

Microsculpture of cypselae surface of *Baccharis* sect. *Caulopterae* (Asteraceae) from Brazil

by

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Abstract

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The aim of this study was to characterize the microsculpture of the cypselae surface of the Brazilian species of *Baccharis* L. sect. *Caulopterae* DC. (Asteraceae), and to compare this data it with the taxonomy of the group. Scanning electron microscopy was used to examine the cypselae surface of 25 taxa of *Baccharis* sect. *Caulopterae* from Brazil. According to the micromorphology of the cypselae surface, the species can be classified into five distinct groups. The cypselae of the species of the *Baccharis trimera* species complex (*B. crispa*, *B. cylindrica*, *B. jocheniana*, *B. myriocephala*, and *B. trimera*) share the same micromorphological features.

Keywords: achene, carpology, carqueja, Compositae, micromorphology, SEM, taxonomy.

Introduction

The fruits of the Asteraceae, denominated cypselae, are dry, indehiscent, unilocular, with a single seed that is usually not adnate to the pericarp (linked only by the funicle) and originating from an inferior ovary (Marzinek & al., 2008). The pappus, a modified calyx, is inserted in the apical region of the cypselae, whilst basally, an abscission region is located in relation to the inflorescence axis (clinanthium) denominated the carpopodium (Roth, 1977). Cypselae microsculpture analysis has been considered more and more a taxonomic tool, being also important for higher and medium level classification within the family (Bremer, 1994; Anderberg, 1991).

Baccharis sect. *Caulopterae* is represented by around 35 species, but the number of species and in-

Resumen

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Para examinar la superficie de cipselas de 25 táxones de *Baccharis* L. sect. *Caulopterae* DC. de Brasil se ha utilizado la microscopía electrónica de barrido. El objetivo del estudio fue caracterizar la microscultura de la superficie de cipselas de la sección y colaborar con la delimitación taxonómica a nivel específico. Las especies fueron clasificadas en cinco grupos distintos según la micromorfología y asignados a la terminología existente. El complejo *Baccharis trimera* (*B. crispa*, *B. cylindrica*, *B. jocheniana*, *B. myriocephala* y *B. trimera*) mostró afinidades micromorfológicas de las cipselas.

Palabras clave: aquenio, carpología, carqueja, Compositae, MEB, micromorfología, taxonomía.

fraspecific taxa included in the section is variable in the literature, especially due to different taxonomic concepts (Heiden & al., 2009). The section is restricted to South America, occurring extensively in the Andes, from Colombia to the Central Argentina, and in Brazil, where the highest number of species in this section is concentrated in the south and southwest (Barroso, 1976; Müller, 2006).

Velez (1981) studied the American genera of Asteraceae and provided a detailed overview of cypselae morphology and anatomy in the genus *Baccharis*. Other studies that have contributed to our knowledge of cypselae morphology in this genus are Ariza (1973), Hellwig (1990), Mukherjee & Sarkar (2001) and Müller (2006). The latter author reviewed cypselae characteristics for the genus, and present data with re-

gard to form, shape, colour, indumentum, number of vascular bundles encircling the fruits (ribs), details of the pericarp, and some general considerations concerning microsculpture of the cypsela cuticle.

Here we characterize the microsculpture of the cypselae surface of the Brazilian species of genus *Baccharis* sect. *Caulopterae*, and we were particularly interested to see if cypsela characters could help resolve the taxonomy of the *B. trimera* complex, comprising *B. crispa*, *B. cylindrica*, *B. jocheniana*, *B. myriocephala*, and *B. trimera* (Barroso 1976)".

Material and methods

Scanning Electron Microscopy

Mature cypselae of 25 Brazilian species of *Baccharis* sect. *Caulopterae* were collected from herbarium specimens (HBR, ICN, PACA and UEC - see Table 1). One representative dry cypsela was then selected per species and mounted on a metallic stub using a carbon adhesive tape and sputter-coated with 20 nm gold using BAL-TEC SCD-050. Electromicrographs of the cypselae were obtained under 10 kV in magnification using a Scanning Electron Microscope (SEM) JEOL-JSM 6060 at the Centro de Microscopia Eletrônica (CME) of the Universidade Federal do Rio Grande do Sul.

Analyses and terminology

The characters we recorded were based on analyses of morphology of the secondary and tertiary sculpture of the surface morphology: smooth or folded, presence or absence of papillae, degree of surface rugosity and presence of cavities. The primary sculpture was not examined since in most species it was lacking. The terminology used for cypselae shape (solid structure) follows Radford (1986), and microsculpture characterization was based on Barthlott (1981; 1990), Mukherjee & Sarkar (2001) and Müller (2006).

Baccharis burchellii Baker and *B. regnellii* Sch. Bip. ex Baker, although belonging to *Baccharis* sect. *Caulopterae* and occurring in Brazil were not included in this study because we could not obtain material with mature cypselae.

The nomenclature of species follows recent works, and the following names were considered: *B. pentaptera* (Less.) DC. (= *B. stenocephala* Baker, according to Schneider & al., 2009), *B. sagittalis* (Less.) DC. (= *B. heeringiana* Malag., = *B. macroptera* D.J.N. Hind), *B. subtropicalis* Heiden (= *B. sagittalis* var. *montevicensis* Baker), and *B. junciformis* (Less.) DC. (= *B. asterii* Heering, all according to Heiden & al., 2009). For species belonging to the *Baccharis trimera*

species complex (*B. crispa* Spreng., *B. cylindrica* (Less.) DC., *B. myriocephala* DC. and *B. trimera* (Less.) DC.) we followed the circumscription proposed by Barroso (1976).

Results

The cypselae of *Baccharis* sect. *Caulopterae* can be divided into three groups with regard to the number of ribs: 18 species with 5-7 ribs; six with ~14 ribs (*B. crispa*, *B. cylindrica*, *B. jocheniana*, *B. myriocephala*, *B. aff. opuntioides*, *B. trimera*); one species with ~20 ribs (*B. riograndensis*). Cypsela shape varies from narrowly oblong, narrowly oblong to cylindrical, narrowly oblong to obovoid, oblanceoloid, oblong and obovoid form (Table 1).

The cypselae surface presents a variable microsculpture, mostly with a folded cuticle, but also rugose with the presence of cavities in two species: *B. articulata* and *B. glaziovii*. Most species are papillose with digitiform (*B. trimera*) or globose papillae (*B. articulata* and *B. sagittalis*), with length ranging from 2-20 µm by 2-5.5 µm in diameter, with variable distribution on the cypselae surface but they are longer on the vascular bundles (ribs). *B. heeringiana*, *B. pseudovillosa*, *B. ramboi*, *B. riograndensis*, *B. stenocephala*, *B. asterii* and *B. vincifolia* did not present papillae. A ring-shaped carpodium was observed in all species, and its diameter ranges from 50-120 µm. The SEM study of the cypselae provided important characters which allowed us to distinguish five groups among the sampled species.

GROUP I. Papillose rugose cypselae

In this group, the cypselae present an evenly distributed rugose surface with digitiform papillae. The papillae are longer on the ribs. Carpodium present, ring-shaped, 90-120 µm diameter. Ribs 5-7. Two species: *B. microcephala* (Fig. 1A-D) and *B. penningtonii* (Fig. 1E-H).

GROUP II. Epapillose rugose cypselae

Cypselae present a rugose surface, but papillae are absent, or just relictual and slightly salient on the ribs. Cypsela surface slightly folded and with delicate and irregular rugosities. Carpodium present, ring-shaped, 80-110 µm diameter. Ribs 5-7. Five species: *B. palustris* (Fig. 2A-D), *B. paranensis* (Fig. 2E-H), *B. pseudovillosa* (Fig. 2I-L), *B. ramboi* (Fig. 2M-P) and *B. vincifolia* (Fig. 2Q-T).

Table 1. Relation of studied species and some characters analyzed with respective vouchers: length (L), diameter (D); approximate (~).

Taxon	Shape	Size ~(length × width, mm)	L/D	Ribs (~)	Source
<i>B. apicifoliosa</i> A.A.Schneid. & Boldrini	oblanceloid	1.29 × 0.41	3/1	7	<i>R. Wasum 802</i> (PACA)
<i>B. articulata</i> (Lam.) Pers.	obovoid	0.74 × 0.38	2/1	5	<i>L.A. Mentz s.n.</i> (ICN 59169)
<i>B. crispa</i> Spreng.	narrowly oblong	1.27 × 0.38	3/1	14	<i>I. Fernandes 641</i> (ICN)
<i>B. cylindrica</i> (Less.) DC.	narrowly oblong	1.38 × 0.32	4/1	14	<i>R. Schmidt s.n</i> (ICN 153106)
<i>B. flexuosiramosa</i> A.A.Schneid. & Boldrini	narrowly oblong	1.37 × 0.46	3/1	7	<i>C.F. Jurinitz s.n.</i> (ICN 153107)
<i>B. glaziovii</i> Baker	narrowly oblong	1.02 × 0.37	3/1	5	<i>J. Mattos 15953</i> (UEC)
<i>B. jocheniana</i> G. Heiden & L. Macias	narrowly oblong	1.24 × 0.37	3/1	14	<i>A.A. Schneider 1267</i> (ICN)
<i>B. junciformis</i> (Less.) DC.	narrowly oblong	1.12 × 0.32	4/1	5	<i>K.D. Barreto & G.D. Fernandes 752</i> (ESA)
<i>B. microcephala</i> (Less.) DC.	narrowly oblong	1.27 × 0.40	3/1	7	<i>J. Dutra 1488</i> (ICN)
<i>B. milleflora</i> (Less.) DC.	narrowly oblong	1.28 × 0.42	3/1	7	<i>B. Rambo 49318</i> (PACA)
<i>B. myriocephala</i> DC.	narrowly oblong	1.16 × 0.29	4/1	14	<i>A.A. Schneider 1161</i> (ICN)
<i>B. aff. opuntioides</i> Mart. ex Baker	narrowly oblong	1.40 × 0.38	4/1	14	<i>A.A. Schneider 1326</i> (ICN)
<i>B. organnensis</i> Baker	narrowly oblong	1.26 × 0.34	4/1	7	<i>A. Sehnem 5119</i> (PACA)
<i>B. palustris</i> Heering	narrowly oblong	1.14 × 0.43	3/1	7	<i>B. Rambo 52024</i> (HBR)
<i>B. paranensis</i> Dusén	narrowly oblong	1.46 × 0.34	4/1	7	<i>J. Iganzi 507</i> (ICN)
<i>B. penningtonii</i> Heering	narrowly oblong	1.00 × 0.31	3/1	7	<i>J.C. Sacco 808</i> (PACA)
<i>B. pentaptera</i> (Less.) DC.	oblong	1.73 × 0.70	2/1	7	<i>A.A. Schneider 1261</i> (ICN)
<i>B. phyteumoides</i> (Less.) DC.	narrowly oblong	1.01 × 0.38	3/1	7	<i>A.A. Schneider 1586</i> (ICN)
<i>B. pseudovillosa</i> Malag. & J.E. Vidal	narrowly oblong	1.73 × 0.34	5/1	7	<i>O. Camargo 2843</i> (PACA)
<i>B. ramboi</i> G. Heiden & L. Macias	narrowly oblong	1.19 × 0.28	4/1	7	<i>A.A. Schneider 1282</i> (ICN)
<i>B. riograndensis</i> Malag. & J.E. Vidal	narrowly oblong-cylindric	2.55 × 0.37	7/1	20	<i>L.T. Pereira 16</i> (ICN)
<i>B. sagittalis</i> (Less.) DC.	narrowly oblong	1.00 × 0.29	3/1	7	<i>A.A. Schneider 1296</i> (ICN)
<i>B. subtropicalis</i> G. Heiden	obovoid	0.76 × 0.42	2/1	5	<i>M. Sobral & al. 5031</i> (ICN)
<i>B. trimera</i> (Less.) DC.	narrowly oblong	1.19 × 0.30	4/1	14	<i>L.T. Pereira 87</i> (ICN)
<i>B. vincifolia</i> Baker	narrowly oblong-obovoid	1.37 × 0.42	3/1	5	<i>B. Rambo 60054</i> (PACA)

GROUP III. Papillose folded cypselae without cavities

In this group, the cypselae present a folded surface with evenly distributed papillae. Longer papillae on the ribs, the number, concentration, and shape of papillae vary in each species. Carpopodium present, ring-shaped, 40-110 µm diameter. This group pre-

sents 12 species and can be divided in two subgroups by the number of ribs: **a.** with 5-7 ribs consists of *B. apicifoliosa* (Fig. 3A-D), *B. flexuosiramosa* (Fig. 3E-H), *B. milleflora* (Fig. 3I-L), *B. organensis* (Fig. 3M-P), *B. phyteumoides* (Fig. 3Q-T) and *B. sagittalis* (Fig. 4A-D); **b.** with ~14 ribs is composed of *B. crispa* (Fig. 4E-H), *B. cylindrica* (Fig. 4I-L), *B. jocheniana* (Fig. 4M-P),

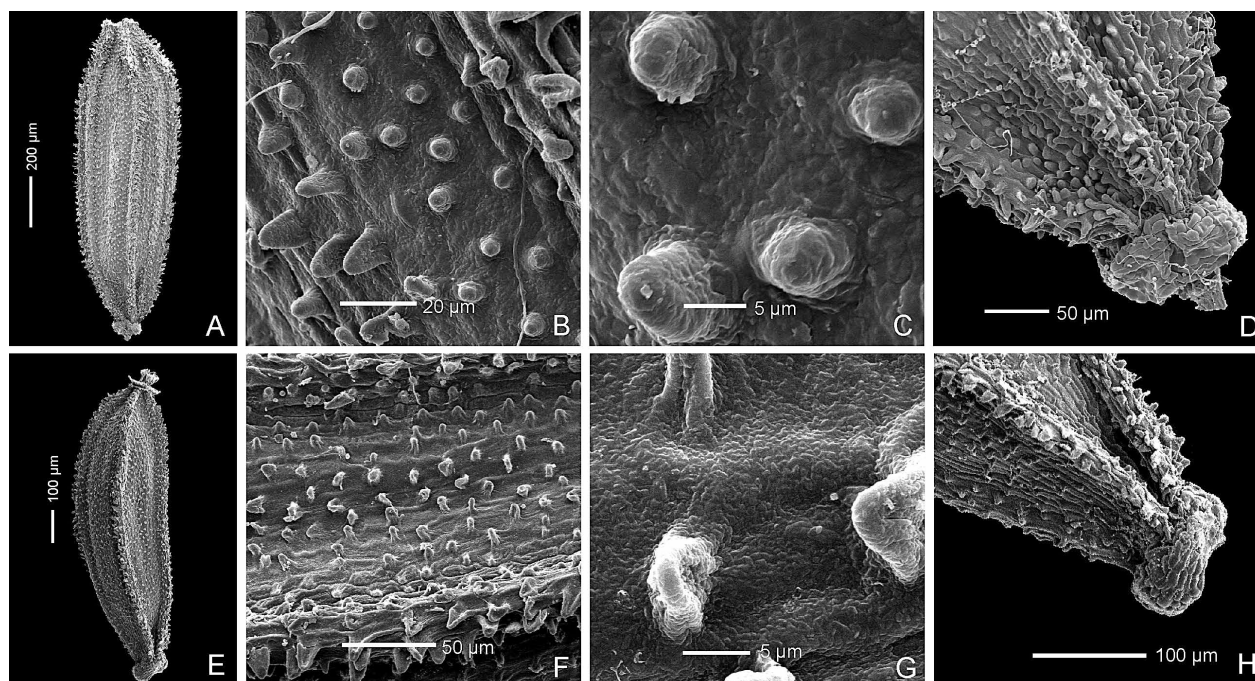


Fig. 1. Scanning electron micrographs of cypselae surface of *Baccharis* sect. *Caulopterae* - Group I: *B. microcephala*: **A**, cypselum; **B**, **C**, papillae detail; **D**, carpopodium. *B. penningtonii*: **E**, cypselum; **F**, **G**, papillae detail; **H**, carpopodium enlarged.

B. myriocephala (Fig. 4Q-T), *B. aff. opuntioides* (Fig. 5A-D), and *B. trimera* (Fig. 5E-H).

GROUP IV. Papillose folded cypselae with cavities

The cypselae present a folded surface with evenly distributed papillae. The papillae are globose (*B. articulata*) or cylindrical and longer on the ribs than in the intercostal region (*B. glaziovii*). Slight cavities occur on the folded surface. Carpopodium present, ring-shaped, 20-60 µm diameter. Ribs ~ 5. Two species: *B. articulata* (Fig. 6A-D) and *B. glaziovii* (Fig. 6E-H).

GROUP V. Epapillose folded cypselae

The cypselae present a folded surface, with longitudinal folds. Papillae are absent in the intercostal areas, or just relictual, and slightly prominent on the ribs. Carpopodium present, ring-shaped, 50-130 µm diameter. Ribs 5-7 or ~ 20 (*B. riograndensis*). Four species: *B. junciformis* (Fig. 7A-D), *B. pentaptera* (Fig. 7E-H), *B. riograndensis* (Fig. 7I-L) and *B. sagittalis* (Fig. 7M-P).

Discussion

Patterns observed in cypselae morphology in *Baccharis* sect. *Caulopterae* were similar to those previously reported for species of other sections of *Baccha-*

ris (Velez, 1981; Hellwig, 1990; Mukherjee & Sarkar, 2001; Müller, 2006), which also show a ring-shaped carpopodium and papillose surface. For the tribe Astereae, and for other *Baccharis* species, the presence of glandular and non-glandular trichomes was also observed (Mukherjee & Sarkar, 2001; Müller, 2006). Velez (1981) reported that the cypselae of genus *Baccharis* are not uniform, and he separated them in two groups. Velez (1981) also reported that cypselae may vary from papillose to epapillose, with epidermal cells with slightly lignified walls or not, and a folded or flat cuticle, and these features were also observed in the present study. Additionally, we found that *B. articulata* and *B. glaziovii* present cavities, a condition structures not previously reported, although it is possible that this feature is an artefact. The *Baccharis* sect. *Caulopterae* species present a carpopodium as characterized by Haque & Godward (1984), who emphasized that most species of the Asteraceae family have this abscission structure.

Species taxonomically close presented similarities in cypselae surface morphology, reflecting on the groups formed. However, since species of the "*Baccharis trimera* complex" (*B. crispa*, *B. cylindrica*, *B. jocheniana*, *B. myriocephala*, and *B. trimera*), all showed a similar cypselae micromorphology (Group III.b), cypselae characters were unhelpful to distinguish the species of this group.

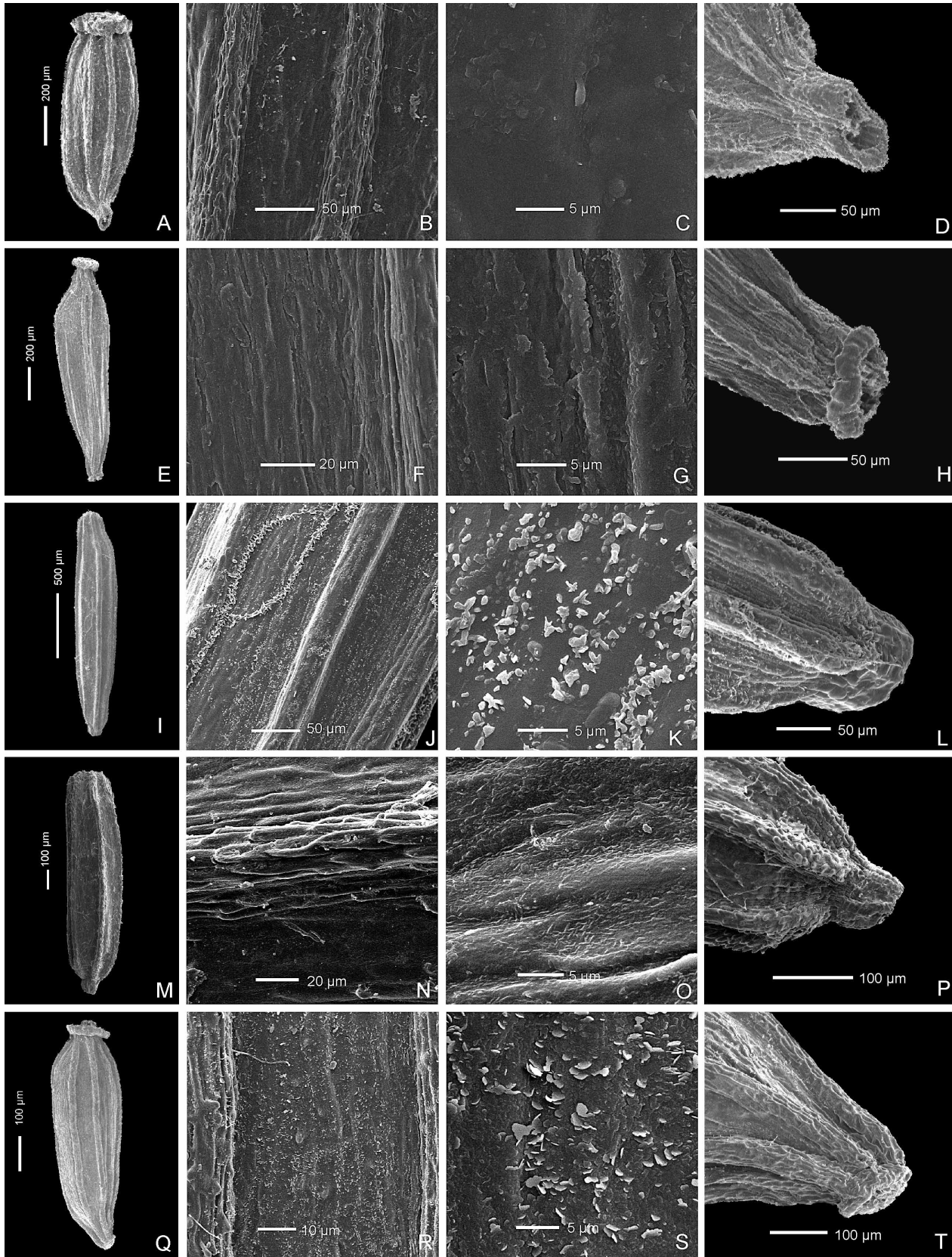


Fig. 2. Scanning electron micrographs of cypselae surface of *Baccharis* sect. *Caulopterae* - Group II: *B. palustris*: **A**, cypselum; **B, C**, epipillose surface; **D**, carpopodium. *B. paranensis*: **E**, cypselum; **F, G**, epipillose surface; **H**, carpopodium. *B. pseudovillosa*: **I**, cypselum; **J, K**, epipillose surface; **L**, carpopodium. *B. ramboi*: **M**, cypselum; **N, O**, epipillose surface; **P**, carpopodium. *B. vincifolia*: **Q**, cypselum; **R, S**, epipillose surface; **T**, carpopodium.

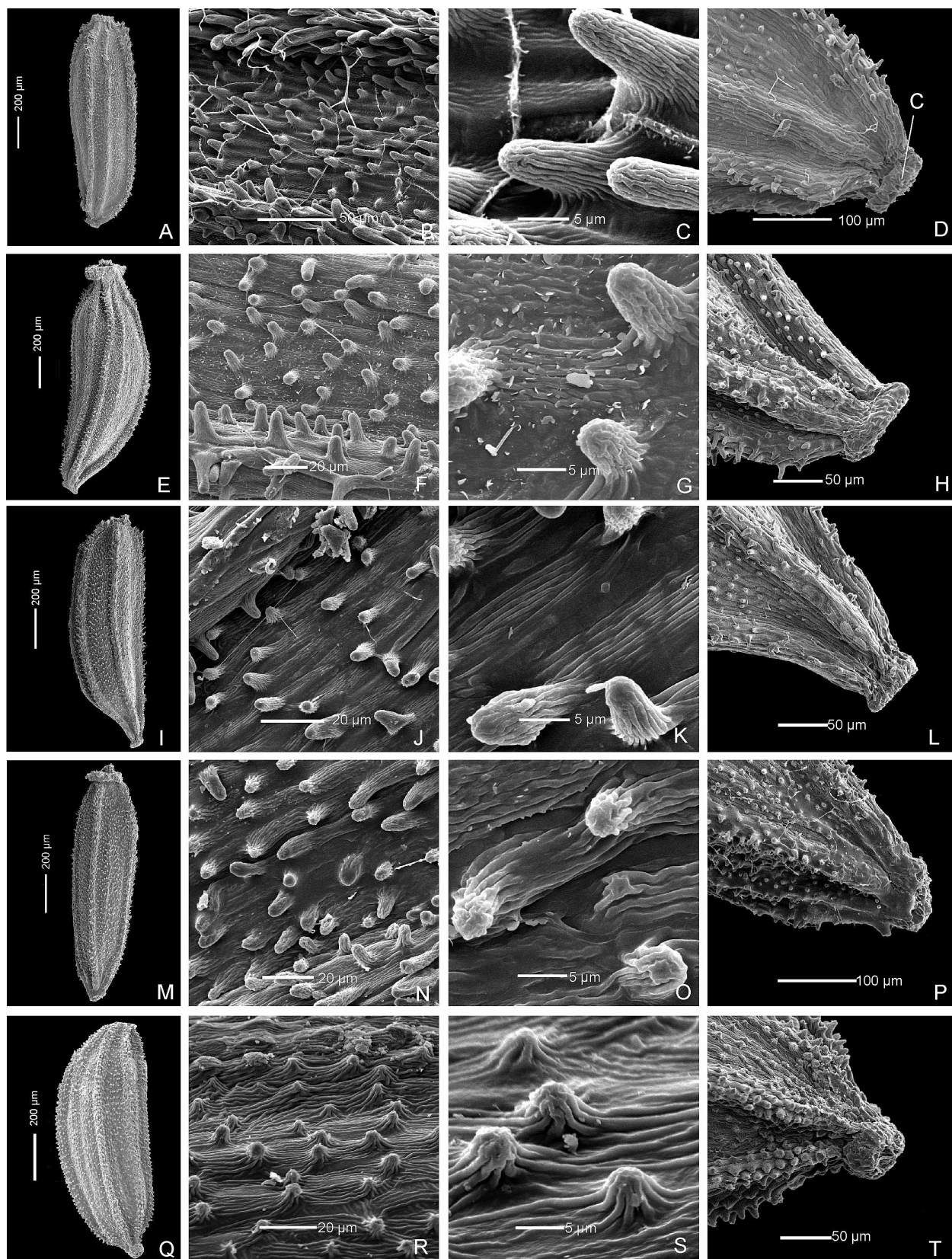


Fig. 3. Scanning electron micrographs of cypselae surface of *Baccharis* sect. *Caulopterae* - Group III.a: *B. apicifoliosa*: **A**, cypselae oblong-cylindrical; **B, C**, papillae detail; **D**, carpodium [C]. *B. flexuosiramosa*: **E**, cypselae; **F, G**, papillae; **H**, carpodium. *B. milleflora*: **I**, cypselae; **J, K**, papillae detail; **L**, carpodium. *B. organensis*: **M**, cypselae; **N, O**, papillae; **P**, carpodium. *B. phyteumoides*: **Q**, cypselae; **R, S**, papillae; **T**, carpodium.

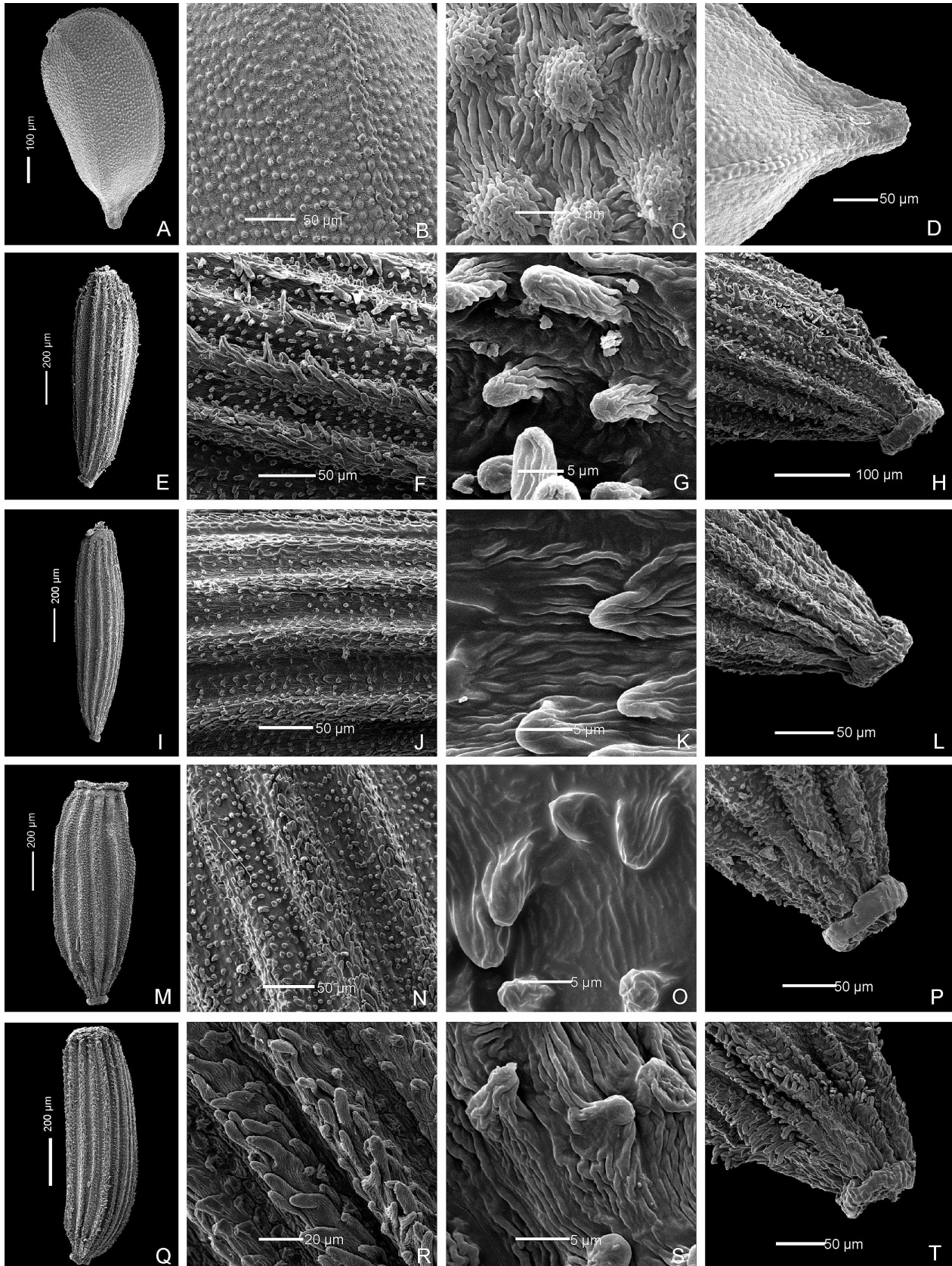


Fig. 4. Scanning electron micrographs of cypselae surface of *Baccharis* sect. *Caulopterae* - Group III.a: *B. subtropicalis*: **A**, cypselae; **B, C**, papillae; **D**, carpodium. Group III.b: *B. crispa*: **E**, cypselae; **F, G**, papillae; **H**, carpodium. *B. cylindrica*: **I**, cypselae; **J, K**, papillae; **L**, carpodium. *B. jocheniana*: **M**, cypselae; **N, O**, papillae; **P**, carpodium. *B. myriocephala*: **Q**, cypselae; **R, S**, papillae; **T**, carpodium.

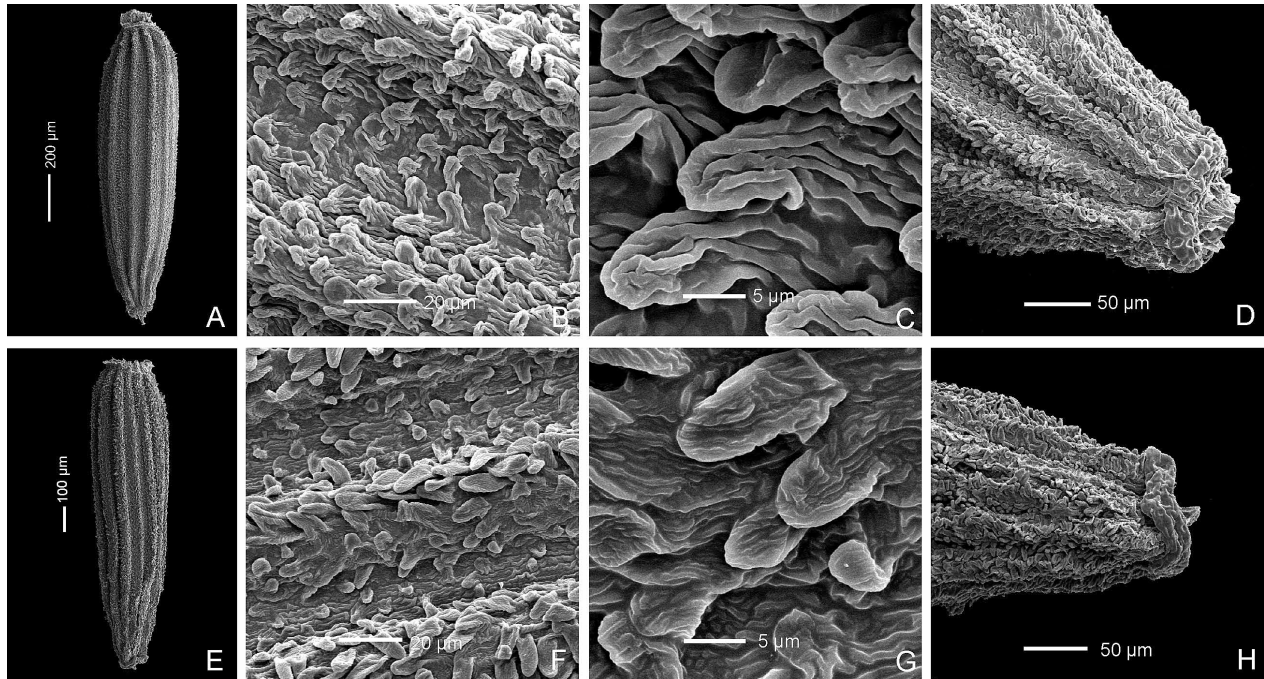


Fig. 5. Scanning electron micrographs of cypselae surface of *Baccharis* sect. *Caulopterae* - Group III.b: *B. aff. opuntoides*: **A**, cypselae; **B, C**, papillae; **D**, carpopodium. *B. trimera*: **E**, cypselae; **F, G**, papillae; **H**, carpopodium.

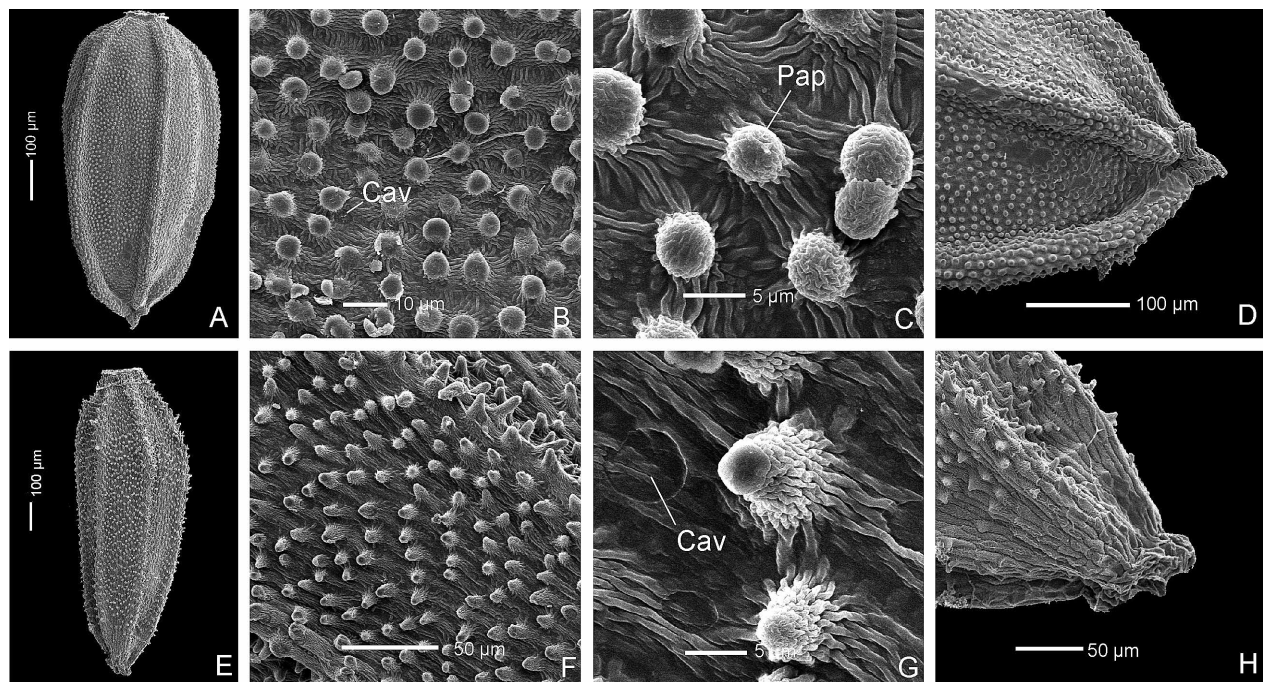


Fig. 6. Scanning electron micrographs of cypselae surface of *Baccharis* sect. *Caulopterae* - Group IV: *B. articulata*: **A**, cypselae oblong-cylindrical; **B, C**, papillae; **D**, no carpopodium. *B. glaziovii*: **E**, cypselae; **F, G**, papillae; **H**, carpopodium. [Cav, cavites, Pap, papilla].

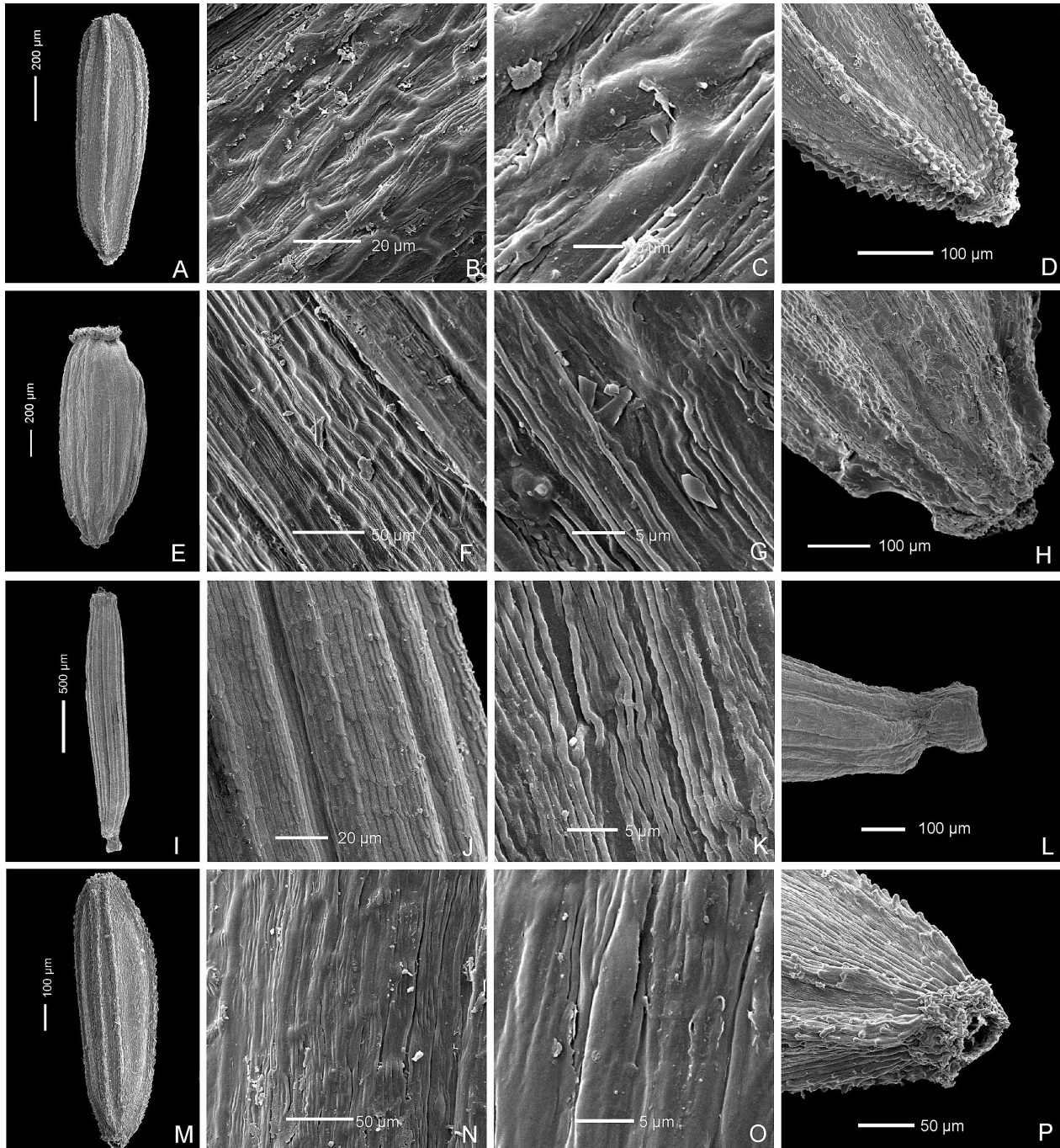


Fig. 7. Scanning electron micrographs of cypselae surface of *Baccharis* sect. *Caulopterae* - Group V: *B. junciformis*: **A**, cypselae; **B, C**, epapillose surface; **D**, carpodium. *B. pentaptera*: **E**, cypselae; **F, G**, epapillose surface; **H**, carpodium. *B. riograndensis*: **I**, cypselae; **J, K**, epapillose surface; **L**, carpodium. *B. sagittalis*: **M**, cypselae; **N, O**, epapillose surface; **P**, carpodium.

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