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Original article

Eleocharis multinerviglumis, a remarkable new aquatic sedge species from the Brazilian Atlantic Forest biome

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ABSTRACT

Eleocharis multinerviglumis, a new species of *Eleocharis* ser. *Tenuissimae* (Cyperaceae) known only from the Poços de Caldas plateau in southeastern Brazil, is described here. The new species was found growing in an Atlantic Forest remnant as a submerged or emergent herb in a flooded environment. *Eleocharis multinerviglumis* differs from other *Eleocharis* ser. *Tenuissimae* species mainly by having dimorphic spikelets, with the upper glumes of the spikelets on the culm apex with 7 to 10 prominent longitudinal nerves on both sides (rib-like). Taxonomic notes, an occurrence map and illustrations (including SEM images) are provided.

Keywords: Cyperoideae, *Eleocharis* ser. *Tenuissimae*, Neotropics, spikerush, taxonomy.

Introduction

The genus *Eleocharis* R. Br. (Cyperaceae) comprises approximately 300 species globally (Larridon 2022; POWO 2023). Its center of diversity is within the tropical and subtropical regions of the Neotropics, where approximately 150 species occur (González-Elizondo & Tena-Flores 2000; Govaerts & Simpson 2007). The genus has 79 species in Brazil, 20 of which are endemic (Nunes *et al.* 2020).

Eleocharis species are associated with aquatic and wetland habitats. They have simple morphological attributes, such as reduced leaves (without a leaf blade), tubular sheaths, the absence of typical Cyperaceae tristichous involucral bracts, photosynthetic culms ending in a single spikelet, and nutlets with a persistent style base called stylopodium (the stylopodium) (Svenson 1929; González-Elizondo & Peterson 1997).

According to the most recent classification based on morphological characteristics, the genus is organized into four subgenera that are delimited based on the shape of the spikelets, the fertility of the lower glumes, the consistency of the upper glumes, and the shape and ornamentation of the nutlets: *Eleocharis* subgen. *Eleocharis* R. Br. (three sections, eight series and seven subseries), *Eleocharis* subgen. *Limnochloa* (P. Beauv. ex T. Lestib.) Torr. (one section), *Eleocharis* subgen. *Scirpidium* (Nees) Kukkonen (one section), and *Eleocharis* subgen. *Zinserlingia* T.V. Egorova (two sections) (González-Elizondo & Peterson 1997).

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This classification does not, however, confirm the phylogenetic studies of Roalson and Friar (2000) and Roalson *et al*. (2010), in which many taxa were shown to be paraphyletic.

Eleocharis subgen. *Eleocharis*, sect. *Eleocharis*, ser. *Tenuissimae* (C.B. Clarke) Svenson, includes over 60 pantropical species (González-Elizondo & Peterson 1997; Trevisan & Boldrini 2010), and 31 have recorded in Brazil (Nunes *et al.* 2020). The series is mainly characterized as being herbs, with capillary culms, sometimes proliferous, usually trifid styles, and trigonous nutlets (with both biconvex and trigonous nutlets being found in some species), and is subdivided into *Eleocharis* subser. *Chaetariae* (C.B. Clarke) Svenson and subser. *Sulcatae* (C.B. Clarke) S. González & P.M. Peterson (*sensu* González-Elizondo & Peterson 1997). Phylogenetic analyses revealed that the clade corresponding to most species of *Eleocharis* ser. *Tenuissimae,* and grouping most of the species with C4 physiology/photosynthesis, is one of the best supported. The phylogenetic relationships between these two subseries within *Eleocharis* ser. *Tenuissimae* are still uncertain (Roalson *et al*. 2010), however, in light of the fragility of their morphological circumscriptions (*sensu* González-Elizondo & Peterson 1997).

The increasing number of taxonomic studies focusing on *Eleocharis* (*e.g.,* Faria 1998; Gil & Bove 2007; Trevisan & Boldrini 2008; Maciel-Silva *et al.* 2018) and the discovery of new species in Brazil (*e.g.,* Trevisan & Boldrini 2010; Trevisan *et al.* 2012; 2014; Lima *et al.* 2014; Ferreira *et al.* 2015; Nunes *et al.* 2016) has drawn attention to the systematics of the genus. The diagnostic features of the genus are associated with plastic structures, however, making species identifications quite challenging, with more detailed studies still being needed, especially for *Eleocharis* ser. *Tenuissimae* (Trevisan & Boldrini 2010; Saarela *et al.* 2010).

In attempt to broaden our understanding of the circumscriptions, morphologies, and evolutionary relationships of the taxa assigned to *Eleocharis* ser. *Tenuissimae,* an integrative systematic study of the group is currently being developed (CS Nunes unpubl. res.). During the course of that study, a new species of *Eleocharis* ser. *Tenuissimae* was identified. We present here a complete morphological description of the new species, accompanied by an illustration, diagnosis, and comments on its morphology, distribution and habitat, as well as a preliminary evaluation of its conservation status.

Materials and methods

The morphological investigation of the new species was based on specimens held at the BHCB, CEN, CEPEC, FLOR, HBR, HSTM, IAN, ICN, INPA, MG, RB, R, SP, SPF, UB herbaria (acronyms according to Thiers 2023, continuously updated). The morphological terminologies follows Trevisan and Boldrini (2010) and Nunes *et al.* (2016). Digital images were prepared using a Leica M205A stereomicroscope equipped with an MC170HD digital camera and the LAS photo-processing software package; the plate was composed using Adobe Photoshop CS5. The Scanning Electron Microscopy (SEM) images were produced with Tescan Mira3 after gold coating, in the Laboratory of Scanning Electron Microscopy of the Museu Paraense Emílio Goeldi (Brazil).

Geographic distribution and habitat data were obtained from herbarium specimen labels as well as through personal communications with the type collector to clarify the geographic coordinates of the holotype and provided details concerning the habitat of the new species. The evaluation of the conservation status of the species followed the guidelines for IUCN Red List Categories and Criteria v.15.1 (IUCN 2022). The Area of Occupancy was estimated using employing Geospatial Conservation Assessment Tool (GeoCAT; Bachman *et al.* 2011), using the IUCN default cell width (4 km). The geographic information map was elaborated using Quantum Geographic System (QGIS 2023) v.3.26. The official political administrative limits and the hydrographic cartographic base were from IBGE (https://www.ibge.gov.br/geociencias/downloads-geociencias.html) and the Digital Elevation Model was freely downloaded from TOPODATA - Geomorphometric Database of Brazil (http://www.dsr.inpe.br/topodata/).

Results and discussion

Taxonomic treatment

Eleocharis multinerviglumis C.S. Nunes, A. Gil & R. Trevis. *sp. nov.* (Fig. 1, 2 and 4A-D)

Type: BRAZIL. Minas Gerais: Poços de Caldas, 30 Sep 1999, [21°50'58" S, 46°35'35" W], *E. Tameirão-Neto 2967* (Holotype: BHCB54193!; isotype: SPF150216!).

Herbs perennial, rhizomatous. Rhizomes inconspicuous, ca. 0.2 cm long, low-lignification, stramineous. Culms 1.8–7.2 × 0.01–0.03 cm, quadrangular to subcircular in cross section, not septate, smooth, capillary, longitudinally sulcate when dry, erect to slightly recurved, green. Sheaths 0.5–1.5 cm long, membranous to papyraceous, castaneous at base and vinaceous at apex, apex oblique to rounded, somewhat inflated, margins hyaline, midrib most evident proximally. Spikelets dimorphic; culmless spikelets clustered at the culm tillering zone, 1–3-flora, 3–4.2 × 0.7–1.2 mm, lanceoloid; glumes 4–6, subdistichously arranged, imbricate, rachis present, 0.7–1.5 mm long; lower glumes 2–3, 2–4 × 0.4–0.6 mm, sterile, lanceolate, membranous, keel greenish, sides vinaceous, ca. 5 prominent longitudinal nerves on each side, apex acute to acuminate, margins hyaline; upper glumes 2–4, 2–4 × 0.5–0.6 mm, fertile, with only pistillate flowers, lanceolate, membranous, keel inconspicuous, sides vinaceous to stramineous, ca. 5 prominent longitudinal

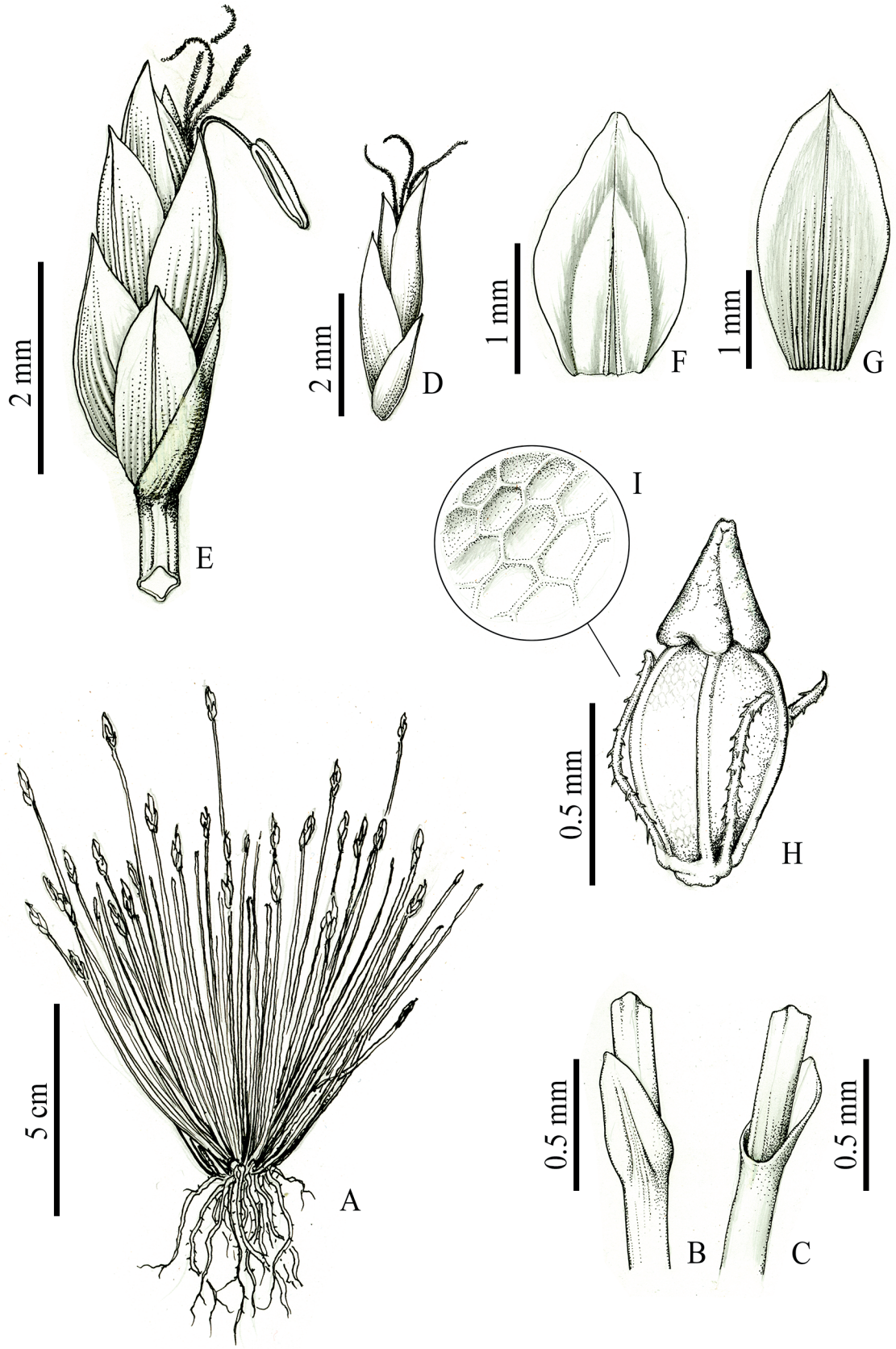

Figure 1. *Eleocharis multinerviglumis*. **A**. Habit. **B**. Sheath apex, dorsal view. **C**. Sheath apex, lateral view. **D**. Culmless spikelets. **E**. Spikelets on the culm apex. **F**. Lower glume. **G**. Upper glume. **H**. Nutlet. **I**. Nutlet surface detail Illustration based on the holotype *E. Tameirão-Neto 2967* (BHCB), and made by Elielson Rocha.

Figure 2. Holotype of *Eleocharis multinerviglumis* (*E. Tameirão-Neto 2967* - BHCB).

nerves on each side, apex acute to acuminate, margins hyaline; spikelets on the culm apex, multiflorous, 3–5 × 1–2.2 mm, ellipsoidal; glumes 10–14, spirally arranged, loosely imbricate, rachis present, 1–2.5 mm long; lower glume 1, ca. 1.8–2 × 1 mm, sterile, oval to oblong, membranaceous, apex obtuse to acute, stramineous, keel inconspicuous, sides stramineous to vinaceous, margins entire, hyaline, inconspicuously veined vertically, continuous with culm, not exceeding the adjacent glumes; upper glumes 11-13, 2–3 × 1–1.5 mm, fertile, lanceolate to oval, membranaceous, apex obtuse to rounded, sometimes lacerated at maturity, keel inconspicuous, stramineous to green, sides longitudinally vinaceous, 7-10 prominent longitudinal nerves on each side, margins entire, hyaline, conspicuously veined vertically. Stamens 2, ca. 2 mm long, anthers ca. 1 mm long; style trifid, 1-2 mm long; perianth bristles 5(6), 0.3–1 mm long, stramineous, retrorsely scabrous. Nutlet 0.8–1.3 × 0.4–0.6 mm, trigonous, obovoid to ellipsoidal, olivaceous to stramineous, short-stipitate, 3-costate; surface finely reticulate, few times inconspicuously, epidermics cells shape hexagonal, isodiametric, silica body absent; stylopodium ca. 0.3 mm long, pyramidal, having confluent angles with the costae of the nutlet, stramineous, apex long-acuminate, base triangular, separated from the nutlet body by a constriction.

Distribution and habitat: *Eleocharis multinerviglumis* is known only from type locality in the municipality of Poços de Caldas, Minas Gerais State, Brazil (Fig. 3). The new species occupies flooded or periodically flooded environments along the banks of the Ribeirão das Antas River. The fertile specimens examined were collected in September (the regional dry winter season).

Paratype: BRAZIL. Minas Gerais: Poços de Caldas, 05 May 2000, *E. Tameirão-Neto 3011* (BHCB54240!).

Conservation status: *Eleocharis multinerviglumis* is classified, according to IUCN Red List criteria (IUCN 2022), as Data Deficient (DD), as only two specimens are known and there is therefore a lack of adequate information to better describe the degree of risk, abundance, and/or distribution of the species. If more detailed investigations of *Eleocharis multinerviglumis* were undertaken, the species would probably be considered Critically Endangered (CR) due to its restricted distribution and the fragmentation and degradation of its natural habitat. The new species is known from only two populations on the Poços de Caldas plateau, with a minimum elevation of 1200 m within the highly fragmented Atlantic Forest. The species has an Area of Occupancy (AOO) of 4000 km; its Extent of Occurrence (EOO) cannot be calculated from only two known points. The specimens were collected in the Poços de Caldas Alkaline Complex region, where large bauxite deposits are found. The region has experienced significant landscape alterations in recent years due to large mining operations, pasture

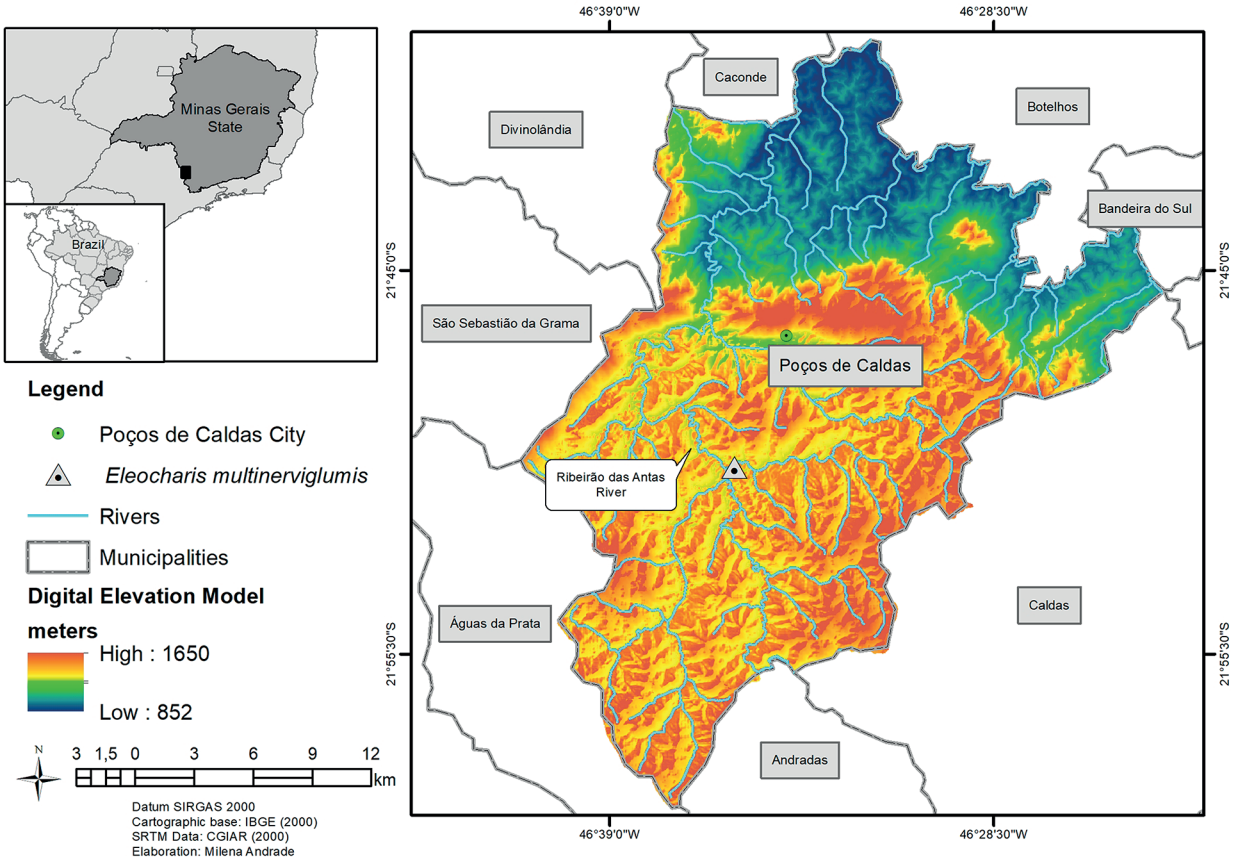

Figure 3. Distribution map of the *Eleocharis multinerviglumis*.

formation, and *Eucalyptus* cultivation (Cordeiro 2008), which may well be affecting the only known population. Additionally, after extensive reviews of many herbaria as well as the published literature, no other records of *E. multinerviglumis* were encountered.

Etymology: The specific epithet of this new species refers to the surfaces of its upper glumes, with prominent longitudinal nerves.

Taxonomic notes: *Eleocharis multinerviglumis* is principally characterized by dimorphic spikelets (Fig. 1D), the upper glumes of the spikelets on the culms apex with 7 to 10 prominent longitudinal nerves on both faces (rib-like), vinaceous sides (Figs. 1G, 4A), obovoid to ellipsoidal, olivaceous to stramineous, trigonous and tricostate nutlets, with finely reticulate surfaces, and a pyramidal stylopodium with a long-acuminate apex and confluent angles with the costae of the nutlets (Fig. 1H, 4B-D). It is similar to *Eleocharis nana* Kunth, a Neotropical species (not registered in the typical locality), by having quadrangular culms, dimorphic spikelets sometimes present, ovoid to ellipsoidal spikelets on the culm apex, with spirally arranged glumes (Fig. 4E), 5-6 perianth bristles, and trigonous and tricostate nutlets (Fig. 4 F-H). It also resembles *Eleocharis braunii* H. Hess (Fig. 4I), an endemic Amazonian species, mainly by being perennial, with nutlets 0.8–1.2 × 0.4–0.6 mm, trigonous, obovoid to ellipsoidal, tricostate, with reticulate to finely reticulate surfaces, without ribs, a pyramidal, stramineous stylopodium having angles confluent with the costae of the nutlet, and a long-acuminate apex, triangular base, separated from the nutlet body by a constriction (Fig. 4 J-L).

Eleocharis multinerviglumis differs from *E. nana* by being perennial (Fig. 1A) (*vs*. annual in *E. nana*), rhizomatous (*vs*. without rizome), with the sheath apex obtuse to rounded (*vs*. oblique, acute to acuminate), stamens 2 (*vs*. 3), upper glume of the spikelets in the culm apex with 7 to 10 prominent longitudinal nerves on each side (vs. prominent longitudinal nerves absent), perianth bristles 5-6 (*vs*. rudimentary or 5), long-acuminate stylopodium apex (vs. acute to apiculate). It differs from *E. braunii* by having culms with 1.8–7.2 × 0.01–0.03 cm (*vs*. 10–30 × 0.03–0.06 cm in *E. braunii*), rhizomatous herbs (*vs*. stoloniferous), sheath apex obtuse to rounded (*vs*. oblique to truncate), dimorphic spikelets present (*vs*. dimorphic spikelets absent), spikelets on the culm apex 3–5 × 1–2 mm (*vs*. 4–10 × 1.5–3 mm), ellipsoidal (*vs*. oblongoid to ellipsoidal), upper glume with 7 to 10 prominent longitudinal nerves on each side (vs. prominent longitudinal nerves absent), perianth bristles 5–6 (*vs*. 7–8) (Tab. 1).

Table 1. Comparative characters of *Eleocharis multinerviglumis*, *E. nana,* and *E. braunii*.

Character	*Eleocharis multinerviglumis*	*Eleocharis nana*	*Eleocharis braunii*
Life cycle	Perennial	Annual	Perennial
Stem system	Rhizomatous	Absent	Stoloniferous
Sheaths apex	Obtuse to rounded	Oblique, acute to acuminate	Oblique to truncate
Culm (cm)	1.8–7.2 × 0.01–0.03	3–14 × 0.02–0.05	10–30 × 0.03–0.06
Dimorphic spikelets	Present	Present or absent	Absent
Spikelets on the apex of culms (mm)	3–5 × 1–2	2–5 × 0.8–2.5	4–10 × 1.5–3
Spikelet shape	Ellipsoidal	Ovoid to ellipsoidal	Oblongoid to ellipsoidal
Upper glume sides	7-10 prominent longitudinal nerves on each side	Prominent longitudinal nerves absent	Prominent longitudinal nerves absent
Stamens	2	3	2
Perianth bristles	5–6	Rudimentary or 5	7–8
Stylopodium shape	Pyramidal with confluent angles with the costae of the nutlet	Pyramidal or depressed pyramidal, angles not confluent	Pyramidal with confluent angles with the costae of the nutlet
Stylopodium apex	Long-acuminate	Acute to apiculate	Long-acuminate

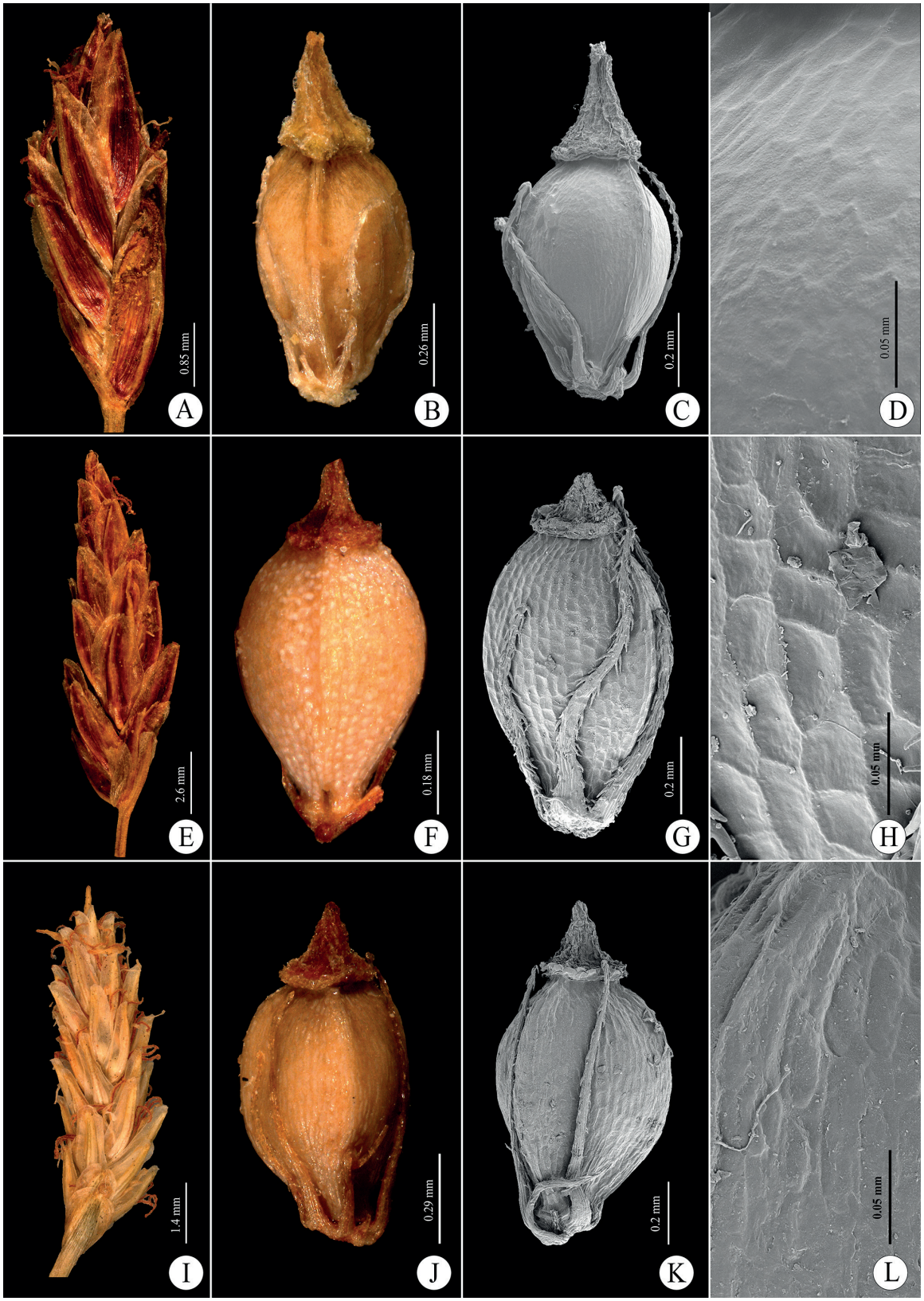

Figure 4. Digital images and scanning electron micrographs (SEM). **A-D**. *Eleocharis multinerviglumis*. **A**. Spikelets on the culm apex, digital image. **B**. Nutlet, digital image. **C**. Nutlet, SEM image. **D**. Nutlet surface detail, SEM image. **E-H** (*E. Tameirão-Neto 2967* - BHCB). *Eleocharis nana*. **E**. Spikelets on the culm apex, digital image. **F**. Nutlet, digital image. **G**. Nutlet, SEM image. **H**. Nutlet surface detail, SEM image. **I-L** (*N.F.O Mota 3058* – MG). *Eleocharis braunii*. **I**. Spikelets on the culm apex, digital image. **J**. Nutlet, digital image. **K**. Nutlet, SEM image. **L**. Nutlet surface detail, SEM image (*N.A. Rosa* 2353 – MG).

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