOTE: The two specimens are identical except for the adaxial portion of midvein that is flattened in Lima & Brade 13298, but pointed in Lima and Brade 14288.

Vellozia metzgerae L. B. Smith

PLATES 5b, 43c

SPECIMENS EXAMINED.—W. Egler s.n.

SURFACE VIEW.—Hairs: present on both adaxial and abaxial surfaces; usually fairly short and in tufts, cells multicellular. Epidermis: adaxial cells square, few rounded; thin walled. Abaxial cells square to rectangular; thin walled. Stomata: paracytic, $21 \times 15 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with median adaxial groove; margins turned inversely. Adaxial surface slightly undulating, abaxial surface furrowed one-third to one-half the thickness of blade. Epidermis: adaxial cells rectangular; abaxial cells rounded to rectangular; cells on both surfaces are thin walled. Two to three layers of parenchyma cells subjacent to adaxial epidermis and interspersed with one to three layers of sclerenchyma strands. Below is a distinct layer or two of large parenchyma cells. Cuticle: fairly thick on both surfaces; only slightly ridged on both surfaces. Stomata: present in furrows; substomatal chamber present; associated with fingerlike projections. Mesophyll: three- to four-layered palisade grading into fairly compact spongy tissue. Two to four layers of large translucent cells arranged radially above vascular bundles and on furrows; large translucent cells quite numerous in median region of lamina. Vascular bundles: 16; few commissural bundles observed. One to three large vessels observed in each vascular bundle. Two phloem units laterally arranged in flanges of Y-shaped or partial U- or V-shaped abaxial girder; each bundle with an inverted V-shaped adaxial sclerenchyma cap. Some abaxial sclerenchyma strands present. Bundle sheath completely

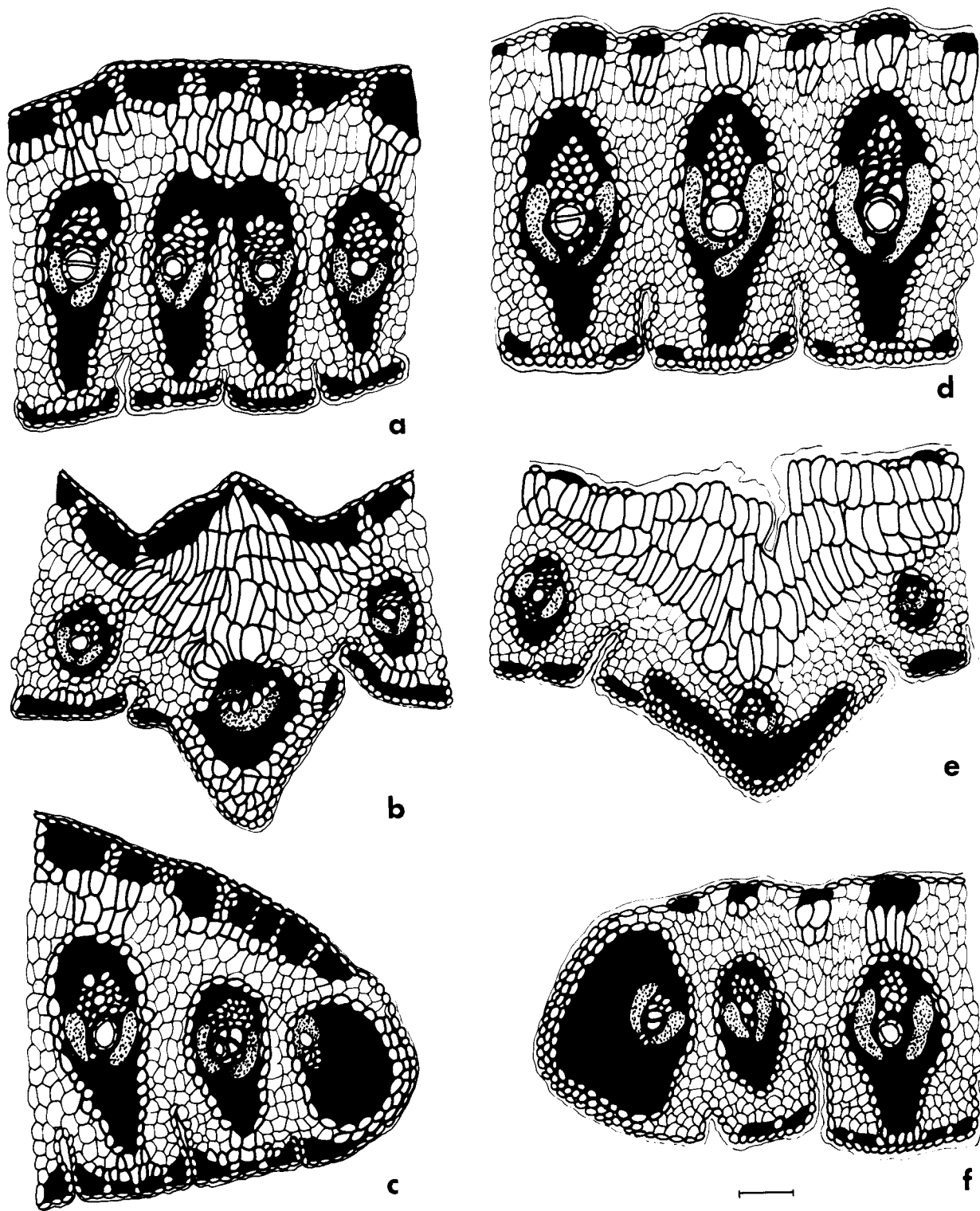


FIGURE 11.—a-c, *Vellozia flavicans* (Gardner 4370); d-f, *V. glauca* (Maguire et al. 44793).

surrounding each vascular bundle. Crystals: not observed. Tannins: few present.

***Vellozia minima* Pohl**

FIGURE 8d; PLATE 15b

SPECIMENS EXAMINED.—Duarte 2379; Maguire et al. 49099.

SURFACE VIEW.—Hairs: absent. Epidermis: cells rounded and rectangular; thin walled. Stomata: paracytic, $15 \times 18 \mu\text{m}$; present on abaxial and adaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; widely V-shaped with small median adaxial groove. Both surfaces slightly undulating; no furrows present. Epidermis: adaxial and abaxial cells rounded to dome shaped; thin walled. Subjacent to adaxial epidermis is a layer of parenchyma cells. Cuticle: very thin on both surfaces. Stomata: present on adaxial and abaxial surfaces; substomatal chamber present. Mesophyll: fairly indistinct palisade tissue of two to three layers grading into a loose spongy tissue. Translucent cells radially arranged above some vascular bundles. Vascular bundles: 6–8; no commissural bundles observed. Two phloem units lying laterally in flanges of U-shaped abaxial girder; adaxial cap present on each bundle. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

NOTE: As its name implies, this species is perhaps the smallest in the New World vellozias. The number of bundles is few but firmly organized. The abaxial portion of the midvein is slightly concave. The translucent cells in the adaxial portion of the midvein are quite distinct. The palisade cells are somewhat indistinct and loosely arranged.

***Vellozia modesta* L. B. Smith & Ayensu**

PLATE 43d

SPECIMENS EXAMINED.—L. B. Smith, Ayensu, Hatschbach 15997; Hatschbach 27869.

SURFACE VIEW.—Hairs: absent. Epidermis: cells rounded to rectangular, thin walled. Stomata: paracytic, $21 \times 15 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; widely V-shaped with small median adaxial groove; margins turned slightly inversely. Adaxial surface

undulating; abaxial surface furrowed about one-half thickness of blade. Epidermis: adaxial cells mostly rectangular; abaxial cells rounded to dome shaped; cells on both surfaces thin walled. Subjacent to adaxial epidermis is one to two layers of parenchyma cells interspersed with sclerenchyma strands. Below is a layer of parenchyma cells. Cuticle: fairly thin and smooth on both surfaces. Stomata: present in furrows and on abaxial surface; substomatal chamber present; stomata associated with numerous epidermal projections in furrows. Mesophyll: three- to five-layered palisade cells changing abruptly into loosely spongy tissue. Large, translucent cells arranged radially above vascular bundles and on furrows. Vascular bundles: 38; no commissural bundles observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units arranged laterally in flanges of thin Y-shaped or partial U- or V-shaped abaxial girder. Small adaxial cap present on all bundles. Sclerenchyma strands present on abaxial side, fiber often replacing epidermal cells. Layer of parenchyma cells separating abaxial sclerenchyma strands from spongy tissue. Bundle sheath completely surrounding each vascular bundle. Crystals: not observed. Tannins: present.

NOTE: This species is very distinctive because of the arrangements of adaxial and abaxial sclerenchyma strands as well as the fusiform epidermal cells at the outer portions of the furrows.

***Vellozia nuda* L. B. Smith & Ayensu**

FIGURE 4c; PLATE 37e

SPECIMENS EXAMINED.—Hatschbach and Pelanda 28029.

SURFACE VIEW.—Hairs: numerous papillae present. Epidermis: adaxial cells square to rectangular; abaxial cells rounded. Walls thin on both surfaces. Stomata: paracytic, $7 \times 15 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with median adaxial groove; turned slightly inversely at extreme margin of lamina. Adaxial surface only very slightly undulating; some papillae present. Abaxial surface furrowed about one-third thickness of blade. Epidermis: adaxial cells slightly rounded; few dome shaped; walls thin. Abaxial cells dome shaped; walls thin.

Subjacent to adaxial epidermis occur five to six layers of sclerenchyma strands interspersed with radially arranged rows of four to five parenchyma cells. Below sclerenchyma strands is a distinct layer of parenchyma cells. Cuticle: adaxial and abaxial cuticle very thin and ridged. Stomata: present in abaxial furrows; small substomatal chamber present. Mesophyll: three- to four-layered palisade cells grading into compactly arranged spongy tissue. Two- to three-layered large translucent cells arranged radially above vascular bundles. Vascular bundles: 24; few commissural bundles observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units arranged laterally in flanges of Y-shaped abaxial girder. Inverted V-shaped adaxial cap present on each vascular bundle. Abaxial sclerenchyma strands present in abaxial corners of furrows and extending partly into furrows. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present.

Vellozia ornata Martius ex Schultes f.

PLATE 37f

SPECIMENS EXAMINED.—L. B. Smith and Ayensu 16001.

SURFACE VIEW.—Hairs: few tufts of multicellular hairs present. Epidermis: adaxial cells square to rectangular; thin walled. Abaxial cells square to rectangular; thin walled. Stomata: paracytic, $18 \times 9 \mu\text{m}$; present on adaxial and abaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove. Extreme margins of lamina turned inversely. Adaxial surface slightly undulating; abaxial surface furrowed one-fourth to one-third thickness of blade. Epidermis: adaxial cells rounded to rectangular, small in size; walls slightly thickened. Abaxial cells rounded to dome shaped; walls slightly thickened. Adaxial epidermis interspersed with strands of sclerenchyma fibers, especially arranged radially above furrows and vascular bundles; subjacent to this occurs a layer of parenchyma cells. Cuticle: thick and quite ridged on both adaxial and abaxial surfaces. Stomata: present on adaxial surface and in abaxial furrows, more numerous on abaxial surface; substomatal chamber present on both surfaces; stomata flush with epidermis. Mesophyll:

three to four layers of palisade cells changing abruptly to small, rounded, compactly arranged spongy tissue. Two to three layers of large transparent cells arranged radially above vascular bundles and furrows. Large translucent cells occur above entire area of midvein. A layer of parenchyma cells on abaxial side occurs between spongy mesophyll and abaxial epidermis. Vascular bundles: 23; few commissural bundles observed. One to three vessels present in each vascular bundle. Two phloem units lying laterally in flanges of thick Y- or U-shaped abaxial girder. Adaxial cap present on each vascular bundle. Abaxial sclerenchyma strands present usually at corners of outer area of furrows. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: few present.

Vellozia phalocarpa Pohl

PLATE 46a

SPECIMENS EXAMINED.—Anderson et al. 35855.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial cells rounded to square, few almost triangular; thin walled; abaxial cells rectangular, few square shaped, thin walled. Stomata: paracytic, $24 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove. Extreme margins of lamina turned slightly inversely. Adaxial surface slightly undulating; abaxial surface furrowed one-third to one-half thickness of blade. Epidermis: cells on adaxial and abaxial surfaces rounded; wall thickened. Adaxial epidermis interspersed with strands of sclerenchyma. Subjacent to epidermis and strands of fibers occur two to three layers of parenchyma cells. Cuticle: markedly thick and slightly ridged on both surfaces. Stomata: present in abaxial furrows; virtually no substomatal chamber observed; somewhat associated with small projections in furrow. Mesophyll: three to four layers of palisade cells changing abruptly into a compactly arranged spongy tissue of small, rounded cells. Two to three layers of large translucent cells radially arranged above vascular bundles and furrows. Large translucent cells occur above midvein. Vascular bundles: 26; few commissural bundles observed. One to two large vessels present in each vascular bundle. Two

phloem units lying laterally in flanges of Y-shaped abaxial girder. Adaxial cap present. One to two layers of sclerenchyma strands between abaxial epidermis and a layer of parenchyma cells subjacent to spongy mesophyll. Bundle sheath present on each vascular bundle. Crystals: present. Tannins: some observed.

Vellozia pilosa Goethart & Henrard

PLATE 43e

SPECIMENS EXAMINED.—Glaziou 19933.

SURFACE VIEW.—Hairs: some present. Epidermis: cells rectangular, thin walled on both surfaces; papillae present. Stomata: paracytic, $18 \times 9 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove. Adaxial surface distinctly ridged; small furrows on abaxial surface. Epidermis: abaxial and adaxial cells rounded to dome shaped; cells on both surfaces thin walled. Subjacent to adaxial epidermis is a layer of parenchyma cells. Cuticle: very thin on adaxial and abaxial surfaces. Stomata: present on abaxial surface; no substomatal chamber observed. Mesophyll: three layers of palisade tissue blending into compactly arranged spongy tissue. Vascular bundles: 15; no commissural bundles observed. One to two large vessels present in each vascular bundle. Two phloem units lying laterally in flanges of U-shaped abaxial girder. Adaxial cap present on each vascular bundle. No abaxial sclerenchyma present. Bundle sheath surrounding each vascular bundle. Crystals and tannins: none observed.

Vellozia piresiana L. B. Smith

PLATE 43f

SPECIMENS EXAMINED.—Duarte 2068.

SURFACE VIEW.—Hairs: absent. Epidermis: cells square to rectangular on both surfaces, thin walled. Stomata: paracytic, $12 \times 6 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small but distinct median adaxial groove. Adaxial surface undulating; abaxial surface furrowed about one-third the thickness of

blade. Epidermis: adaxial and abaxial cells rectangular to dome shaped; cell walls thin on both surfaces. Subjacent to adaxial epidermis occur sclerenchyma strands interspersed with one to two layers of parenchyma cells. Cuticle: adaxial cuticle thin and slightly ridged; abaxial cuticle thin but deeply ridged. Stomata: present in abaxial furrows; no substomatal chamber observed. Mesophyll: three layers of indistinct palisade tissue grading into fairly compactly arranged spongy tissue. Large translucent cells arranged radially above vascular bundles and furrows; adaxial translucent cells in midvein very distinct. Vascular bundles: 37; no commissural bundles observed. Each vascular bundle contains one to two large vessels, mainly one. Two phloem units lying laterally in flanges of U-shaped abaxial girder. Large adaxial cap on each bundle, often larger than abaxial girders. Abaxial sclerenchyma strands present; some parenchyma cells between abaxial sclerenchyma and spongy tissue. Crystals: none observed. Tannins: present.

NOTE: The adaxial sclerenchyma girders which are often larger than the abaxial girders are very distinctive in *Vellozia*.

Vellozia plicata Martius

FIGURE 4f; PLATE 44a

SPECIMENS EXAMINED.—Porto 29572; Frazão s.n.; Duarte 3635—Gomes 420; Lima 192; Brade 15947.

SURFACE VIEW.—Hairs: present in clusters as well as in fingerlike multicellular projections. Epidermis: adaxial cells almost rounded; few square to rectangular; abaxial cells square to rectangular, few rounded; walls thin on adaxial and abaxial surfaces. Stomata: paracytic, $15 \times 6 \mu\text{m}$; present on abaxial and adaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; W-shaped with margins turned inversely. Adaxial surface conspicuously undulating in some specimens; abaxial furrows very large in places. Entire lamina distinctly corrugated. Epidermis: adaxial and abaxial cells rounded to dome shaped; cells on both surfaces very thick walled. Subjacent to adaxial epidermis occur one to two layers of sclerenchyma strands interspersed with parenchyma cells. Below sclerenchyma strands is a layer of parenchyma cells. Cuticle: thin and slightly ridged on

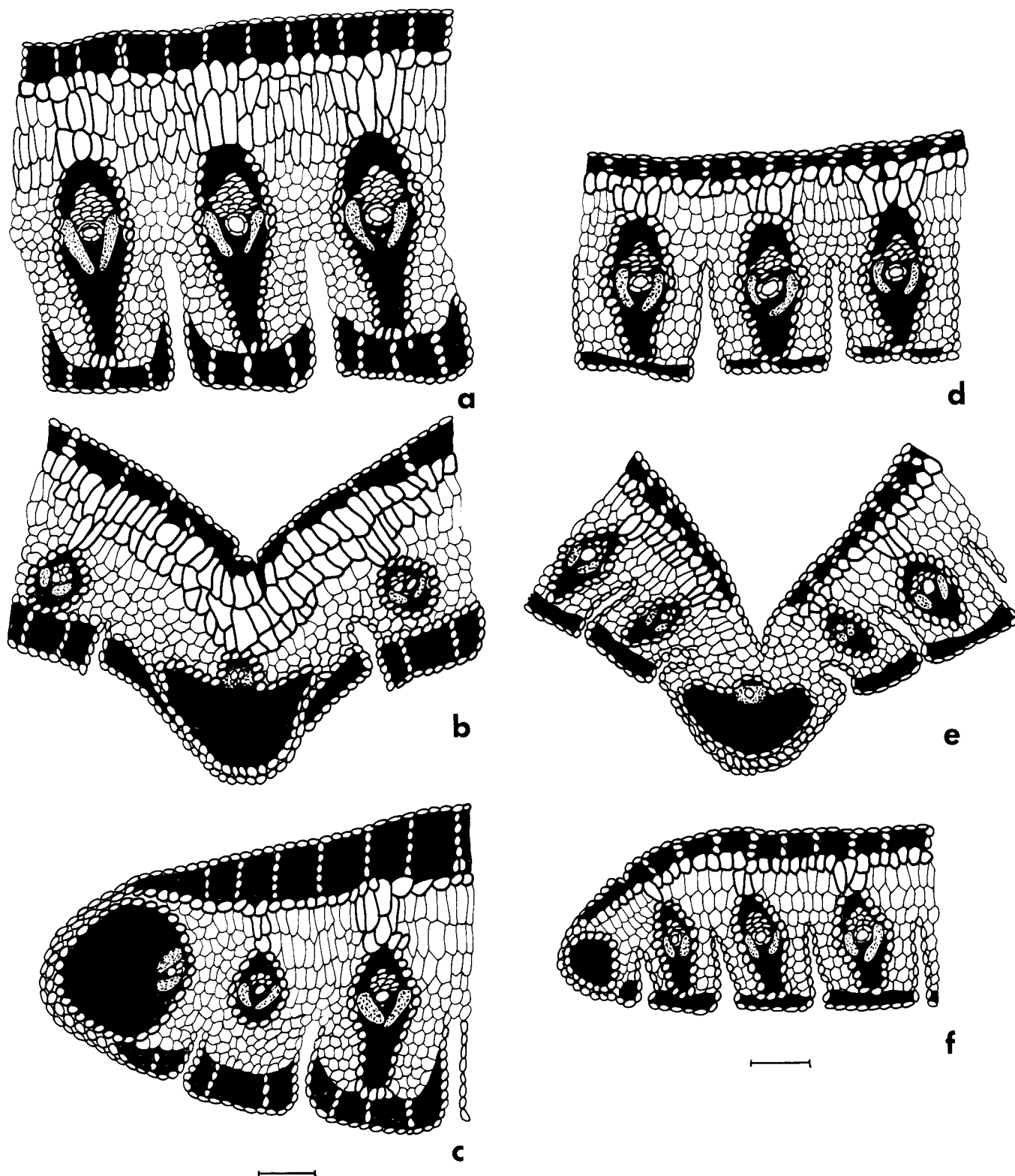


FIGURE 12.—a-c, *Vellozia glochidea* (Irwin et al. 14584); d-f, *V. crassicaulis* (Irwin et al. 9744).

both surfaces. Stomata: present on abaxial surface as well as furrows; almost flush with epidermal surface; present on adaxial surface; substomatal chamber present. Mesophyll: three layers of palisade tissue grading into compactly arranged spongy tissue. Vascular bundles: consisting of two types, major and minor veins; major veins 11–15; minor veins 30–63; no commissural bundles observed. Major veins have three to four large vessels. Two phloem units arranged laterally in flanges of U-shaped abaxial girder; adaxial girder present on each major vein, often extending close to adaxial epidermis; each major vascular bundle completely surrounded by a bundle sheath. Sclerenchyma strands present between abaxial epidermis and a layer of parenchyma cells of some specimens (Duarte 3635–Gomes 420; Lima 192; Porto 29572; Frazão s.n.; Brade 15947). Crystals: not observed. Tannins: few present.

NOTE: This species is very distinctive because of the plicate habit of its leaves, the presence of major and minor vascular bundles, and its striking resemblance to *Vellozia triquetra* (Gardner 2735).

Vellozia pumila Goethart & Henrard

PLATES 5d, 44b

SPECIMENS EXAMINED.—Irwin et al. 9230; Irwin et al. 9428; Irwin et al. 10922; Glaziou 22215.

SURFACE VIEW.—Hairs: absent. Epidermis: cells square to rectangular on both surfaces; thin walled. Stomata: paracytic, $27 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped; adaxial surface undulating, sometimes conspicuously ridged; abaxial surface furrowed about one-fifth to one-third thickness of the blade. Epidermis: cells on both surfaces rounded or dome shaped; few conical; thin walled. Subjacent to adaxial epidermis occur sclerenchyma strands interspersed with parenchyma cells. Below sclerenchyma strands is a distinct layer of parenchyma cells. Cuticle: adaxial cuticle thin and slightly ridged; abaxial cuticle thicker and very ridged. Stomata: present in abaxial furrows; substomatal chamber present. Mesophyll: two to three layers of palisade grading into a compactly arranged spongy tissue. One to two layers large translucent

palisade cells arranged radially above vascular bundles. Vascular bundles: 21; no commissural bundles observed. Usually one large vessel present in each vascular bundle. Two phloem units arranged laterally in flanges of Y-shaped abaxial girder. Adaxial cap present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present.

Vellozia punctulata Seubert in Martius

FIGURE 4a; PLATE 44c

SPECIMENS EXAMINED.—Blanchet 2561.

SURFACE VIEW.—Hairs: present in tufts. Epidermis: cells square to rectangular on both surfaces; thin walled. Stomata: paracytic, $15 \times 9 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove; margins turned slightly inversely. Adaxial surface slightly ridged; abaxial surface furrowed about one-half thickness of blade. Epidermis: cells on both surfaces rounded to dome shaped; thin walled. Subjacent to adaxial epidermis are sclerenchyma strands interspersed with parenchyma cells. Below sclerenchyma strands is a layer of parenchyma cells. Cuticle: thick on adaxial surface and slightly ridged; thinner on abaxial surface and slightly ridged. Stomata: present in abaxial furrows; no substomatal chamber observed. Mesophyll: three layers of palisade cells grading into fairly compact spongy tissue. Two to three layers of large translucent cells arranged radially above vascular bundles and furrows. Vascular bundles: 25; no commissural bundles observed. One to three large vessels present. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Adaxial cap present on each vascular bundle. Some abaxial sclerenchyma strands present between abaxial epidermis and a layer of parenchyma. Bundle sheath completely surrounding vascular bundle. Crystals: none observed. Tannins: present.

Vellozia resinosa Martius ex Schultes f.

FIGURE 8a–c; PLATES 30g–h, 31a

SPECIMENS EXAMINED.—Maguire et al. 44694.

SURFACE VIEW.—Hairs: absent. Epidermis: cells

square to rectangular on both surfaces; thin walled. Stomata: paracytic, $21 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with median adaxial groove; margins turned slightly inversely. Adaxial surface slightly undulating; abaxial surface furrowed about one-half thickness of blade. Epidermis: adaxial cells rectangular to dome shaped; abaxial cells rounded to dome shaped. Cells on both surfaces thin walled. Subjacent to adaxial epidermis are two to three layers of parenchyma cells interspersed with sclerenchyma strands. Below is a distinct layer of parenchyma cells. Cuticle: thick on adaxial surface; about one-half as thick on abaxial surface; smooth on both surfaces. Stomata: present in furrows; associated with hairlike protrusions; substomatal chamber present. Mesophyll: three to four layers of palisade cells grading into compactly arranged spongy tissue. Two to three layers of large translucent cells arranged radially above vascular bundles and furrows. Vascular bundles: 33; few commissural bundles observed. Two phloem units laterally arranged in flanges of Y-shaped abaxial girder. Adaxial cap on each vascular bundle. Few abaxial sclerenchyma strands present. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

Vellozia sellovii Seubert in Martius

PLATE 46c

SPECIMENS EXAMINED.—Pereira 2677—Pabst 3513.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial cells rounded; thin walled. Abaxial cells square to rectangular; thin walled. Stomata: paracytic, $12 \times 6 \mu\text{m}$; present on abaxial surface and adaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with median adaxial groove. Both adaxial and abaxial surfaces slightly undulating. Epidermis: cells on adaxial surface mostly rounded to dome shaped, few conical; thin walled. Cells on abaxial surface rounded to dome shaped; thin walled. Cuticle: thick on adaxial and abaxial surfaces, slightly ridged. Stomata: present on adaxial and abaxial surfaces; large substomatal chamber present on both surfaces. Mesophyll: four to five

layers of indistinct palisade tissue grading into compactly arranged spongy tissue. Two to three layers of large translucent cells arranged in mid-vein region and radially above each vascular bundle. Vascular bundles: 19; few commissural bundles observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted V-shaped adaxial cap present on each vascular bundle. No abaxial sclerenchyma strands or layers observed. Distinct layer of parenchyma cells immediately subjacent to abaxial epidermis. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

NOTE: The mesophyll in this species is poorly differentiated and therefore resembles the mesophyll pattern encountered in *Barbacenia* species. However, all other characteristics indicate that it is in the correct genus.

Vellozia squalida Martius ex Schultes f.

PLATE 29a-c

SPECIMENS EXAMINED.—W. A. Archer and M. Barreto 4937; Duarte 6401.

SURFACE VIEW.—Hairs: absent. Epidermis: cells rectangular and thin walled on both surfaces. Stomata: paracytic, $27 \times 15 \mu\text{m}$; present on the abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove; margins turned very slightly inversely. Adaxial surface slightly undulating; abaxial surface furrowed about one-half thickness of blade. Epidermis: adaxial cells rounded, thin walled. Abaxial cells dome shaped to conical, thin walled. Subjacent to adaxial epidermis are two to three layers sclerenchyma strands interspersed with two to three rows of parenchyma cells. Below is a distinct layer of parenchyma cells. Cuticle: thin and smooth on adaxial surface; ridged on abaxial surface. Stomata: present in abaxial furrows; small substomatal chamber present; furrows lined with epidermal projections. Mesophyll: three layers of palisade cells grading into compactly arranged spongy tissue. One to two layers of large translucent cells arranged radially above vascular bundles. Vascular bundles: 27; few commissural bundles observed.

One to two large vessels, mostly one, present in each vascular bundle. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Adaxial cap present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Abaxial sclerenchyma strands present at entrances to furrows. Crystals and tannins: none observed.

Vellozia swallenii L. B. Smith

FIGURE 13a-b; PLATE 33b-c

SPECIMENS EXAMINED.—G. Fonjecs 11; Pires et al. 9712, 9655.

SURFACE VIEW.—Hairs: absent. Epidermis: cells rectangular on both surfaces, thin walled. Stomata: paracytic, $15 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped, turned slightly inversely at margins; lamina thickens about halfway to margins, then tapers off. Adaxial surface slightly undulating; abaxial surface furrowed about one-fourth thickness of blade. Epidermis: abaxial and adaxial cells dome shaped to rectangular; cells on both surfaces thin walled. Four to five layers of sclerenchyma cells subjacent to adaxial epidermis and interspersed with four to five layers of parenchyma cells. Cuticle: thin and slightly ridged on both surfaces. Stomata: present in abaxial furrows; small substomatal chamber present. Mesophyll: two to three layers of large palisade cells present; four to five layers of translucent cells arranged radially above vascular bundles. Two to three layers of palisade tissue subjacent to translucent cells and grading into compactly arranged spongy tissue. One to two layers of large translucent cells arranged radially below vascular bundles. Vascular bundles: 13–33; no commissural bundles observed. One to three large vessels present in each vascular bundle. Two phloem units arranged laterally in flanges of Y-shaped abaxial girder. Adaxial cap present on each vascular bundle. Three to four layers of abaxial sclerenchyma strands interspersed with three to four layers of parenchyma cells. Crystals and tannins: none observed.

NOTE: The thickening of the lamina in the intercostal portion of the leaf is very characteristic of all the specimens examined.

Vellozia taxifolia Martius ex Schultes f.

FIGURE 8f; PLATE 30a-c

SPECIMENS EXAMINED.—Pereira 1290; Ynes Mexia 4289.

SURFACE VIEW.—Hairs: absent. Epidermis: cells rounded; few rectangular on both surfaces; walls thin. Stomata: paracytic, $21 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with shallow median adaxial groove; margins turned slightly inversely. Adaxial surface slightly undulating; abaxial surface furrowed about one-third thickness of blade. Epidermis: adaxial cells dome shaped to rectangular; abaxial cells rounded to dome shaped; cells on both surfaces have thin walls. One layer of sclerenchyma strands subjacent to adaxial epidermis interspersed with few parenchyma cells. Below sclerenchyma is a layer of distinct parenchyma cells. Cuticle: fairly thick and ridged on adaxial and abaxial surfaces. Stomata: present in abaxial furrows; associated with small hairlike projections; substomatal chamber virtually absent. Mesophyll: three- to four-layered palisade tissue grading into compactly arranged spongy tissue. One to two layers of large translucent cells arranged radially above vascular bundles and furrows. Vascular bundles: 15–17; no commissural bundles observed. One to two large vessels present in each vascular bundle. Two phloem units lying laterally in flanges of U- or Y-shaped abaxial girder. Adaxial cap present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present.

NOTE: The abaxial sclerenchyma recalls the type in Madagascan species which I originally termed the *Xerophyta* Type (cf. Ayensu 1969).

Vellozia tenella Martius ex Schultes f.

PLATE 44d

SPECIMENS EXAMINED.—Damazio Herb. No. 91185, 91192; Pereira 2549–Pabst 3385; Herb. Schwache 6470, 6749.

SURFACE VIEW.—Hairs: absent. Epidermis: cells square to rectangular on both surfaces; thin walled. Stomata: paracytic, $15 \times 9 \mu\text{m}$; present on abaxial surface.

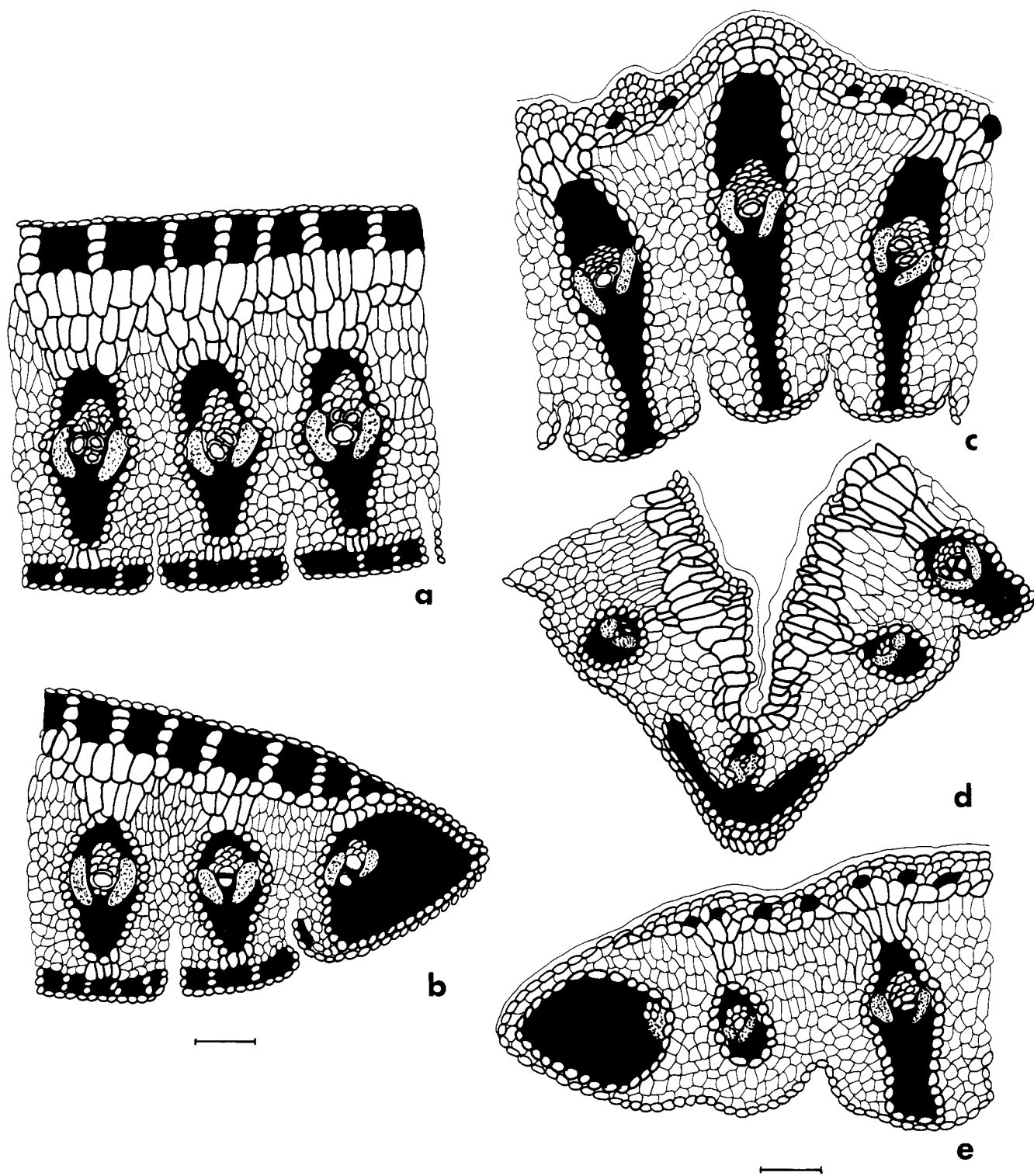


FIGURE 13.—a-b, *Vellozia swallenii* (Pires 9712); c-e, *V. dasypus* (Rose and Russell 19697).

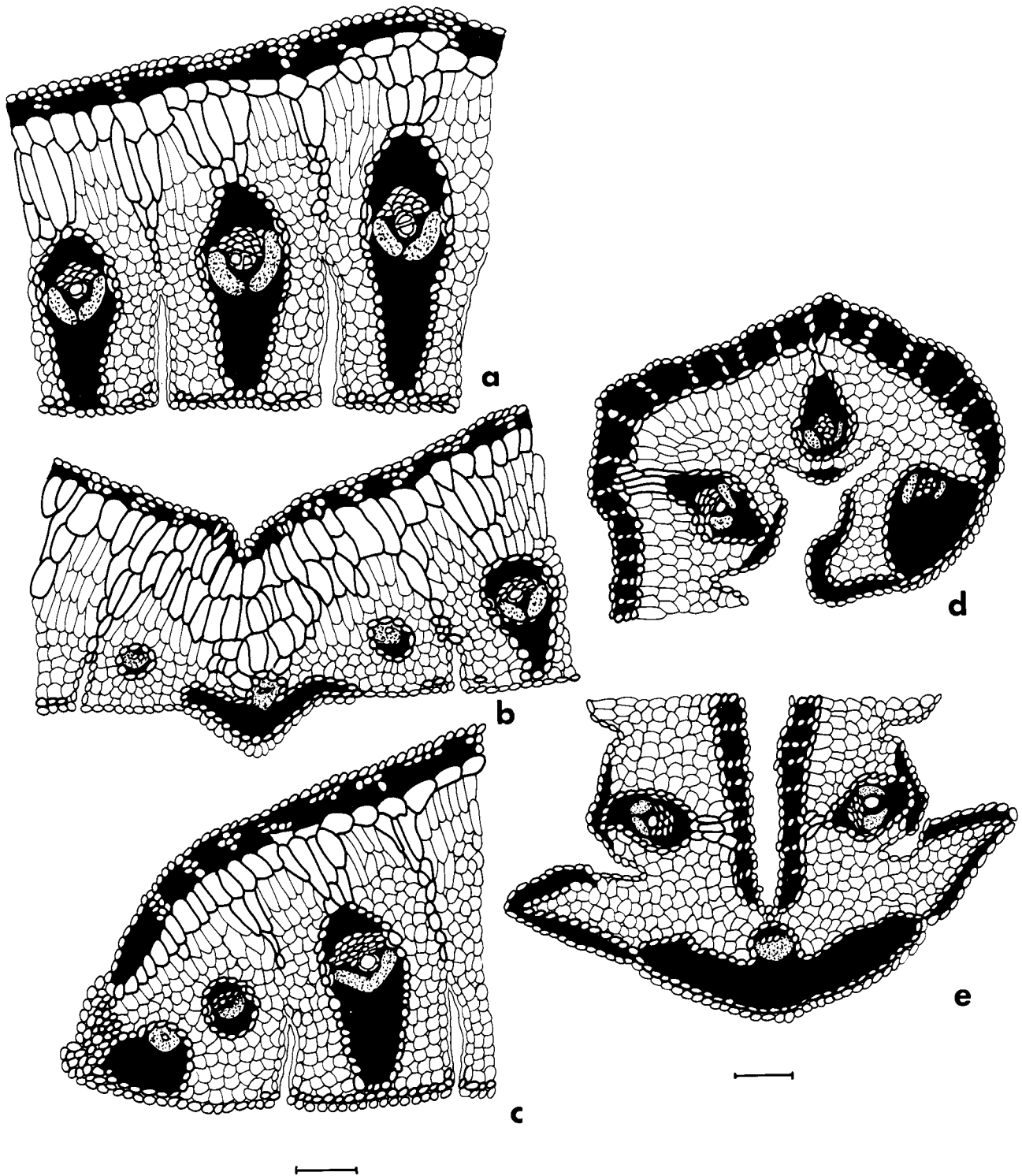


FIGURE 14.—a-c, *Vellozia caruncularis* (Heringer 5265); d-e, *V. exilis* (Irwin et al. 9507).

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small adaxial median groove. Adaxial surface slightly undulating; abaxial surface furrowed about one-half thickness of blade. Epidermis: cells on both surfaces rounded to dome shaped and thin walled. Subjacent to adaxial epidermis is a layer of sclerenchyma cells, below which is a distinct layer of parenchyma. Cuticle: slightly thickened and ridged on adaxial and abaxial surfaces. Stomata: present in abaxial furrows; substomatal chamber virtually absent. Mesophyll: two layers of palisade tissue grading into loosely arranged spongy tissue. One to two large palisade cells arranged radially above vascular bundles and furrows of Damazio H. N. 91192. Vascular bundles: 12–29; no commissural bundles observed. One to two large vessels in each vascular bundle. Two phloem units lying laterally in flanges of U-shaped abaxial girder. Adaxial cap present on all vascular bundles. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present.

NOTE: Abaxial sclerenchyma girder recalls the *Xerophyta* Type (cf. Ayensu 1969).

Vellozia teres L. B. Smith & Ayensu

PLATE 44e

SPECIMENS EXAMINED.—Irwin, Maxwell, and Wasshausen 21000.

SURFACE VIEW.—Hairs: papillae present. Epidermis: cells square to rectangular on both surfaces; thin walled. Stomata: paracytic; $21 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with median adaxial groove; margins turned slightly inversely. Adaxial surface slightly undulating; abaxial surface furrowed about one-half thickness of blade. Epidermis: adaxial cells dome shaped to conical, thin walled. Abaxial cells rounded, interspersed with some sclerenchyma strands. Subjacent to adaxial epidermis are one to two layers parenchyma cells interspersed with sclerenchyma strands. Below is a distinct layer of parenchyma cells. Cuticle: thin on both adaxial and abaxial surfaces; ridged. Stomata: present on abaxial furrows; substomatal chamber not observed. Mesophyll: palisade tissue not very distinct, grading into loosely arranged spongy tissue. One

to two layers of large translucent cells arranged radially above vascular bundle and furrows. Vascular bundles: 28; no commissural bundles observed. One to two large vessels present in each vascular bundle. Two phloem units arranged laterally in flanges of large U-shaped abaxial girder. Small adaxial cap present on each vascular bundle. A layer of abaxial sclerenchyma band present. Crystals and tannins: none observed.

Vellozia tragacantha Martius ex Seubert

FIGURE 6a–b

SPECIMENS EXAMINED.—H. S. Irwin 2495; Clausen 13, 1794.

SURFACE VIEW.—Hairs: few present in small tufts. Epidermis: cells mostly square to rectangular on both surfaces, few rounded, thin walled. Stomata: paracytic, $15 \times 9 \mu\text{m}$; present on abaxial and adaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove. Adaxial and abaxial surfaces only very slightly undulating. Epidermis: adaxial cells rounded to dome shaped, few conical; cells larger in median adaxial groove. Abaxial cells rounded to dome shaped. Cuticle: thin and slightly ridged on adaxial surface; thick and slightly ridged on abaxial surface. Stomata: present on abaxial and adaxial surfaces; substomatal chamber present; distinctly sunken. Mesophyll: four to five layers of palisade cells grading into compactly arranged spongy tissue. Two layers of large translucent tissue arranged radially above midvein and some vascular bundles. Vascular bundles: 8; no commissural bundles observed. One to two large vessels present in each vascular bundle. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Adaxial cap present on each vascular bundle, sometimes as large as abaxial girder. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

Vellozia triquetra Pohl

PLATE 44f

SPECIMENS EXAMINED.—Gardner 2735.

SURFACE VIEW.—Hairs: absent. Epidermis: cells round to rectangular on both surfaces; walls thin.

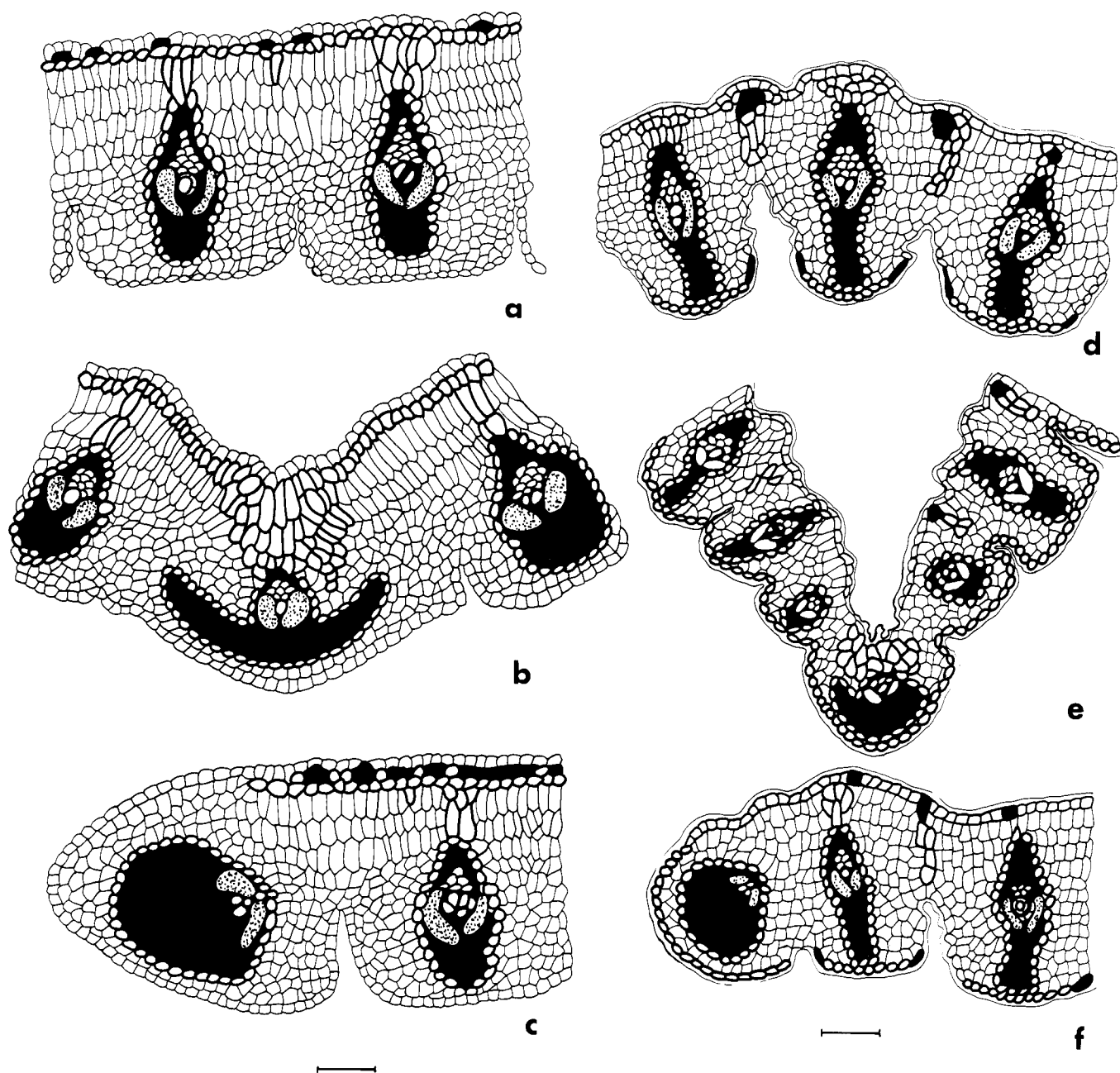


FIGURE 15.—a-c, *Vellozia candida* (Carauta 1868); d-f, *V. cachimbensis* (Pires et al. 6235).

Stomata: paracytic, $18 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; roughly V-shaped with lamina highly corrugated. Both surfaces deeply undulating. Epidermis: adaxial and abaxial cells rounded to dome shaped, thick walled. Subjacent to adaxial epidermis are

sclerenchyma strands interspersed with parenchyma cells. Below sclerenchyma strands is a distinct layer of parenchyma cells. Cuticle: thin and slightly ridged on adaxial and abaxial surfaces. Stomata: present in abaxial surface; flush with epidermis; substomatal chamber present. Mesophyll: two to three layers of indistinct palisade tissue grading

into compactly arranged spongy tissue. Some large translucent cells present between major veins. Large lacunae present in mesophyll especially toward abaxial side. Vascular bundles: two types present; major veins 15; minor veins 86; no commissural bundles observed. Major veins with one to two large vessels; two phloem units lying laterally in flanges of abaxial crescentiform or U-shaped girder; adaxial cap present on each vascular bundle and extending almost to adaxial epidermis. Each vascular bundle completely surrounded by a bundle sheath. Minor veins have one to two larger vessels and a single phloem unit; few sclerenchyma strands, completely surrounded by bundle sheath. Some abaxial strands present between abaxial epidermis and a single layer of parenchyma cells. Crystals: none observed. Tannins: present.

NOTE: This species is in every respect similar to *Vellozia plicata*.

Vellozia variabilis Martius ex Schultes f.

PLATES 12a-b, 27a-f

SPECIMENS EXAMINED.—Pereira 2857—Pabst 3493; Brade 13893; Lima 58-3003; Irwin et al. 9867; Irwin et al. 9915, 11709, 9809, 9726; Maguire 49262.

SURFACE VIEW.—Hairs: absent. Epidermis: cells square to rectangular on both surfaces, thin walled. Stomata: paracytic, $15 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with slight median adaxial groove. Adaxial surface slightly undulating; abaxial surface furrowed about one-third to one-half thickness of blade. Epidermis: adaxial cells dome shaped to rectangular; abaxial cells rounded to dome shaped; cells on both surfaces are thin walled. Subjacent to adaxial epidermis are two layers of parenchyma cells interspersed with sclerenchyma strands. Below parenchyma and sclerenchyma is a distinct layer of translucent parenchyma cells. Cuticle: thick and ridged on adaxial surface; thin and ridged on abaxial surface. Stomata: present in abaxial furrows; small substomatal chamber present, small hairs present in furrows. Mesophyll: distinctly three-layered palisade cells grading into compactly

arranged spongy tissue. Two to three layers of large translucent cells arranged radially above vascular bundles and on furrows. Vascular bundles: 21-46; few commissural bundles observed. One to two large vessels present, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Adaxial cap present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. A layer of abaxial sclerenchyma present between abaxial epidermis and a distinct layer of parenchyma. Crystals: none observed. Tannins: present.

Vellozia verruculosa Martius ex Schultes f.

PLATES 19a-b, 26a-c

SPECIMENS EXAMINED.—L. O. Williams 8112.

SURFACE VIEW.—Hairs: few papillae present. Epidermis: cells square to rectangular on both surfaces; few rounded on abaxial surface; walls thin on both surfaces. Stomata: paracytic, $12 \times 6 \mu\text{m}$; present on adaxial and abaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove. Adaxial surface slightly undulating; abaxial surface furrowed about one-half thickness of blade. Epidermis: cells on both surfaces rounded to rectangular; thin walled. One to two layers of parenchyma cells interspersed with sclerenchyma strands occur between adaxial epidermis and a distinct layer of parenchyma cells. Cuticle: fairly thick on both surfaces and slightly ridged. Stomata: present in abaxial furrows as well as on abaxial and adaxial surfaces. Substomatal chamber present; stomata almost flush with surface. Mesophyll: three- to four-layered palisade tissue grading into compactly arranged spongy tissue. One to two layers of large translucent cells arranged radially above vascular bundles and on furrows. Vascular bundles: 21; few commissural bundles observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units arranged laterally in flanges of V- or U-shaped abaxial girder. Adaxial cap present on each vascular bundle. Some abaxial sclerenchyma strands present between abaxial epidermis and a layer of parenchyma cells. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present.

Vellozia virgata Goethart & Henrard

FIGURE 3a-b; PLATE 46d

SPECIMENS EXAMINED.—Schwacke 5889; Porto 543.

SURFACE VIEW.—Hairs: few papillae present. Epidermis: cells square to rectangular on both surfaces; some rounded on adaxial surface; walls thin on both surfaces. Stomata: paracytic, $12 \times 3 \mu\text{m}$; present on abaxial and adaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; widely V-shaped with large median adaxial groove. Adaxial and abaxial surfaces slightly ridged; very small furrows in Porto 543. Epidermis: cells rounded to dome shaped on both surfaces; thin walled. Cuticle: slightly thickened and ridged on both surfaces; a little thicker on abaxial surface. Stomata: present on abaxial and adaxial surfaces; substomatal chamber present. Mesophyll: palisade tissue indistinct; spongy tissue compact. Vascular bundle: 7–10; few commissural bundles observed. One to two large vessels present in each vascular bundle. Two phloem units laterally arranged in flanges of Y-shaped abaxial girder. Adaxial cap present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: not observed.

Vellozia wasshausenii L. B. Smith

PLATE 45d

SPECIMENS EXAMINED.—Irwin et al. 20318.

SURFACE VIEW.—Hairs: few papillae present on abaxial surface. Epidermis: cells rectangular on adaxial surface; cells square to rectangular, rounded on abaxial surface; walls thin on abaxial and adaxial surfaces. Stomata: paracytic, $15 \times 9 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; widely V-shaped, intercostal region significantly expanded. Adaxial surface undulating; abaxial surface furrowed about one-half thickness of blade. Epidermis: cells on both surfaces rounded to dome shaped. Subjacent to adaxial epidermis is a layer of sclerenchyma strands interspersed with parenchyma cells. Below sclerenchyma is a distinct layer of parenchyma cells. Cuticle: thick and smooth on adaxial surface; thinner and smooth on abaxial surface. Stomata: present in abaxial furrows; sub-

stomatal chamber not observed. Mesophyll: three- to four-layered palisade cells changing abruptly into compactly arranged spongy tissue. Two to three large translucent palisade cells radially arranged above vascular bundles and on furrows. Vascular bundles: 17; no commissural bundles observed. One to two large vessels present in each vascular bundle. Two phloem units laterally arranged in flanges of Y-shaped abaxial girder. Abaxial sclerenchyma layer present. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

Section II: Radia

Vellozia cachimbensis L. B. Smith

FIGURES 3m-n, 15d-f

SPECIMENS EXAMINED.—Pires et al. 6235; Pires 6111.

SURFACE VIEW.—Hairs: small papillae present in clusters on both surfaces. Epidermis: cells square to rectangular; few adaxial and abaxial cells rounded; thin walled on both surfaces. Stomata: paracytic, $15 \times 9 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with slight median adaxial groove. Adaxial surface slightly ridged; abaxial surface furrowed about one-third thickness of blade. Epidermis: adaxial cells rectangular to rounded; abaxial cells rounded to dome shaped. Subjacent to adaxial epidermis are one to two rows of parenchyma cells interspersed with sclerenchyma strands above radially arranged translucent cells on each furrow; below parenchyma cells occurs a distinct layer of parenchyma cells; few abaxial sclerenchyma strands. Cuticle: fairly thick and smooth on adaxial surface; fairly thick and slightly ridged on abaxial surface. Stomata: present in abaxial furrows with small substomatal chamber. Mesophyll: three to four layers of indistinct palisade tissue grading onto compactly arranged spongy tissue. One to two layers of large translucent palisade cells radially arranged above vascular bundles and furrows. Vascular bundle: 21–36; commissural bundles not observed. Large veins with one to three large vessels, mostly one. Two phloem units arranged laterally in flanges of Y-shaped abaxial girder. Each vascular bundle accompanied by an

abaxial girder and adaxial cap. Bundle sheath completely surrounding vascular bundle. Crystals: none observed. Tannins: few present in mesophyll.

NOTE: The adaxial inverted caps are almost V-shaped and extend closely to epidermis.

Vellozia cana Goethart & Henrard

PLATES 18a, 45b

SPECIMENS EXAMINED.—Irwin et al. 11734, 12556.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial and abaxial cells mostly rectangular, generally thin walled; slightly thick on veins. Stomata: paracytic, $18 \times 12 \mu\text{m}$; observed on both surfaces.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with slight median adaxial groove. Adaxial surface evenly undulating; abaxial surface furrowed about one-third of blade thickness. Epidermis: cells more or less square shaped, adaxial cells slightly larger than abaxial ones; adaxial cells evenly interrupted by strands of sclerenchyma. Some of abaxial cells replaced by almost continuous band of sclerenchyma. Cuticle: thin on both surfaces. Stomata: almost flush with epidermis; few on adaxial surface, mostly confined to abaxial surface, specifically in furrows; guard cells thick walled with no projecting ledges; substomatal chamber present. Mesophyll: adaxial palisade four to six layered, occupying about half of mesophyll and abruptly changing into spongy tissue. Palisade layers alternate with large translucent cells radially arranged above vascular bundles and furrows; rest of mesophyll compactly arranged and filled with chloroplast. Translucent cells radially arranged above vascular bundles and furrows. Vascular bundles: 57–59; commissural bundles present. Large veins each with one to two large vessels, occasionally three or more. Two phloem units lying laterally in flanges of abaxial Y-shaped girder. Each vascular bundle always accompanied by abaxial inverted V-shaped sclerenchyma cap, both in turn completely surrounded by a distinct bundle sheath. Crystals: not observed. Tannins: present but not abundant.

NOTE: The abaxial strands at the wide end of the furrows and the almost horizontal median abaxial portion are very distinctive.

Vellozia candida Mikan

FIGURE 15a–c; PLATES 34g–h, 35a, 50a

SPECIMENS EXAMINED.—Carauta 160; Kuhlman 8–XI–922; Porto 91195; Jardim Bot., Rio de Janeiro 2485.

SURFACE VIEW.—Hairs: absent. Epidermis: cells rounded, square to rectangular on both surfaces; thin walled. Stomata: paracytic, $24 \times 15 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with margins turned inversely. Adaxial surface undulating; abaxial surface furrowed about one-third thickness of blade. Epidermis: adaxial cells dome shaped or rectangular; abaxial cells rounded to dome shaped; cell walls thin on both surfaces. Subjacent to adaxial epidermis are sclerenchyma strands interspersed with parenchyma cells. Below is a distinct row of parenchyma cells. Cuticle: thick and slightly ridged on adaxial surface; thinner and slightly ridged on abaxial surface. Stomata: present on abaxial surface especially in furrows; substomatal chamber present; stomata flush with epidermal surface. Mesophyll: three-layered palisade tissue changing abruptly to compactly arranged spongy tissue. Large translucent cells arranged radially above vascular bundles. Vascular bundles: 25–35; commissural bundles not observed. One to two large vessels observed, mostly one. Two phloem units laterally arranged in flanges of Y- or U-shaped abaxial girder. Each vascular bundle always accompanied by inverted adaxial cap and bundle sheath completely surrounding vascular bundles. Crystals: none observed. Tannins: few.

NOTE: The large abaxial crescentiform sclerenchyma band is very distinctive.

Vellozia caput-ardeae L. B. Smith & Ayensu

PLATE 36a

SPECIMENS EXAMINED.—L. B. Smith and Ayensu 15989.

SURFACE VIEW.—Hairs: none present. Epidermis: adaxial cells mostly square, few rounded; thin walled. Abaxial cells rectangular; thin walled. Stomata: paracytic, $18 \times 12 \mu\text{m}$; present on abaxial surface.

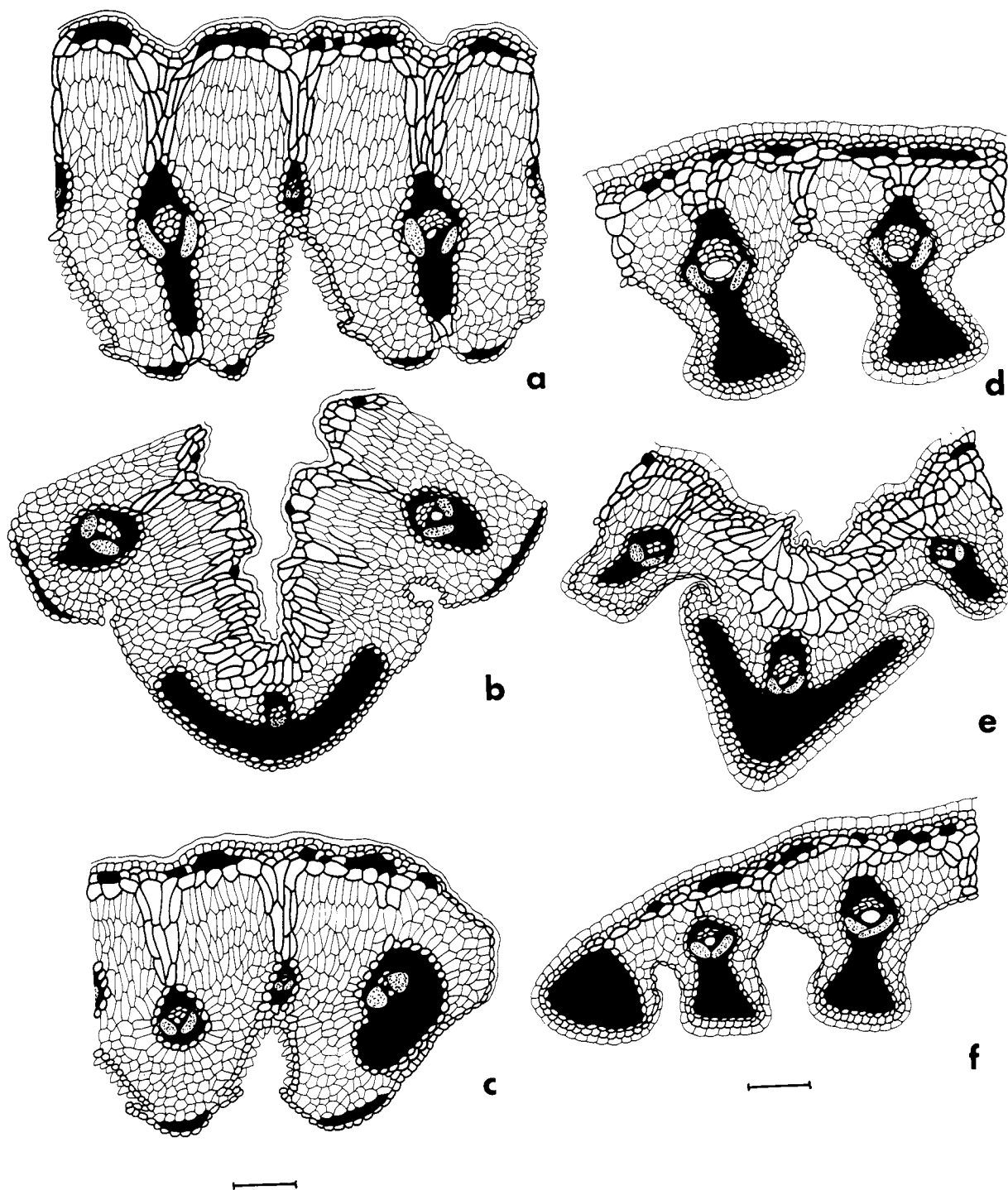


FIGURE 16.—a-c, *Vellozia burle-marxii* (U.S. 2537159);
d-f, *V. lithophila* (Schultes and Cabrera 18317).

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove present. Adaxial surface slightly undulating; abaxial surface furrowed one-half thickness of blade. Epidermis: cells dome shaped on abaxial and adaxial surface; few square on adaxial surface; walls thin on both surfaces. Subjacent to adaxial epidermis are three to four layers parenchyma cells interspersed with some sclerenchyma strands. Clusters of radially arranged parenchyma cells are intermittently present subjacent to adaxial epidermis. Below parenchyma cells and sclerenchyma strands is a distinct layer of parenchyma cells. Cuticle: thin and ridged on abaxial and adaxial surfaces. Stomata: present in abaxial furrows; substomatal chamber not observed; somewhat protected by projections in furrow. Mesophyll: one to two layers translucent palisade cells radially arranged above vascular bundles and furrows. Three to four layers small palisade cells present between translucent rows; small palisade grading into compact spongy tissue. Vascular bundle: 49; few commissural bundles present. One to two vessels present in each vascular bundle, mostly one. Two phloem units laterally arranged in flanges of thin Y-shaped abaxial girder. Adaxial cap present on each bundle, but very small. Bundle sheath completely surrounding vascular bundle. Few abaxial sclerenchyma strands present. Crystals: none observed. Tannins: few present.

Vellozia dawsonii L. B. Smith

FIGURE 3g-h; PLATES 1a-b, 45c, 51a

SPECIMENS EXAMINED.—Irwin et al. 12648.

SURFACE VIEW.—Hairs: present, tuftlike. Epidermis: adaxial and abaxial cells mostly rectangular. Stomata: paracytic, $18 \times 15 \mu\text{m}$; occur on both surfaces but highly concentrated in abaxial furrows.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with slight median adaxial groove and abaxially two grooved. Adaxial surface undulating; abaxial surface furrowed about one-third of blade thickness. Epidermis: cells more or less rectangular shaped on adaxial surface and almost rounded on abaxial surface. Abaxial epidermis partially replaced with sclerenchyma fibers. Subjacent to adaxial epidermis occur one to two layers of paren-

chyma cells interspersed with short strands of sclerenchyma. Below sclerenchyma strands and subjacent paranchyma is a layer of large translucent cells separating subjacent cells from mesophyll. Cuticle: generally thin, but slightly thickened around median region. Stomata: mostly confined to furrows in abaxial surface, conspicuous in places. Mesophyll: adaxial palisade three to four layered, occupying a little under half of mesophyll and changing abruptly into spongy tissue; three to four rows of large translucent cells arranged radially above vascular bundles and furrows. Palisade and spongy cells compactly arranged and filled with chloroplasts. Mesophyll in median section of leaf composed of large translucent cells, bulliform-like. Vascular bundles: 52; commissural bundles present. Large veins with one to two wide vessels. Two phloem units lying laterally in flanges of abaxial Y-shaped girder. Each vascular bundle always accompanied by adaxial inverted V-shaped sclerenchyma cap; both in turn completely surrounded by a distinct bundle sheath. Crystals: not observed. Tannin: few in mesophyll.

NOTE: The tuftlike appearance of unicellular and multicellular macro-hairs is very distinctive.

Vellozia dumitiana R. E. Schultes

PLATES 2a-b, 45a

SPECIMENS EXAMINED.—Barriga 13804; Cabrera and Schultes 15050A.

SURFACE VIEW.—Hairs: long and narrow, unicellular and multicellular, often with coalesced bases, observed on abaxial surface only. Epidermis: adaxial and abaxial cells uniformly rectangular. Stomata: tetracytic, $21 \times 18 \mu\text{m}$; present on abaxial surface only.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with shallow median adaxial groove but tending to shallowly corrugate. Adaxial surface gently undulating. Abaxial surface deeply furrowed about two-thirds of blade thickness. Epidermis: cells square shaped, adaxial cells slightly larger than abaxial ones; cells somewhat translucent. Subjacent to epidermis occur two to three layers of parenchyma cells followed by strands of fibers. Below these layers and fibers occurs a layer of large translucent cells separating epidermal and subepidermal layers of cells from mesophyll.

Cuticle: thin on both surfaces. Stomata: confined to abaxial furrows only; almost flush with epidermis. Mesophyll: adaxial palisade four- to five-layered, occupying about half of mesophyll, and abruptly changing into spongy tissue; three to five rows of translucent layers radially arranged above vascular bundles and abaxial furrows. Vascular bundles: 18–33; commissural bundles few. Large veins each with one to two wide vessels, mostly one. Two phloem units lying laterally in flanges of abaxial Y-shaped girder. Each vascular bundle always accompanied by adaxial inverted V-shaped sclerenchyma cap and abaxial Y-shaped girder; both in turn completely surrounded by a distinct bundle sheath. Crystals: square shaped and styloid-like. Tannin: present especially in palisade cells.

NOTE: The two collections are identical in their anatomy except that Barriga 13804 has a slightly narrower leaf.

Vellozia hirsuta Goethart & Henrard

FIGURE 4d; PLATE 37b

SPECIMENS EXAMINED.—Hatschbach 28093; L. B. Smith and Ayensu 15999.

SURFACE VIEW.—Hairs: some present in clumps on adaxial and abaxial surfaces; multicellular. Epidermis: cells square; few rounded and rectangular on both surfaces. Cells thin walled. Stomata: tetracytic, $18 \times 15 \mu\text{m}$; present on abaxial and adaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with median adaxial groove; turned slightly inversely at margins. Surface slightly undulating on adaxial surface; abaxial surface furrowed about one-fourth to one-half thickness of blade. Epidermis: adaxial cells dome shaped; few conical. Abaxial cells rounded. Walls thin on abaxial and adaxial surface. Subjacent to adaxial epidermis are two to three layers of parenchyma cells, interspersed with sclerenchyma strands. Below this is a complete layer of parenchyma cells. Stomata: present in abaxial furrows and on abaxial and adaxial surfaces; substomatal chamber present. Mesophyll: three layers palisade tissue grading into compact spongy tissue. One to two layers large translucent palisade cells arranged radially above vascular bundles; large number translucent pali-

sade cells above midvein. Vascular bundles: 35; few commissural bundles observed. One to two large vessels present in each vascular bundle; mostly one. Two phloem units arranged laterally in flanges of Y-shaped abaxial girder. Each vascular bundle has an adaxial cap or partial girder. Some abaxial sclerenchyma strands present on abaxial corners of furrows. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

Vellozia lanata Pohl

PLATES 3b, 17b, 45e

SPECIMENS EXAMINED.—Pires et al. 9895; Vera-lucia and Graziella 26/1/1968.

SURFACE VIEW.—Hairs: absent. Epidermis: cells rectangular, thin walled. Stomata: tetracytic, $21 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; deeply V-shaped with median adaxial groove. Adaxial surface slightly undulating; abaxial surface furrowed about one-half thickness of blade. Epidermis: adaxial cells rounded to rectangular; abaxial cells rounded to dome shaped. One to two layers parenchyma cells subjacent to epidermis and interspersed with sclerenchyma strands. Below parenchyma and sclerenchyma is a distinct layer of parenchyma cells. Cuticle: thick and slightly ridged on adaxial surface; very thin on abaxial surface. Stomata: present in furrows; large substomatal chamber present. Mesophyll: three-layered palisade tissue grading into compact spongy tissue. One to two layers of large translucent cells arranged radially above vascular bundles and furrows. Vascular bundles: 37; few commissural bundles observed. One to three large vessels, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Each vascular bundle accompanied by an adaxial cap. Abaxial strands present, sometimes displacing abaxial epidermis. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: few present.

Vellozia lithophila Schultes

FIGURES 2b, 16d–f; PLATE 2c–d

SPECIMENS EXAMINED.—Schultes and Cabrera 18317.

SURFACE VIEW.—Hairs: present in tufts. Epidermis: cells square to rectangular; thin walled. Stomata: paracytic, $21 \times 15 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with margins turned slightly inversely. Adaxial surface slightly undulating, more so near midvein; abaxial surface furrowed one-half the thickness of blade; furrows wide and arch shaped. Epidermis: adaxial cells mostly dome shaped, with outer tangential wall concave. Abaxial cells rectangular to slightly dome shaped. Walls thin on both surfaces. One to two layers of parenchyma cells subjacent to adaxial epidermis and interspersed with sclerenchyma strands. Below sclerenchyma and parenchyma is a distinct single layer of parenchyma cells. Cuticle: very thick and slightly ridged on adaxial surface; one-half as thick on abaxial surface and slightly ridged. Stomata: present in abaxial furrows, substomatal chambers not observed. Mesophyll: two to three layers of palisade cells grading into compact spongy tissue. One to two layers of large translucent cells arranged radially above vascular bundles and on furrows. Vascular bundles: 49; few commissural bundles observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder; adaxial cap present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present.

NOTE: This species exhibits rather wide abaxial furrows resembling arches of large gates.

Vellozia machrisiana L. B. Smith

FIGURE 17d-f; PLATES 4a-b, 35b-d

SPECIMENS EXAMINED.—Irwin et al. 12454; Irwin et al. 12697.

SURFACE VIEW.—Hairs: absent. Epidermis: cells rounded to rectangular on both surfaces; thin walled. Stomata: paracytic, $15 \times 15 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove; turned slightly inversely at margins. Adaxial surface slightly undulating; abaxial surface furrowed about one-half thickness of blade and narrow.

Epidermis: adaxial and abaxial cells rounded to dome shaped; thin walled. Subjacent to adaxial epidermis occur one to two layers of parenchyma cells interspersed with one- to two-layered strands of sclerenchyma. Below parenchyma layers and sclerenchyma strands is a distinct layer of parenchyma cells. Cuticle: thick on both surfaces; slightly ridged on abaxial surface; smooth on adaxial surface. Stomata: present in abaxial furrows; almost flush with surface; small substomatal chamber observed. Mesophyll: three to four layers of indistinct palisade tissue grading into compact spongy tissue. Two to three layers of large translucent cells arranged radially above vascular bundles and furrows. Vascular bundles: 28–31; some commissural bundles observed. One to three large vessels present in each vascular bundle, mostly one. Two phloem units arranged laterally in flanges of Y-shaped abaxial girder, adaxial cap present on each vascular bundle. Abaxial strands present; separated from spongy mesophyll by a distinct layer of parenchyma cells. Each vascular bundle is completely surrounded by a bundle sheath. Crystals and tannins: none observed.

NOTE: The two specimens are identical; however, the abaxial portion of the midvein is flattened in Irwin et al. 12697, while it is pointed in Irwin et al. 12454.

Vellozia maculata Goethart & Henrard

FIGURE 30p; PLATES 3c-d, 45f

SPECIMENS EXAMINED.—Glaziou 22218-a.

SURFACE VIEW.—Hairs: few present. Epidermis: cells square to rectangular on both surfaces; thin walled. Stomata: paracytic, $18 \times 18 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped; margins turned inversely. Adaxial surface distinctly undulating especially in median region; two small adaxial grooves present laterally to midvein. Abaxial surface with fairly wide furrows about one-third to one-half thickness of blade. Epidermis: adaxial cells dome shaped to rectangular; abaxial cells rounded to dome shaped. Cells on both surfaces thin walled. Subjacent to adaxial epidermis occur layers of parenchyma cells interspersed with sclerenchyma strands. Below these layers is a distinct layer of parenchyma cells.

Cuticle: thick on adaxial surface; about one-half as thick on abaxial surface. Cuticle on both surfaces slightly ridged. Stomata: present in furrows; substomatal chamber virtually absent. Mesophyll: two to three layers of indistinct palisade tissue grading into compact spongy tissue. One layer large translucent cells arranged radially above vascular bundles; one to two layers above furrows. Vascular bundles: 21; no commissural bundles observed. One to two large vessels present in each vascular bundle. Two phloem units arranged laterally in flanges of Y-shaped abaxial girder. Adaxial girder present on all vascular bundles and almost extended to adaxial epidermis. Some abaxial sclerenchyma strands present. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present.

NOTE: The lateral extensions of the outer edges of the abaxial furrows serve as valves enclosing the areas where stomata are present. The extensions also recall similar structures in *Vellozia hemispherica* and *V. burle-marxii*.

Vellozia riedeliana Goethart & Henrard

FIGURE 4c; PLATE 46b

SPECIMENS EXAMINED.—L. B. Smith and Ayensu 15983.

SURFACE VIEW.—Hairs: numerous, present in clusters. Epidermis: adaxial cells square to rectangular on both surfaces; some rounded on abaxial surface. Cells thin walled. Stomata: paracytic, $15 \times 3 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with median adaxial groove. Adaxial surface undulating; sometimes deeply ridged abaxial surface furrowed about one-third thickness of blade. Epidermis: adaxial cells rounded to rectangular; thin walled; some papillae present on adaxial surface. Abaxial cells dome shaped; thin walled. Subjacent to adaxial epidermis occur two to three layers of parenchyma cells interspersed with sclerenchyma strands. Below is a distinct layer of parenchyma cells. Cuticle: very thick and fairly smooth on adaxial surface; thin and ridged on abaxial surface. Stomata: present in abaxial furrows; small substomatal chamber present. Stomata flush with or slightly above epidermal surface. Mesophyll: three layers of distinct palisade tissue

grading into compactly arranged spongy tissue. Two to three layers of large translucent cells arranged radially above vascular bundles. Vascular bundles: 30; few commissural bundles observed. One large vessel present in each vascular bundle. Two phloem units arranged laterally in flanges of Y-shaped abaxial girder. Fairly large adaxial cap present on each vascular bundle. Few abaxial sclerenchyma strands present on abaxial corners of furrows. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

Vellozia tubiflora A. Richard

FIGURE 17a-c; PLATES 35c-h, 38a-b

SPECIMENS EXAMINED.—Foldats 3526; Maguire et al. 29156, 29245, 30703, 30835, 30941, 30955, 31003, 31679, 31777, 32307, 33532, 35131, 35136, 35248, 36051, 43855, 45918; L. Williams 12974, 13459, 16022; Steyermark 93208, 60326; Steyermark and Aristiquita 54; Steyermark and Nilsson 554; Tamayo 3105; Tate 1196; Lasser 1777.

SURFACE VIEW.—Hairs: present on abaxial surface of most specimens. Epidermis: cells square to rectangular on both surfaces, thin walled. Stomata: paracytic, $21 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with margins turned slightly inversely; small median adaxial groove present. Adaxial surface slightly undulating; abaxial surface furrowed about one-half thickness of blade; furrows may be wide or narrow. Epidermis: adaxial cells rectangular; abaxial cells rounded to dome shaped. Walls thin on both surfaces. Subjacent to adaxial epidermis are one to three layers of parenchyma cells interspersed with sclerenchyma strands. Below is a distinct layer of parenchyma cells. Cuticle: thick on both adaxial and abaxial surfaces. Stomata: present in abaxial furrows; substomatal chamber present. Mesophyll: three to four layers of palisade cells grading into compactly arranged spongy tissue. One to two layers of large translucent cells arranged radially above vascular bundles and on furrows. Vascular bundles: 13–55; no commissural bundles observed. One to two large vessels present. Two phloem units lying laterally in flanges of Y-shaped abaxial girder extending to epidermis. Adaxial cap present on each vascular bundle. Few

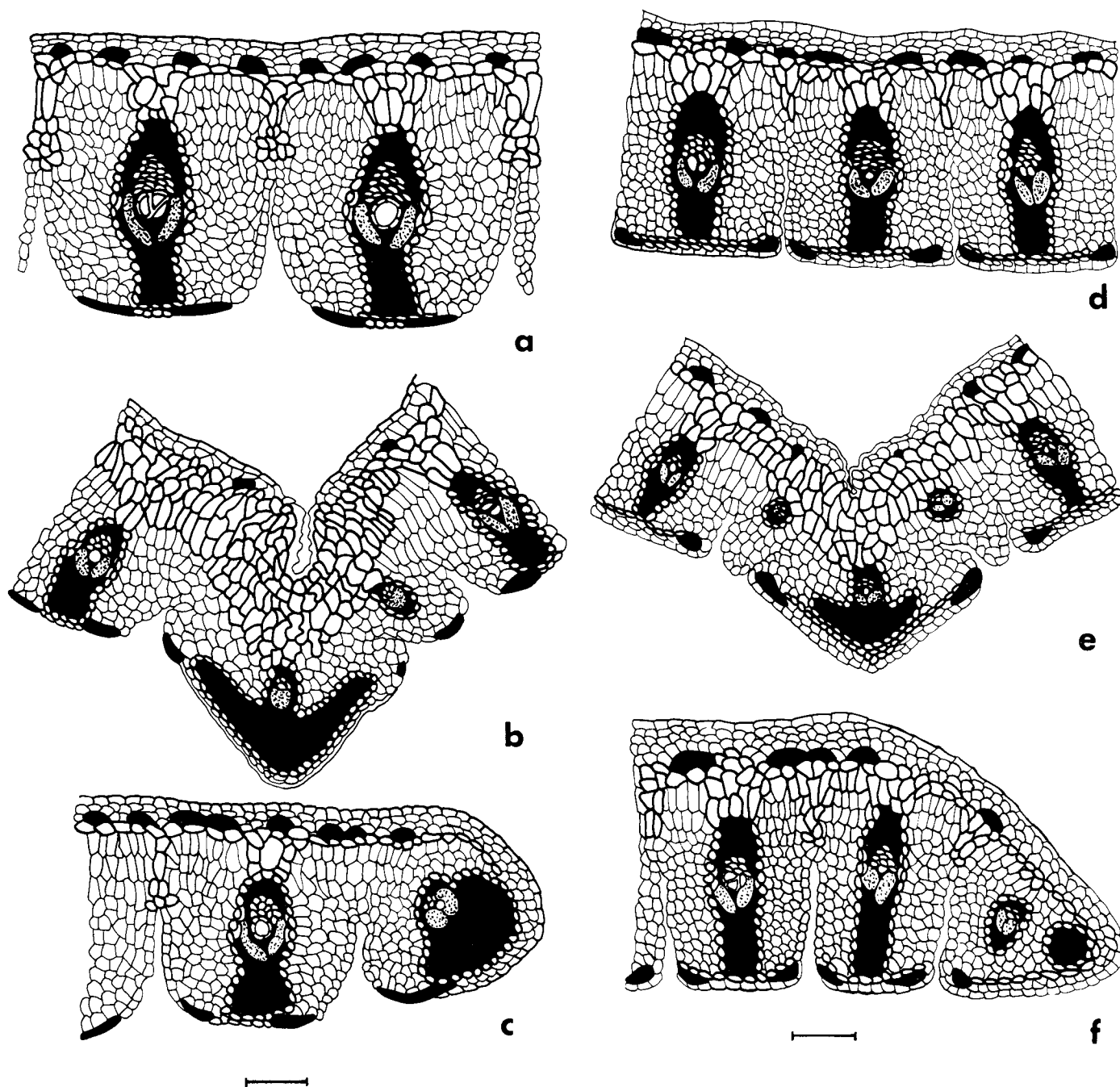


FIGURE 17.—a-c, *Vellozia tubiflora* (Maguire et al. 35131);
d-f, *V. machrisiana* (Irwin et al. 12454).

abaxial strands present. Bundle sheath completely surrounding each vascular bundle. Crystals: present. Tannins: few observed.

NOTE: The diagnostic features that character-

ize this species were found to be very uniform in all the specimens examined. This observation is indicative of the reliability of the leaf characters in the identification of species.

Barbacenia

Subkey I

Barbacenia delicatula L. B. Smith & Ayensu

PLATE 46f

SPECIMENS EXAMINED.—L. B. Smith and Ayensu 15975.

SURFACE VIEW.—Hairs: none present. Epidermis: adaxial cells mostly rectangular, few square and rounded; thin walled. Abaxial cells rectangular; thin walled. Stomata: paracytic, $15 \times 16 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped; margins of lamina turned slightly inversely. Adaxial and abaxial surfaces uniformly smooth with slight grooves separating each vascular bundle. Epidermis: adaxial cells rounded to dome shaped; thick walled. Abaxial cells rounded; thin walled. Subjacent to adaxial epidermis is a distinct layer of parenchyma cells. Following parenchyma cell layer are clusters of sclerenchyma strands surrounded by one-layered parenchyma cells; usually occur above vascular bundles. Other smaller sclerenchyma strands observed. Cuticle: thin on both surfaces and slightly ridged. Stomata: present on abaxial surface; small substomatal chamber present; flush with surface but appearing in grooves. Mesophyll: spongy tissue uniformly arranged with some large translucent cells especially in midvein region as well as midportion of mesophyll. Vascular bundles: 27; many commissural bundles observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Adaxial cap strictly nonexistent. Each vascular bundle completely surrounded by a bundle sheath. Crystals and tannins: none observed.

NOTE: This species is anatomically unique because of the lack of direct contact of sclerenchyma adaxial cap on the vascular bundles. The sclerenchyma caps that appear above the vascular bundles are separated by two to four layers of mesophyll cells.

Barbacenia gaveensis Goethart & Henrard

FIGURE 18a-c

SPECIMENS EXAMINED.—L. B. Smith 6445; Menezes 2.

SURFACE VIEW.—Hairs: absent. Epidermis: cells are mostly rectangular, few square; thin walled. Stomata: paracytic, $21 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped with small median adaxial groove. Adaxial and abaxial surfaces slightly ridged, especially that of Smith 6445. Epidermis: cells on both surfaces rounded to dome shaped; thin walled. Subjacent to adaxial epidermis is a layer of parenchyma cells, some of which form part of bundle sheath. Cuticle: thin on adaxial surface, slightly thicker on abaxial surface; both cuticles slightly ridged. Stomata: present on abaxial surface; almost flush with epidermal surface; small substomatal chamber present. Mesophyll: three to four layers of indistinct palisade-like tissue grading into spongy tissue. Large translucent cells present in midportion of mesophyll. Vascular bundles: 38–40; no commissural bundles observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units arranged laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present in mesophyll.

Barbacenia gounelleana Beauverd

FIGURES 1a–b, 20d–f; PLATES 6d, 38f–h, 51b

SPECIMENS EXAMINED.—Emygdio 1428.

SURFACE VIEW.—Hairs: absent. Epidermis: cells square to rectangular; thin walled. Stomata: paracytic, $27 \times 9 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Somewhat dorsiventral; V-shaped with slight median adaxial groove; turned slightly inversely at margins. Adaxial and abaxial surfaces slightly undulating. Epidermis: adaxial cells dome shaped to rectangular; abaxial cells rounded to dome shaped. Cells on both surfaces thin walled. Parenchyma layer subjacent to adaxial epidermis. Cuticle: thick on adaxial surface; thinner on abaxial surface; both slightly ridged. Stomata: present on abaxial surface; substomatal chamber present; stomata almost flush with epidermal surface. Mesophyll: three to four layers of palisade-like cells grading into loosely arranged spongy tissue. Some translucent cells

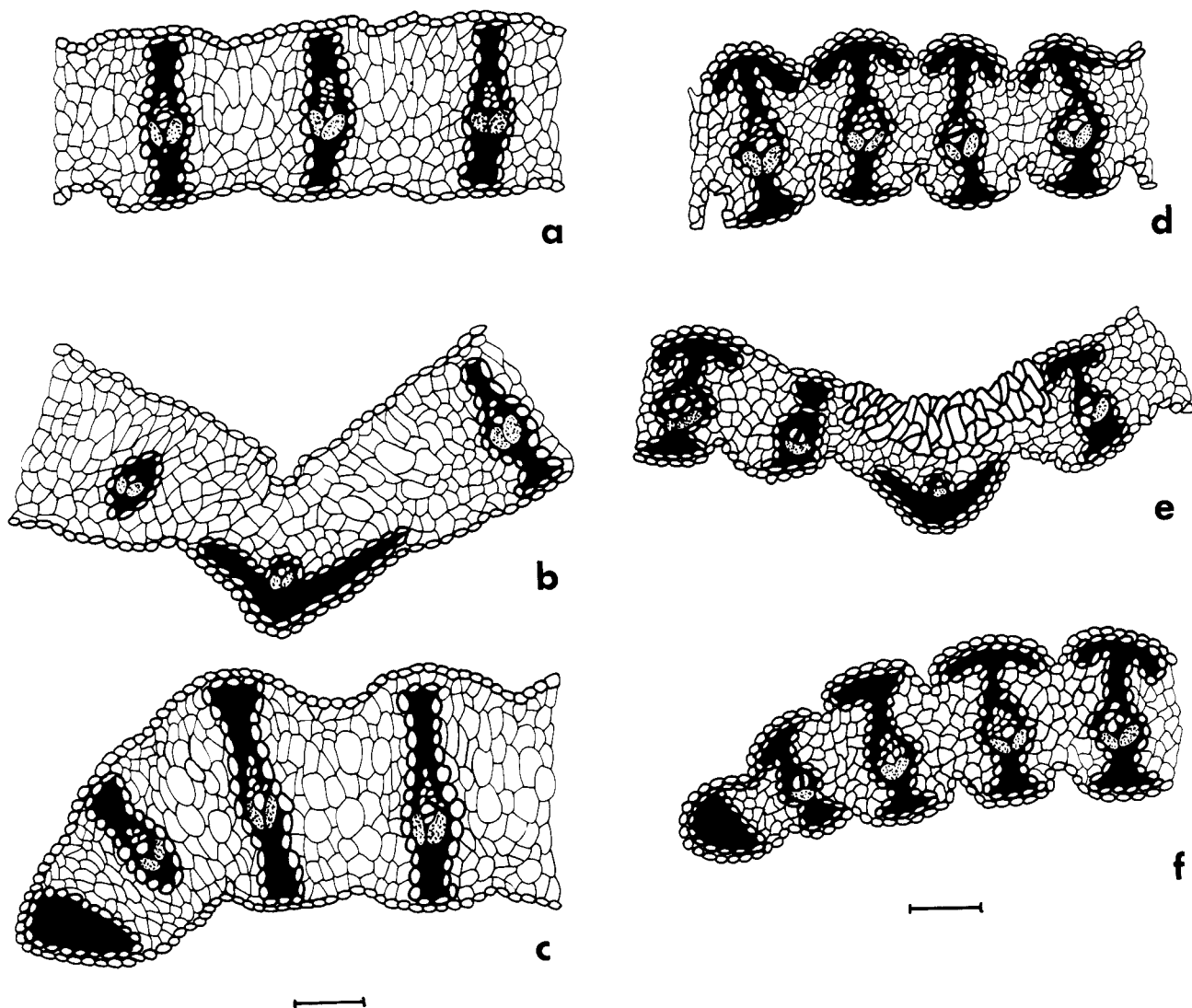


FIGURE 18.—a-c, *Barbacenia gaveensis* (L. B. Smith 6445); d-f, *B. purpurea* (U.S. 151098).

present in spongy tissue. Vascular bundles: 80; few commissural bundles observed. One to two vessels present in each vascular bundle, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present.

***Barbacenia hatschbachii* L. B. Smith & Ayensu**

PLATES 21a, 47b

SPECIMENS EXAMINED.—Hatschbach 24284.

SURFACE VIEW.—Hairs: none present. Epidermis: adaxial and abaxial cells square to rectangular; thin walled. Stomata: paracytic, $30 \times 15 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped with slight median adaxial groove. Margins of lamina turned slightly inversely. Both adaxial and abaxial surfaces slightly undulating. Epidermis: adaxial cells dome shaped; few conical; thin walled. Abaxial cells rounded to dome shaped; thin walled. Subjacent to adaxial epidermis is a distinct layer of parenchyma cells. Cuticle: thick and ridged on adaxial and abaxial surfaces. Sto-

mata: present on abaxial surface; small substomatal chamber present. Mesophyll: palisade cells nonexistent; mesophyll almost entirely made up of spongy tissue with especially large thin-walled translucent cells. Vascular bundles: 35; few commissural bundles observed. One large vessel present in each vascular bundle. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. T-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: few present.

***Barbacenia irwiniana* L. B. Smith**

PLATE 48a

SPECIMENS EXAMINED.—Porto 1140.

SURFACE VIEW.—Hairs: few fingerlike projections present on abaxial surface. Epidermis: adaxial cells square to rectangular; abaxial cells square to rectangular; cells thin walled. Stomata: paracytic, $15 \times 6 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove; margins of lamina turned inversely. Adaxial surface slightly undulating; abaxial surface with very small furrows. Epidermis: adaxial cells rounded to rectangular in shape; abaxial cells mainly dome shaped; cells on both surfaces thin walled. Subjacent to adaxial epidermis is a single layer of parenchyma cells. Cuticle: very thick and slightly ridged on adaxial surface; thin and slightly ridged on abaxial surface. Stomata: present in abaxial furrows; no substomatal chamber observed. Mesophyll: two to three layers palisade cells grading into loosely arranged spongy tissue. Few translucent cells in spongy tissue. Vascular bundles: 39; few commissural bundles observed. Usually one large vessel present in each vascular bundle. Two phloem units laterally arranged in flanges of Y-shaped abaxial girder. Adaxial girder present on each vascular bundle. Each vascular bundle completely surrounded by a bundle sheath. Crystals and tannins: none observed.

***Barbacenia longiscapa* Goethart & Henrard**

PLATE 47d

SPECIMENS EXAMINED.—Irwin et al. 22186.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial cells rectangular, few square to rounded; thin walled. Abaxial cells rectangular, few square to rounded; thin walled. Stomata: paracytic, $21 \times 12 \mu\text{m}$; present on both abaxial and adaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with small median adaxial groove. Both adaxial and abaxial surfaces slightly undulating. Epidermis: cells on adaxial and abaxial surfaces rounded to dome shaped; thin walled. Layer of parenchyma cells subjacent to adaxial epidermis. Cuticle: thin and smooth on both adaxial and abaxial surfaces. Stomata: present on adaxial and abaxial surfaces; mainly flush with epidermis; substomatal chamber present. Mesophyll: two to three layers of large palisade tissue changing into spongy tissue. Vascular bundles: 31–37; commissural bundles observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present.

***Barbacenia purpurea* Hooker**

FIGURE 18d–f; PLATE 39a–c

SPECIMENS EXAMINED.—A. L. Schott s.n. US 151098.

SURFACE VIEW.—Hairs: none present. Epidermis: adaxial cells rounded; abaxial cells square to rectangular; cells thin walled on both surfaces. Stomata: paracytic, $21 \times 6 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped with margins turned inversely. Adaxial and abaxial surfaces furrowed about one-fourth thickness of blade. Epidermis: cells on adaxial surface dome shaped to rectangular; cells on abaxial surface rounded to dome shaped; thick walled on both surfaces. Cuticle: thin and slightly ridged on adaxial and abaxial surfaces. Stomata: present in abaxial furrows; substomatal chamber present. Mesophyll: undifferentiated. Some large translucent cells radially arranged above the midvein; few translucent cells present in mesophyll. Vascular bundles: 37; commissural bundles not observed. One to two large vessels present in each

vascular bundle, mostly one. Two phloem units arranged laterally in flanges of Y-shaped adaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Both girders extend laterally below epidermis on both surfaces. Vascular bundles surrounded by bundle sheath. Crystals and tannins: none observed.

Barbacenia seubertiana Goethart & Henrard

FIGURE 19a-c; PLATE 38c-e

SPECIMENS EXAMINED.—Lanna-Sobro 4488; Strang 239, 523; Goethart and Henrard 4332.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial cells rounded; abaxial cells square to rectangular.

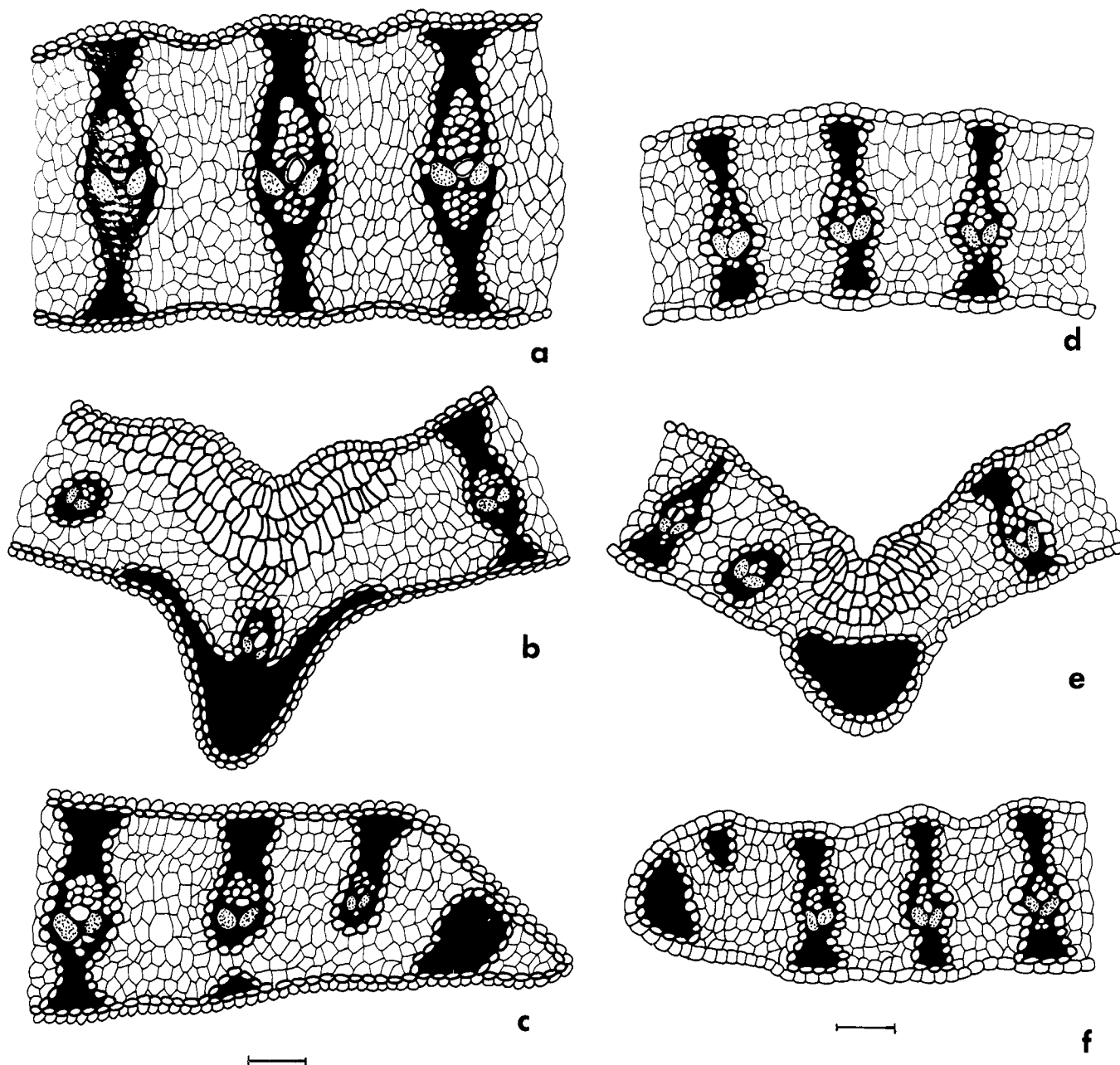


FIGURE 19.—a-c, *Barbacenia seubertiana* (Strang 239); d-f, *B. stenophylla* (Irwin et al. 9901).

lar; walls thin on both surfaces. Stomata: paracytic, $21 \times 9 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped. Adaxial and abaxial surfaces slightly undulating. Epidermis: cells on adaxial surface rounded to dome shaped; cells on abaxial surface dome shaped to conical; cell thin walled. Layer of parenchyma cells subjacent to epidermis. Cuticle: thin and ridged on abaxial and adaxial surfaces. Stomata: present on abaxial surface; small substomatal chamber present. Mesophyll: three to four layers of palisade-like cells grading into spongy tissue. Three to four layers of large mesophyll cells in midportion of lamina. Some translucent spongy tissue present on adaxial side of midvein. Vascular bundles: 19–57; commissural bundles not observed. One to two large vessels present in each vascular bundle; mostly one. Two phloem units laterally arranged in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: few in mesophyll.

***Barbacenia stenophylla* Goethart & Henrard**

FIGURES 1i–j, 19d–f

SPECIMENS EXAMINED.—Irwin et al. 9901.

SURFACE VIEW.—Hairs: few present in tufts. Epidermis: cells square to rectangular, few rounded; thin walled. Stomata: paracytic, $30 \times 12 \mu\text{m}$; present on adaxial and abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped with small median adaxial groove. Adaxial and abaxial surfaces slightly undulating. Epidermis: cells on adaxial and abaxial surfaces rounded to dome shaped; walls on both surfaces thin. Layer of parenchyma cells subjacent to adaxial epidermis. Cuticle: very thin and ridged on both surfaces. Stomata: present on abaxial and adaxial surfaces; substomatal chamber present; flush with epidermal surface. Mesophyll: undifferentiated. Some translucent cells scattered in spongy mesophyll. Two to three layers translucent palisade cells arranged radially above midvein. Vascular bundles: 23; no commissural bundles observed. One large vessel present in each vascular bundle. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial

sclerenchyma present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present mostly in mesophyll.

Subkey II

***Barbacenia celiae* Maguire**

PLATE 48b

SPECIMENS EXAMINED.—Maguire et al. 40025, 40154, 40298.

SURFACE VIEW.—Hairs: absent. Epidermis: cells square to rectangular on both surfaces, walls thin. Stomata: paracytic, $27 \times 12 \mu\text{m}$; present mainly on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Somewhat dorsiventral; widely V-shaped. Adaxial surface undulating; abaxial surface slightly ridged. Epidermis: cells on adaxial and abaxial surfaces rounded to dome shaped; thin walled. Subjacent to adaxial and abaxial epidermis a layer of parenchyma cells, some of which also form part of the bundle sheath. Cuticle: fairly thick and slightly ridged on adaxial surface; thinner and slightly ridged on abaxial surface. Stomata: present on abaxial surface; substomatal chamber present; usually occur in depression of small ridges. Mesophyll: three-layered palisade-like tissue grading into fairly compact spongy tissue; most of spongy tissue composed of large translucent cells. Vascular bundles: 39–47; no commissural bundles observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present, numerous and occupying most of mesophyll.

***Barbacenia flava* Martius ex Schultes f.**

FIGURES 1c–d, 23a–c; PLATES 6a–b, 40e–g

SPECIMENS EXAMINED.—L. B. Smith 6695, 6856; Segadas-Vianna and Loredó 1100; Maguire et al. 49116; Tryon and Tryon 6836; Maguire et al. 49011; Macedo 3747; Maguire et al. 44691.

SURFACE VIEW.—Hairs: absent. Epidermis: cells circular to rectangular on both surfaces; thin walled. Stomata: paracytic, $21 \times 15 \mu\text{m}$; present on both surfaces.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped with margins turned inversely. Both surfaces slightly undulating (except for Tryon & Tryon 6836 which has large ridges on both surfaces). Epidermis: adaxial cells rounded to dome shaped; abaxial cells dome shaped, slightly conical. Subjacent to adaxial epidermis is a distinct layer of parenchyma cells. Cuticle: thick and ridged on both surfaces. Stomata: present on adaxial and abaxial surfaces; small substomatal chamber present; usually flush with epidermis or slightly sunken. Mesophyll: undifferentiated spongy tissue largely composed of translucent cells. Vascular bundle: 25–91; commissural bundles observed. One to two large vessels present in each vascular bundle. Two phloem units laterally arranged in flange of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: not observed. Tannins: present, numerous, filling most of mesophyll.

NOTE: The specimen Tryon & Tryon 6836 does not seem to belong to this species.

Barbacenia ignea Martius ex Schultes f.

FIGURE 21d–f; PLATES 39e–f, 40a

SPECIMENS EXAMINED.—L. O. Williams and Assis 6817.

SURFACE VIEW.—Hairs: absent. Epidermis: cells square to rectangular; thin walled. Stomata: paracytic, $24 \times 12 \mu\text{m}$; present on abaxial and adaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped; turned slightly inversely at margins of lamina. Adaxial and abaxial surfaces only very slightly undulating. Epidermis: cells dome shaped to rectangular on adaxial and abaxial surfaces. Layer of parenchyma cells subjacent to adaxial and abaxial epidermis. Cuticle: thin and slightly ridged on both surfaces. Stomata: present on abaxial and adaxial surfaces. Substomatal chamber present; stomata almost flush with epidermal surface. Mesophyll: two to three layers of small cells grading into large spongy tissue. Large number of trans-

lucent cells present in center of spongy mesophyll. Vascular bundles: 49; few commissural bundles observed. One to two large vessels observed, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on all vascular bundles. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: numerous, present in mesophyll especially toward adaxial and abaxial surface.

Barbacenia involucrata L. B. Smith

FIGURE 1k–l; PLATES 20b, 47c

SPECIMENS EXAMINED.—Irwin et al. 20973.

SURFACE VIEW.—Hairs: none present. Epidermis: adaxial cells rounded; abaxial cells square to rectangular; cells on both surfaces thin walled. Stomata: paracytic, $30 \times 15 \mu\text{m}$; present on adaxial and abaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Somewhat dorsiventral; V-shaped. Both adaxial and abaxial surfaces slightly undulating. Epidermis: abaxial and adaxial cells rounded; few dome shaped. Thin walled on both surfaces. Distinct layer of parenchyma cells subjacent to adaxial and abaxial epidermis. Cuticle: thick and slightly ridged on adaxial and abaxial surfaces. Stomata: present on both adaxial and abaxial surfaces; large substomatal chamber present. Mesophyll: three to four layers of palisade-like cells grading into spongy tissue. Large translucent cells present in midregion of mesophyll. Large translucent spongy cells present in adaxial portion of midvein. Vascular bundles: 69; few commissural bundles present. One to two large vessels present, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

Barbacenia schwackei Goethart & Henrard

FIGURE 21a–c; PLATE 39d

SPECIMENS EXAMINED.—Heringer 5263.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial cells rounded; abaxial cells rectangular, few

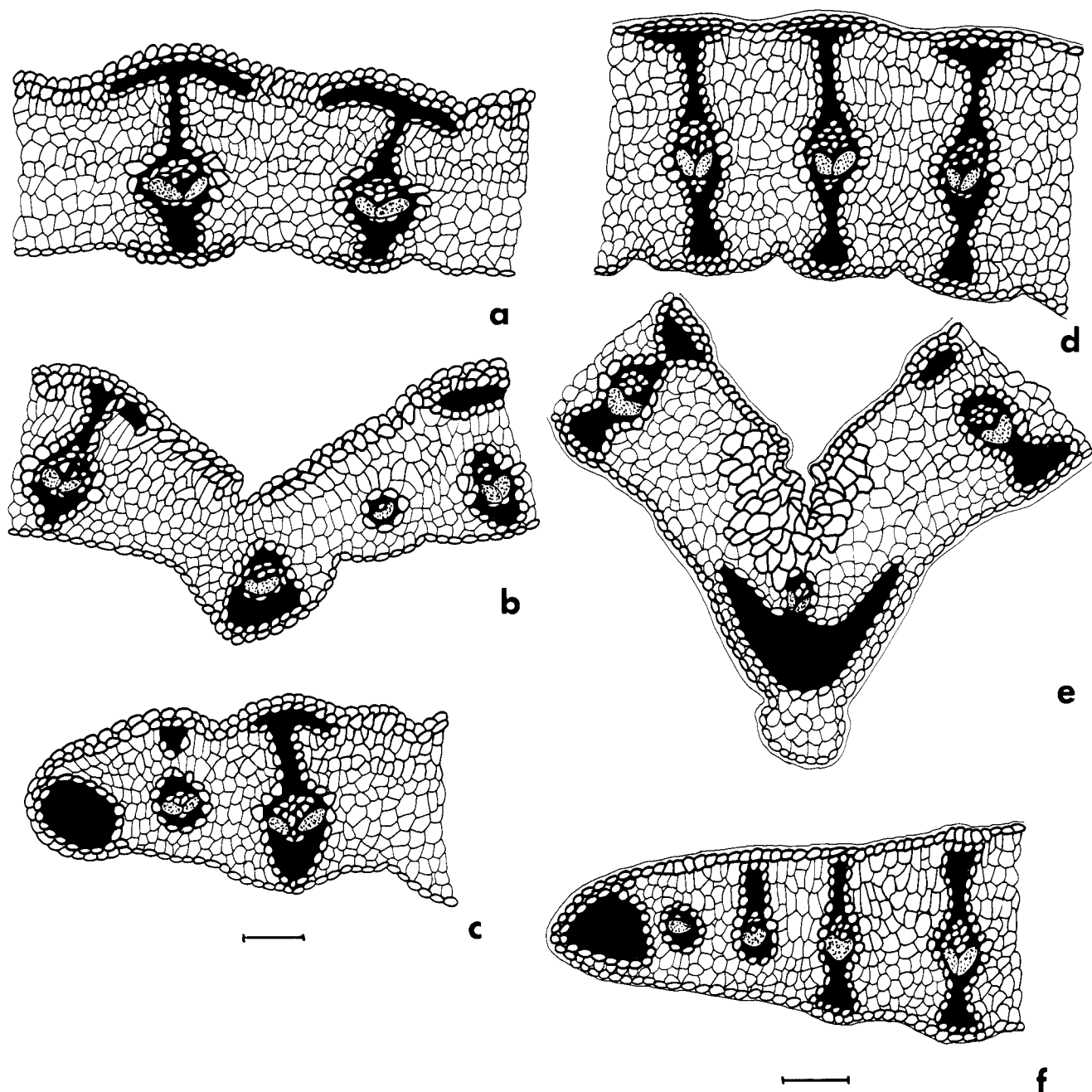


FIGURE 20.—a-c, *Barbacenia gentianoides* (Segades-Vianna and Loredó 1066);
 d-f, *B. gounelleana* (Eymygdio 1428).

rounded; cell walls thin on both surfaces. Stomata: paracytic, $27 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped. Abaxial and adaxial surfaces slightly undulating. Epidermis: cells on abaxial and adaxial surface rounded to dome shaped, few conical;

cells thin walled. Layer of parenchyma cells subjacent to adaxial epidermis. Cuticle: thin and ridged on adaxial and abaxial surfaces. Stomata: present on abaxial surface; small substomatal chamber present. Mesophyll: undifferentiated. Compactly arranged spongy tissue interspersed

with some translucent cells. Vascular bundles: 41; few commissural bundles observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed.

Tannins: numerous, virtually filling most mesophyll tissue.

Barbacenia sellovii Goethard & Henrard

PLATES 21b, 47h

SPECIMENS EXAMINED.—Menezes and Continho 5.

SURFACE VIEW.—Hairs: few papillae present.

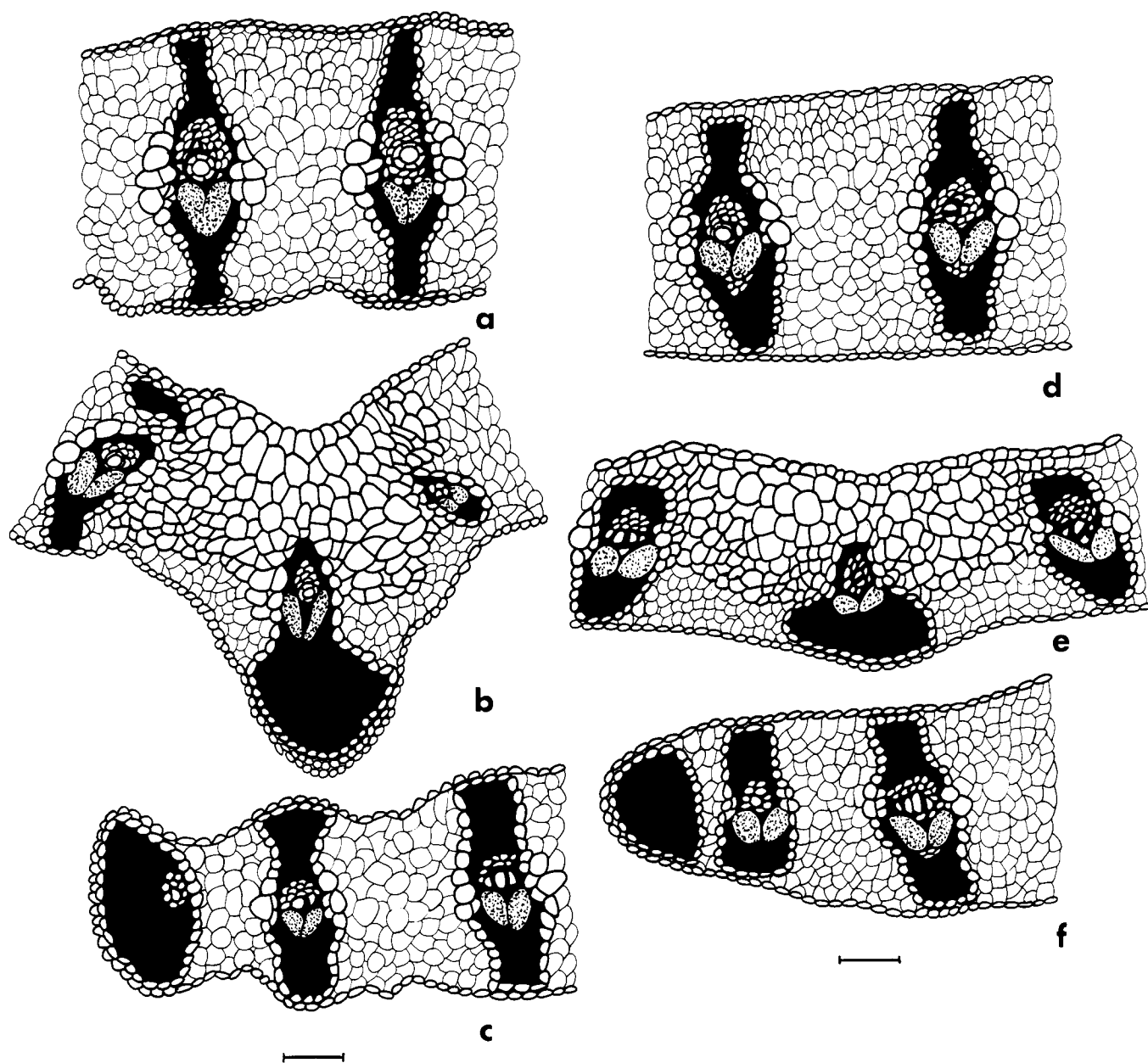


FIGURE 21.—a-c, *Barbacenia schwackei* (Heringer 5263); d-f, *B. ignea* (Williams and Assis 6817).

Epidermis: adaxial cells rounded; abaxial cells square to rectangular; cell walls thin on both surfaces. Stomata: paracytic, $12 \times 3 \mu\text{m}$; present on abaxial and adaxial surface.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped. Margins of lamina turned slightly inversely. Adaxial and abaxial surfaces only gently undulating. Epidermis: cells on adaxial and abaxial surfaces rounded to dome shaped, few conical; thin walled. Cuticle: very thin, but smooth on both surfaces. Stomata: present on abaxial and adaxial surfaces; large substomatal chamber present; flush with or slightly above epidermal surface. Mesophyll: undifferentiated. Spongy tissue composed of small rounded cells, some large and translucent. Two to three layers of large translucent cells above midvein changing abruptly into compactly arranged spongy tissue. Vascular bundles: 29; few commissural bundles observed. One to three large vessels present in each vascular bundle. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Each vascular bundle completely surrounded by bundle sheath. Crystals: none observed. Tannin: numerous, filling most of mesophyll cells.

***Barbacenia vandellii* Pohl ex Seubert in Martius**

FIGURES 1e-f, 22a-c

SPECIMENS EXAMINED.—Gardner 5224.

SURFACE VIEW.—Hairs: absent. Epidermis: cells square to rectangular; thin walled. Stomata: paracytic, $24 \times 15 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Isolateral; widely V-shaped. Adaxial and abaxial surfaces deeply undulating. Epidermis: adaxial cells mostly dome shaped, few conical. Abaxial cells largely conical. Cells on both surfaces thin walled. Cuticle: thin and ridged on adaxial surface; thicker and ridged on abaxial surface. Stomata: present on abaxial surface; substomatal chamber not observed. Mesophyll: undifferentiated; mesophyll composed almost entirely of spongy tissue interspersed with few translucent cells. Vascular bundles: 89; commissural bundles observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial

girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present in mesophyll.

***Barbacenia williamsii* L. B. Smith**

FIGURE 22d-f; PLATE 40b-d

SPECIMENS EXAMINED.—Dueke s.n.; Williams and Assis 6386; Pereira 2460—Pabst 3296.

SURFACE VIEW.—Hairs: absent. Epidermis: adaxial cells square to rectangular; abaxial cells more rounded. Walls thin on both surfaces. Stomata: paracytic, $18 \times 12 \mu\text{m}$; present on abaxial and adaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped. Adaxial and abaxial surfaces only slightly undulating. Epidermis: rounded to dome-shaped cells on abaxial and adaxial surfaces; few conical abaxial cells. Cells thin walled on both surfaces. Layer of parenchyma cells subjacent to epidermis. Cuticle: thin on adaxial and abaxial surfaces; slightly thicker on midvein. Stomata: present on abaxial and adaxial surfaces; small substomatal chamber present; flush with epidermal surface. Mesophyll: undifferentiated, spongy tissue compactly arranged. Two to three layers of large translucent palisade cells arranged radially above midvein. Some translucent cells present in midportion of spongy tissue. Vascular bundles: 33–49; commissural bundles few. One large vessel present in each vascular bundle. Two phloem units arranged laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: numerous, mostly in mesophyll.

Subkey III

***Barbacenia blackii* L. B. Smith**

PLATES 9c-d, 48c

SPECIMENS EXAMINED.—Macedo 2962.

SURFACE VIEW.—Hairs: numerous multicellular hairs on abaxial and adaxial surfaces in variable length. Epidermis: cells square to rectangular on both surfaces; thin walled. Stomata: paracytic, 21

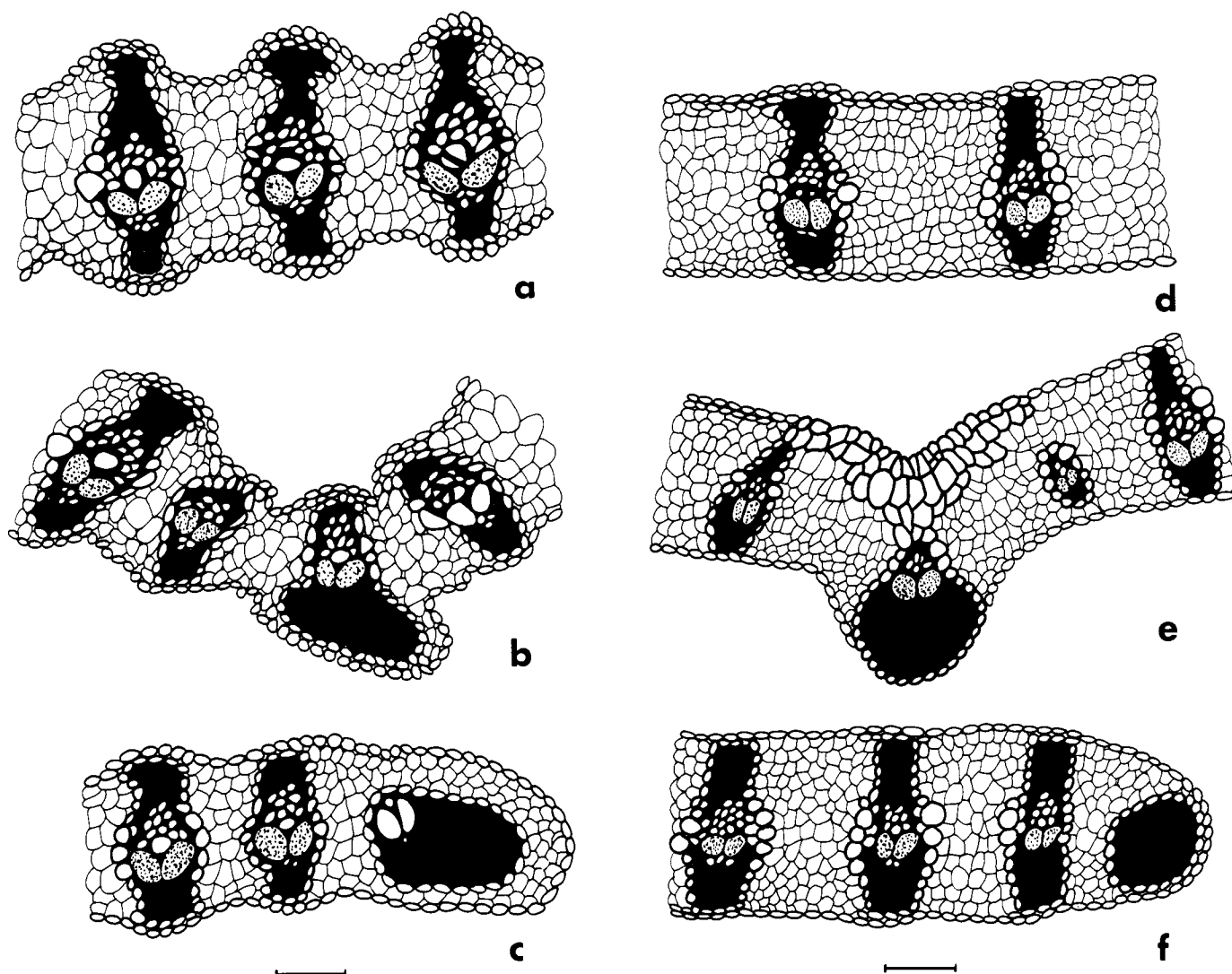


FIGURE 22.—a-c, *Barbacenia vandellii* (Gardner 5224);
d-f, *B. williamsii* (L. O. Williams and Assis 6386).

$\times 18 \mu\text{m}$; present on adaxial and abaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Somewhat dorsiventral; V-shaped with margins turned slightly inversely. Both adaxial and abaxial surfaces slightly undulating. Epidermis: adaxial cells dome shaped, few conical; walls slightly thickened. Abaxial cells rounded to dome shaped, few conical; thin walled. Multicellular hairs present on adaxial and abaxial surfaces. Cuticle: very thin on both surfaces. Stomata: present on adaxial and abaxial surfaces; small substomatal chamber present. Mesophyll:

two to three layers of palisade-like tissue grading into compactly arranged spongy tissue; translucent cells present in spongy layer. Vascular bundles: 31; few commissural bundles observed. One to three large vessels present in each vascular bundle. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. No abaxial sclerenchyma strands observed. Each vascular bundle completely surrounded by a bundle sheath. Crystals: present. Tannins: none observed.

***Barbacenia conicostigma* Goethart & Henrard**

FIGURE 1g-h; PLATES 23a-b, 46e

SPECIMENS EXAMINED.—L. B. Smith and Ayensu 15982.

SURFACE VIEW.—Hairs: none present. Epidermis: cells square to rectangular on abaxial and adaxial surfaces, few rounded; thin walled. Stomata: paracytic, $21 \times 15 \mu\text{m}$; present on adaxial and abaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped with median abaxial sclerenchyma quite prominent below abaxial surface. Both adaxial and abaxial surfaces very slightly undulating, almost smooth. Epidermis: adaxial cells rounded to dome shaped, thin walled. Abaxial cells more rounded to rectangular, thin walled. Layer of parenchyma cells subjacent to adaxial epidermis. Cuticle: slightly thickened and ridged on adaxial and abaxial surfaces. Stomata: present on both adaxial and abaxial surfaces; small substomatal chamber present. Mesophyll: palisade tissue non-existent. Fairly loosely arranged spongy tissue present especially toward adaxial surface; large part made up of large translucent spongy cells. Cells larger in midsection of mesophyll. Vascular bundles: 42; few commissural bundles observed. One large vessel present in each vascular bundle. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

***Barbacenia exscapa* Martius**

PLATE 46g

SPECIMENS EXAMINED.—Anderson et al. 35831.

SURFACE VIEW.—Hairs: present mostly on abaxial surface. Epidermis: adaxial cells mostly square to rectangular, few rounded; thin walled. Abaxial cells rectangular, thin walled. Stomata: paracytic, $27 \times 21 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped. Both adaxial and abaxial surfaces gently undulating. Epidermis: cells on adaxial and abaxial surfaces rounded to dome shaped, walls slightly thickened. Subjacent to adaxial epidermis are one to two layers of parenchyma cells; parenchyma

layers in midvein region much larger. Cuticle: fairly thick and slightly ridged on adaxial and abaxial surfaces. Stomata: present on abaxial surface, small substomatal chamber observed; flush with epidermal surface. Mesophyll: three to four layers of palisade tissue occupying about one-half of the mesophyll. Abrupt change to spongy tissue. Elongated palisade cells not usually found in the midvein region. Vascular bundles: 25 to 27; of small sizes; few commissural bundles observed. Usually one large vessel present in each vascular bundle. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Each vascular bundle completely surrounded by a bundle sheath. Crystals: none observed. Tannins: few present in mesophyll.

NOTE: The adaxial and abaxial sclerenchyma girders are poorly developed. In some cases they are no more than lignified parenchyma cells.

***Barbacenia fragrans* Goethart & Henrard**

FIGURES 2d, 24a-c; PLATES 9a, 22a

SPECIMENS EXAMINED.—Dueke s.n.; Regnell 1239; Widgren s.n. US 933895.

SURFACE VIEW.—Hairs: numerous, spreading over entire surfaces. Epidermis: adaxial cells square to rectangular; abaxial cells rounded to square, few rectangular; cell walls thin. Stomata: paracytic, $12 \times 12 \mu\text{m}$; present on abaxial and adaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; widely V-shaped with margins turned inversely. Adaxial surface slightly undulating; abaxial surface quite ridged. Epidermis: cells on adaxial and abaxial surfaces are dome shaped to conical; thin walled. Subjacent to adaxial epidermis is a layer of parenchyma cells. Cuticle: thin and ridged on both surfaces. Stomata: present on abaxial and adaxial surfaces; substomatal chamber present. Mesophyll: two- to three-layered palisade cells grading into loosely arranged spongy tissue containing large translucent cells. Vascular bundles: 37-47; no commissural bundles observed. One to two large vessels present in each vascular bundle, mostly one. Two phloem units lying laterally in flanges of Y-shaped abaxial girder extending to abaxial epidermis. Inverted Y-shaped adaxial girder

present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: numerous, mostly in mesophyll.

***Barbacenia gardneri* Seubert in Martius**

PLATES 7a-b, 47a

SPECIMENS EXAMINED.—Pereira 2849—Pabst 3685.

SURFACE VIEW.—Hairs: long, thin, multicellular hairs present on adaxial surface. Epidermis: cells square to rectangular on both adaxial and abaxial surfaces; few rounded; thin walled. Stomata: paracytic, $18 \times 12 \mu\text{m}$; present on both adaxial and abaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with extreme margins of lamina turned slightly inversely. Both abaxial and adaxial surfaces slightly undulating; abaxial a little more than adaxial. Epidermis: adaxial cells rounded, dome shaped and conical, few crescent shaped; walls thin. Abaxial cells dome shaped to conical; walls thin. Cuticle: very thin and following contour of cells on both surfaces. Stomata: present on both adaxial and abaxial surfaces; substomatal chamber quite large on both surfaces; either flush with or slightly above epidermal surface. Mesophyll: two to three layers of small palisade cells changing abruptly to large, rounded translucent cells with thickened walls occurring in middle of mesophyll, especially next to the vascular bundles. Cells change abruptly to two or three layers of small rounded cells on the abaxial side. Very large midvein cells abruptly changing into small cells toward abaxial side. Vascular bundles: 48; many commissural bundles observed. One to three large vessels present in each bundle, mostly one. Two phloem units in flanges of V- or Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

***Barbacenia gentianoides* Goethart & Henrard**

FIGURE 20a-c; PLATE 41c-e

SPECIMENS EXAMINED.—Segadas-Vianna and Loredó 1066.

SURFACE VIEW.—Hairs: multicellular; some papillae present. Epidermis: cells rounded, square to rectangular. Stomata: paracytic, $27 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; widely V-shaped with slight median adaxial groove. Both adaxial and abaxial surfaces undulating. Epidermis: cells on adaxial and abaxial surfaces dome shaped; thin walled. Distinct layer of parenchyma cells subjacent to adaxial epidermis. Sclerenchyma strands occur below parenchyma layer, usually extending on either side of adaxial side of vascular bundle. Cuticle; very thin on adaxial and abaxial surfaces. Stomata: present on abaxial surface. Substomatal chamber present. Mesophyll: three to four layers of palisade cells present. Abruptly changing into loosely arranged spongy tissue. Some translucent cells present in spongy layer. Vascular bundles: 30; commissural bundles observed. One to two large vessels, mostly one. Two phloem units lying laterally in flanges of V- or Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding vascular bundles. Crystals: none observed. Tannins: few present.

***Barbacenia longiflora* Martius**

FIGURE 24d-f; PLATE 41f-h

SPECIMENS EXAMINED.—Archer 4089, Irwin 2486.

SURFACE VIEW.—Hairs: absent. Epidermis: cells rounded to rectangular, few squarish on abaxial and adaxial surfaces; walls thin. Stomata: paracytic, $18 \times 15 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Isolateral; widely V-shaped with slight median adaxial groove. Adaxial and abaxial surfaces slightly undulating. Epidermis: cells on both surfaces dome shaped, few conical; thin walled. Layer of parenchyma cells subjacent to adaxial epidermis. Cuticle: thin and ridged on adaxial and abaxial surfaces. Stomata: present on abaxial surface; substomatal chamber present; mainly flush with epidermal surface. Mesophyll: two to three layers of small cells grading into spongy tissue. Two to three layers of translucent cells present in median portion of lamina. Vascular bundles: 33; few commissural bundles observed. One to two large vessels in each vascular bundle, mostly one. Two phloem units

arranged laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Each vascular bundle completely surrounded by a bundle sheath; two to four bundle sheath cells in midportion of vascular bundles conspicuously enlarged. Crystals and tannins: none observed.

***Barbacenia luzulifolia* Martius ex Schultes f.**

FIGURE 10-p; PLATES 6c, 47e

SPECIMENS EXAMINED.—Pereira 2664—Pabst 3500.

SURFACE VIEW.—Hairs: none present. Epidermis: cells square to rectangular, few rounded on abaxial and adaxial surfaces; thin walled. Stomata: paracytic, $24 \times 9 \mu\text{m}$; present on both adaxial and abaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Somewhat dorsiventral; V-shaped with margins turned slightly inversely. Both adaxial and abaxial surfaces evenly undulating. Epidermis: adaxial cells mostly rounded to dome shaped, few conical; thin walled. Abaxial cells rounded to dome shaped, few elongated; cell walls thicker than adaxial ones. Adaxial epidermal cells larger around midvein. Cuticle: very thin on both adaxial and abaxial surfaces. Stomata: present on both adaxial and abaxial surfaces; substomatal chamber quite large; usually flush with epidermal surface. Mesophyll: three layers of elongated palisade-like cells changing into large, rounded, translucent cells in the mid-region of mesophyll. Vascular bundles: 43; no commissural bundles observed. One to two large vessels present in each bundle, mostly one. Two phloem units lying laterally in flanges of V- or Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

***Barbacenia macrantha* Lem**

FIGURE 2f; PLATES 8a-b, 48d

SPECIMENS EXAMINED.—Irwin, Maxwell, and Wasshausen 20071.

SURFACE VIEW.—Hairs: numerous on both surfaces. Epidermis: adaxial cells rectangular; abaxial cells rounded, some square. Walls thin on both

surfaces. Stomata: paracytic, $12 \times 6 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with margins of lamina turned inversely. Both adaxial and abaxial surfaces slightly undulating; large numbers of hairs present on both surfaces. Epidermis: thin cell walls on abaxial and adaxial surfaces rounded to dome shaped; few conical. Cuticle: on abaxial and adaxial surfaces thin and ridged. Stomata: present on abaxial surface; substomatal chamber present. Mesophyll: two to three layers of palisade cells grading into spongy tissue. Some large translucent cells present in spongy tissue. Vascular bundles: 41; no commissural bundles observed. One to two large vessels present in each vascular bundle. Two phloem units lying laterally in flanges or V- or Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Crystals: none observed. Tannins: present and in numerous quantities, especially in palisade cells.

***Barbacenia nana* L. B. Smith & Ayensu**

FIGURE 2e; PLATES 8c-d, 22b, 47f

SPECIMENS EXAMINED.—L. B. Smith and Ayensu 15973.

SURFACE VIEW.—Hairs: present on adaxial and abaxial surfaces; long and multicellular. Epidermis: adaxial cells square; thin walled. Abaxial cells square to rectangular; thin walled. Stomata: tetracytic, $21 \times 18 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; V-shaped with margins turned slightly inversely. Adaxial and abaxial surfaces only slightly undulating; both surfaces covered with hairs. Epidermis: adaxial cells dome shaped to conical; thin walled. Abaxial cells more rounded to dome shaped; thin walled. Subjacent to adaxial epidermis is a distinct layer of parenchyma cells. Cuticle: thin and ridged on adaxial and abaxial surfaces. Stomata: present on abaxial surface; substomatal chamber present; usually flush with or slightly above epidermal surface. Mesophyll: two to three layers of palisade cells grading into a loosely arranged spongy tissue. Large number of translucent cells in spongy tissue, especially in midvein region. Vascular bundles: 44; few commissural bundles observed. One to two large vessels present in each vascular bundle,

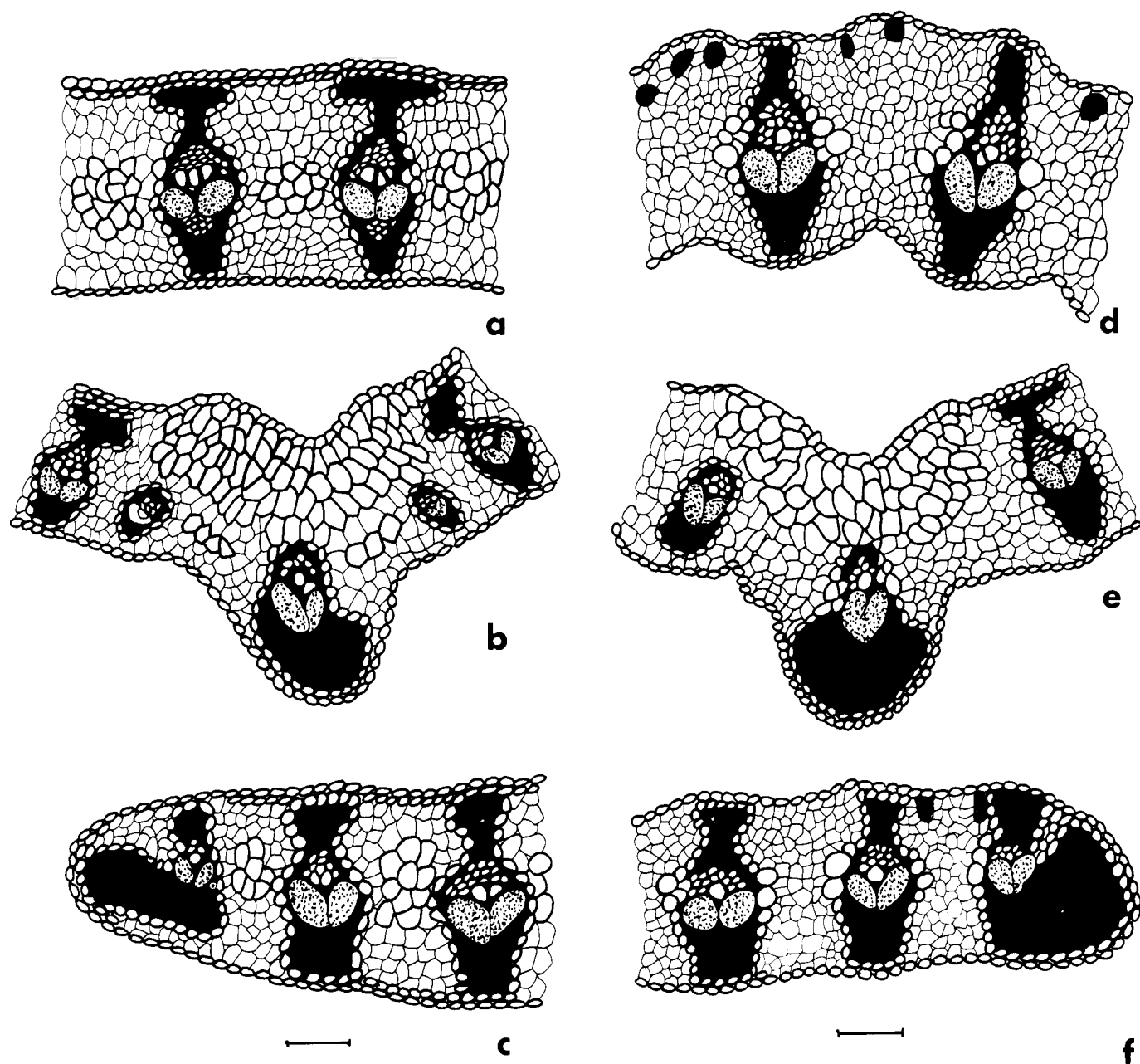


FIGURE 23.—a-c, *Barbacenia flava* (Segadas-Vianna and Loredó 1100);
d-f, *B. rubro-virens* (Maguire et al. 49260).

mostly one. Two phloem units lying in flanges of wide Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle; sometimes appearing T-shaped near adaxial surface. Some sclerenchyma strands observed on adaxial side of lamina replacing some palisade cells. Bundle sheath completely surrounding each vascular bundle. Crystals and tannins: none observed.

***Barbacenia paranaensis* L. B. Smith**

PLATES 20a, 48e

SPECIMENS EXAMINED.—Hatschbach 15715.

SURFACE VIEW.—Hairs: numerous, present on both surfaces. Epidermis: adaxial cells rounded. Abaxial cells square to rectangular. Walls thin. Stomata: paracytic, $18 \times 15 \mu\text{m}$; present on

abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral; widely V-shaped. Adaxial and abaxial surfaces undulating. Epidermis: cells on adaxial and abaxial surfaces rounded to dome shaped; thin walled. Multicellular hairs present on epidermal surfaces. Cuticle: very thin on both surfaces; ridged. Stomata: present on adaxial surface; substomatal chamber present. Mesophyll: three- to four-layered palisade cells changing abruptly into compactly arranged spongy tissue. Two to three layers of large translucent cells arranged radially above midvein. Some large translucent spongy cells present in mid-portion of mesophyll. Vascular bundles: 43; few commissural bundles observed. One large vessel present in each vascular bundle. Two phloem units arranged laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: not observed. Tannins: present, especially in mid-portion of mesophyll.

***Barbacenia riedeliana* Goethart & Henrard**

PLATES 9b, 47g

SPECIMENS EXAMINED.—Anderson et al. 35123.

SURFACE VIEW.—Hairs: short, multicellular papillae present on both surfaces. Epidermis: adaxial and abaxial cells rectangular, few square; thin walled. Stomata: paracytic, $18 \times 12 \mu\text{m}$; present on both adaxial and abaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped. Adaxial and abaxial surfaces undulating with small furrows on each. Epidermis: adaxial and abaxial cells rounded to dome shaped, few conical; thin walled. Cuticle: very thin and smooth on both surfaces. Stomata: present on both adaxial and abaxial surfaces; flush with or slightly above epidermal surface; large substomatal chamber present. Mesophyll: two or three layers of small cells changing into one or two layers of large, rounded, translucent spongy cells. Two to three layers of large translucent cells above midvein changing into compactly arranged spongy tissue. Few papillae present in furrows of both surfaces. Vascular bundles: 17; few commissural bundles observed. One to two large vessels, mostly one, in each vascular bundle. Two phloem units lying

laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath surrounding each vascular bundle. Crystals and tannins: none observed.

***Barbacenia rubro-virens* Martius**

FIGURES 1m-n, 23d-f

SPECIMENS EXAMINED.—Maguire et al. 49177, 49260.

SURFACE VIEW.—Hairs; absent. Epidermis: cells square to rectangular on both surfaces; some rounded on abaxial surface; thin walled on both surfaces. Stomata: paracytic, $27 \times 15 \mu\text{m}$; present on abaxial and adaxial surface.

TRANSVERSE SECTION OF LAMINA.—Isolateral; V-shaped with margins of lamina turned inversely. Abaxial and adaxial surfaces slightly undulating. Epidermis: cells on abaxial and adaxial surfaces rounded to dome shaped; thin walled. Layer of parenchyma cells subjacent to both surfaces. Cuticle: thick and slightly ridged on adaxial and abaxial surfaces. Stomata: present on both surfaces; substomatal chamber present; more or less flush with epidermal surface. Mesophyll: three to four layers of small cells grading into compactly arranged spongy tissue. Some large translucent cells present in spongy mesophyll. Vascular bundles: 44; few commissural bundles observed. One large vessel present in each vascular bundle. Two phloem units laterally arranged in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: numerous, especially in mesophyll cells near the epidermis.

***Barbacenia tomentosa* Martius**

PLATE 7c-d

SPECIMENS EXAMINED.—Irwin et al. 29559; Menezes 1.

SURFACE VIEW.—Hairs: present on adaxial and abaxial surfaces; multicellular. Epidermis: cells on adaxial and abaxial surfaces square to rectangular, few rounded; thin walled. Stomata: tetracytic, $24 \times 9 \mu\text{m}$; present on adaxial and abaxial surfaces.

TRANSVERSE SECTION OF LAMINA.—Dorsiventral;

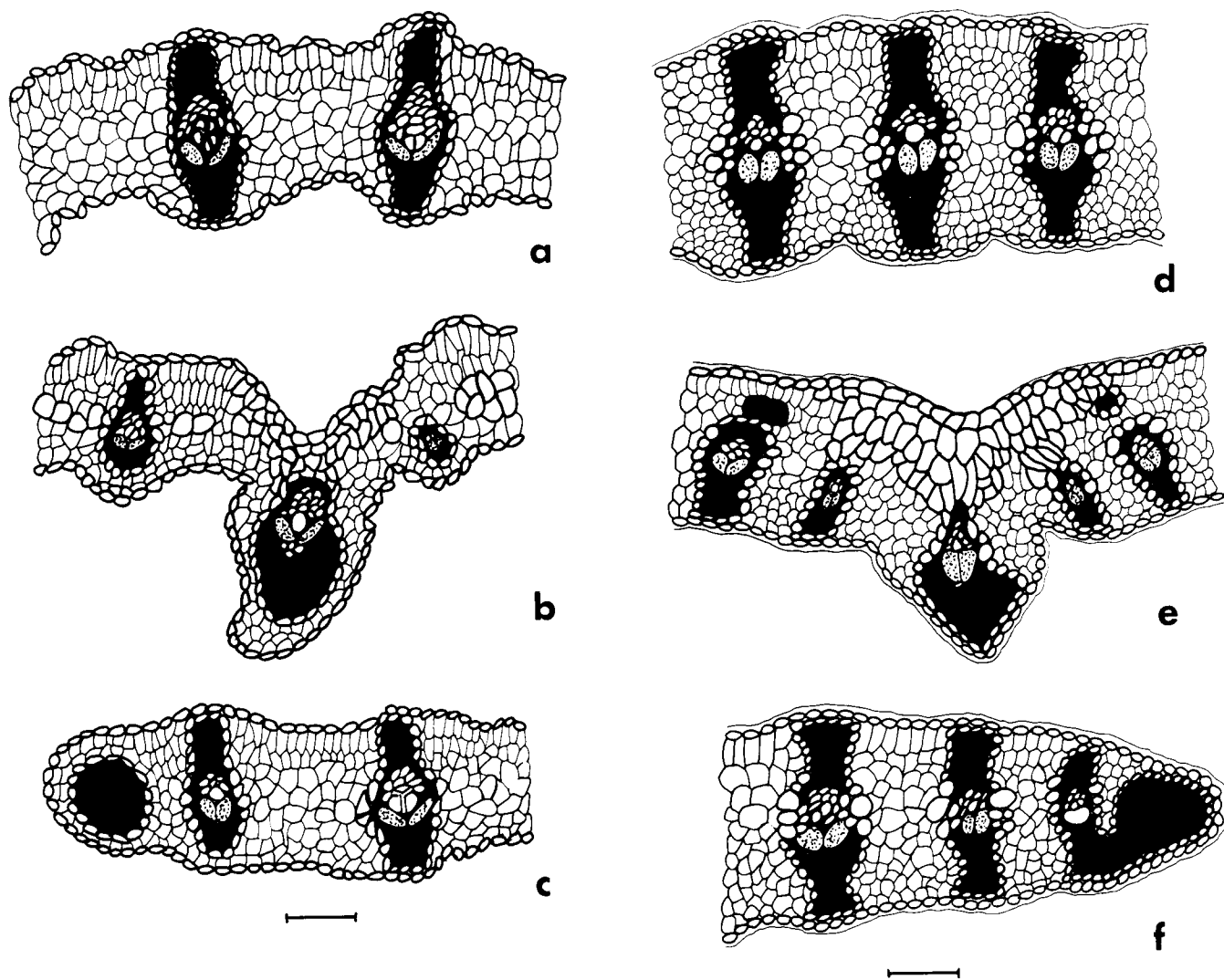


FIGURE 24.—a-c, *Barbacenia fragrans* (Widgren 1267); d-f, *B. longiflora* (Archer 4089).

wide V-shaped. Both adaxial and abaxial surfaces with ridges or small furrows. Tufts of multicellular hairs present on both surfaces. Epidermis: adaxial cells dome shaped, few conical, thin walled; abaxial cells dome shaped, few conical, thin walled. Subjacent to adaxial epidermis is a layer of thin-walled parenchyma cells. Cuticle: very thin on adaxial and abaxial surfaces. Stomata: present in abaxial furrows and on adaxial surface; substomatal chamber present. Mesophyll: small, rectangular, palisade-like cells, closely packed. Abrupt

change to loosely arranged spongy tissue with some large translucent cells. Vascular bundles: 43-44; few commissural bundles observed. Usually one large vessel present in each vascular bundle. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannins: present in mesophyll.

***Barbacenia viscosissima* Goethart & Henrard**

PLATES 40h, 41a-b

SPECIMENS EXAMINED.—Macedo 2826.

SURFACE VIEW.—Hairs: present on both surfaces. Epidermis: cells mostly square to rectangular, few rounded; cells thick walled. Stomata: paracytic, $24 \times 12 \mu\text{m}$; present on abaxial surface.

TRANSVERSE SECTION OF LAMINA.—Isolateral; widely V-shaped, turned slightly inversely at margins. Adaxial and abaxial surfaces undulating. Epidermis: adaxial cells rounded to dome shaped; few crescent shaped. Abaxial cells rounded to dome shaped; few conical. Cells on both surfaces thick walled. Distinct layer of parenchyma cells subjacent to epidermis. Cuticle: thin on adaxial and abaxial surfaces. Stomata: present on abaxial surface; substomatal chamber present. Mesophyll: composed of mainly large translucent cells except for few rows of small cells subjacent to epidermis. Vascular bundles: 40; few commissural bundles observed. Two phloem units lying laterally in flanges of Y-shaped abaxial girder. Inverted Y-shaped adaxial girder present on each vascular bundle. Bundle sheath completely surrounding each vascular bundle. Crystals: none observed. Tannin: few present.

Observations

The following observations are focused on certain highlights in the anatomical differences which are found within this family. The accompanying line drawings, along with the light microscope and scanning electron photomicrographs, will hopefully express more clearly the anatomical characteristics of the species and thereby serve as an additional aid to identification of the species.

LIGHT MICROSCOPIC OBSERVATIONS.—*Section I: Vellozia*: *Vellozia abietina* and *V. tragacantha* have in common certain anatomical features. Apart from their leaf shapes that are almost identical, the sclerenchyma girders associated with the vascular bundles are strongly developed. The adaxial sclerenchyma girders extend closely to the epidermis except for those associated with the vascular bundles next to the midvein. The mesophyll differ, however. In *V. tragacantha* there is a distinct differentiation between the palisade cells and

the spongy tissue, while that of *V. abietina* is not so clear-cut as demonstrated in *V. sellovii*.

As its name implies, the leaf of *V. plicata* is folded lengthwise into plaits. The lamina exhibits a strong development of sclerenchyma around the main veins where there is lateral expansion. The regions between the principal veins are slender and exhibit minimal sclerenchyma strands subjacent to the adaxial epidermis and to a minor degree they are developed toward the abaxial surface. In addition to the principal veins there are many smaller secondary, or tertiary, veins in the slender regions between the large vascular bundles. Another species that exhibits the characteristics described for *V. plicata* is *V. triquetra* and, in fact, the two species are almost inseparable.

Another group of species that share basically similar anatomical structures includes *V. glabra*, *V. incurvata*, and *V. compacta*. The midvein regions show strongly developed translucent cells which occupy over two-thirds of the primary vein portion of the leaf. The costal regions of the blade are pointed, while the intercostal regions are significantly expanded and pointed adaxially. Furthermore the furrows in the region are very deep, in some cases occupying over two-thirds of the lamina. Most of the specimens examined under these species have pointed abaxial midveins. However, in *V. incurvata* (Maguire 44752) and *V. compacta* (Segades-Vianna and Loredó 1085) the abaxial portions of the midveins are distinctly flattened. These differences seem to be prevalent in other specimens of a particular species, while all other characters are practically the same. It seems obvious that such differences may represent variations within species complex and therefore do not have a distinct taxonomic importance.

The *Xerophyta* type of sclerenchyma pattern which I described for some Madagascan species (Ayensu, 1969) seems to occur in some of the New World species. *Vellozia terella*, *V. verruculosa*, *V. variabilis*, *V. fibrosa*, *V. taxifolia*, *V. declinans*, *V. leptopetala*, *V. epidendroides*, *V. asperula*, *V. swallenii*, *V. cinerascens*, *V. costata*, *V. hatschbachii*, *V. lappa*, *V. modesta*, and *V. wasshausenii* share several more or less common mesophyll characteristics, but in addition, their abaxial sclerenchyma girders are more or less U- or V-shaped, and they do not extend to the abaxial epidermis as is the case

in the *Vellozia* type of abaxial sclerenchyma pattern.

The presence of fingerlike projections in the abaxial furrows of such species as *V. metzgerae*, *V. glandulifera*, *V. aloifolia*, *V. intermedia*, and *V. echinata*, as well as the distribution of translucent cells above the vascular bundles and the furrows, indicate some form of relationship amongst these species. Whether these close resemblances are dependent solely on environmental pressures is not quite clear.

Of the array of species studied, *Vellozia burlemarxii* and *V. hemisphaerica* share two distinct features that set them apart from all other vellozias. The development of secondary vascular bundles directly above the abaxial furrows and the extra appendages at the wider portions of the furrows are certainly convergent morphological and anatomical characteristics.

Vellozia epidendroides is one of the species most easily identified by its anatomical characters and the shape of leaf in transverse section. Among the major distinctive features are (a) the presence of an almost continuous band of highly developed sclerenchyma fibers subjacent to both the adaxial and abaxial epidermis and (b) the sandal-shaped appearance of the sclerenchyma associated with the vascular bundles. Of the specimens examined, the abaxial portion of the midrib was found to be either flattened or pointed. This observation further weakens the importance of this feature in the taxonomy of the species.

Vellozia minima and *V. virgata* are among the small-leaved species of the family. Their anatomy depicts compactly arranged palisade and spongy tissues. Translucent cells are absent in these species, which are among the few members of *Vellozia* that lack abaxial furrows. Other species that fall under this category are *V. abietina*, *V. tragacantha*, and *V. sellovii*.

In most species of *Vellozia*, translucent cells are arranged radially on the adaxial side of the vascular bundles, as well as on the furrows. However, there are few species in which the translucent cells occur only on the vascular bundles: *V. flavicans*, *V. glauca*, *V. glochidea*, *V. crassicaulis*, *V. swallenii*, *V. cincerascens*, and *V. dasypus*.

The most striking anatomical feature of *Vellozia exilis* is the lateral expansion of the midvein region, making it one of the most distinctive species

in the family. To my knowledge there is no other species in the family that exhibits a similar morphological feature.

Three species that appear to be closely related from the standpoint of their leaf anatomy, especially the development of fingerlike projections in the abaxial furrows, are *Vellozia caput-ardeae*, *V. lappa*, and *V. phalocarpa*. However, upon close examination it becomes obvious that whereas the two phloem units in *V. lappa* are distinctly separated, those of *V. caput-ardeae* and *V. phalocarpa* appear as one. Furthermore, the Y-shaped abaxial sclerenchyma of *V. caput-ardeae* and *V. phalocarpa* extends to the epidermis, while that of *V. lappa* ends about two-thirds into the spongy mesophyll.

Another group of species that appear to be closely related on account of the arrangement of the adaxial translucent cells are *Vellozia costata*, *V. ciliata*, and to some extent *V. hatschbachii*. In this instant also, the species can be easily separated from each other by the shape of the large parenchyma cells below the adaxial sclerenchyma strands.

Vellozia modesta exhibits certain features that set it apart from other members of this genus. Generally there are two abaxial sclerenchyma strands between two furrows. Furthermore the outermost cells of the furrows are made up of elongated parenchyma cells instead of sclerenchyma strands which often occur in this region. The palisade cells are completely filled with tannin. The cells of the abaxial spongy tissue are also filled with tannin.

Section II: Radia: In this section each species seems to be anatomically distinct. *Vellozia riedeliana* and *V. candida* have one major characteristic in common, the lack of translucent cells above the furrows. All other species examined in this section possess translucent cells on both the adaxial side of the vascular bundles and in furrows.

In *Vellozia maculata* the vascular bundles and their associated sclerenchyma girders occupy more than two-thirds of the mesophyll space between two furrows. Furthermore, the abaxial sides of the furrows are laterally extended in a way that they virtually obscure the entrances into the furrows.

Three species that share several anatomical characters, especially the shape of the sclerenchyma girders and width of their furrows, are *Vellozia dumitiana*, *V. lithophila*, and *V. tubiflora*. The

examination of several specimens of *V. tubiflora* has shown conclusively that the various collections belong to one species-complex. The slight variations among the specimens may be the result of environmental influences. Maguire (1969:35) was indeed correct when he noted that "*Vellozia tubiflora* is a highly variable and polymorphic species with a wide ecological amplitude." Some of the specimens can easily be attributed to either *V. dumitiana* or *V. lithophila* on anatomical grounds.

Barbacenia Subkey I: The species examined in this subkey are all distinct. *Barbacenia gaveensis*, *B. seubertiana*, *B. stenophylla*, *B. longiscapa*, and *B. gounelleana* have slightly undulating epidermal surfaces while *B. purpurea* is distinctly corrugated on both surfaces. *Barbacenia irwiniana* shows corrugation on the abaxial surface only and a gentle undulation on the adaxial sclerenchyma from the vascular bundle. The adaxial sclerenchyma appears in the form of strands completely surrounded by distinct bundle sheaths. If the mesophyll had been slightly differentiated this species could easily be assigned to *Vellozia* on anatomical grounds. Another distinct feature that has not been observed in other species under this subkey is the virtual obliteration of about two-thirds of the mesophyll in *Barbacenia hatschbachii*. Unfortunately only one specimen was available for study, and therefore no conclusive statement can be made to characterize this species.

Barbacenia Subkey II: Each species under this group is very distinct anatomically; therefore, they do not form a distinct group that can set them apart from the subkeys. As observed in subkey I, the presence of marked corrugations on both surfaces of the leaf occur in few species. The only species that exhibits this character in subkey II is *Barbacenia vandellii*.

Barbacenia Subkey III: One of the characteristic features of this group is the presences of hairs on both surfaces of many species. *Barbacenia macrantha*, *B. viscosissima*, *B. paranaensis*, *B. fragrans*, *B. blackii*, and *B. nana* possess hairs that are often longer than the width of lamina. The hairs on *B. riedeliana* are short and occur mainly on the furrows in the form of fingerlike projections.

Another feature that is characteristic of some species of this group is the differentiation of the mesophyll into distinct palisade and spongy tissues. Such features occur in *Barbacenia paranaensis*,

B. exscapa, *B. gardneri*, *B. fragrans*, *B. gentianoides*, and *B. nana*.

It is obvious from the above observations that on anatomical grounds the species of the New World Velloziaceae cannot be subdivided under the same sections and subkeys of Smith's (1962). However, his classification of species is clearly supported by this study.

SCANNING ELECTRON MICROSCOPIC OBSERVATIONS.—The use of the SEM in the studies of Velloziaceae has revealed remarkable three-dimensional characteristics that emphasize the diversity in the leaf surfaces. In addition to the light microscopic observations, the SEM has brought to light anatomical details that were not previously obtainable with conventional microscopes.

Trichomes: The two types of trichomes that occur generally in Velloziaceae are hairs and fingerlike projections or protuberances. The hairs come in a variety of forms. Generally they are either unicellular or multicellular and vary considerably in length. In general, hairs appear to cover most of the leaf epidermis. Usually they are more frequent on the abaxial surface. In fact, their short multicellular bases form distinct tufts (Plates 1a,b; 3a-d; 4a-d), while the terminal cells are long and free. Sometimes hairs occur either in furrows, as in *Vellozia dumitiana* and *V. lithophila* (Plate 2a-d), or on the surfaces between furrows, as in *V. dawsonii* (Plate 1a,b). In some cases the hairs appear very close to the furrows as in *V. pumila* (Plate 5d).

The hairs come in a variety of shapes. They are either straight (Plates 7a,b; 9a-d), curved (Plate 5d), or twisted (Plate 1c,d). In species such as *Barbacenia macrantha* (Plate 8a,b) and *B. nana* (Plate 8c,d), the hairs appear to be coalesced. Transverse sections of hairs (Plate 8b-d) indicate that in these species the four to nine hairs have coalesced to form a unit. In the center of Plate 8a is an indication of the process of coalescence of already coalesced hairs. It is obvious from this observation that there is no systematic pattern in the manner and the number of individual hairs that form a coalesced unit. After this process has been completed, the outer walls of the hairs stretch out to form a smooth membrane around the coalesced hairs.

Fingerlike projections emerge from epidermal cells in the furrows, as shown in transverse sections

of *Vellozia ciliata* (Plates 5c; 49a-c) and *V. metzgerae* (Plate 5b). A vertical section through a furrow of a leaf of *V. ciliata* (Plate 49c) shows very clearly the sporadic arrangement of the protuberances. Among these fingerlike projections are the stomata.

Epidermal Cells: Generally the epidermal cells are arranged in longitudinal files which run parallel to the midvein and the long axis of the leaf. The cells are generally rectangular, but in some cases are isodiametric. The SEM has also shown that in some species the cells appear to be regularly arranged in folds (cf. *Barbacenia flava*, Plate 6a,b), or they are somewhat verrucata as in *Vellozia glochidea* (Plate 5a). At higher magnifications the cells appear three-dimensional and thus reveal the remarkable topographic details of the epidermis.

Stomata: Generally the stomata are confined to the abaxial epidermis. In a few species they occur on the adaxial epidermis, but they are less numerous. In species that possess furrows, one often finds that the highest concentration of stomata occurs in the furrows and that the stomata are often associated with papillae. The stomata are generally arranged in longitudinal rows which run parallel to the leaf axis. Sometimes the stomata appear to

be crowded on certain portions of the leaf surface, particularly in the furrows.

Most species of the Velloziaceae have paracytic type of stomata (Plates 10-23). Few are tetracytic; i.e., there are two parallel and two polar subsidiary cells.

One of the distinctive features of the stomata is the clearly defined guard cells that are fully extended around the pore. The lip of the stomatal pores may be smooth (Plates 10, 17; 21a) or distinctly pronounced (Plates 11-16, 18-21b, 22). The subsidiary cells are often robust, but occasionally they are conspicuously ridged as shown in *Vellozia squalida* (Plate 14b) and in other species (Plates 16a, 18a, 23b).

The SEM was used to observe the internal structure of some of the leaves. These observations generally confirmed the findings based on light microscopy.

In summary, the scanning observations have added numerous factual data to aid in the assessment of the anatomy and systematics of this family. Hopefully this new information will enable future studies to expand on some of the information I have presented here.

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PLATES 1-51

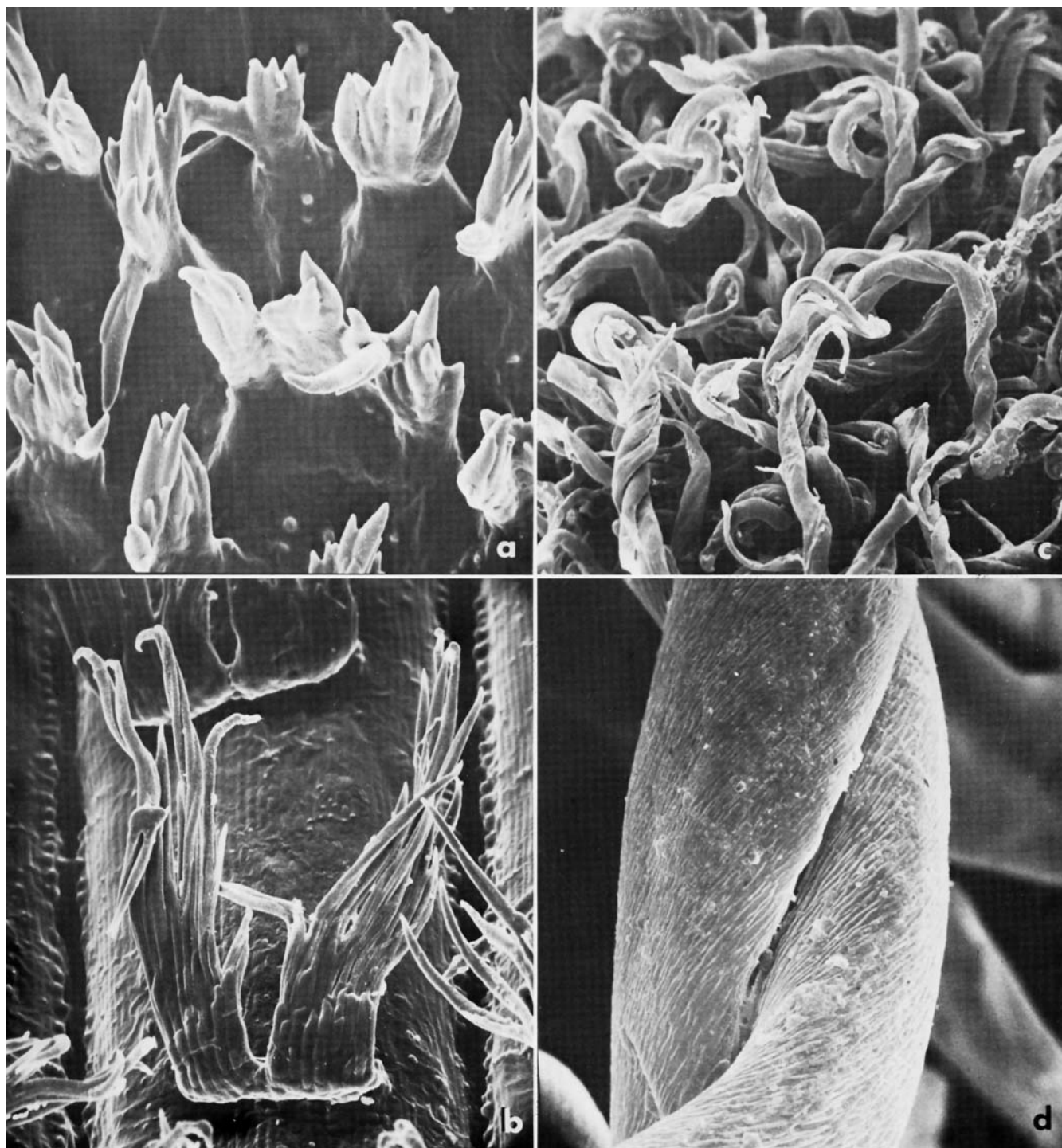


PLATE 1.—*Vellozia dawsonii* (Irwin et al. 12622), showing the distribution and the tuftlike appearance of hairs: a, adaxial view; b, abaxial view ($\times 200$). *Vellozia glandulifera* (L. B. Smith & Ayensu 15998): c-d, abaxial views of the epidermis illustrating the twisted nature of the hairs (c, $\times 200$; d, $\times 2000$).

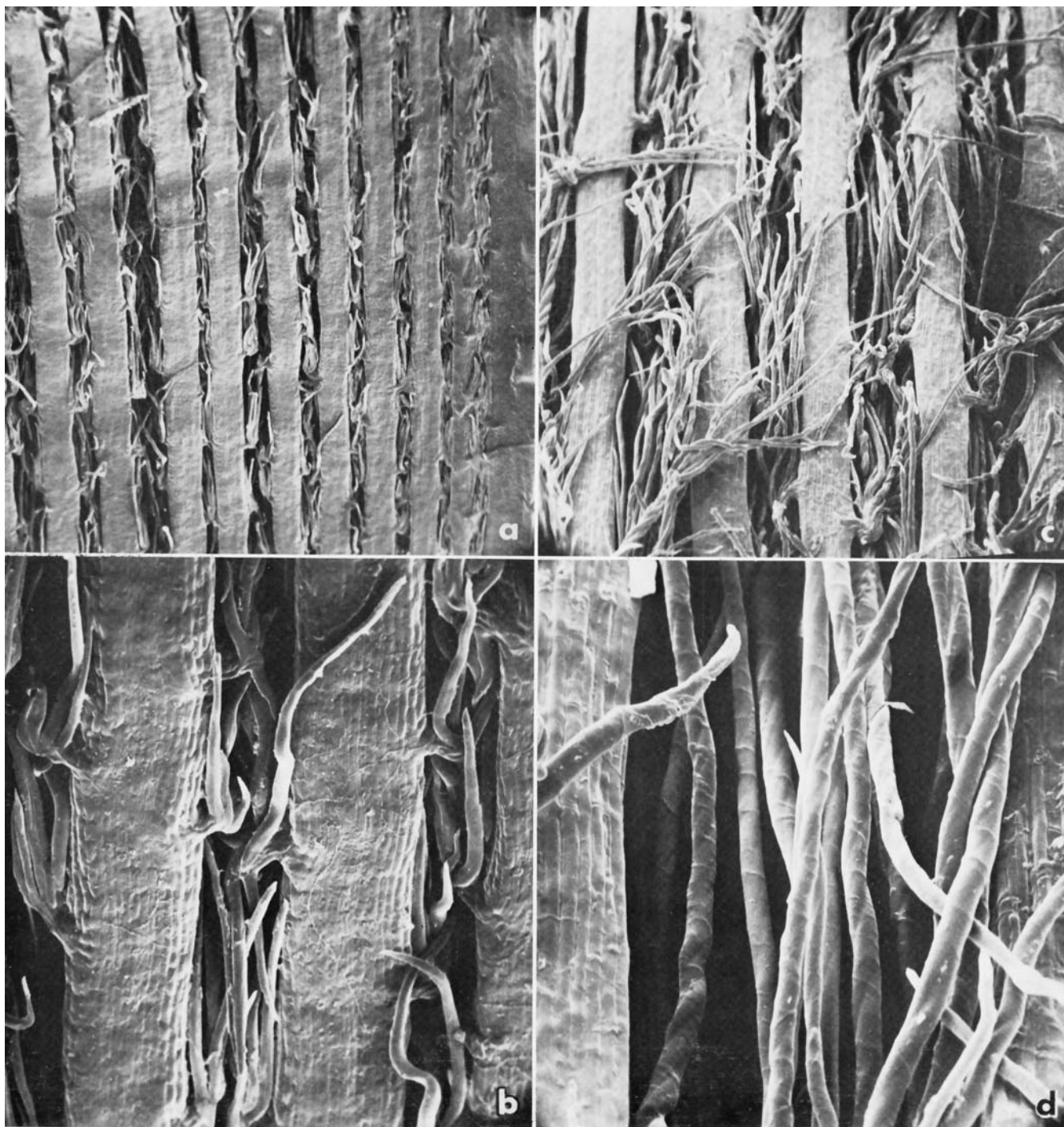


PLATE 2.—Surface view of abaxial leaf epidermis showing the arrangement of long multicellular hairs at the entrances of the furrows: a-b, *Vellozia dumitiana* (Garcia-Barriga 13804) (a, $\times 95$; b, $\times 190$); c-d, *V. lithophila* (Cuatrecasas 7700) (c, $\times 90$; d, $\times 440$).

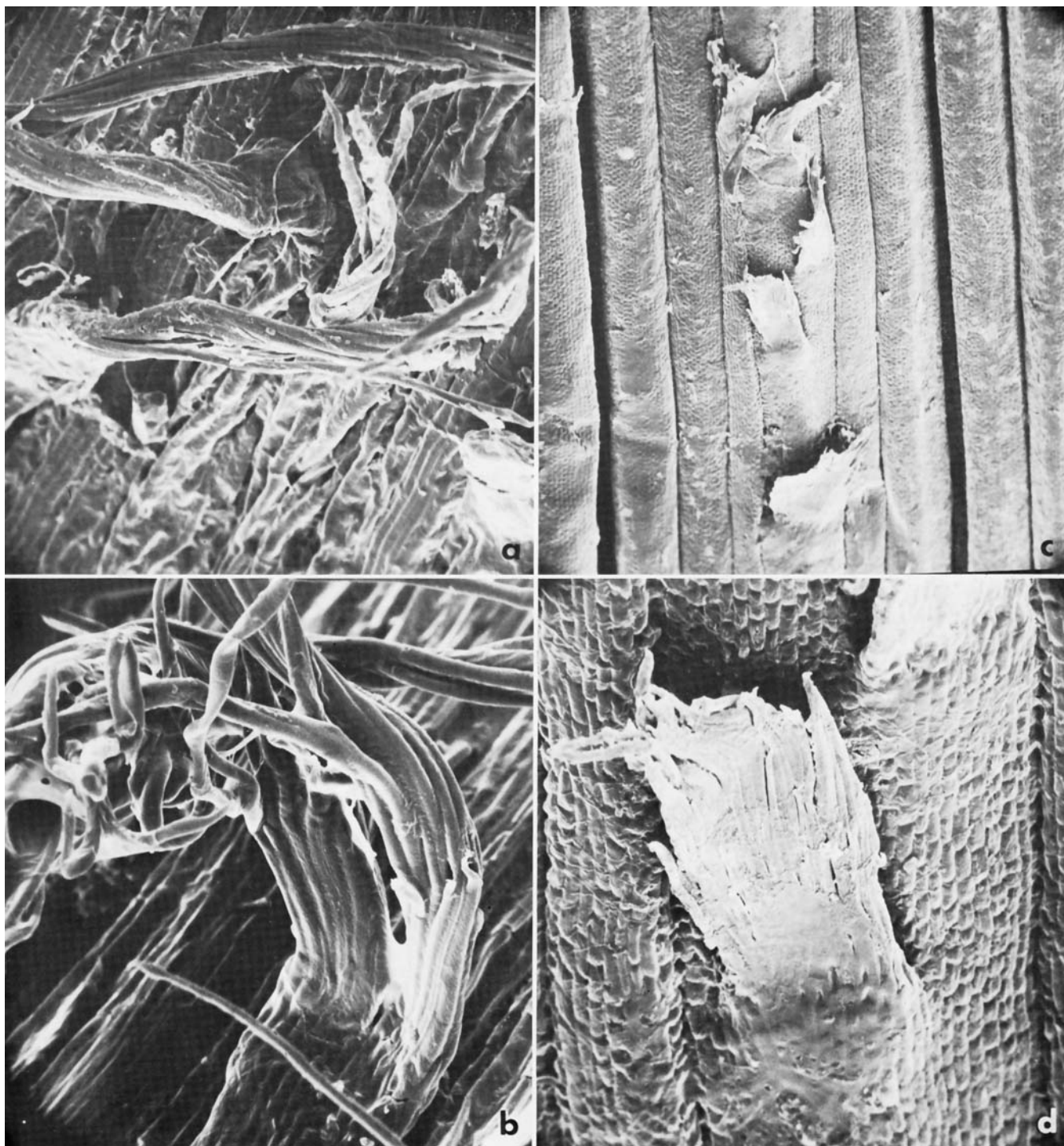


PLATE 3.—*Vellozia lanata* (Veralucia & Graziella s.n.): a, adaxial epidermis showing the rounded base and the twisted nature of the hairs ($\times 240$); b, abaxial epidermis showing the flattened arrangement of the clumped hair ($\times 260$); c-d, abaxial leaf epidermis showing finlike arrangement of hairs of *Vellozia maculata* (Glaziou 22218a) (c, $\times 65$; d, $\times 270$).



PLATE 4.—a-b, *Vellozia machrisiana* (Prance and Silva 58275); c-d, *V. cinerascens* (Lehmkner 323), showing the type and distribution of hairs on the abaxial surface (a, $\times 65$; b, $\times 385$; c, $\times 120$; d, $\times 290$).

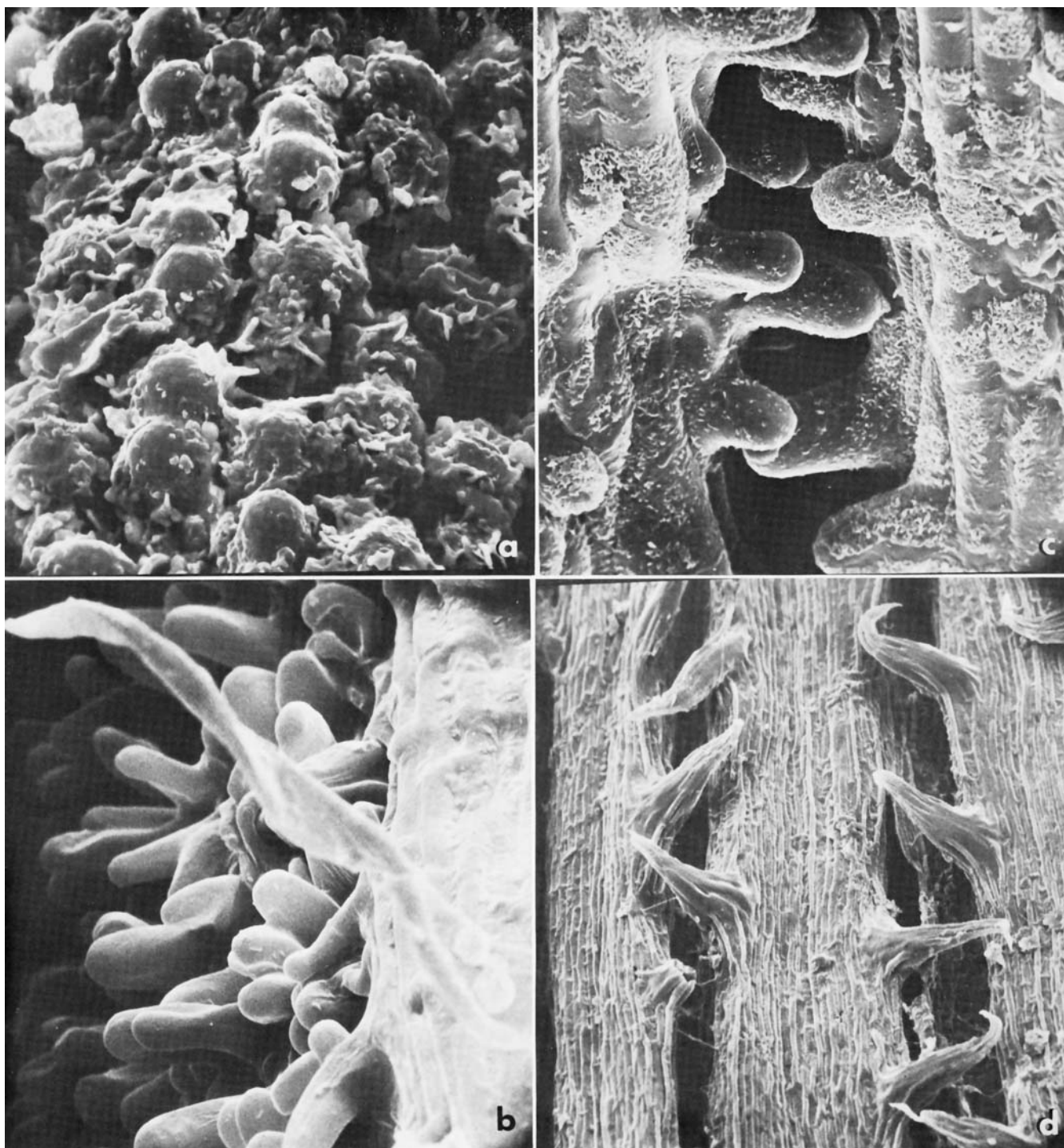


PLATE 5.—a, *Vellozia glochidea* (Duarte 8340–Mattos 677), abaxial epidermal surface exhibiting a nodular profile ($\times 1350$); b, *V. metzgerae* (Engler s.n.), a view through an abaxial furrow showing the disposition of the fingerlike projections ($\times 950$); c, *V. ciliata* (L. B. Smith and Ayensu 15595), surface view of an abaxial furrow showing the arrangement of the fingerlike projections ($\times 1100$); d, *V. pumila* (Glaziou 22215), surface view of the abaxial epidermis exhibiting the arrangement of hairs overarched the entrances to the furrows ($\times 180$).

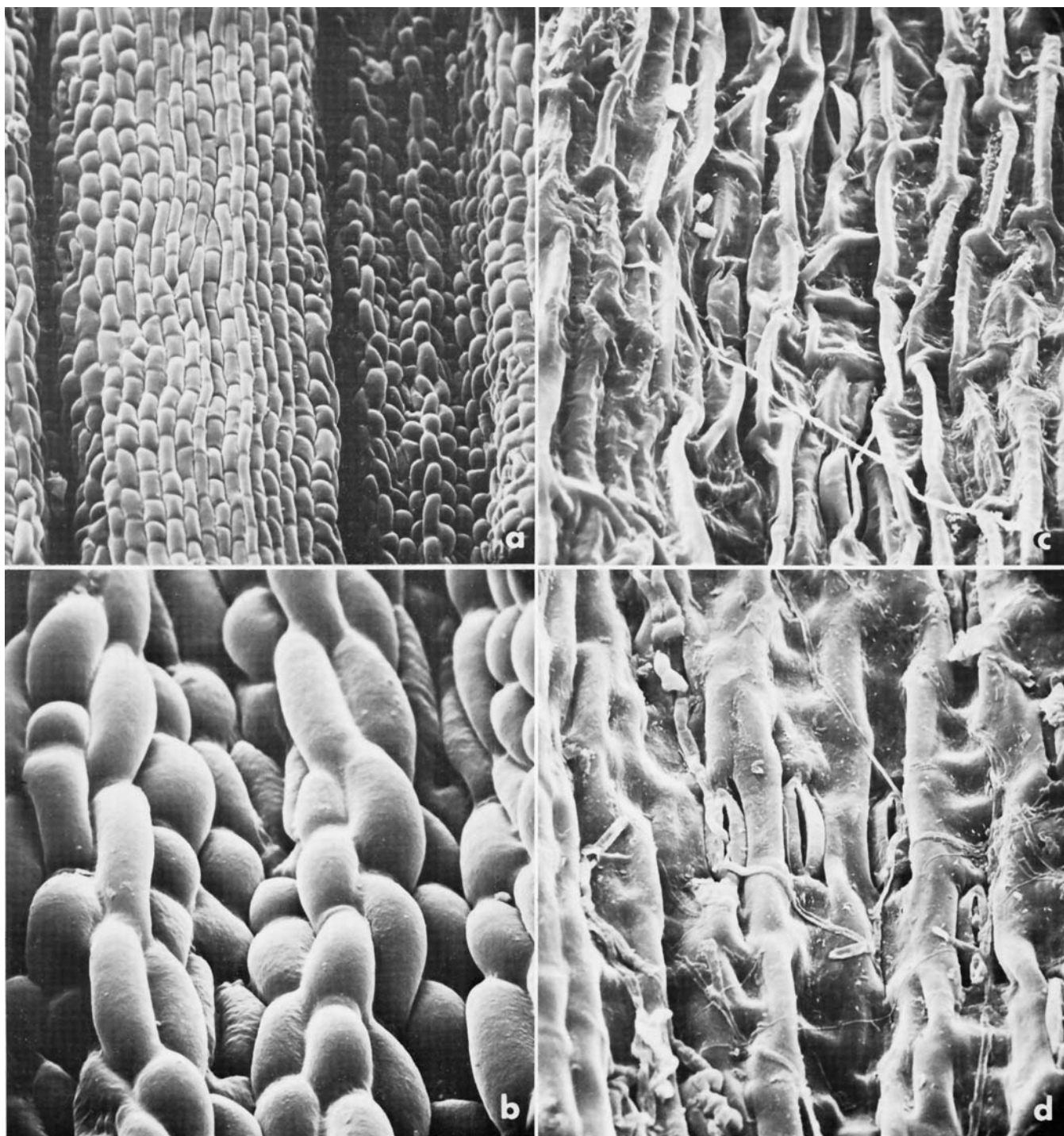


PLATE 6.—Abaxial surface view showing the arrangement and types of folding of the epidermal cells (a, $\times 245$; b, $\times 950$): a-b, *Barbacenia flava* (Tryon and Tryon 6836). Surface view of abaxial epidermis showing the relationship between epidermal ridges and the arrangement of the stomata: c, *B. luzulifolia* (Pereira 2664-Pabst 3500); d, *B. gounelleana* (Pereira 7050) (c, $\times 875$; d, $\times 950$).

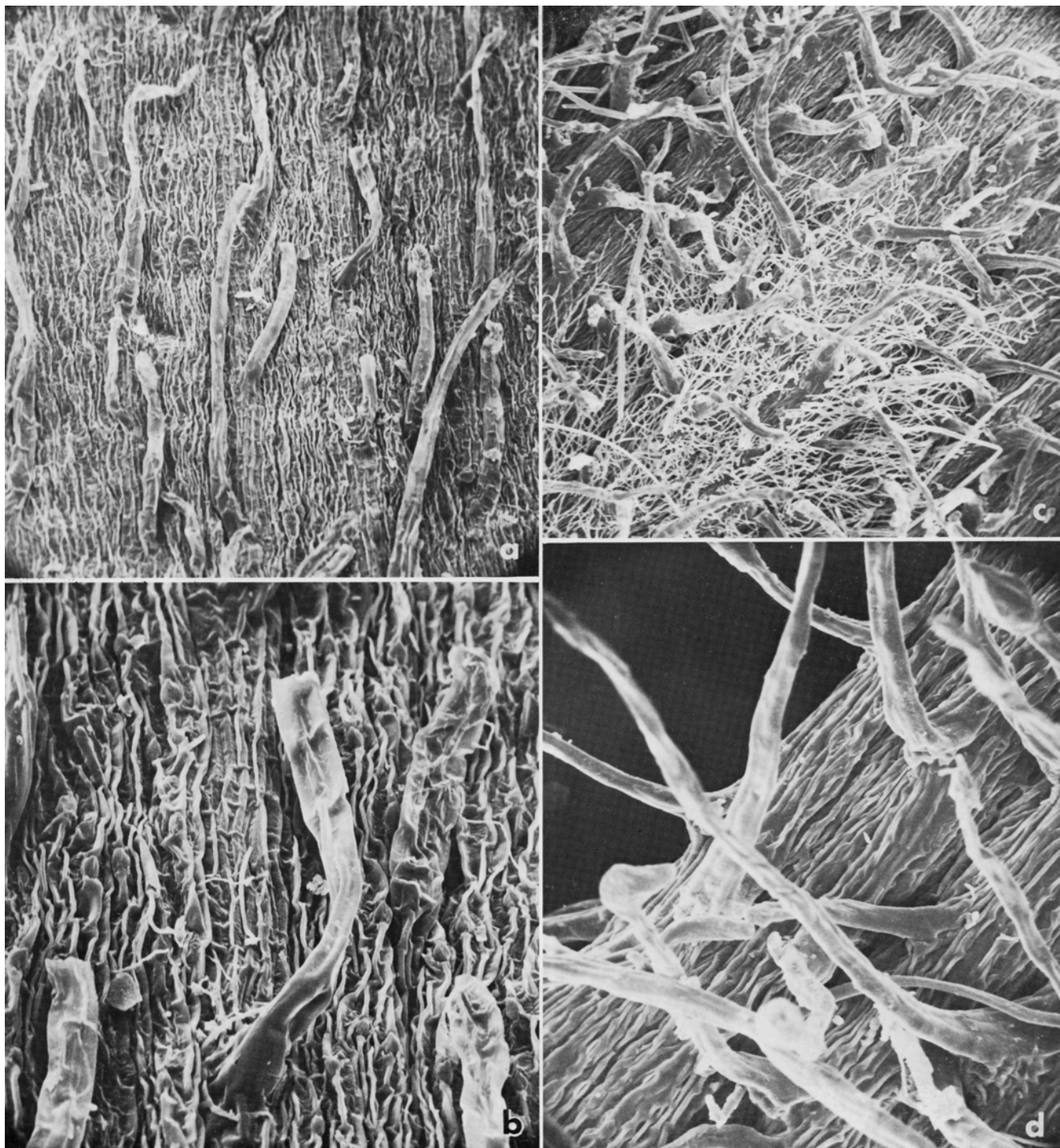


PLATE 7.—Adaxial epidermal surfaces illustrating the distribution of long hairs: a-b, *Barbacenia gardneri* (Pereira 2849-Pabst 3685) (a, $\times 115$; b, $\times 340$); c-d, *B. tomentosa* (Irwin et al. 29559) (c, $\times 80$; d, $\times 280$).

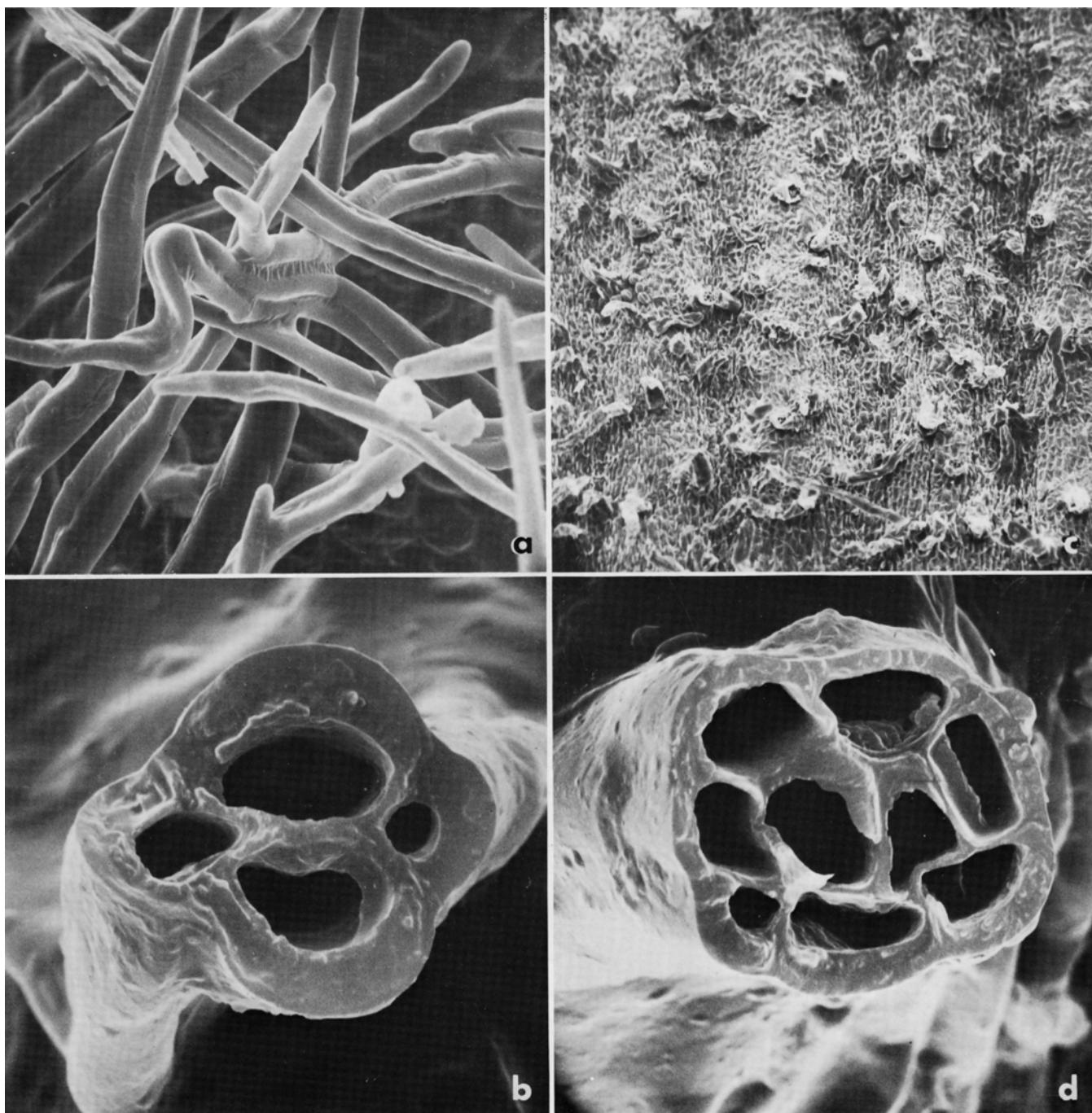


PLATE 8.—Surface views of epidermis showing the presence of coalescent hairs. *Barbacenia macrantha* (Irwin et al. 20017): a, abaxial surface showing hairs in the process of coalescence ($\times 450$); b, transverse section of coalesced hairs on the abaxial surface ($\times 2860$). *Barbacenia nana* (L. B. Smith and Ayensu 15973): c, adaxial surface view ($\times 85$); d, transverse section of nine coalesced hairs on adaxial surface ($\times 2275$).



PLATE 9.—Adaxial surface views of leaf epidermis showing the presence of hairs and their arrangement: a, *Barbacenia fragrans* (Ducke s.n.) ($\times 85$); b, *B. riedeliana* (Hatschbach 27806) ($\times 170$); c-d, *Barbacenia blackii* (Macedo 2962) (c, $\times 95$; d, $\times 250$).

PLATES 10-23.—Scanning electron micrographs illustrating epidermal surfaces showing the type and arrangement of stomata in Velloziaceae.

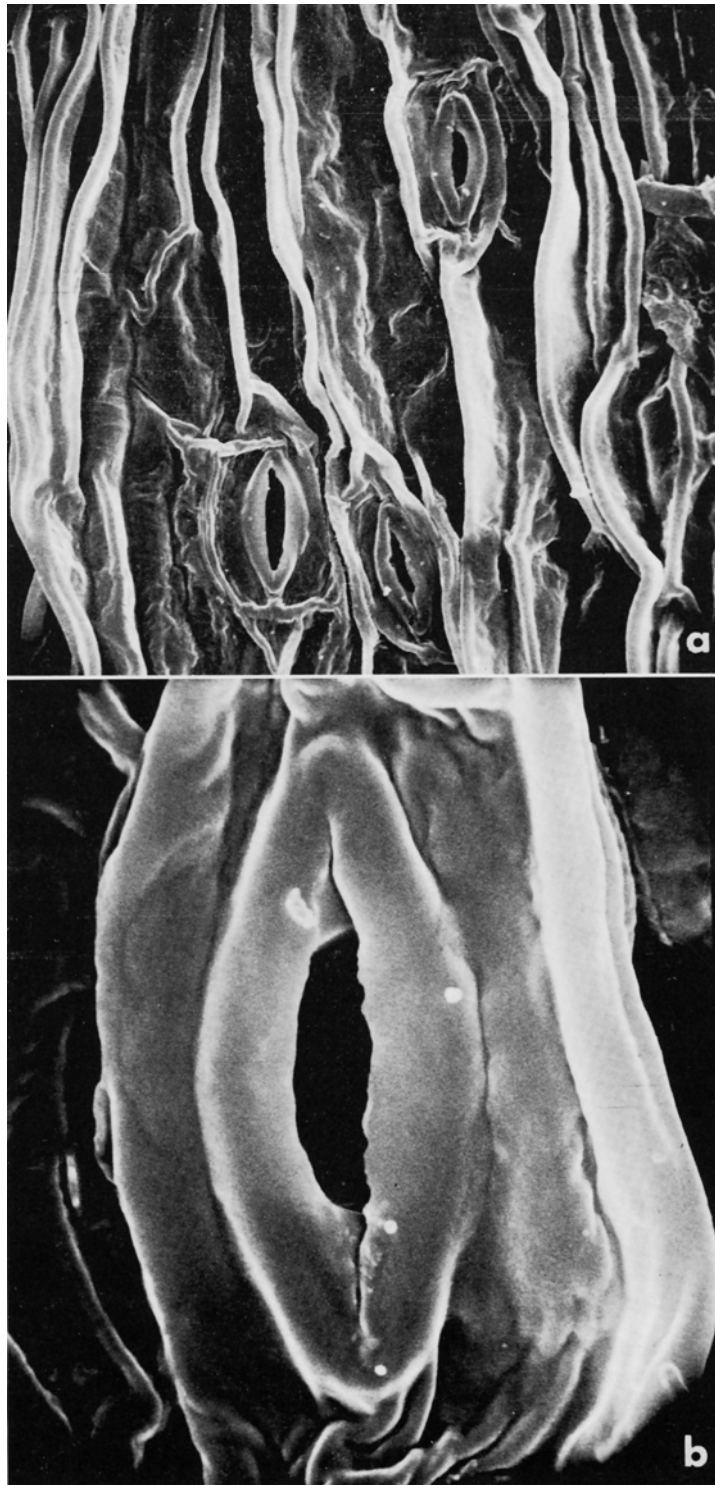


PLATE 10.—*Vellozia hatschbachii* (L. B. Smith and Ayensu 16002):
a-b, abaxial surface (a, $\times 1000$; b, $\times 5000$).

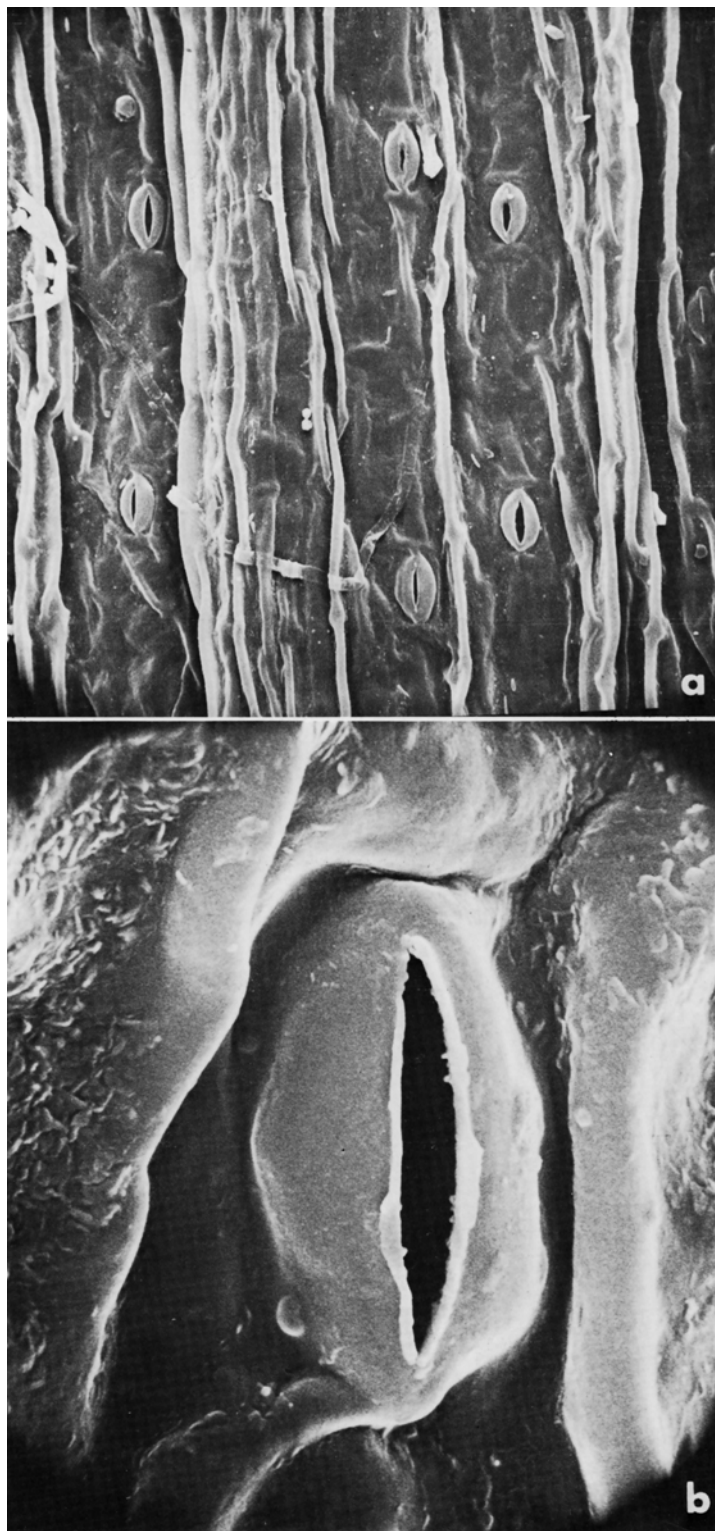


PLATE 11.—*Vellozia crassicaulis* (L. B. Smith & Ayensu 15965): a, adaxial surface ($\times 500$); b. abaxial surface ($\times 5000$).

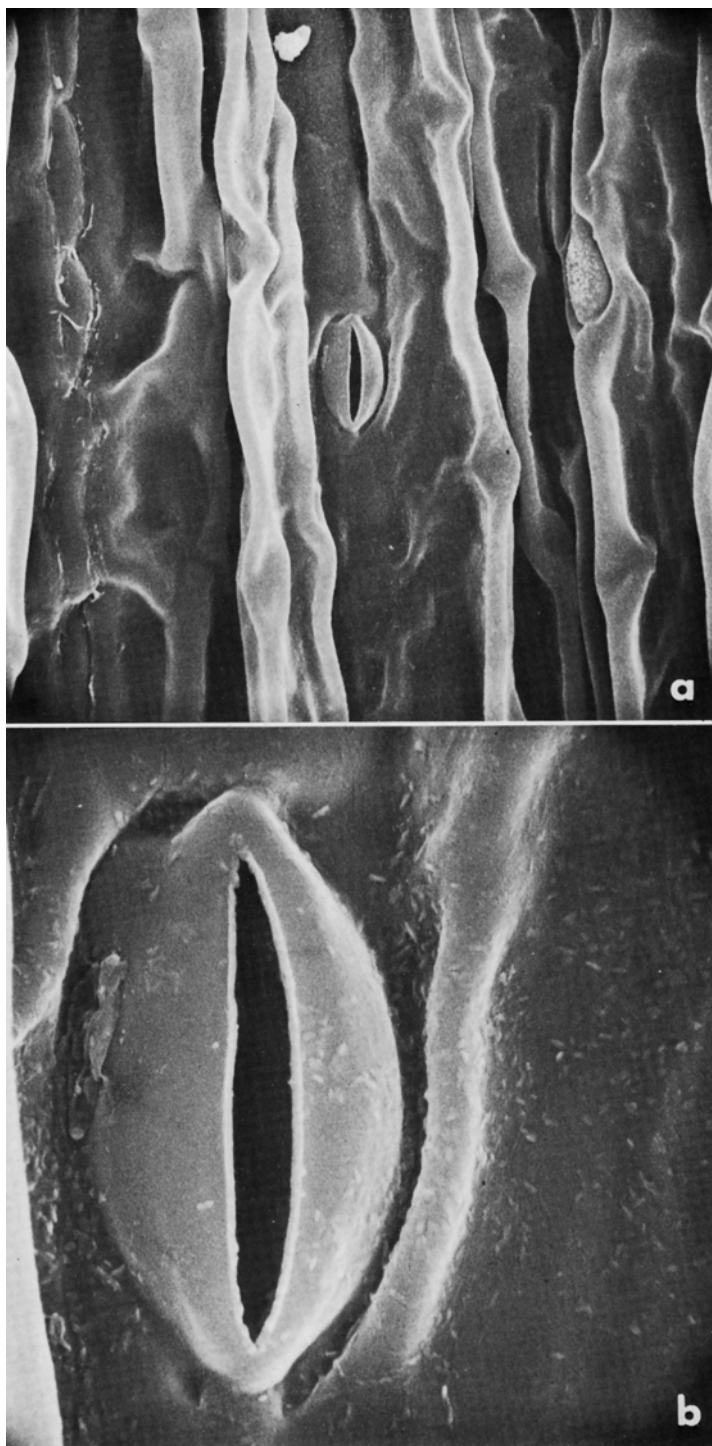


PLATE 12.—*Vellozia variabilis* (L. B. Smith & Ayensu 15981), adaxial surface (a, $\times 1000$; b, $\times 5000$).

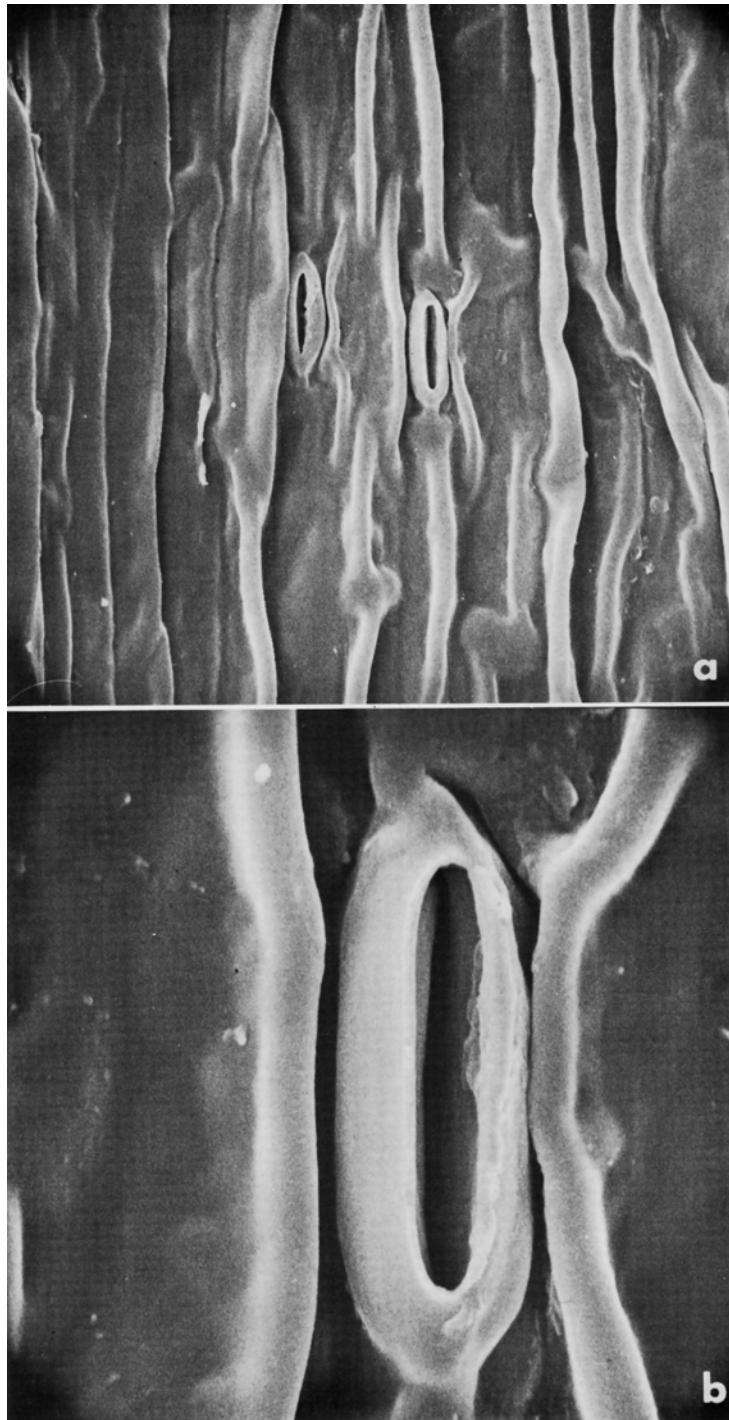


PLATE 13.—*Vellozia tubiflora* (Tamayo 3105), abaxial surface (a, \times 1000; b, \times 5000).

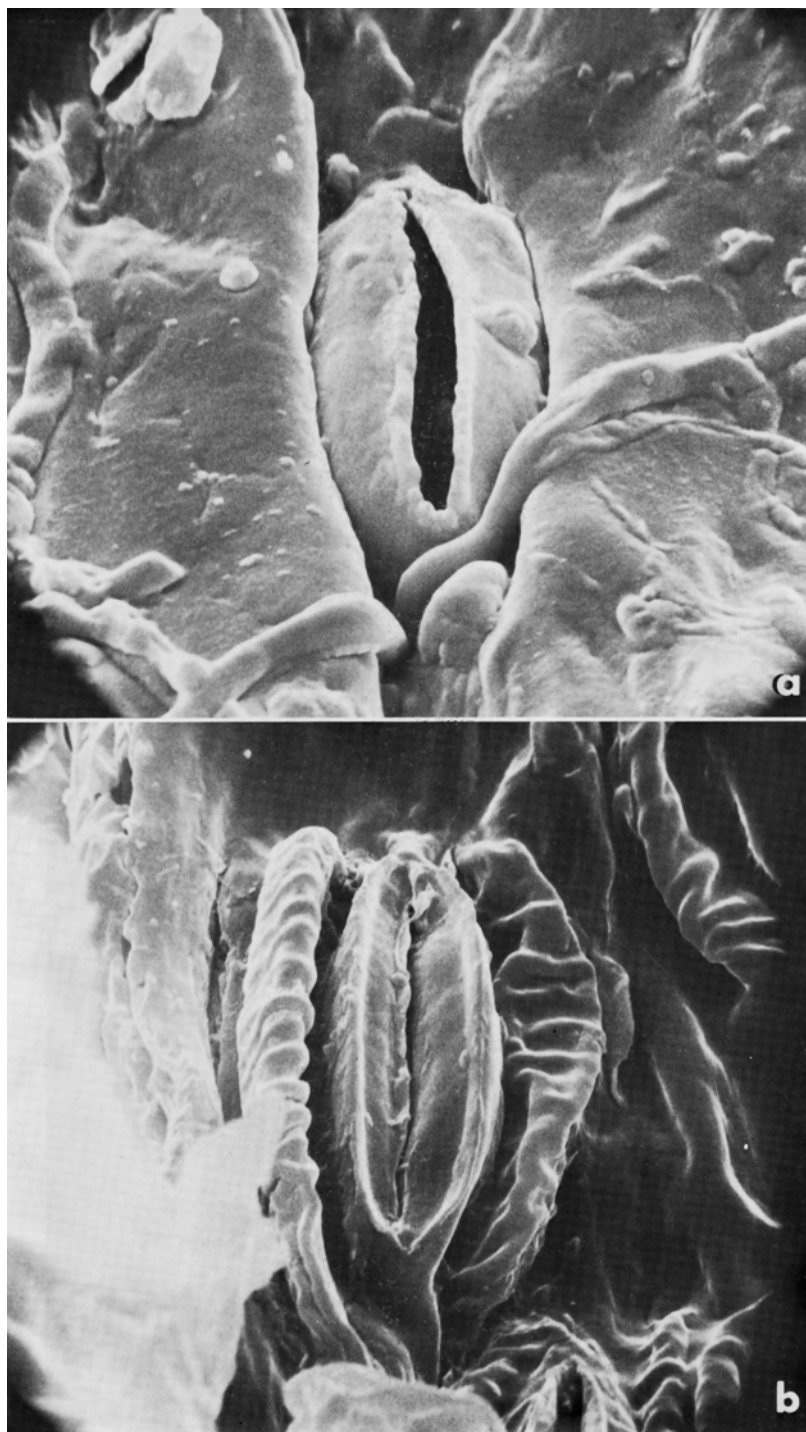


PLATE 14.—a, *Vellozia magdalenae* (Santos et al. 13298), abaxial surface ($\times 4700$); b, *V. squalida* (Duarte 6401), abaxial surface ($\times 2890$).

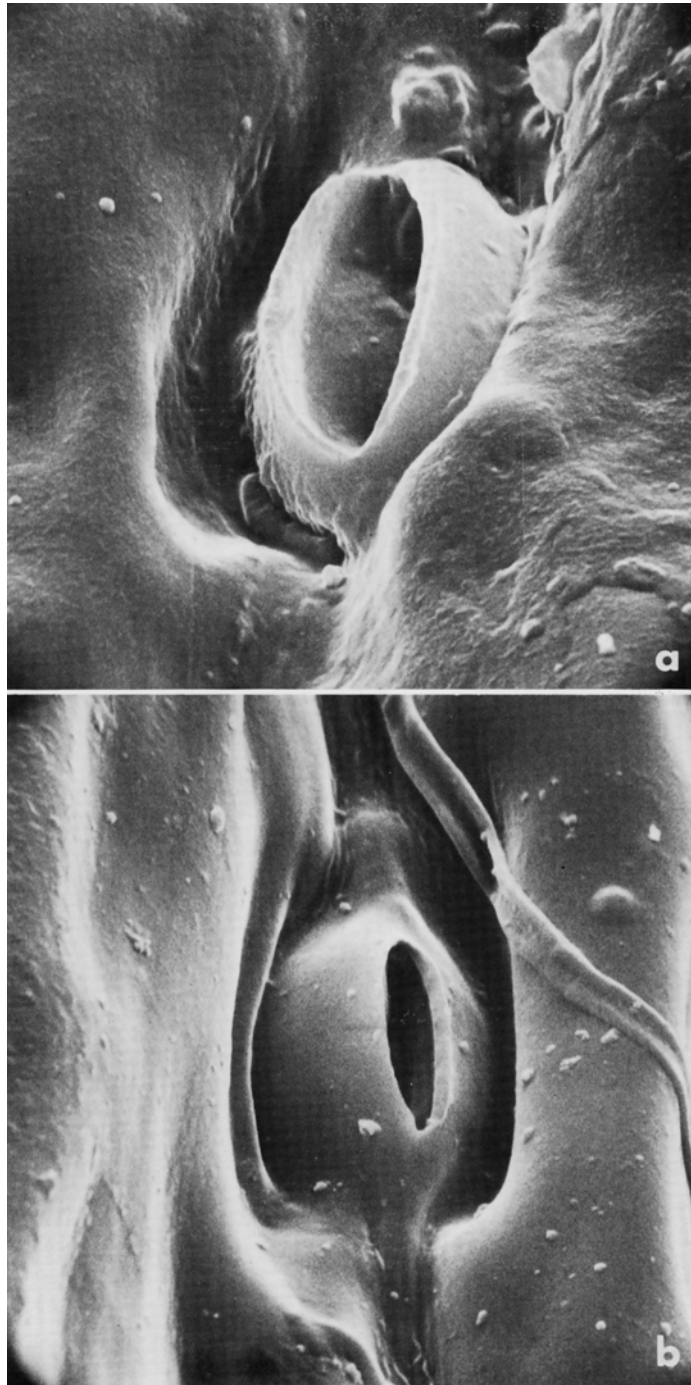


PLATE 15.—a, *Vellozia modesta* (L. B. Smith et al. 15997), abaxial surface ($\times 4500$); b, *V. minima* (Irwin et al. 20630), abaxial surface ($\times 4500$).

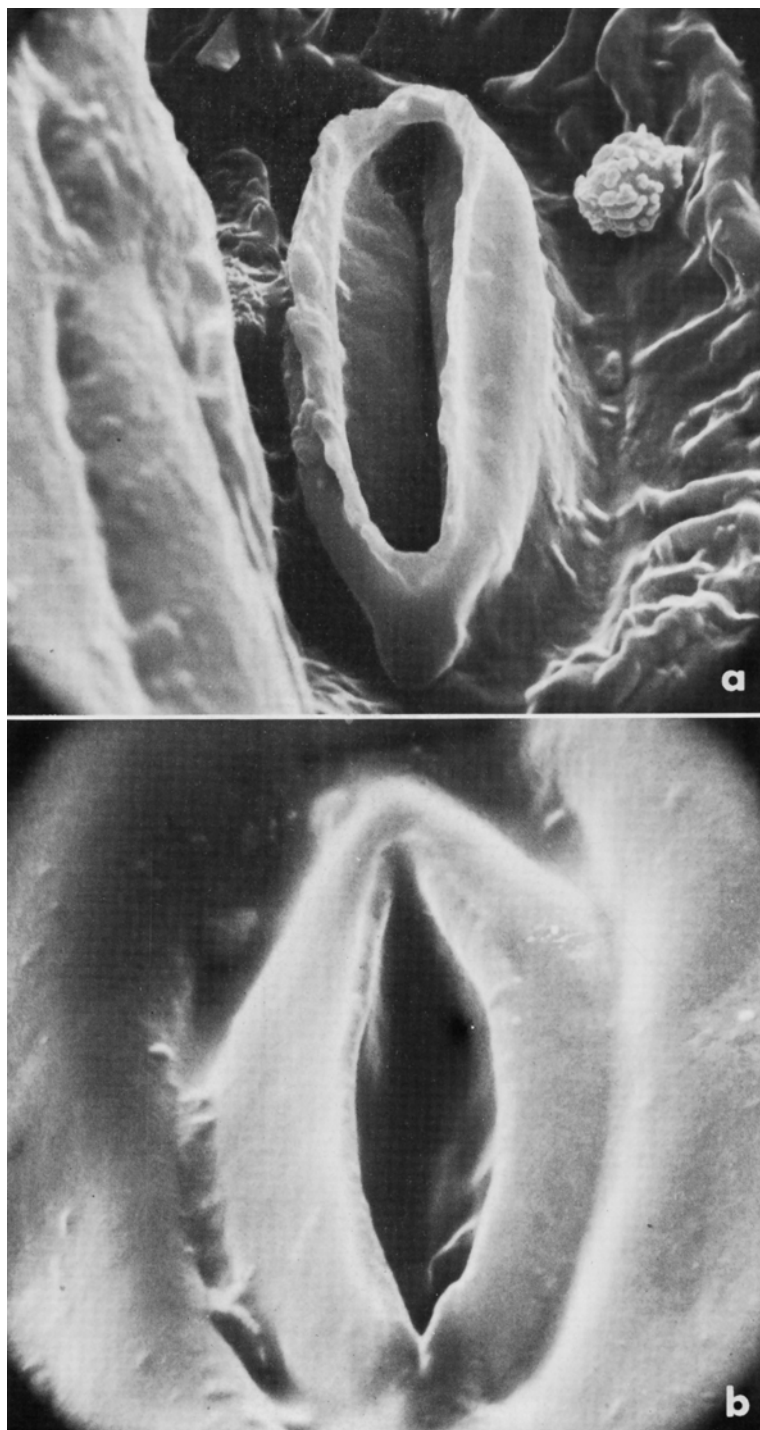


PLATE 16.—a, *Vellozia dasypus* (Blanchet 3558), abaxial surface ($\times 3750$);
b, *V. grisea* (Weddell 3006), abaxial surface ($\times 7830$).

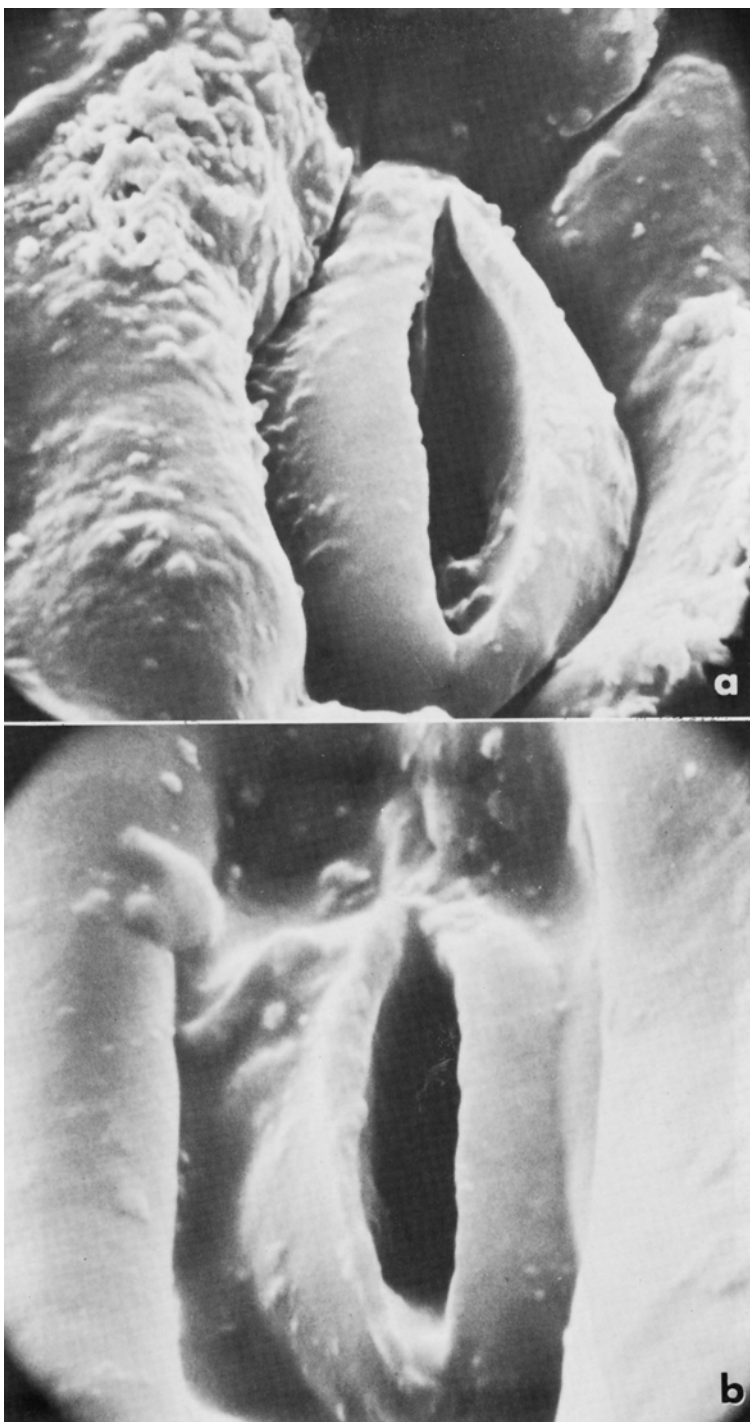


PLATE 17.—a, *Vellozia fibrosa* (Azevedo 5592), abaxial surface ($\times 6600$);
b, *V. lanata* (Veralucia and Graziella s.n.), adaxial surface ($\times 8075$).

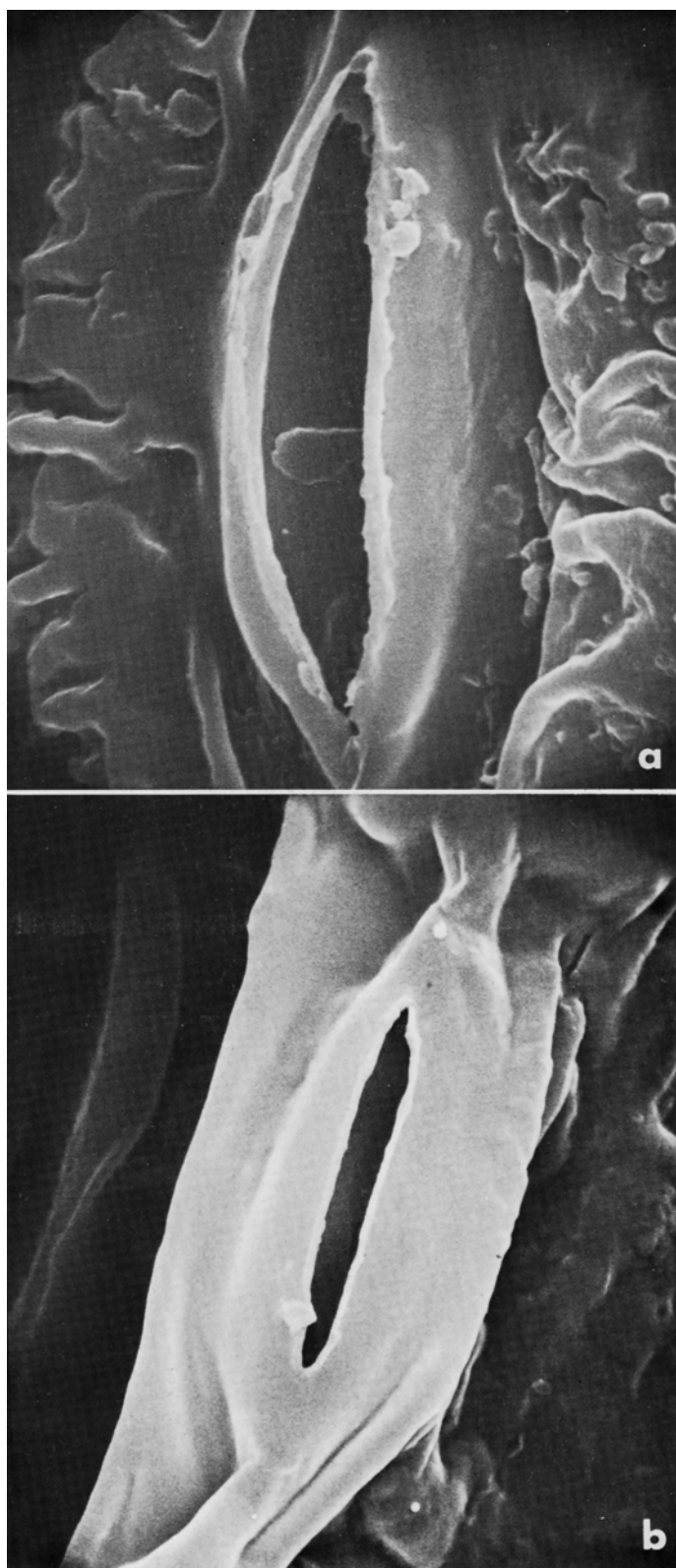


PLATE 18.—a, *Vellozia candida* (Rose and Russell 20669), abaxial surface ($\times 5000$); b, *V. caruncularis* (L. B. Smith and Ayensu 15977), abaxial surface ($\times 5000$).

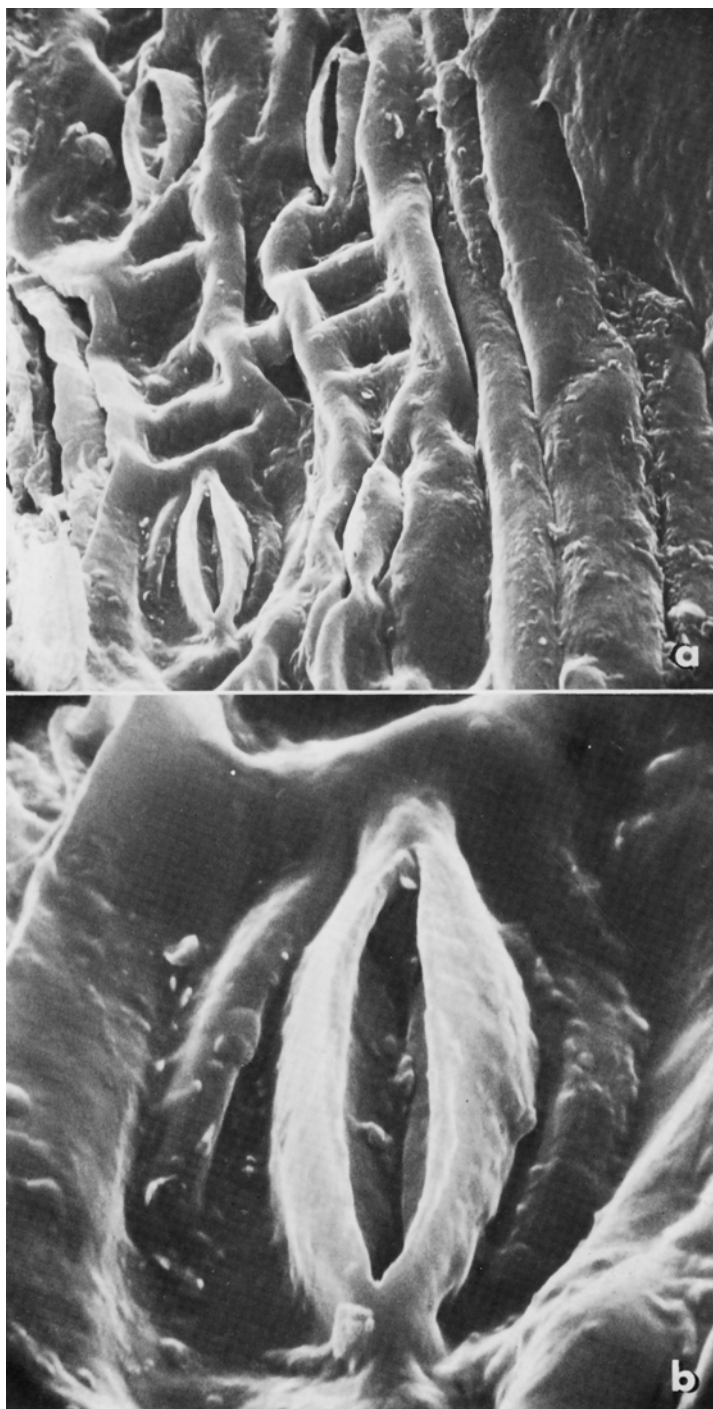


PLATE 19.—*Vellozia verruculosa* (Williams 8112), abaxial surfaces
(a, $\times 3060$; b, $\times 5310$).

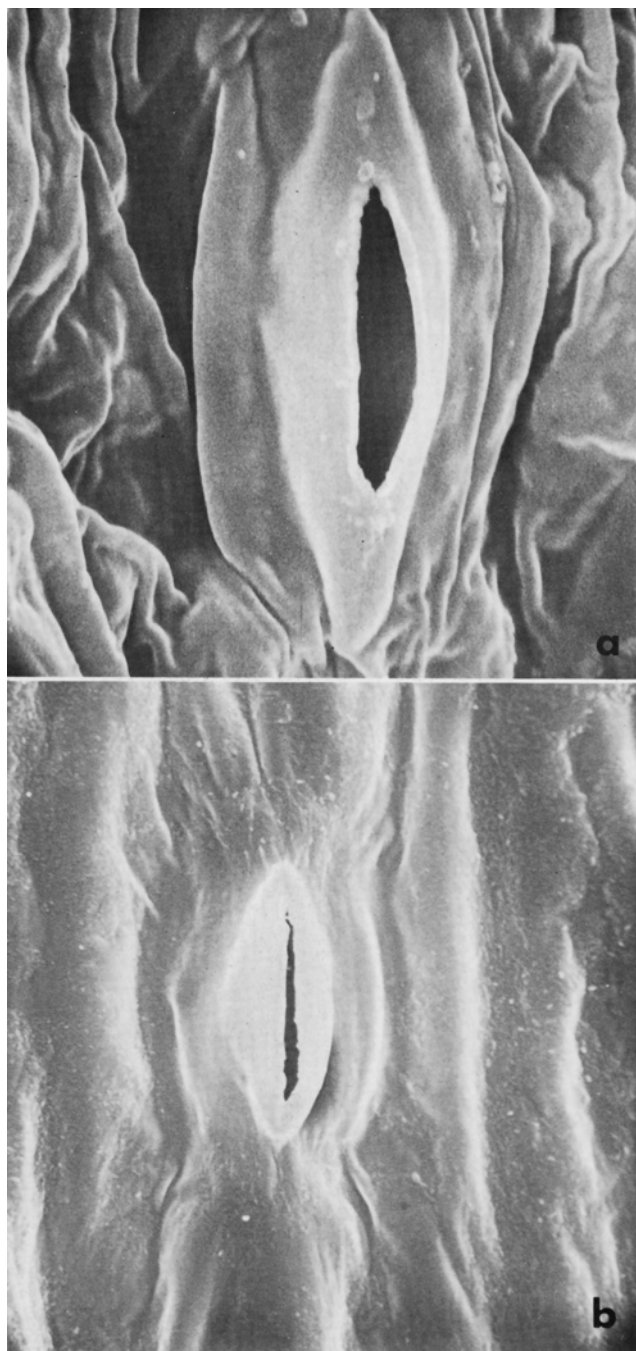


PLATE 20.—a, *Barbacenia paranaensis* (Hatschbach 29212), abaxial surface ($\times 5000$); b, *B. involucrata* (Irwin et al. 20973), adaxial surface ($\times 2000$).

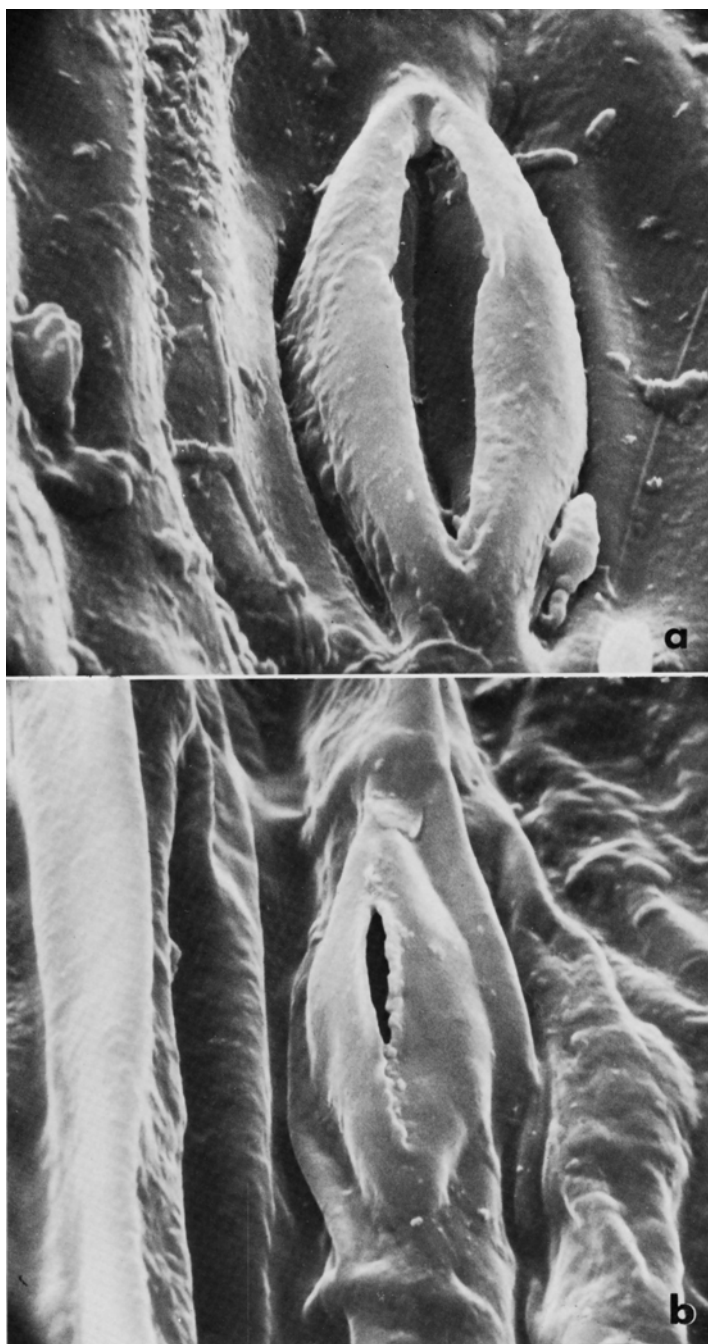


PLATE 21.—a, *Barbacenia hatschbachii* (Hatschbach 24284), abaxial ($\times 3400$); b, *B. sellovii* (Menezes and Continho 5), adaxial surface ($\times 4200$).

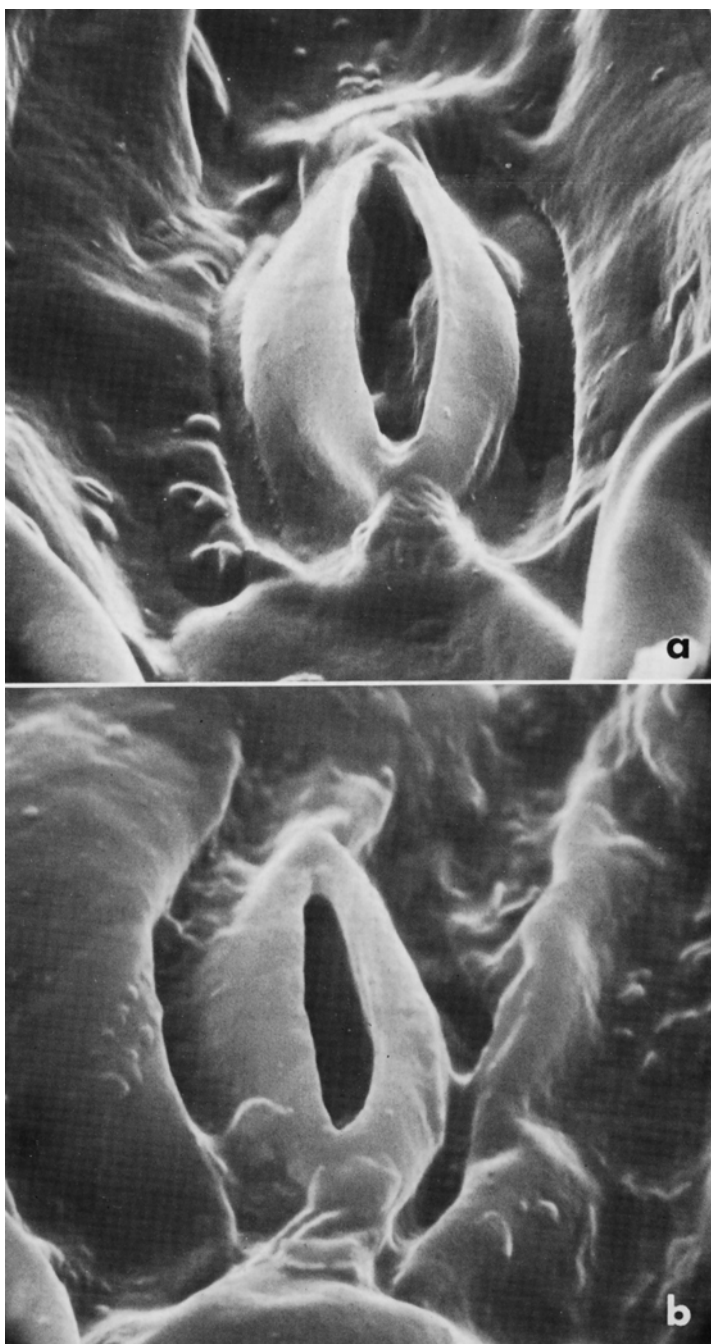


PLATE 22.—a, *Barbacenia fragrans* (Dueke s.n.), abaxial surface ($\times 4250$);
b, *B. nana* (L. B. Smith and Ayensu 15973), adaxial surface ($\times 4350$).

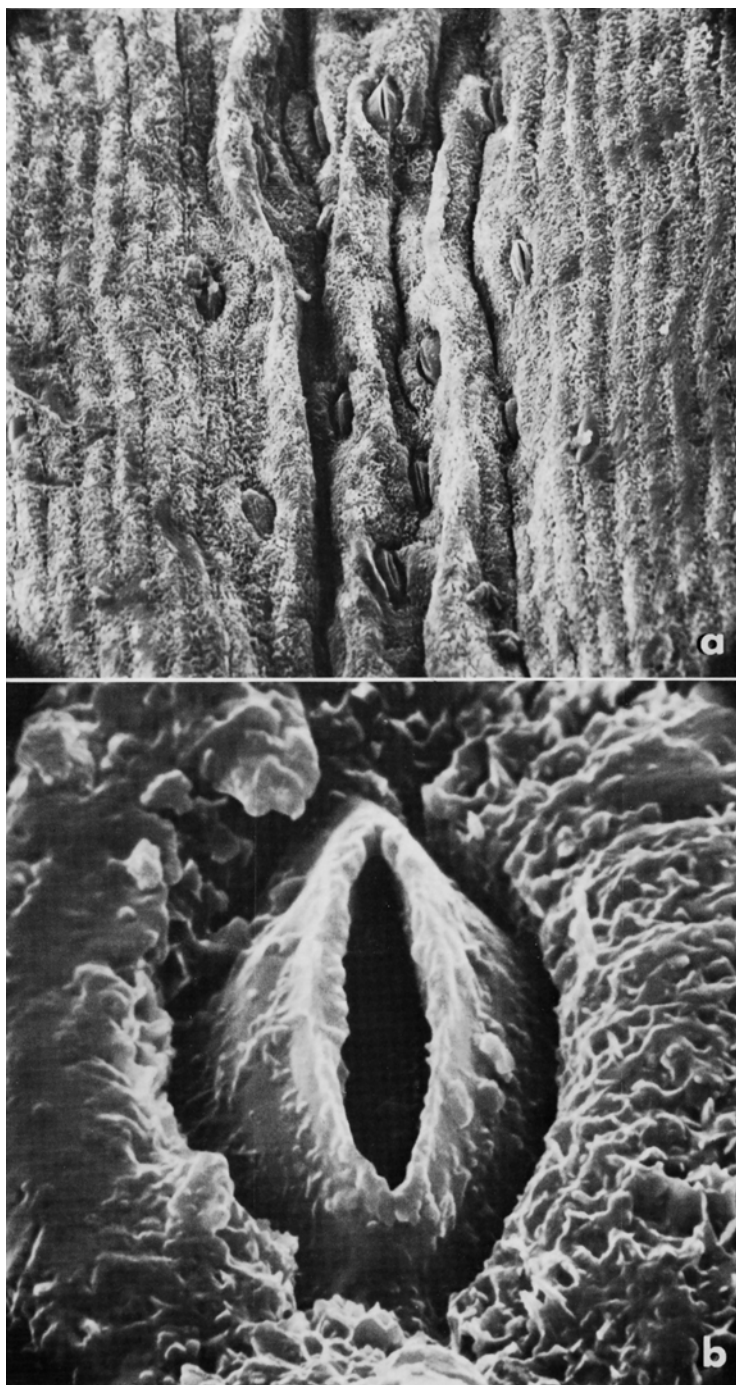


PLATE 23.—*Barbacenia conicostigma* (L. B. Smith and Ayensu 15982),
adaxial surfaces (a, $\times 430$; b, $\times 4300$).

PLATES 24-28.—Transverse sections of leaves of Velloziaceae showing sclerenchyma patterns and mesophyll. Each species may include sections of either the midvein, coastal, or intercoastal regions.

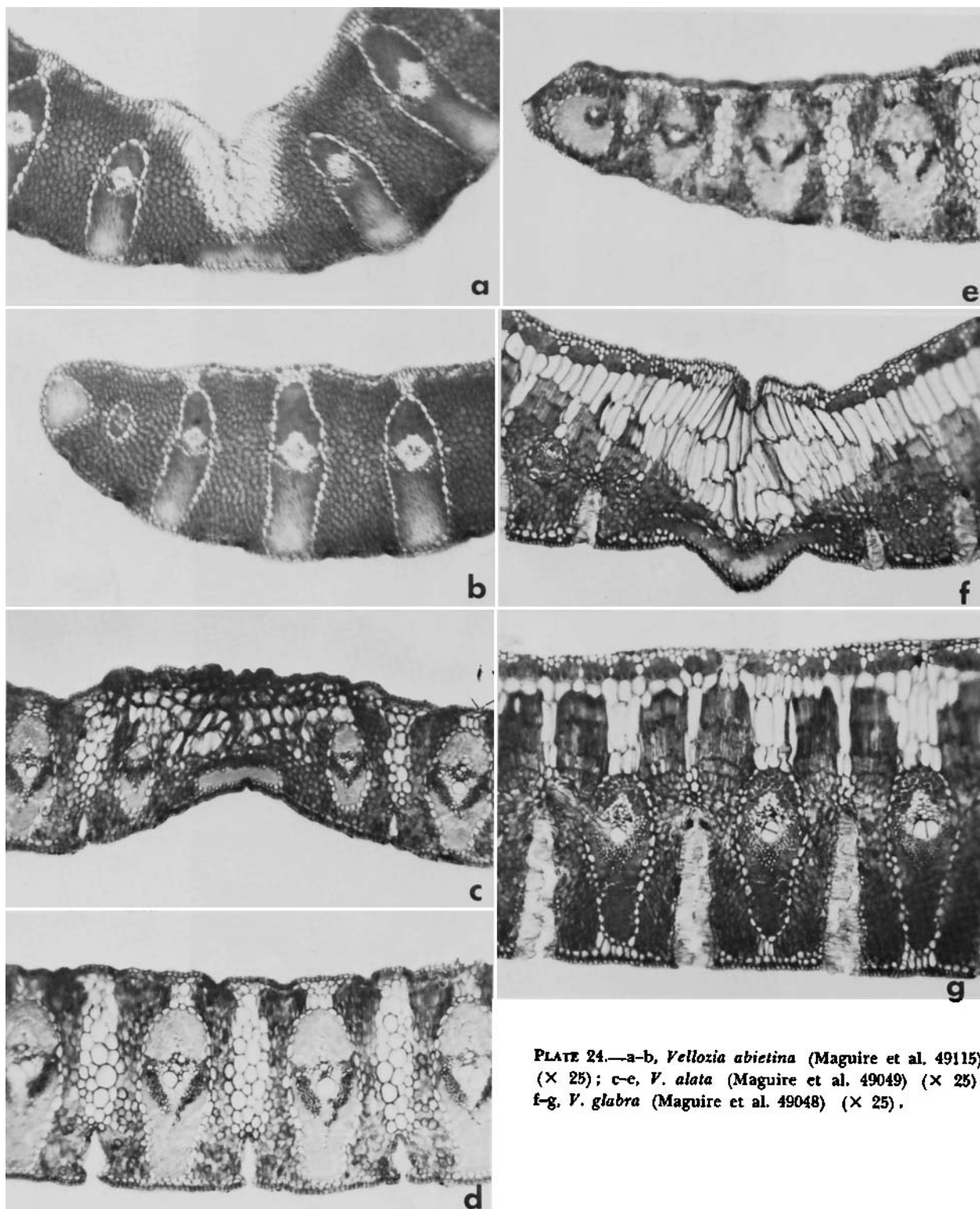


PLATE 24.—a-b, *Vellozia abietina* (Maguire et al. 49115) ($\times 25$); c-d, *V. alata* (Maguire et al. 49049) ($\times 25$); f-g, *V. glabra* (Maguire et al. 49048) ($\times 25$).

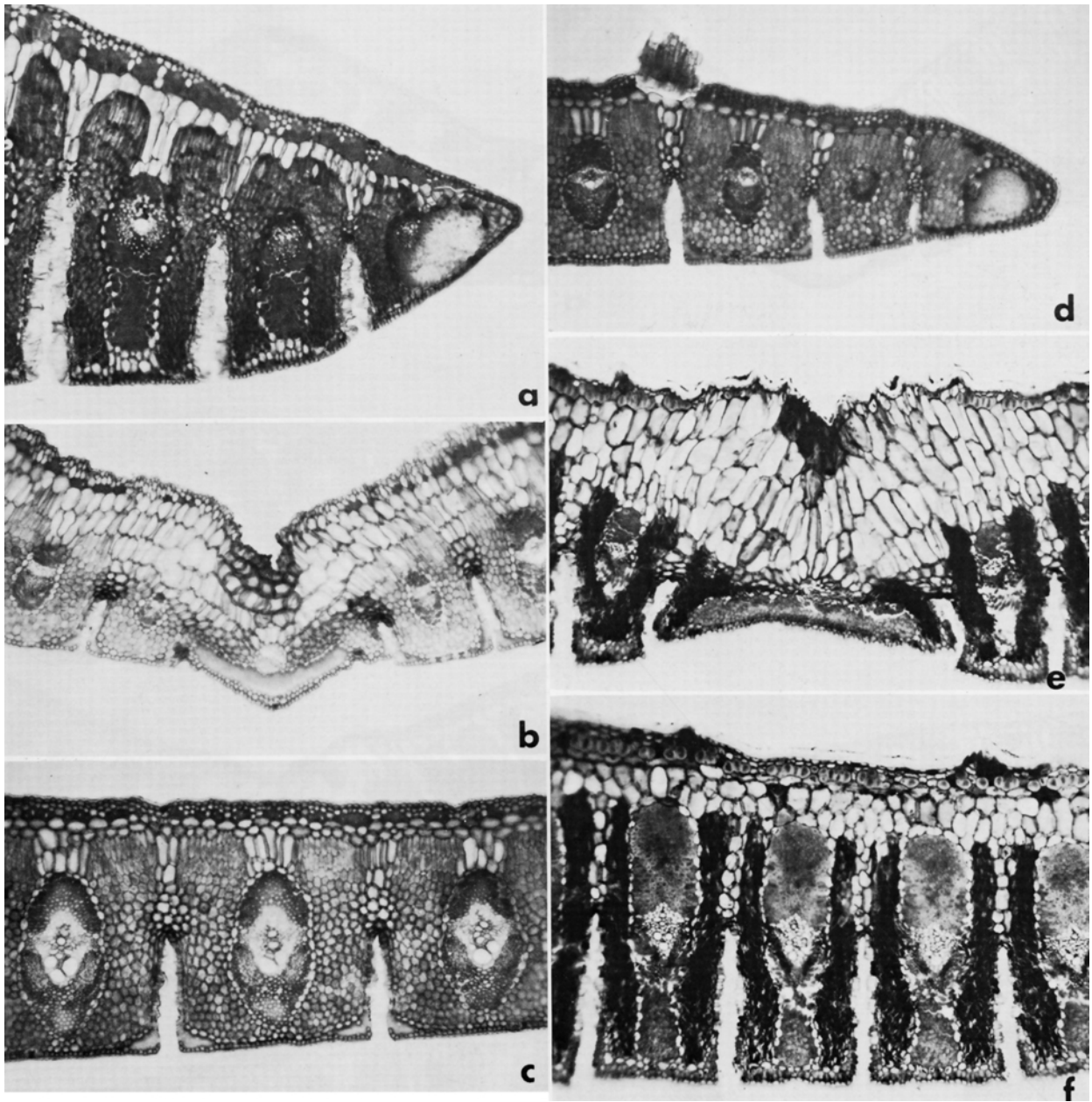


PLATE 25.—a, *Vellozia glabra* (Maguire et al. 49048) ($\times 25$); b-d, *V. compacta* (Irwin 2407) ($\times 25$); e-f, *V. compacta* (Segades-Vianna and Loredó 1085) ($\times 25$).

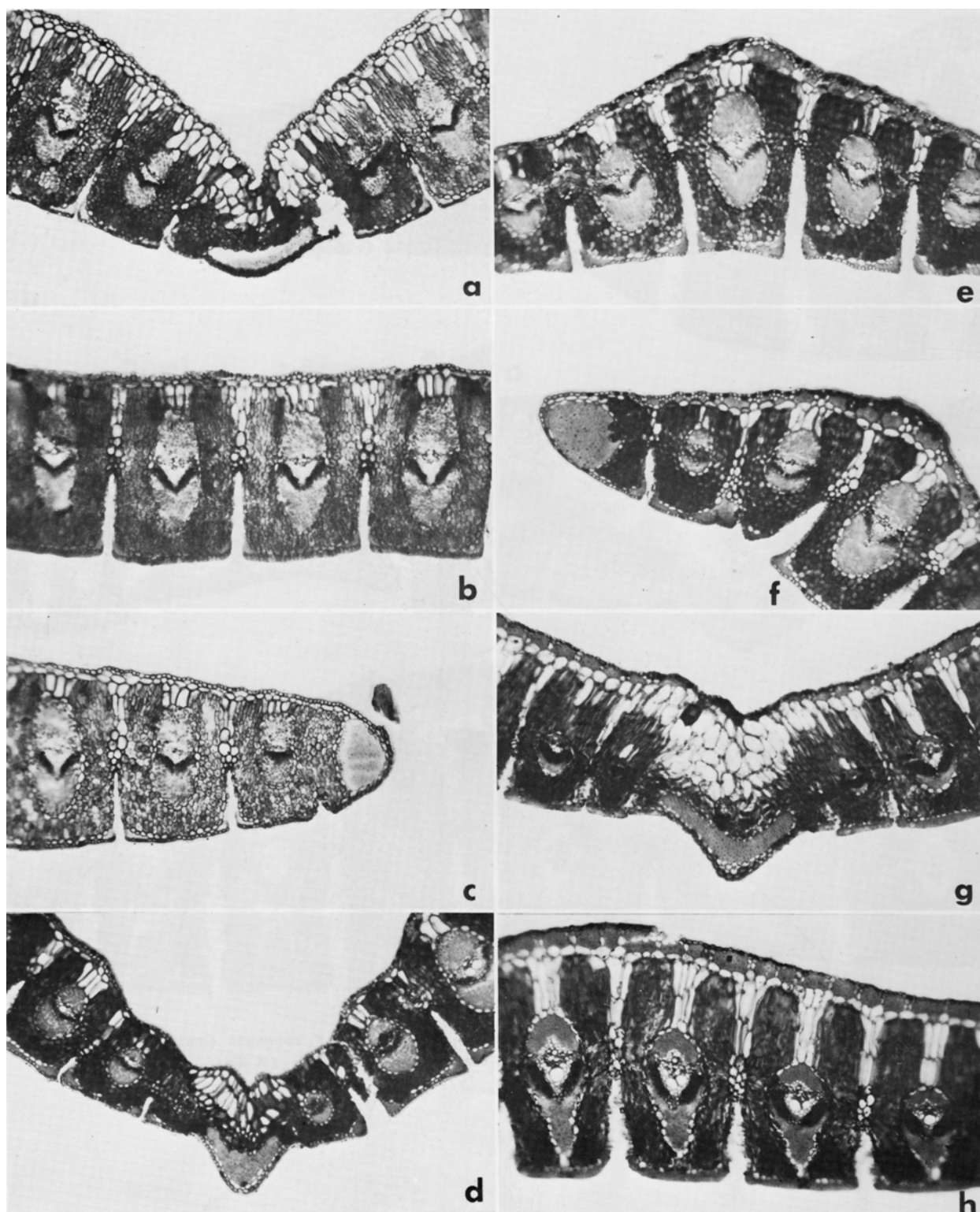


PLATE 26.—a-c, *Vellozia verruculosa* (Williams 8112) ($\times 25$); d-f, *V. fibrosa* (Azevedo 5592) ($\times 25$); g-h, *V. variabilis* (Irwin et al. 9809) ($\times 25$).

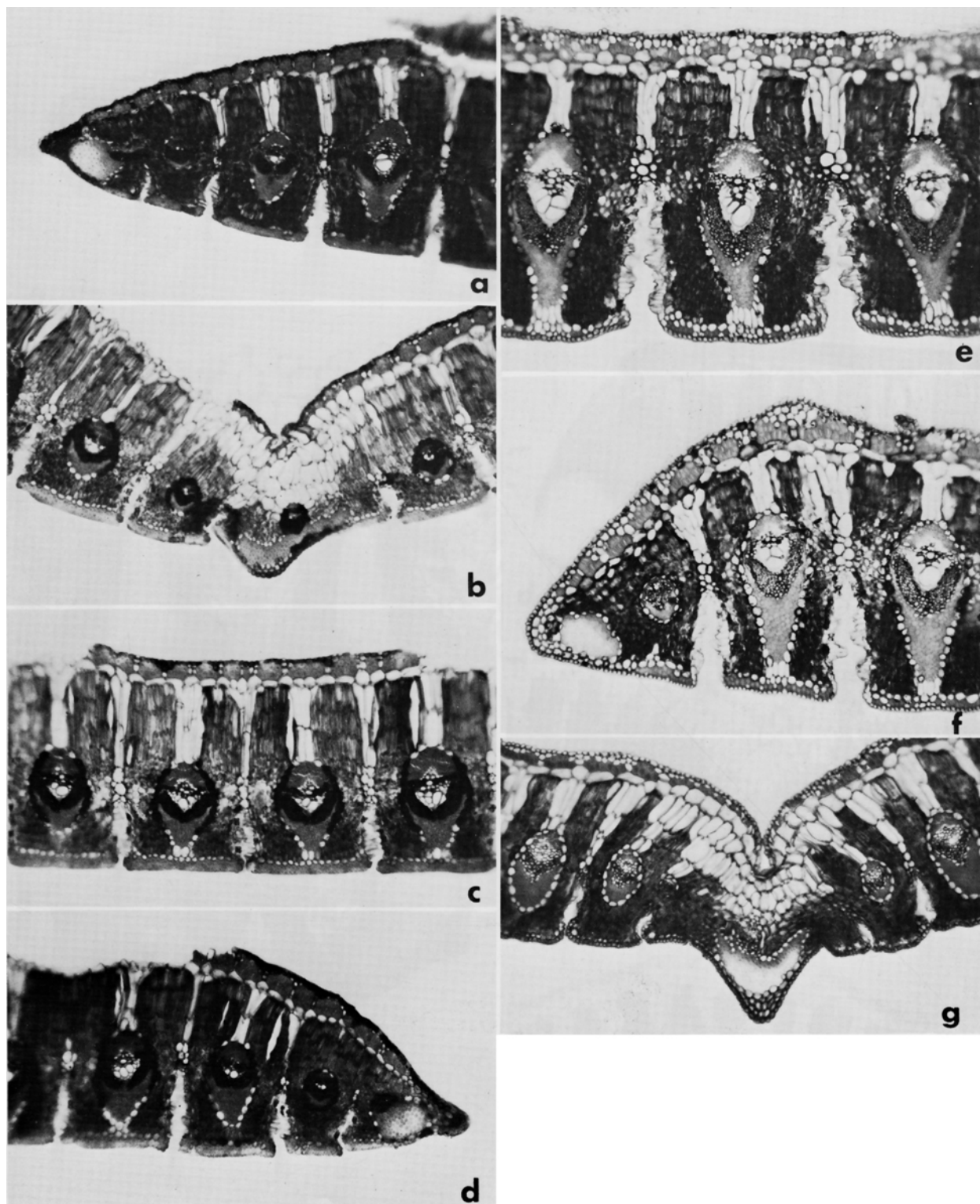


PLATE 27.—a, *Vellozia variabilis* (Irwin et al. 9809) ($\times 25$); b-d, *V. variabilis* (Irwin et al. 9915) ($\times 25$); e-f, *V. variabilis* (Maguire et al. 49262) ($\times 25$); g, *V. angustifolia* (Archer 4092) ($\times 25$).

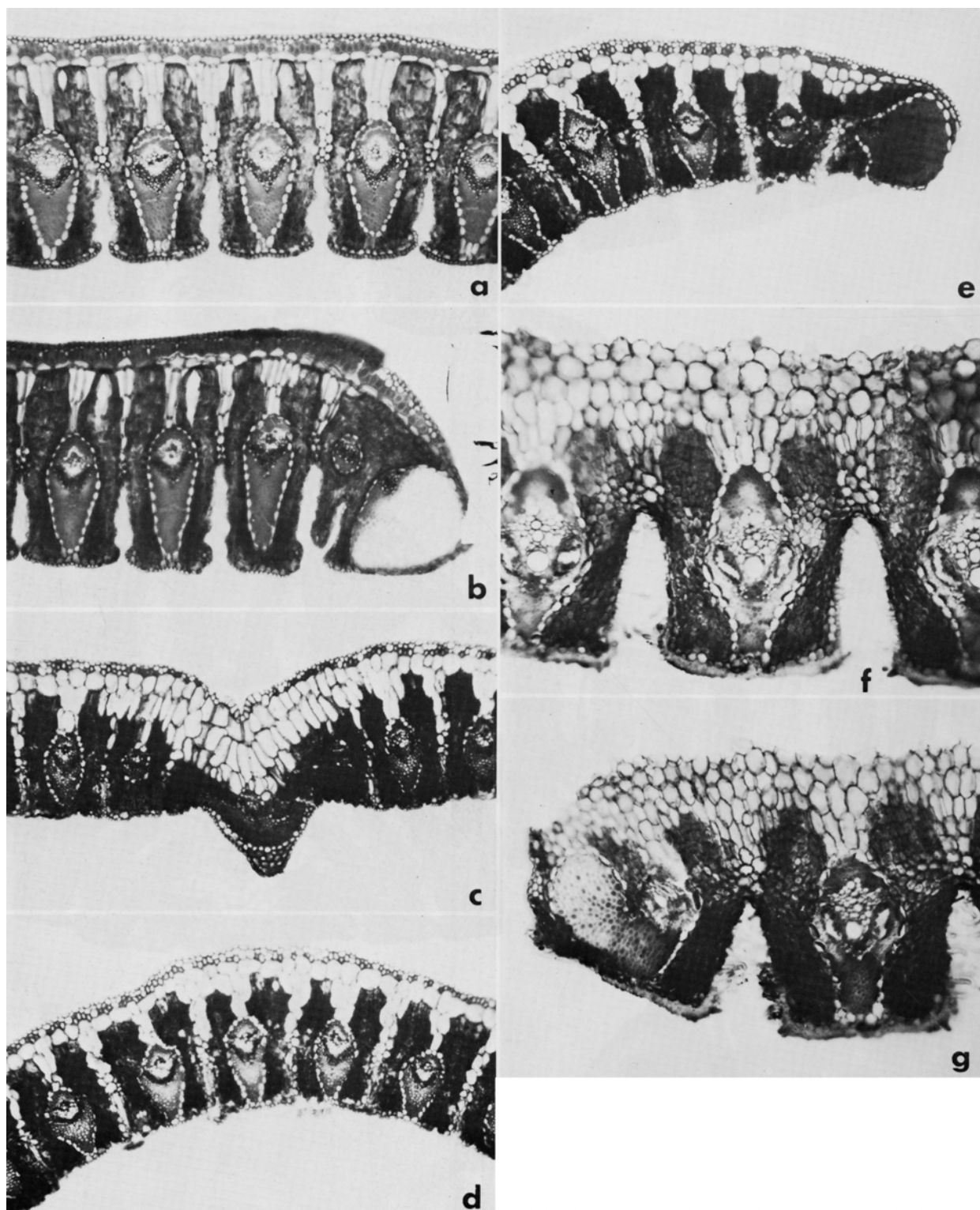


PLATE 28.—a-b, *Vellozia angustifolia* (Archer 4092) ($\times 25$); c-e, *V. angustifolia* (Riedel 1824) ($\times 25$); f-g, *V. intermedia* (L. B. Smith 6854) ($\times 25$).

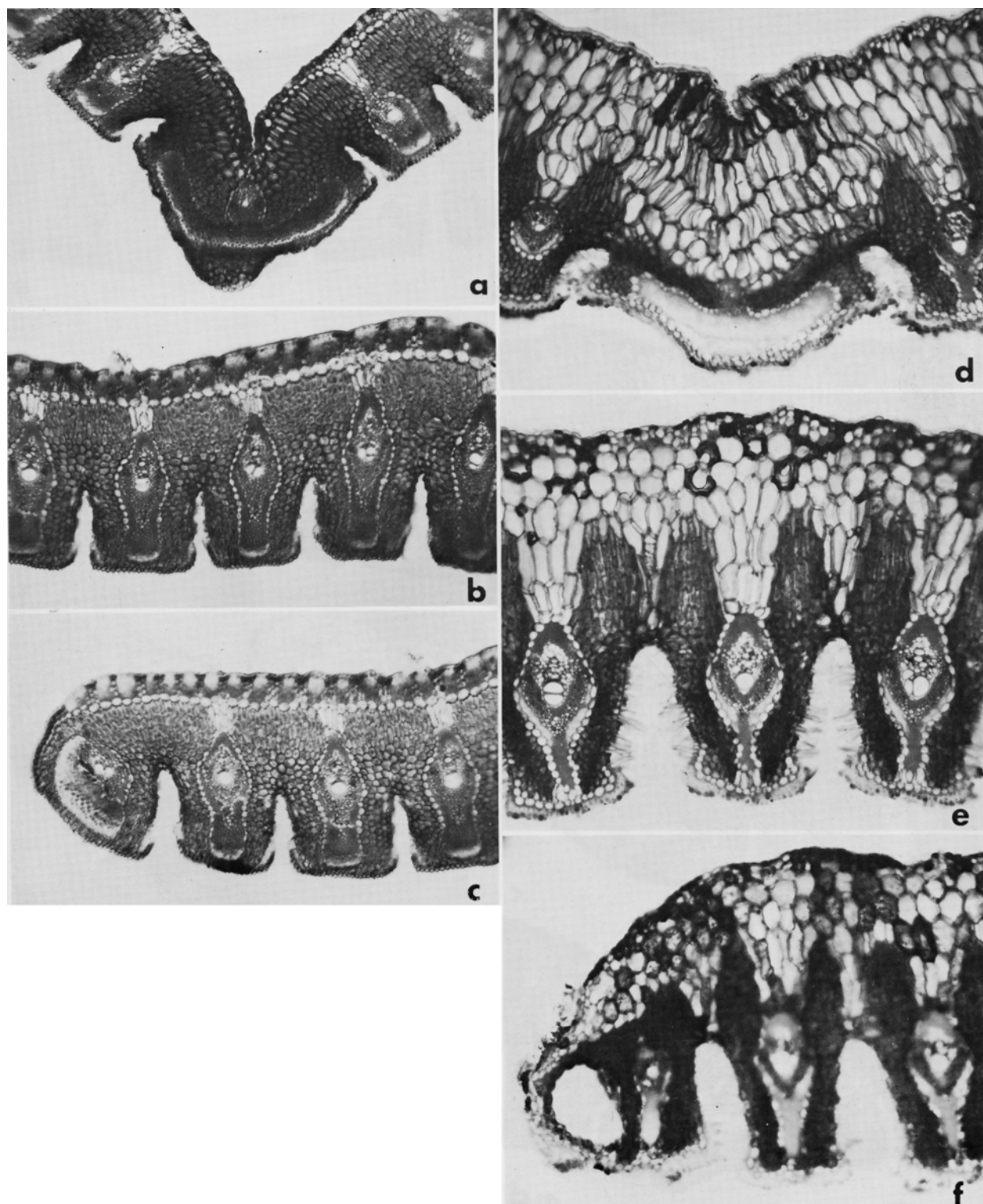


PLATE 29.—a-c, *Vellozia squalida* (Archer and Barreto 4937) ($\times 25$);
d-f, *V. aloifolia* (Mexia 5870) ($\times 25$).

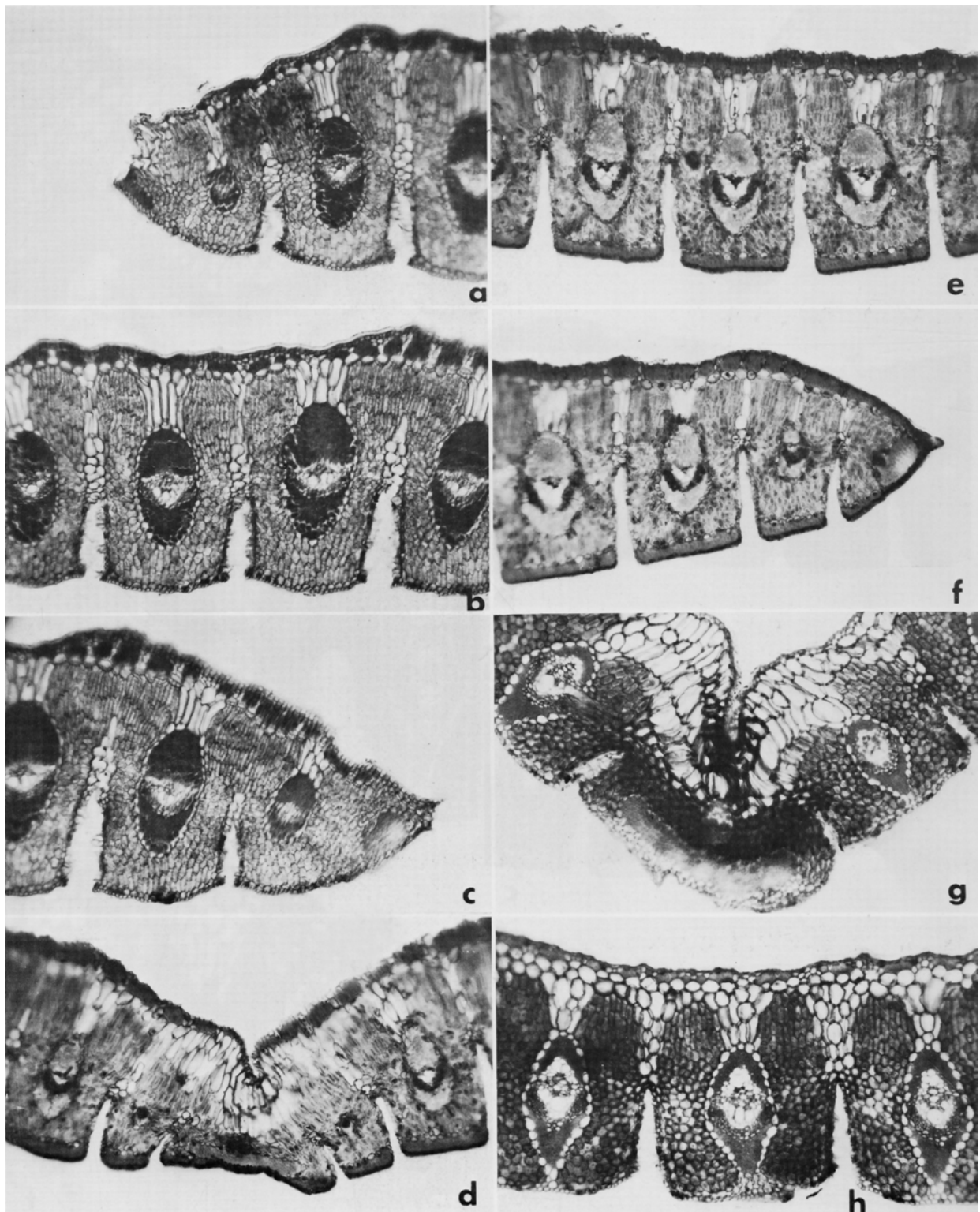


PLATE 30.—a-c, *Vellozia taxifolia* (Mexia 4289) ($\times 25$); d-f, *V. leptopetala* (Maguire et al. 49184) ($\times 25$); g-h, *V. resinosa* (Maguire et al. 44694) ($\times 25$).

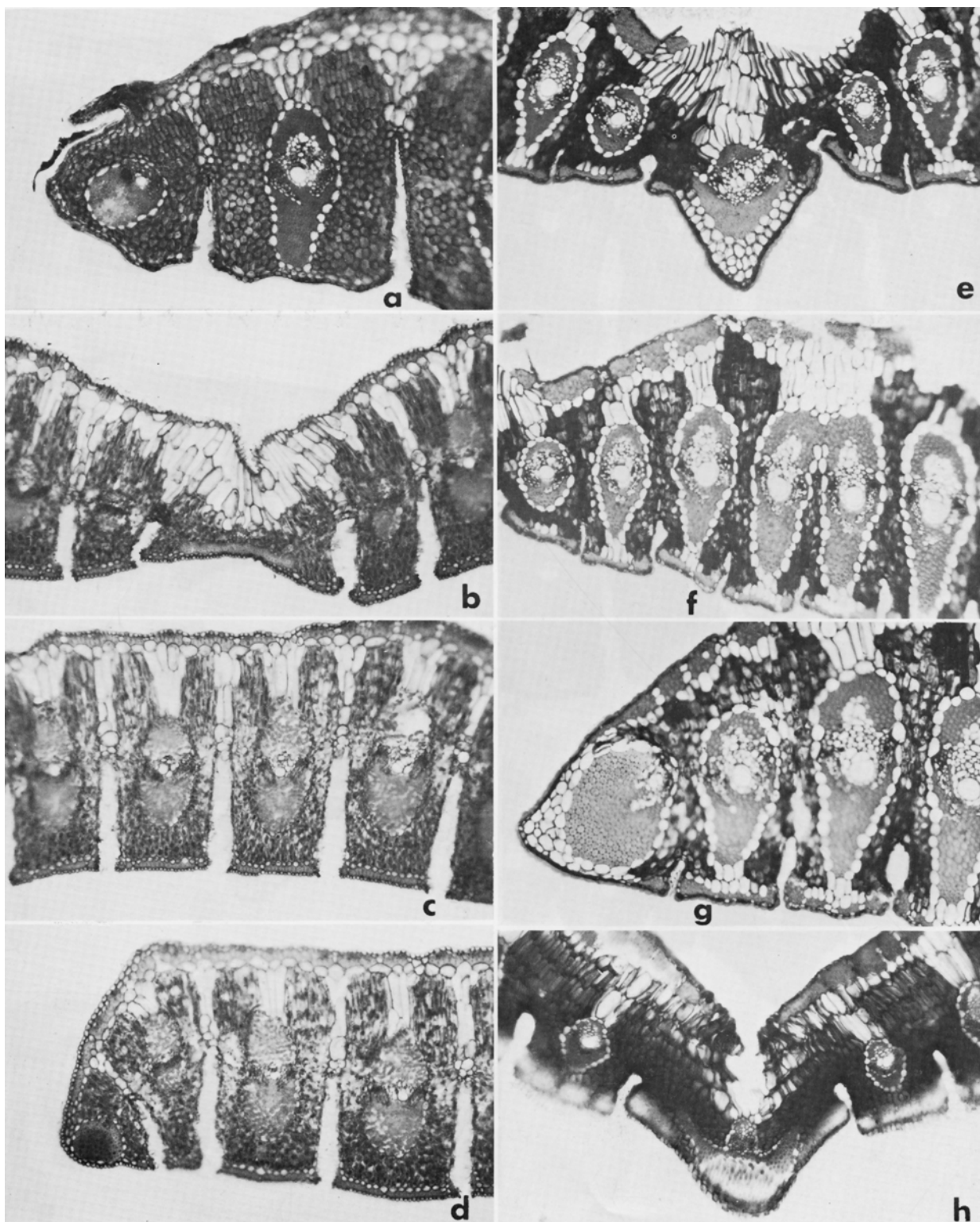


PLATE 31.—a, *Vellozia resinosa* (Maguire et al. 44694) ($\times 25$); b-d, *V. epidendroides* (Maguire et al. 49060) ($\times 25$); e-g, *V. flavicans* (Gardner 4370) ($\times 25$); h, *V. glochidea* (Irwin et al. 14584) ($\times 25$).

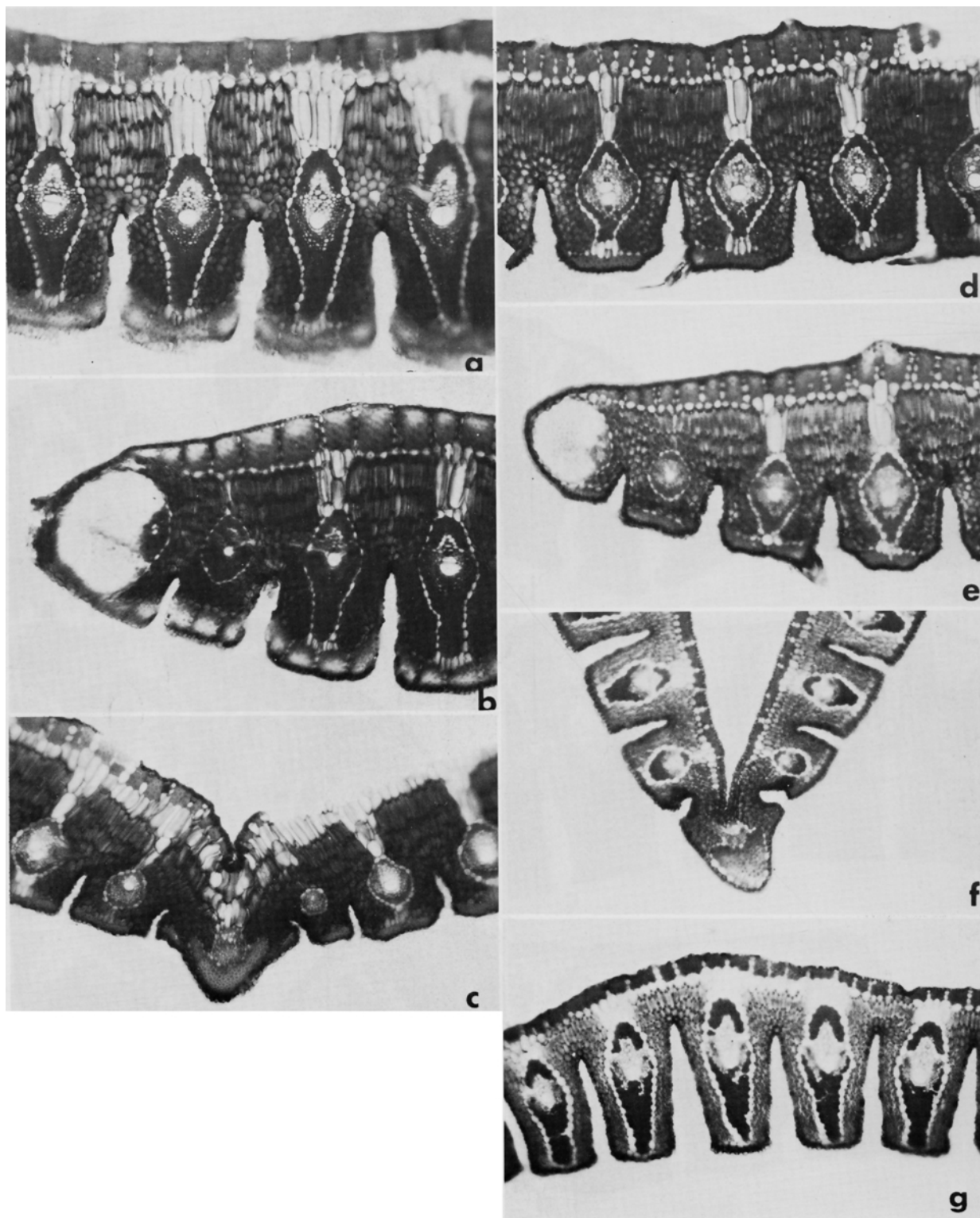


PLATE 32.—a-b, *Vellozia glochidea* (Irwin et al. 14584) ($\times 25$); c-e, *V. crassicaulis* (Irwin et al. 11699) ($\times 25$); f-g, *V. crassicaulis* (Irwin et al. 13377) ($\times 25$).

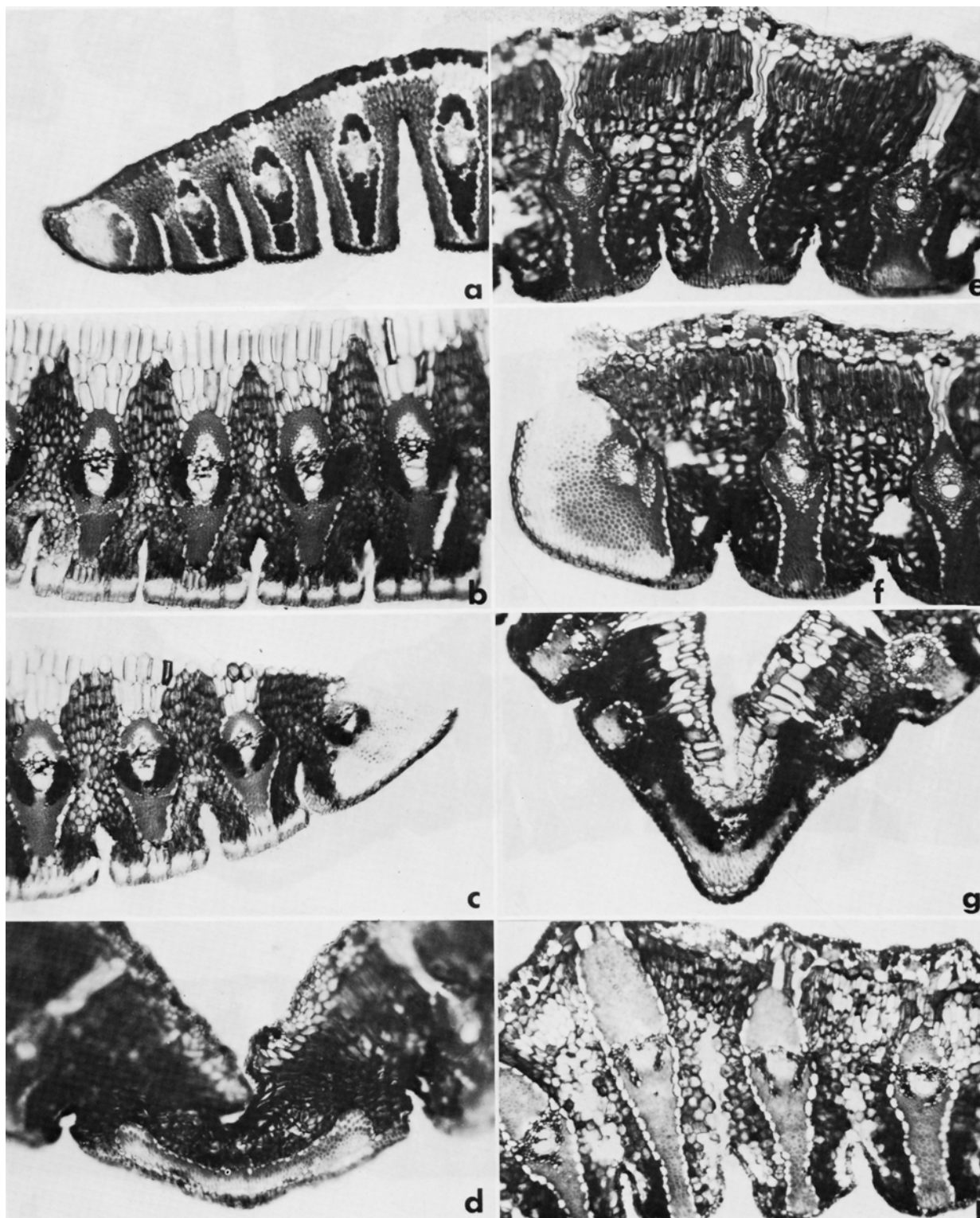


PLATE 33.—a, *Vellozia crassicaulis* (Irwin et al. 13377) ($\times 25$); b-c, *V. swollenii* (Pires 9712) ($\times 25$); d-f, *V. dasypus* (de Lemos and Froes 20246) ($\times 25$); g-h, *V. dasypus* (Rose and Russell 9697) ($\times 25$).

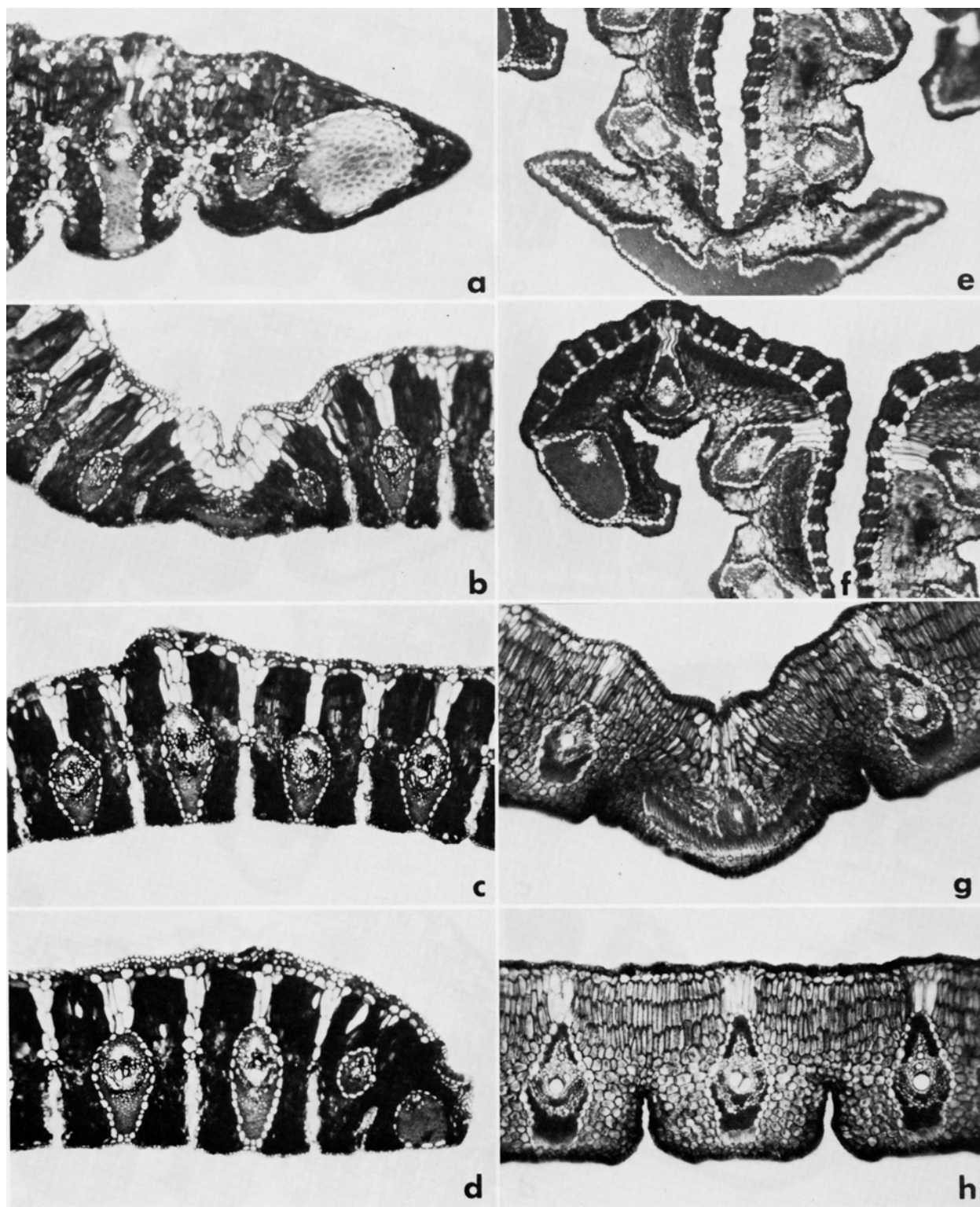


PLATE 34.—a, *Vellozia dasypus* (Rose and Russell 19697) ($\times 25$); b-d, *V. caruncularis* (L. B. Smith 6855) ($\times 25$); e-f, *V. exilis* (Irwin et al. 9507) ($\times 25$); g-h, *v. candida* (Carauta 1868) ($\times 25$).

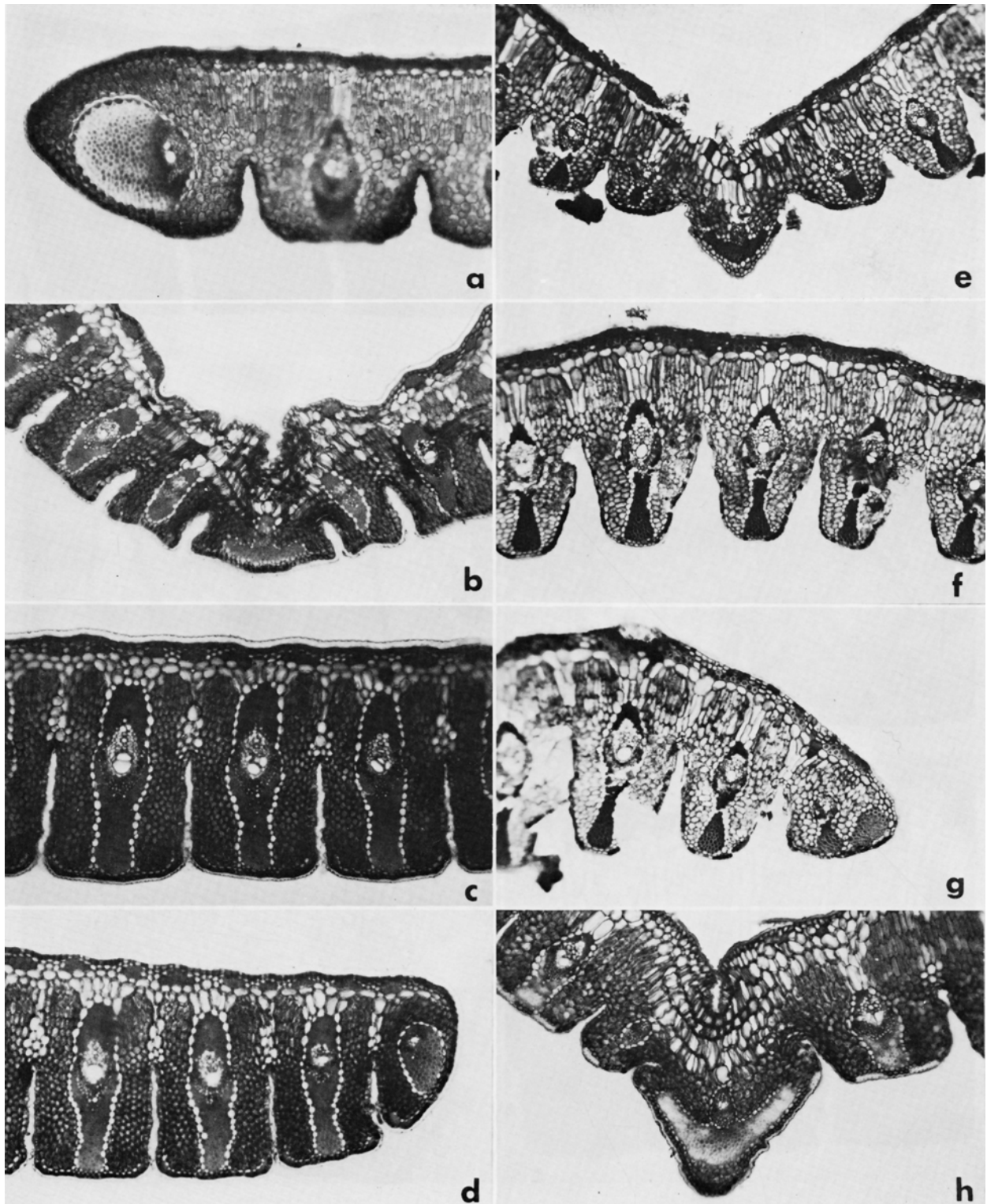


PLATE 35.—a, *Vellozia candida* (Carauta 1868) ($\times 25$); b-d, *V. machrisiana* (Irwin 12697) ($\times 25$); e-g, *V. tubiflora* (Lasser 1777) ($\times 25$); h, *V. tubiflora* (Maguire et al. 35131) ($\times 25$).

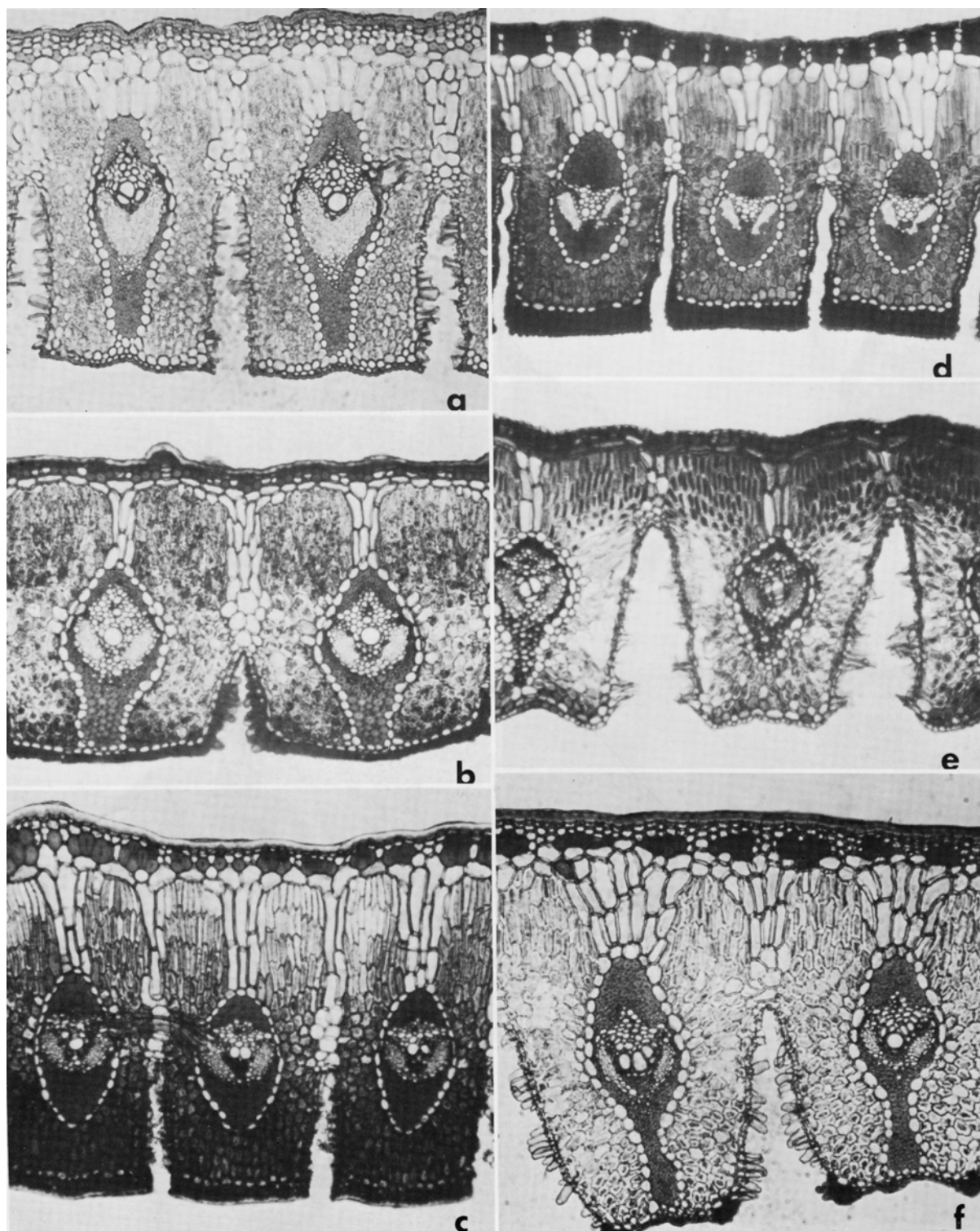


PLATE 36.—a, *Vellozia caput-ardeae* (L. B. Smith and Ayensu 15989); b, *V. ciliata* (L. B. Smith and Ayensu 15595); c, *V. costata* (Irwin et al. 20999); d, *V. declinans* (Hatschbach 27842); e, *V. echinata* (Riedel 1780); f, *V. glandulifera* (L. B. Smith and Ayensu 15998) (a-f, $\times 100$).

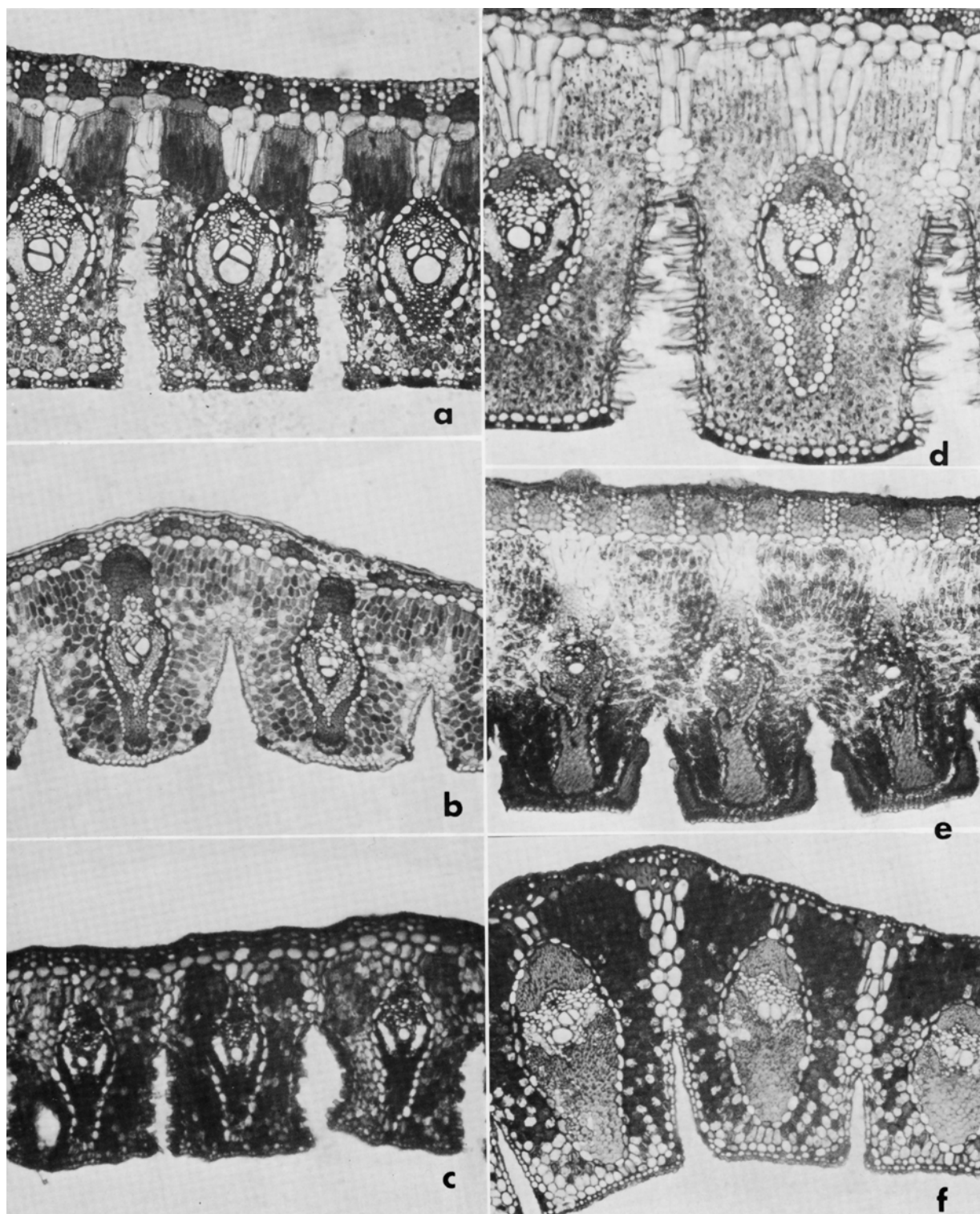


PLATE 37.—a, *Vellozia hatschbachii* (L. B. Smith and Ayensu 16002); b, *V. hirsuta* (L. B. Smith and Ayensu 15990); c, *V. hypoxoides* (Irwin et al. 34120); d, *V. lappa* (L. B. Smith and Ayensu 15988); e, *V. nuda* (Hatschbach and Pelanda 28029); f, *V. ornata* (L. B. Smith and Ayensu 16001) (a-f, $\times 100$).

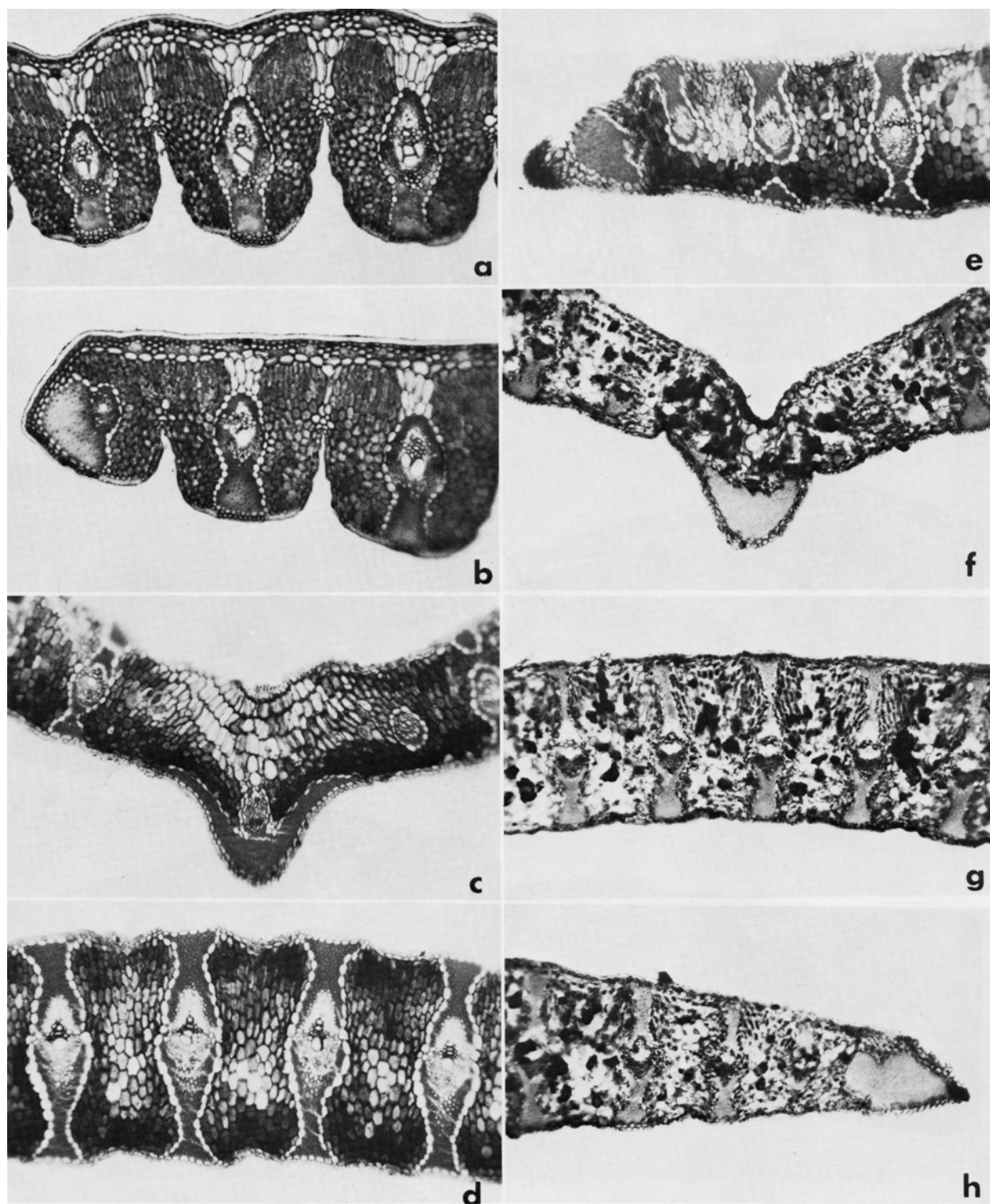


PLATE 38.—a-b, *Vellozia tubiflora* (Maguire et al. 35131); c-e, *Barbacenia seubertiana* (Strang 239); f-h, *B. gounelleana* (Emygdio 1428) (a-h, $\times 25$).

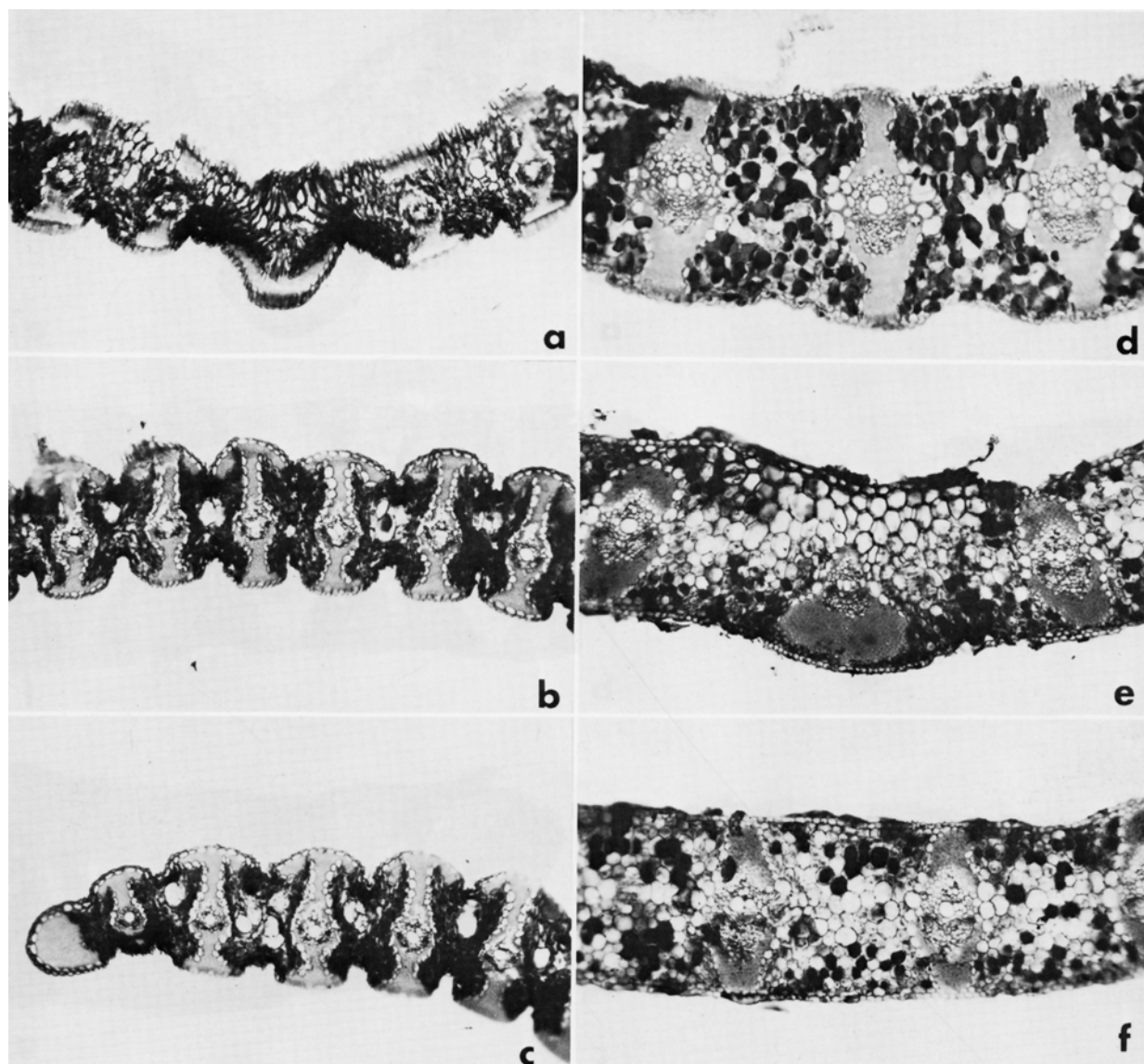


PLATE 39.—a-c, *Barbacenia purpurea* (Schott s.n. U.S. 151098); d, *B. schwackeii* (Heringer 5263); e-f, *B. ignea* (Williams & Assis 6817) (a-f, $\times 25$).

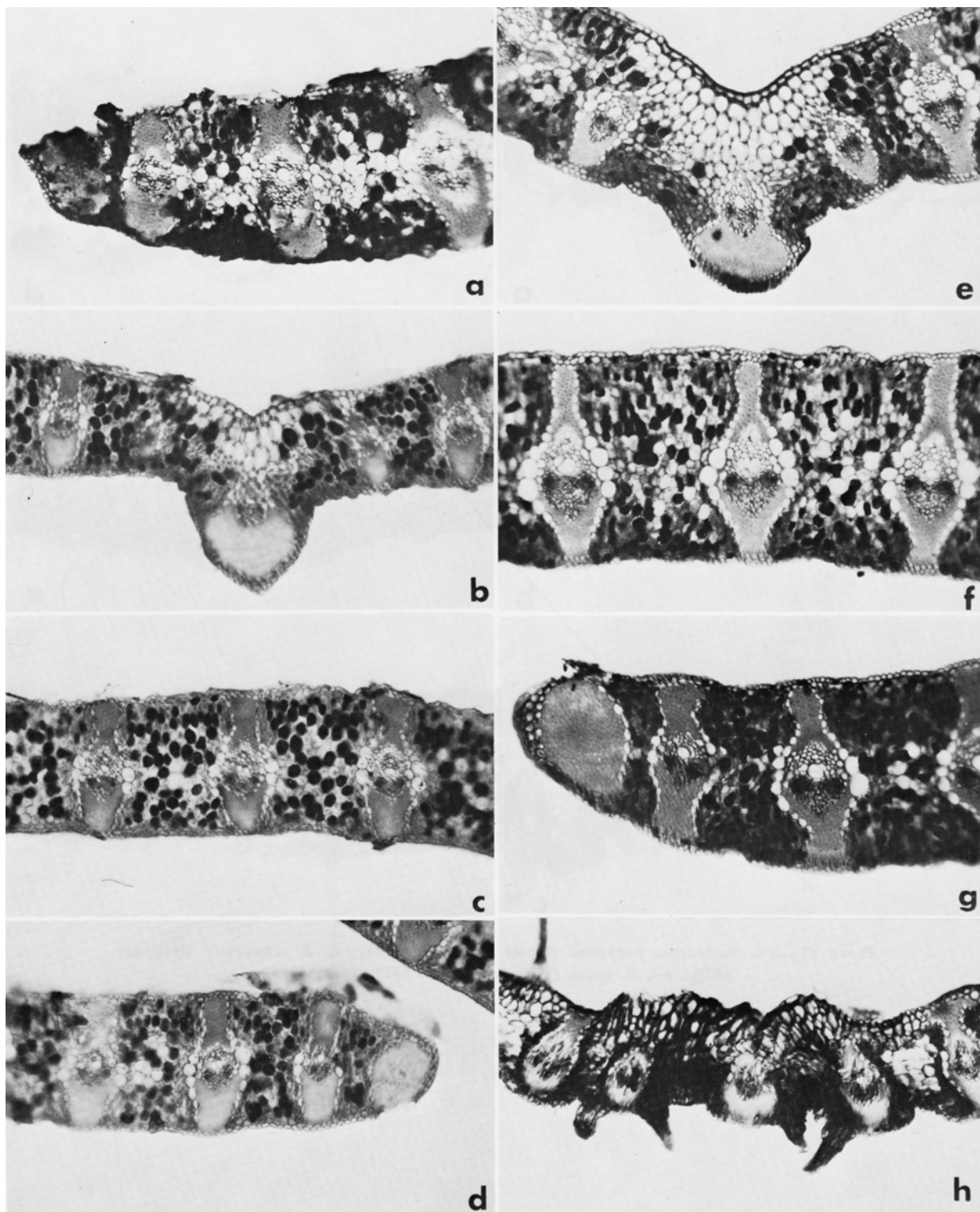


PLATE 40.—a, *Barbacenia ignea* (Williams and Assis 6817); b-d, *B. williamsii* (Williams and Assis 6386); e-g, *B. flava* (Maguire et al. 49116); h, *B. viscosissima* (Macedo 2826) (a-h, $\times 25$).

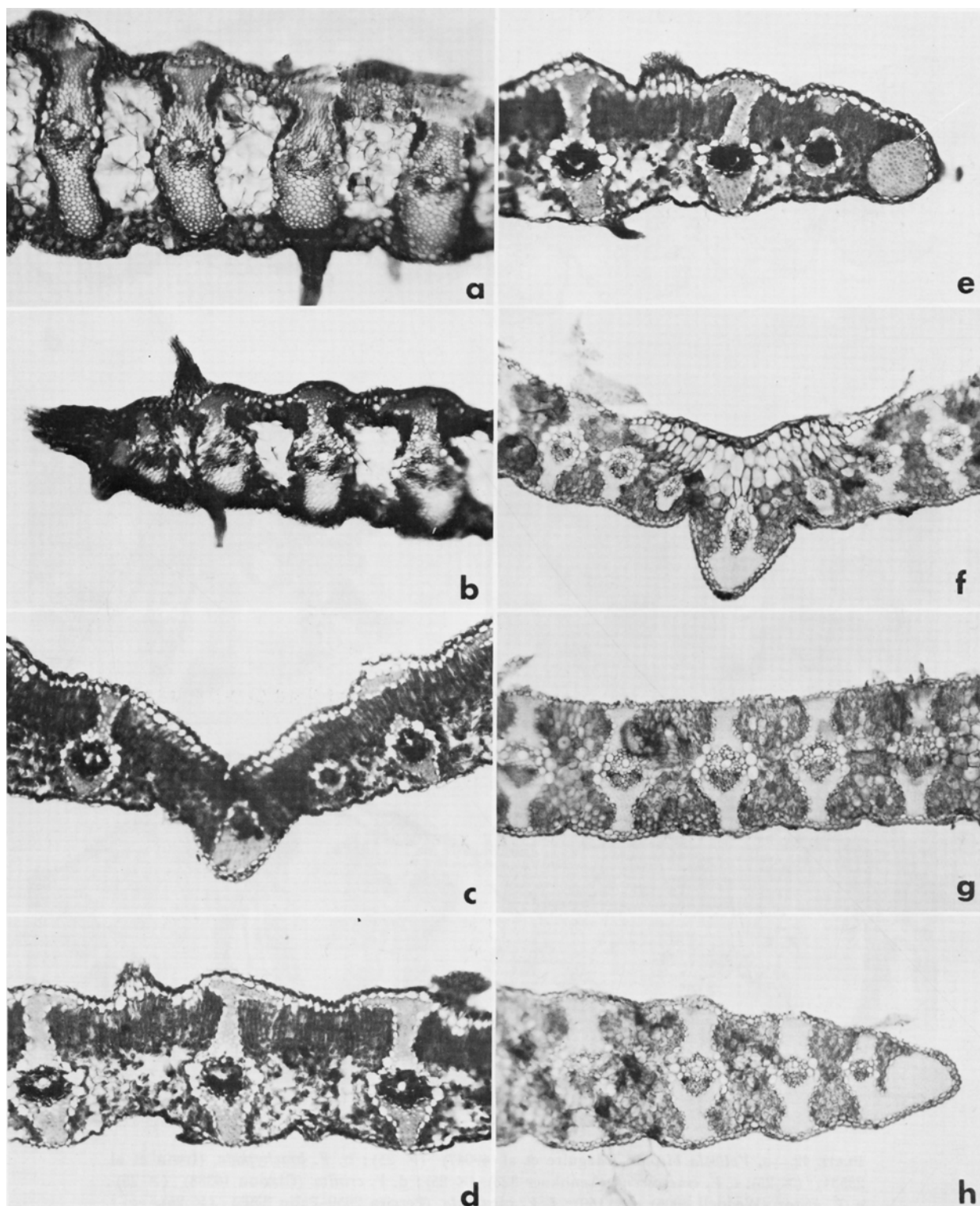


PLATE 41.—a-b, *Barbacenia viscosissima* (Macedo 2826); c-e, *B. gentianoides* (Segades-Vianna and Loredo 1066); f-h, *B. longiflora* (Irwin 2486) (a-h, $\times 25$).

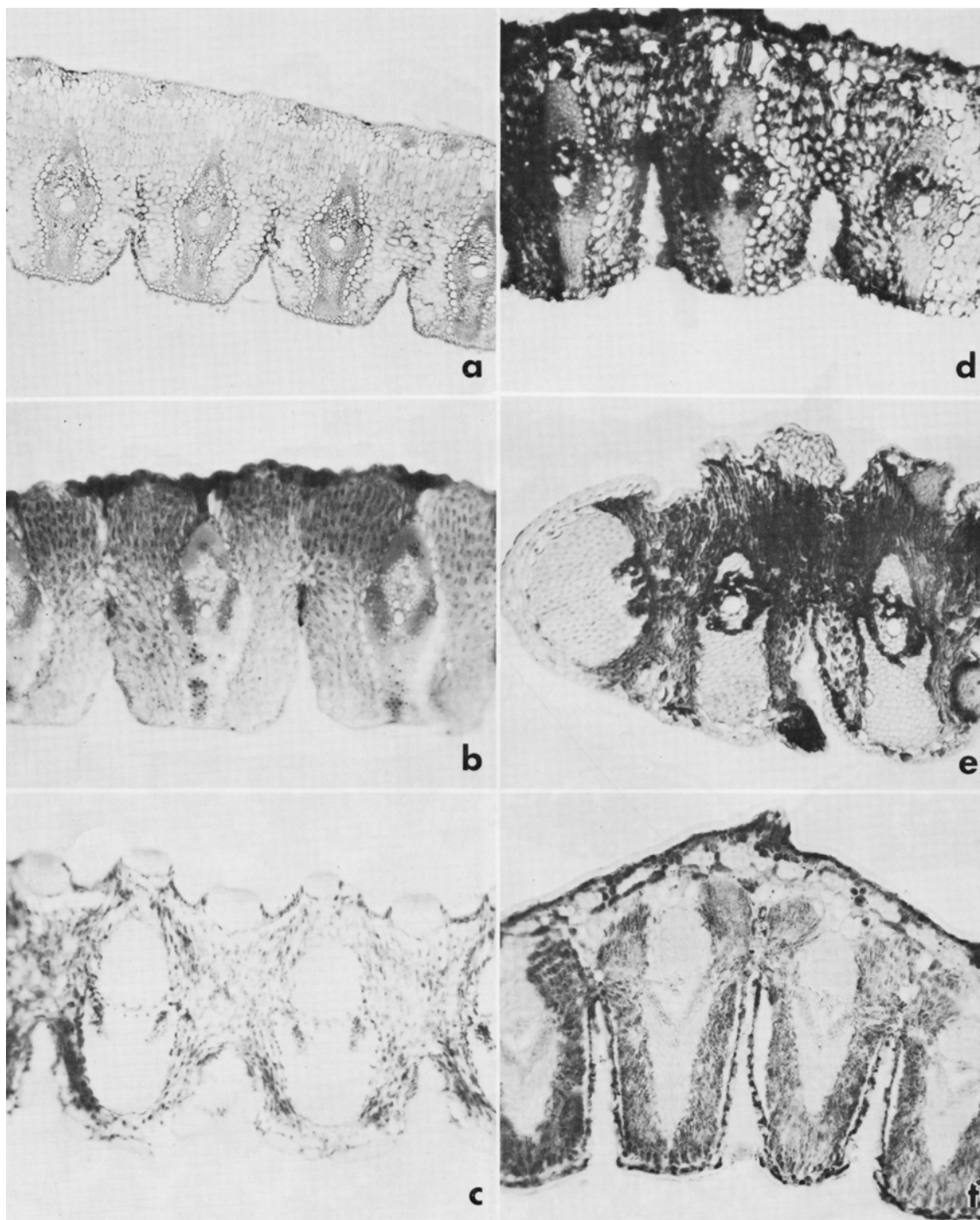


PLATE 42.—a, *Vellozia bicolor* (Maguire et al. 49047) ($\times 25$); b, *V. brachypoda* (Irwin et al. 23534) ($\times 25$); c, *V. cinerascens* (Lenhkner 323) ($\times 25$); d, *V. crinita* (Glaziou 16388) ($\times 25$); e, *V. grisea* (Weddell 3006) ($\times 150$); f, *V. incurvata* (Pereira 2959-Pabst 3795) ($\times 25$).

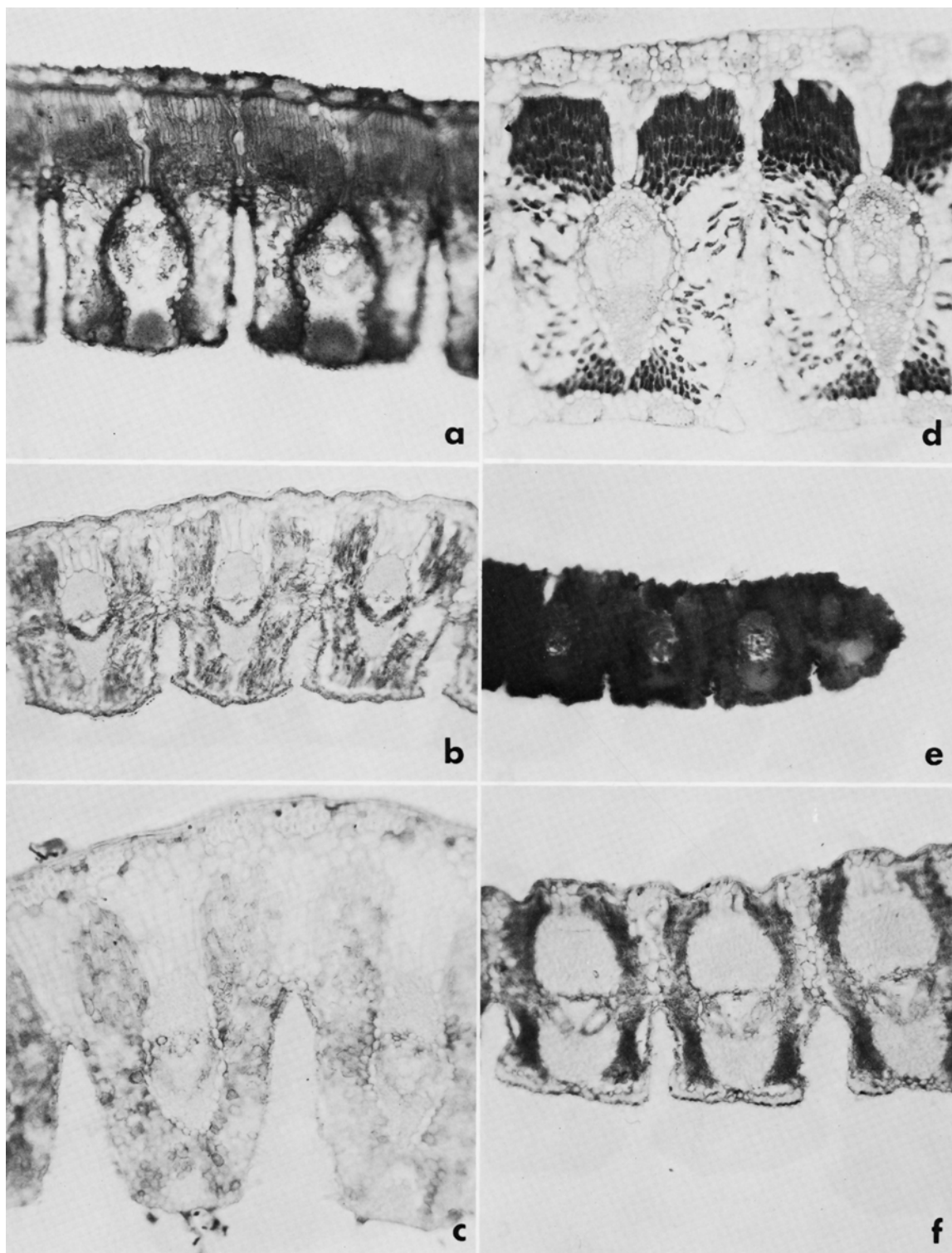


PLATE 43.—a, *Vellozia irwinii* (Irwin et al. 20998); b, *V. magdalenae* (Lima and Brade f4288); c, *V. metzgerae* (Engler s.n.); d, *V. modesta* (Hatschbach and Pelanda 27869); e, *V. pilosa* (Glaziou 19933); f, *V. piresiana* (Duarte 2068) (a-f, $\times 25$).

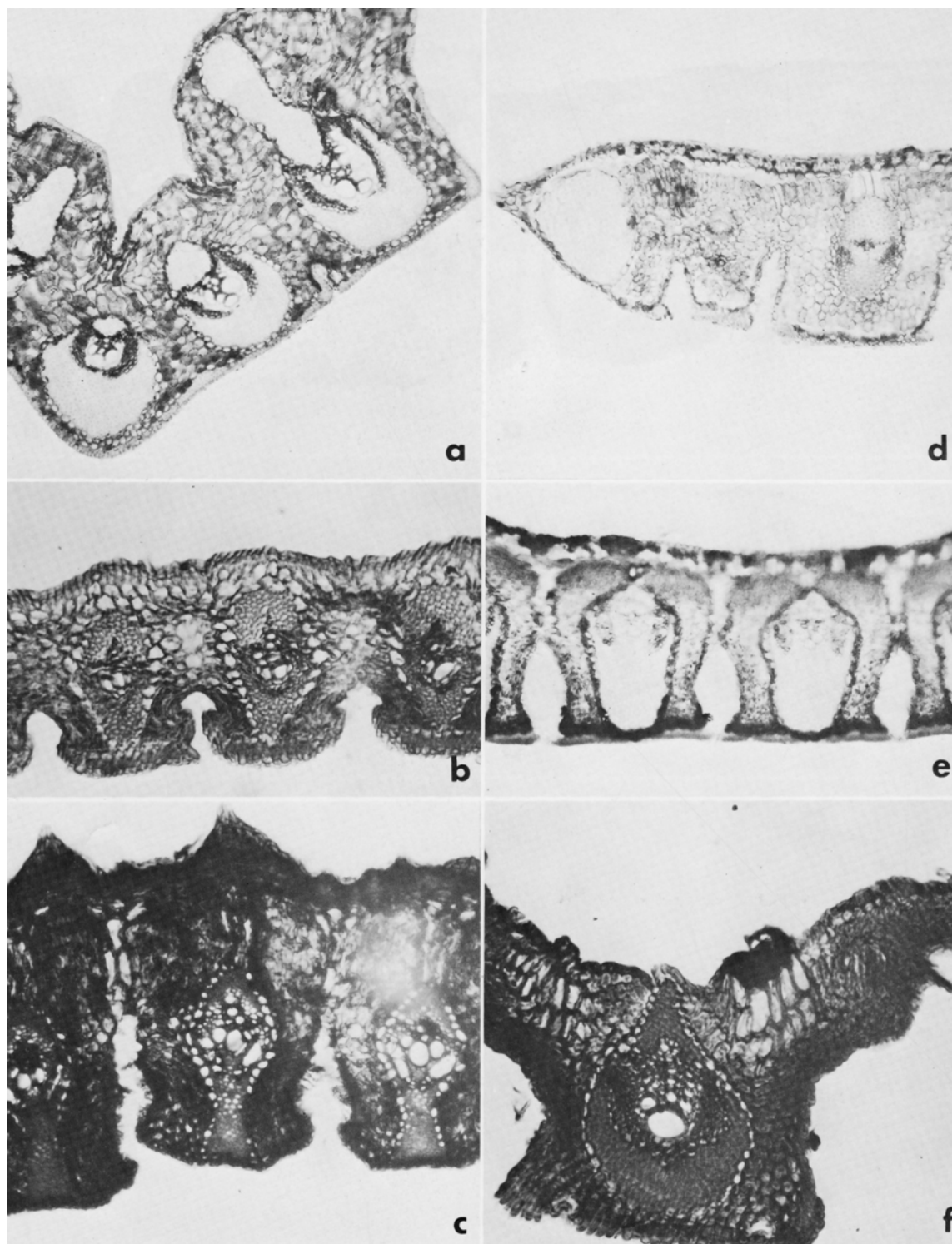


PLATE 44.—a, *Vellozia plicata* (Frazao s.n.) ($\times 25$); b, *V. pumila* (Irwin et al. 9230) ($\times 150$); c, *V. punctulata* (Blanchet 2561) ($\times 150$); d, *V. tenella* (Damazio 91185) ($\times 25$); e, *V. teres* (Irwin et al. 21000) ($\times 25$); f, *V. triquetra* (Gardner 2735) ($\times 150$).

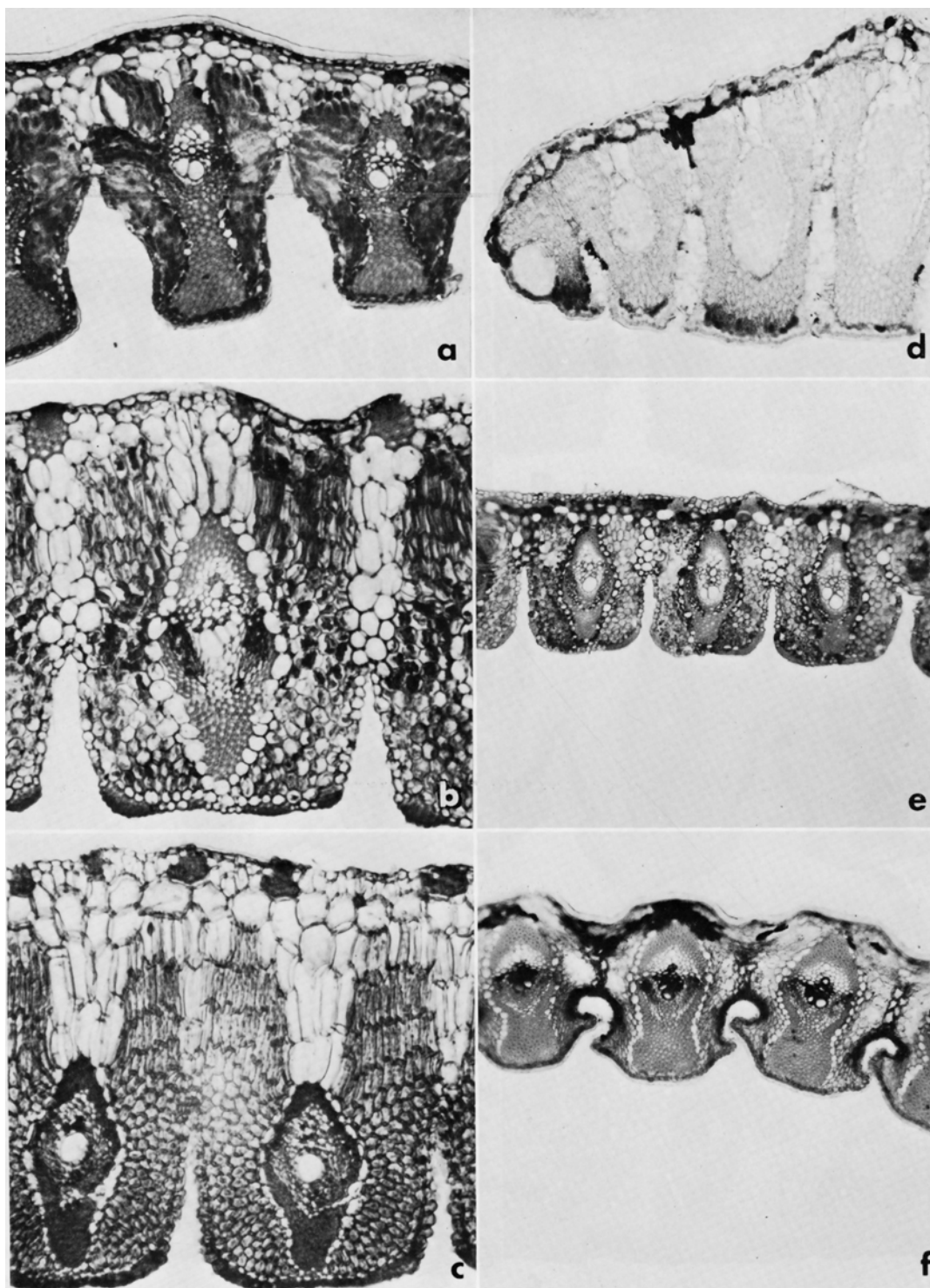


PLATE 45.—a, *Vellozia wasshausenii* (Irwin et al. 20318) ($\times 25$); b, *V. cana* (Irwin et al. 12556) ($\times 150$); c, *V. dawsonii* (Irwin et al. 12648) ($\times 150$); d, *V. dumitiana* (Schultes and Cabrera 15050A) ($\times 150$); e, *V. lanata* (Pires 9895) ($\times 25$); f, *V. maculata* (Glaziou 222-18a) ($\times 25$).

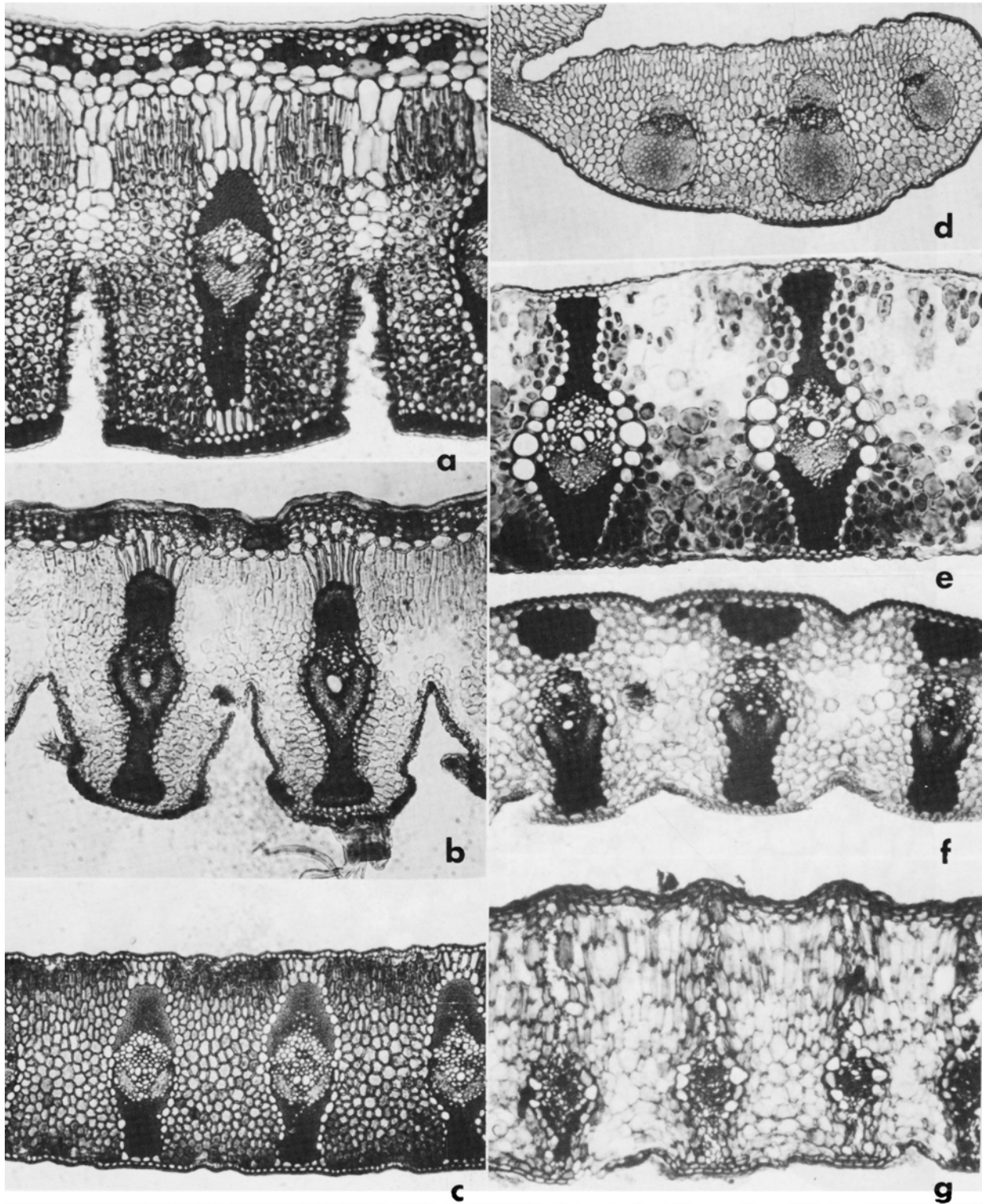


PLATE 46.—a, *Vellozia phalocarpa* (Anderson et al. 35855); b, *V. riedeliana* (L. B. Smith and Ayensu 15983); c, *V. sellovii* (Pereira 2677); d, *V. virgata* (Schwacke 5889); e, *Barbacenia conicostigma* (L. B. Smith and Ayensu 15982); f, *B. delicatula* (L. B. Smith and Ayensu 15975); g, *B. exscapa* (Anderson et al. 35831) (a-g, $\times 100$).

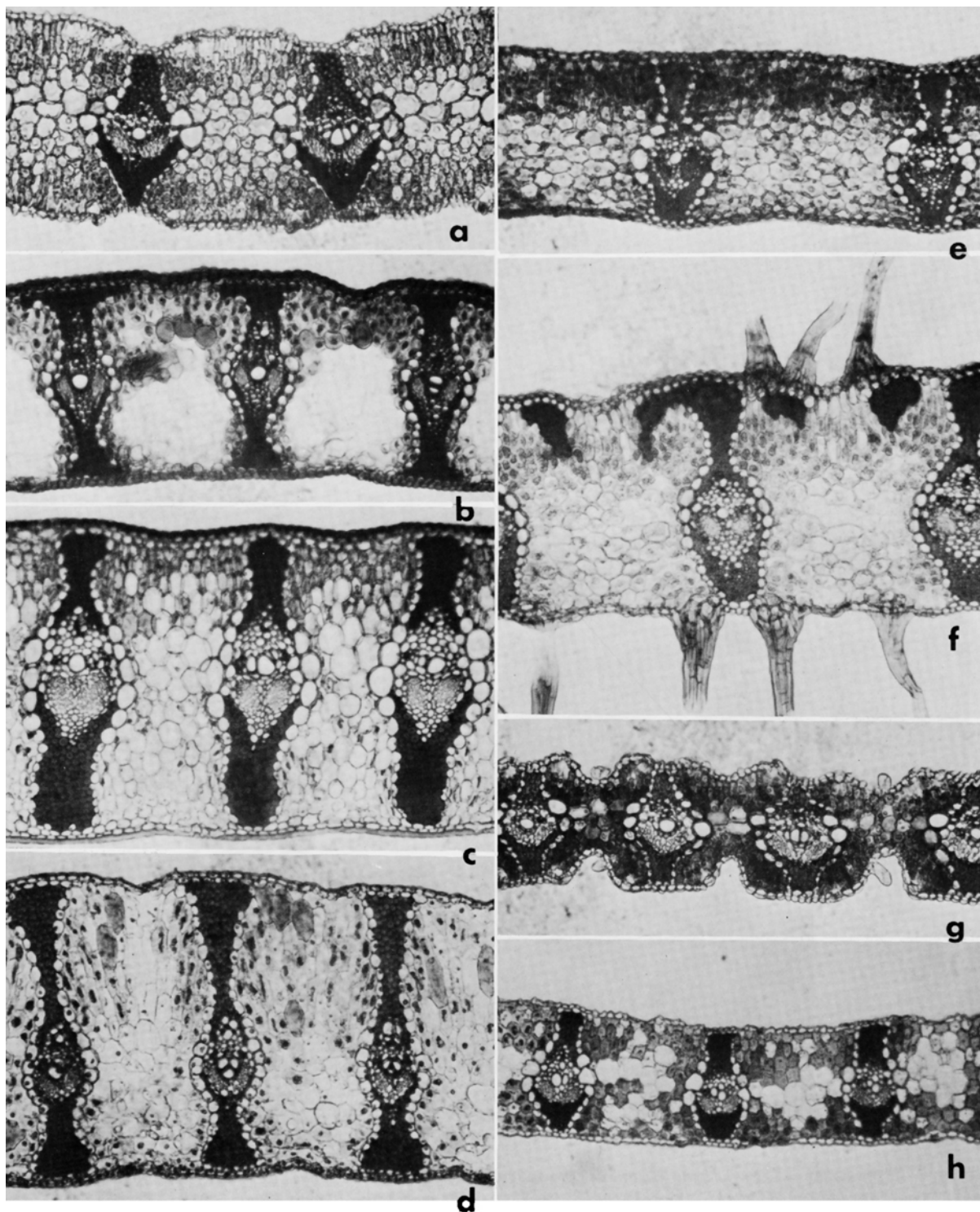


PLATE 47.—a, *Barbacenia gardneri* (Pereira 2849—Pabst 3685); b, *B. hatschbachii* (Hatschbach 24284); c, *B. involocrata* (Irwin et al. 20973); d, *B. longiscapa* (Irwin et al. 22186); e, *B. luzulifolia* (Pereira 2664—Pabst 3500); f, *B. nana* (L. B. Smith and Ayensu 15973); g, *B. riedeliana* (Anderson et al. 35123); h, *B. sellovii* (Continho 5) (a-h, $\times 100$).

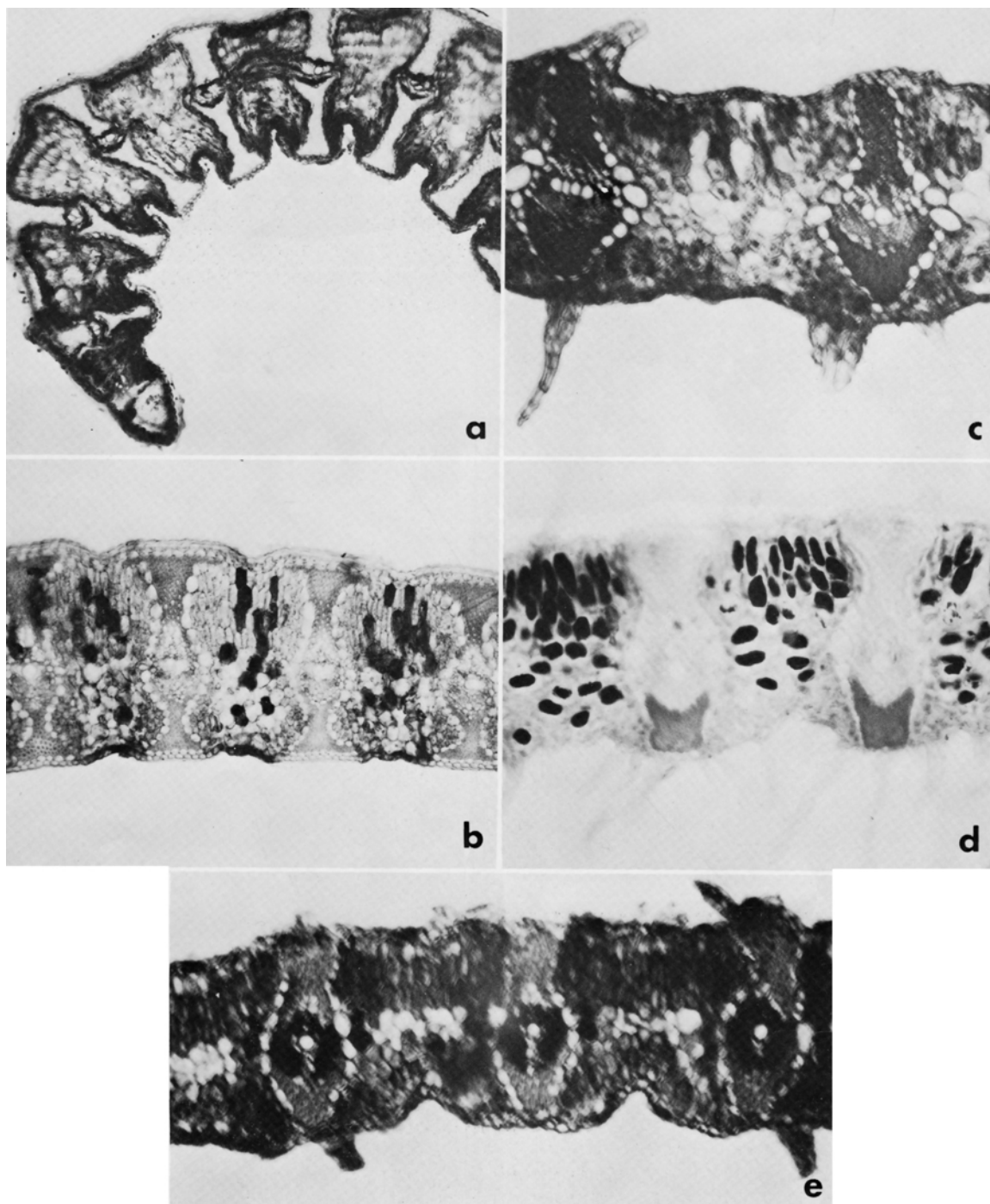


PLATE 48.—a, *Barbacenia irwiniana* (Porto 1140) ($\times 25$); b, *B. celiae* (Maguire et al. 40298) ($\times 25$); c, *B. blachii* (Macedo 2962) ($\times 25$); d, *B. macrantha* (Irwin et al. 20071) ($\times 25$); e, *B. paranaensis* (Hatschbach 15715) ($\times 150$).

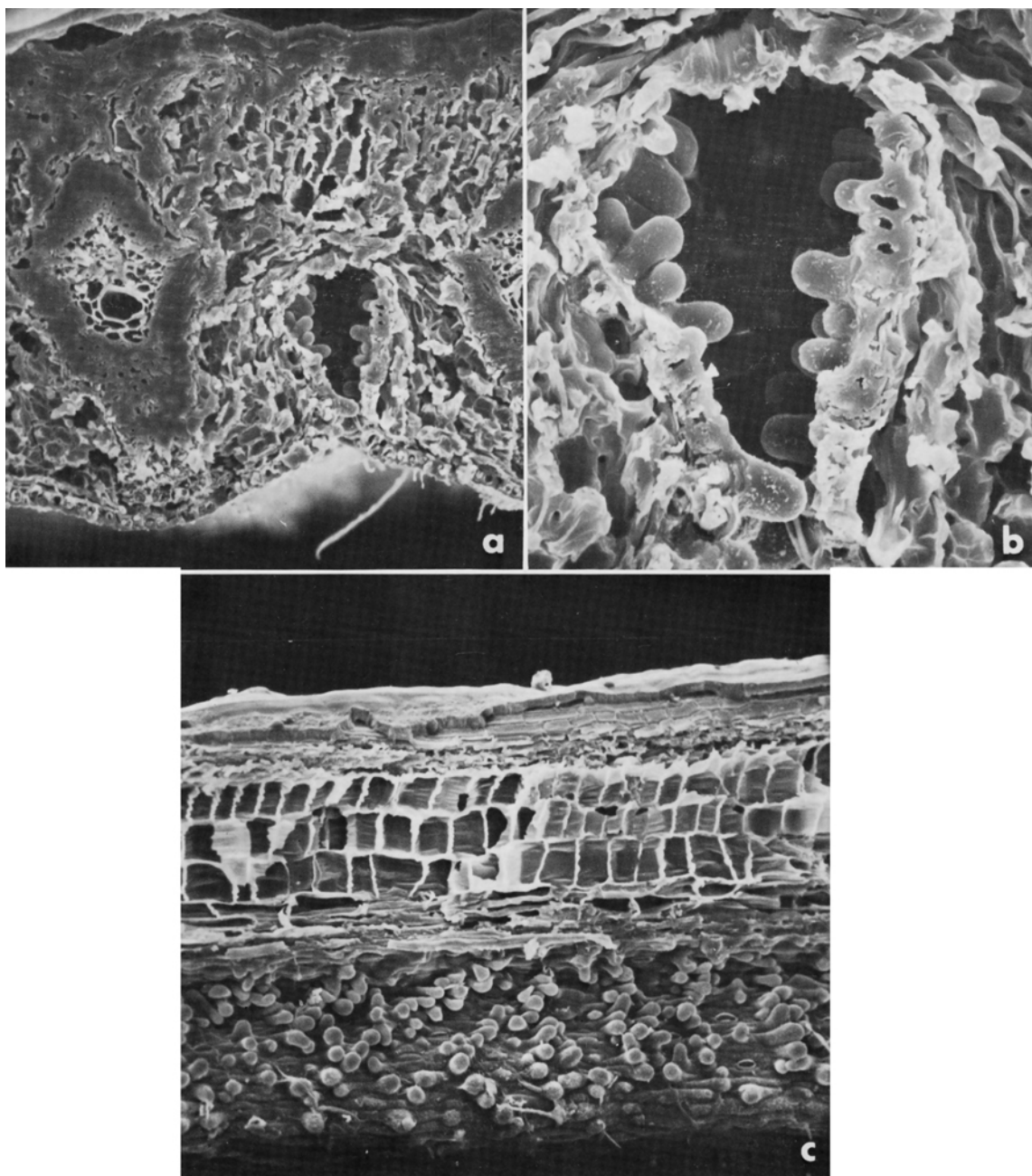


PLATE 49.—SEM photomicrographs of leaf of *Vellozia ciliata*: a, transverse section of lamina showing the arrangement of sclerenchyma, mesophyll tissue, and furrow ($\times 210$); b, an enlargement of the furrow showing the arrangement of the fingerlike projections ($\times 630$); c, longitudinal section through a lamina exposing one surface of a furrow. Note the sporadic distribution of the fingerlike projections and stomata ($\times 200$).

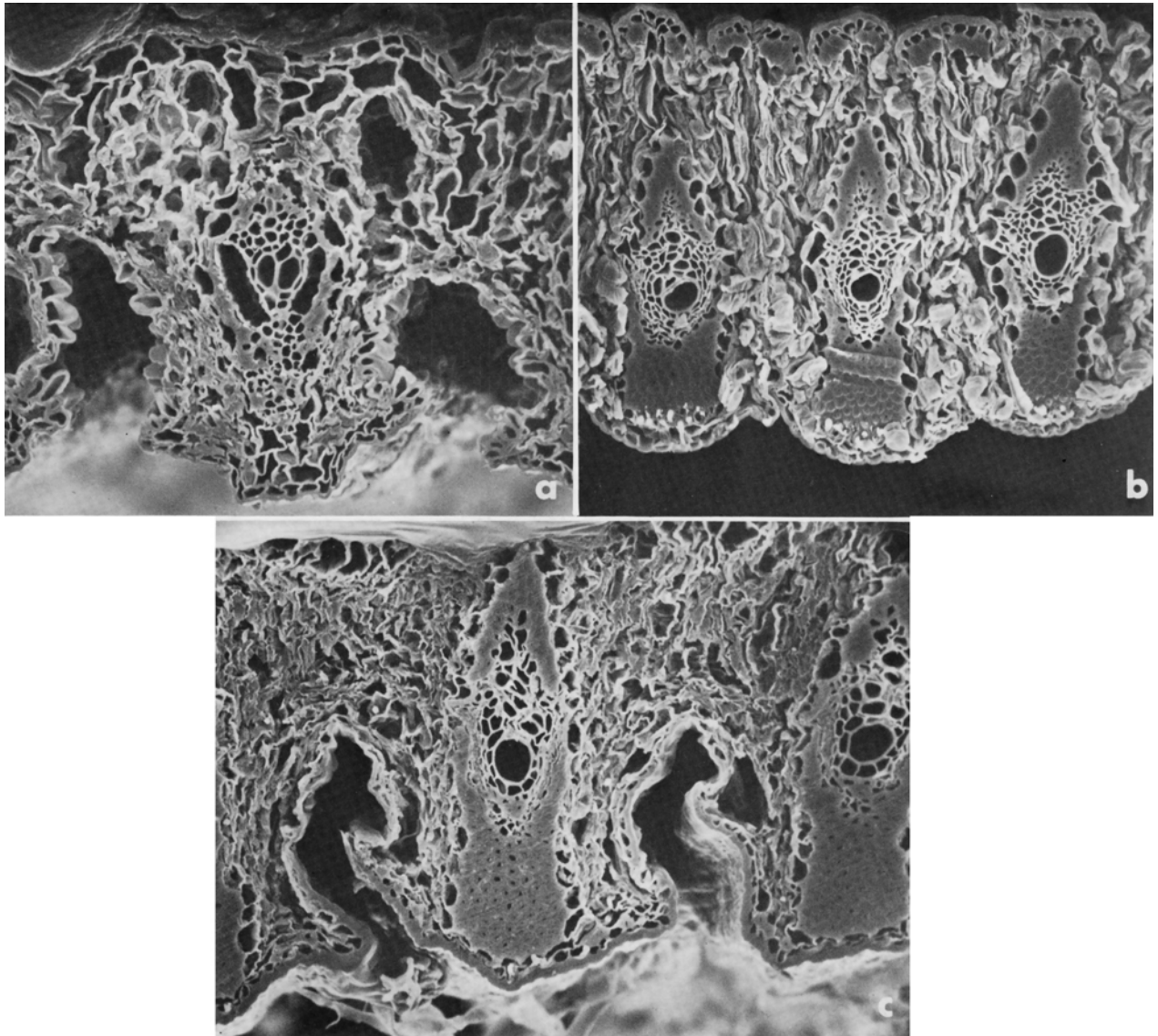


PLATE 50.—Transverse sections of leaves viewed with the SEM to show sclerenchyma and mesophyll tissues: a, *Vellozia hypoxoides* (Irwin et al. 34120) ($\times 335$); b, *V. candida* (Rose and Russell 20669) ($\times 240$); c, *V. grisea* (Weddell 3006) ($\times 315$).

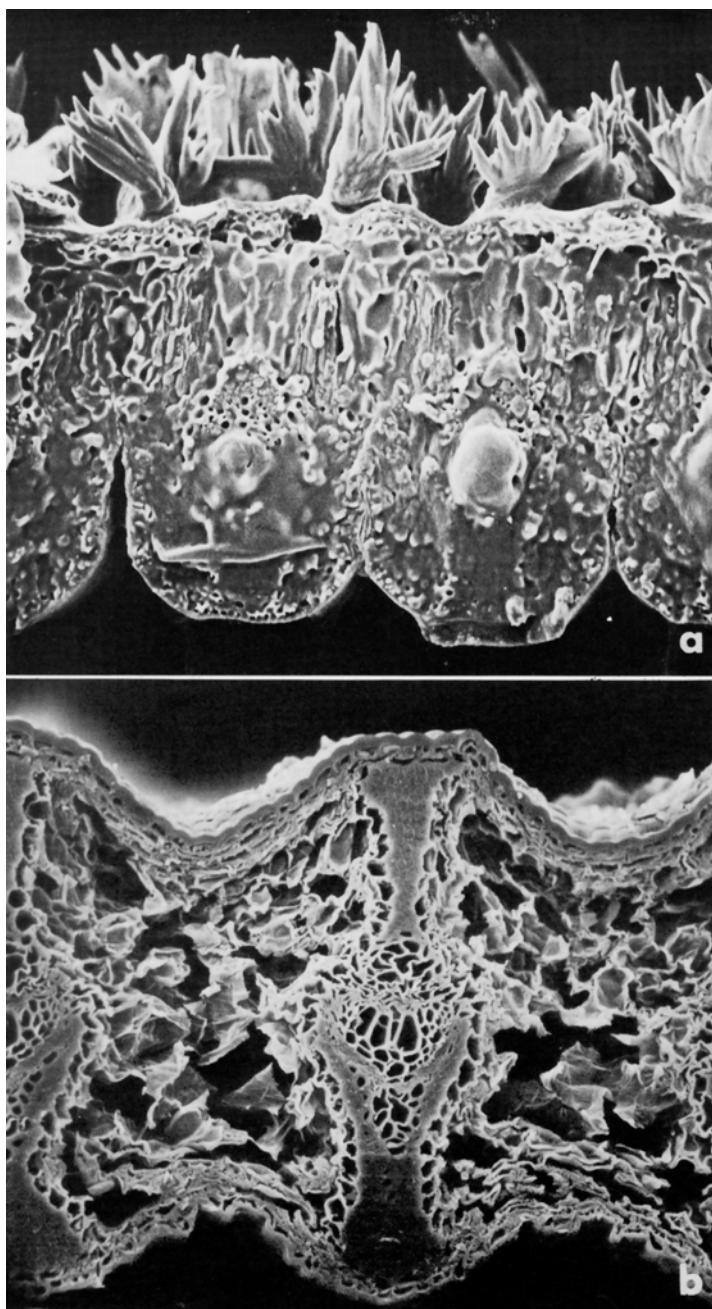


PLATE 51.—Transverse sections of leaves viewed with the SEM to show surface and internal structure: a, *Vellozia dawsonii* (Irwin et al. 12622), illustrating the surface arrangement of tuft hairs, the clear delineation of palisade cells, and spongy mesophyll ($\times 110$); b, *Barbacenia gounelleana* (Pereira 7050), showing a typical example of *Barbacenia* type of sclerenchyma and mesophyll patterns ($\times 265$).