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Taxonomic notes for *Portulaca* (Portulacaceae) in South America II: synonymisation of *P. diegoi* under *P. hatschbachii* based on macro and microcharacters

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Summary. *Portulaca diegoi* is here proposed as a heterotypic synonym (synon. nov.) of *P. hatschbachii*, a species endemic to southern Brazil. Analysis of type specimens and protologues of both names demonstrated that they do not differ in root, leaf, flower, fruit or seed morphology. *P. hatschbachii* can be distinguished from other *Portulaca* species by its decumbent habit, oblanceolate leaves with purplish and recurved apex, lanate leaf axillary trichomes, hemispheric operculum and thick and elongated roots. In addition, based on examination of specimens of *P. hatschbachii*, they are quite distinct, because their leaves turn black after drying. Illustrations and comments about the taxonomy, phenology, distribution, habitat and conservation status are provided for *P. hatschbachii*.

Key Words. Basaltic rocky outcrops, Caryophyllales, endemism, new synonym, threatened species.

Introduction

Portulaca L. (Portulacaceae) is a monophyletic and cosmopolitan genus (Nyffeler & Eggli 2010), comprising about 100 species mainly distributed in South America and Africa (Ocampo & Columbus 2012; Hernández-Ledesma *et al.* 2015). It includes rupicolous and terrestrial herbs; usually with fibrous or tuberous roots; succulent, opposite or alternate leaves, with usually axillary trichomes (hairs or scales); flowers arranged in cymose or capituliform inflorescences; and fruit circumscissile dehiscent (Legrand 1962; Geesink 1969; Gilbert & Phillips 2000).

The most recent taxonomic treatments of *Portulaca* from Brazil were published by Coelho & Giulietti (2010) and Coelho *et al.* (2010) who recognised 13 species. These species are mainly distributed in the northeast and southeast regions of Brazil, growing in rocky outcrops or shallow soils (Coelho & Giulietti 2006; Coelho & Giulietti 2010). Although together these studies have entailed an extensive effort, several names have been neglected by them, such as *P. costata* Poelln., *P. diegoi* Mattos and *P. hoehnei* D.Legrand.

Portulaca diegoi was described on the basis of specimens collected by Raulino Reitz and Roberto Klein, in Dec. 1958 and Jan. 1959, respectively, from rocky outcrop vegetation in Santa Catarina State of southern Brazil (Mattos 1984a). Mattos (1984a) did not compare these specimens with related species and he did not give information about fruits, roots or seeds, whose characters have taxonomic value in the identification of *Portulaca* species (Legrand 1962; Ocampo 2018). *P. diegoi* is currently considered as a rare plant, endemic to the Brazilian Subtropical Highland Grasslands (BSHG) also referred to as the Campos de Cima da Serra (Iganci *et al.* 2011; Hassemer 2015) and known from just five populations (Mattos 1984b). *P. hatschbachii* D.Legrand, another rare and endemic species from grasslands on basaltic rocky outcrops in Paraná State, also in southern Brazil (Coelho 2009; Coelho & Giulietti 2010), was described on the basis of specimens collected by Gerdt Hatschbach in Nov. 1957 and Oct. 1960 (Legrand 1962). This species is well known for having thick and elongated roots in relation to its stem size, as well as for the leaves of herbarium specimens turning black (Coelho & Giulietti 2010). Moreover, Legrand (1962) described *P. hatschbachii* indicating, as main features, the seeds light grey and capsules subspherical and sessile.

As part of the ongoing taxonomic studies of the South American *Portulaca* species (Ferraz *et al.* 2022), we here propose to synonymise *Portulaca diegoi* and *P. hatschbachii* based on ecological and morphological characters. Moreover, we provide a distribution map, ecological characteristics, an improved description, taxonomic comments, and a conservation status for *P. hatschbachii*.

Materials and Methods

This study is based on a review of the relevant literature and study of herbarium specimens preserved at ASE, C, CGMS, EFC, FLOR, FUEL, FURB, GB, HAS, HBR, HTL, MBM, UPCB, and UPS, as well as digital images of specimens preserved at B, BM, F, G, GH,

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Fig. 1. Holotype of *Portulaca hatschbachii* (*Hatschbach* 7518, MVM).

HCF, HUEFS, K, L, LIL, MO, MVM, NY, P, RB, S, SP, US, USF, W, and Z (herbarium acronyms follow Thiers 2023, continuously updated).

Macromorphological analyses were performed using a stereomicroscope, digital calliper and the microscope software ZEN lite blue version 2.6 (Zeiss, Germany, https://www.zeiss.com). Micromorphology of seed surfaces was observed using scanning electron microscopy (SEM) FEI Quanta 200 (FEI – Thermo Fischer Scientific, USA, https://www.thermofisher.com). For the preparation of microphotographs, seeds were adhered to stubs with a double-sided carbon tape and covered with gold in a metallizer (BALTEC SCD 050 Sputter Coater, Germany, https://www.baltic-praeparation.de). Morphological terms follow Beentje (2016) and Ocampo (2013). The ecological characteristics and colours of plant structures were observed during floristic surveys carried out between the years 2016 and 2020.

The conservation status was assessed using IUCN (2012, 2022) criteria and guidelines. The Geospatial Conservation Assessment Tool (Bachman *et al.* 2011) and Google Earth Pro software (Google 2020) were used to

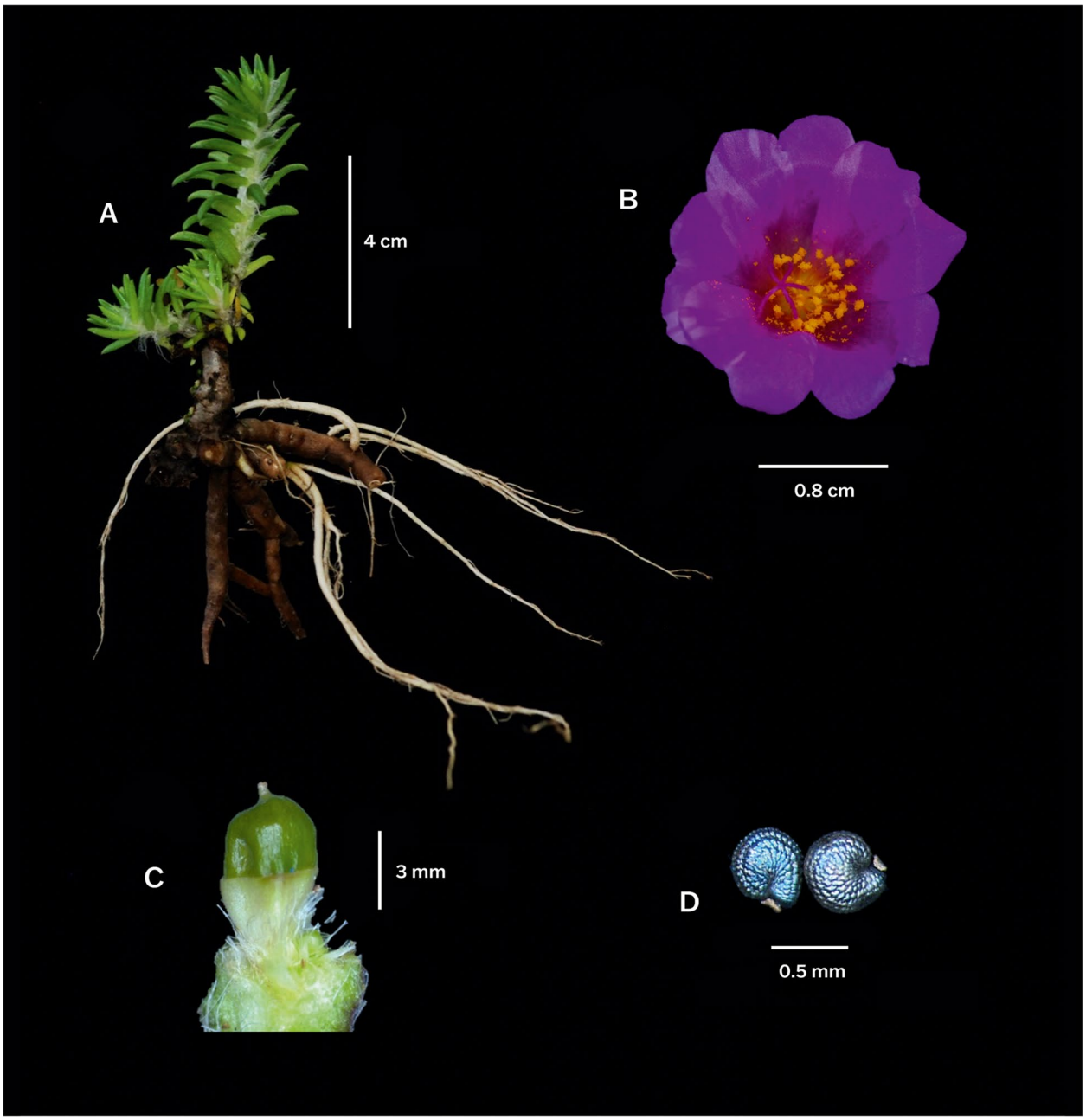


Fig. 2. *Portulaca hatschbachii*. **A** habit; **B** flower; **C** fruit; **D** seeds. PHOTOS: J. R. FERRAZ.

calculate the Area of Occupancy (AOO) using a 2 × 2 km^2 grid. The distribution map was prepared using ArcGIS (ESRI 2014). The AOO of *Portulaca hatschbachii* is intrinsically related to the delimitation of rocky ecosystems belonging to the BSHG which, until now have not been recorded north of Paraná, constituting the southernmost limit of this vegetation. These patches of rocky grasslands consist of areas ranging in size from 2,515 m^2 to 235,849 m^2 and it is, given the resolution it would require, unfeasible here to publish maps that include all 33 locations.

Diagnoses are presented for all species treated, as per the recommendations in Hassemer *et al.* (2020). The nomenclature used here follows the Shenzhen Code (Turland *et al.* 2018, hereafter ICN).

Taxonomic Treatment

Portulaca hatschbachii *D.Legrand* (1962: 105). Type: Brazil, Paraná: Guarapuava, Rio Coutinho, 21 Oct. 1960, *Hatschbach* 7518 (holotype MVM!; isotypes HAS!, L!, LIL!, MBM!, RB!, SP!, Z!).

Portulaca diegoi Mattos (1984a: 1), **synon. nov.** Type: Brazil, Santa Catarina: Bom Jardim da Serra, 1300 m, 14 Jan. 1959, *Reitz & Klein* 4096 (holotype HAS!; isotypes HBR!, US!).

Herbs up to 10 cm high. *Taproots* thickened, 6 – 30 cm long. *Stems* green or purplish, decumbent or decumbent to erect, rarely erect, usually very branched. *Leaves* alternate, subopposite at the apex, entire, simple, fleshy, green in living specimens, black in herbarium material; petiole 0.5 – 1.2 mm long, terete, lighter green than the blade; blades 4 – 14 × 1.0 – 2.2 mm, adaxial surface convex, abaxial surface flat, oblanceolate; base slightly rounded; apex acute, usually purplish, slightly recurved; margin entire; leaf axillary trichomes abundant and denser at the apex, up to 1.5 cm long, lanate, white in living specimens, yellow or brownish in herbarium material. *Inflorescence* a terminal head, 2 – 5-flowered; subtended by an involucre of 12 – 16 leaves. *Flowers* bisexual, sessile; sepals 2, unequal, connate at the base, 6.0 – 7.2 × 4.8 – 5.0 mm,

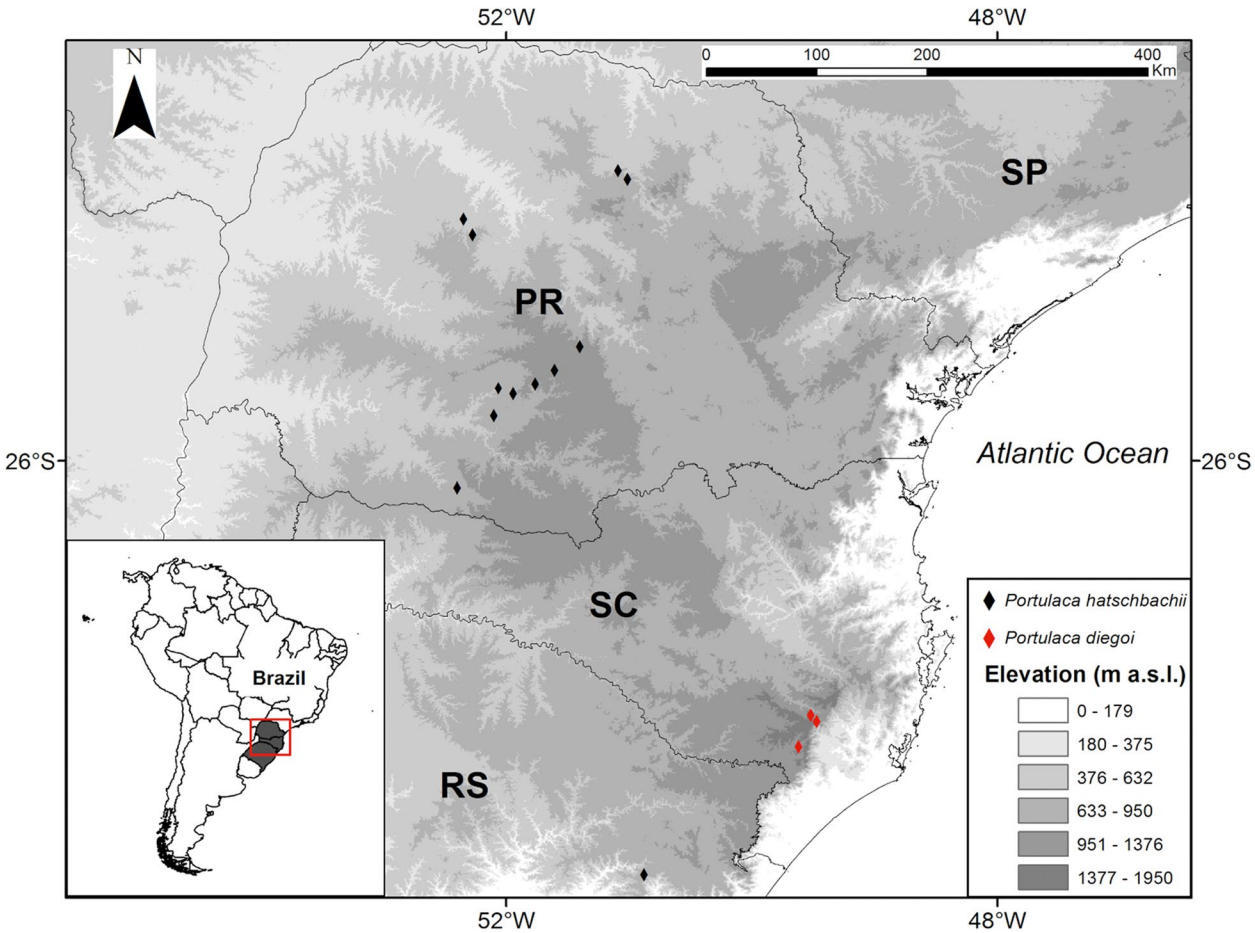
Fig. 3. *Portulaca hatschbachii*. **A** decumbent individual associated with *Bryum argenteum*; **B** decumbent to erect individual growing in shallow soil; **C** aspect of the leaves and branches when dry; **D** aggregated individuals. PHOTOS: J. R. FERRAZ.

ovate, apex acuminate, margins scarious; petals 5 (– 6), quincuncial, magenta, yellow in the adaxial base, 1.0 – 1.8 × 0.6 – 1.2 cm, obovate, apex obcordate, emarginate; stamens 15 – 35, filaments 2.0 – 5.0 (– 7.5) mm long, unequal, yellow, magenta or yellow at the base, turning purplish towards the apex, glabrous; anthers bithecate, 0.5 – 0.8 mm long, yellow, pollen released through longitudinal slits; ovary sub-globose; style 4.0 – 8.6 mm long, magenta, glabrous; stigma magenta, 3 – 7-lobed, 1.2 – 2.0 mm long, linear-lanceolate, the stigmatic surfaces covered with small hairs. *Fruit* a circumscissile capsule, sessile or pedicellate; pedicel 0.4 – 2.3 mm long; capsule 3.0 – 4.2 × 2.5 – 3.5 (– 4.0) mm; operculum hemispheric, sometimes truncate and asymmetric at the apex, green, shiny; base pale green. *Seeds* 15 – 30 per fruit, 0.4 – 0.7 mm, subreniform, black or grey, shiny, ornate, individual cells elongated; anticlinal walls undulate with T-, U-, and V-type patterns, the cells toward the peripheral face of the seed par-domed. Figs. 1, 2 and 3.

RECOGNITION. *Portulaca hatschbachii* can be distinguished from other species of the genus by its decumbent habit, thick and elongate roots, lanate leaf axillary trichomes, oblanceolate leaves with purplish and recurved apices and hemispheric operculum.

DISTRIBUTION. *Portulaca hatschbachii* occurs in southern Brazil, in the States of Paraná, Santa Catarina and Rio Grande do Sul (Map 1).

SPECIMENS EXAMINED. BRAZIL. Paraná: Campo Mourão, afloramento rochoso de basalto, 14 Nov. 2013, *Lozano et al.* 1857 (MBM!); Rio da Vargem, 5 Feb. 1962, *Hatschbach* 8754 (MBM!, UPCB!); Jardim Albuquerque, 1 Nov. 2005, *Geraldino & Oliveira* 173 (HCF); terreno frente ao Pesqueiro do Nishida, 27 Aug. 2009, *Silva & Siqueira* 730 (HCF); Candói, estrada para Fazenda Capão Redondo, 12 Dec. 2013, *Engels & Lozano* 2153 (MBM!, RB); Lagoa Seca, 26 Oct. 2006, *Barbosa & Cunha* 1768 (HUEFS, MBM!); ibid. 6 Nov. 2019, *Ferraz* 808 (FUEL!); Fazenda São Manoel, 21 Aug. 2017, *Ferraz* 168 (FUEL!); próximo ao Rio Campo Real, 5



Map 1. Distributions of specimens of *Portulaca hatschbachii* (black diamonds) and formerly referred to as *P. diegoi* (red diamonds) in southern Brazil. Inset map bottom left shows the location in South America. Abbreviations: **PR** Paraná; **SC** Santa Catarina; **SP** São Paulo; **RS** Rio Grande do Sul.

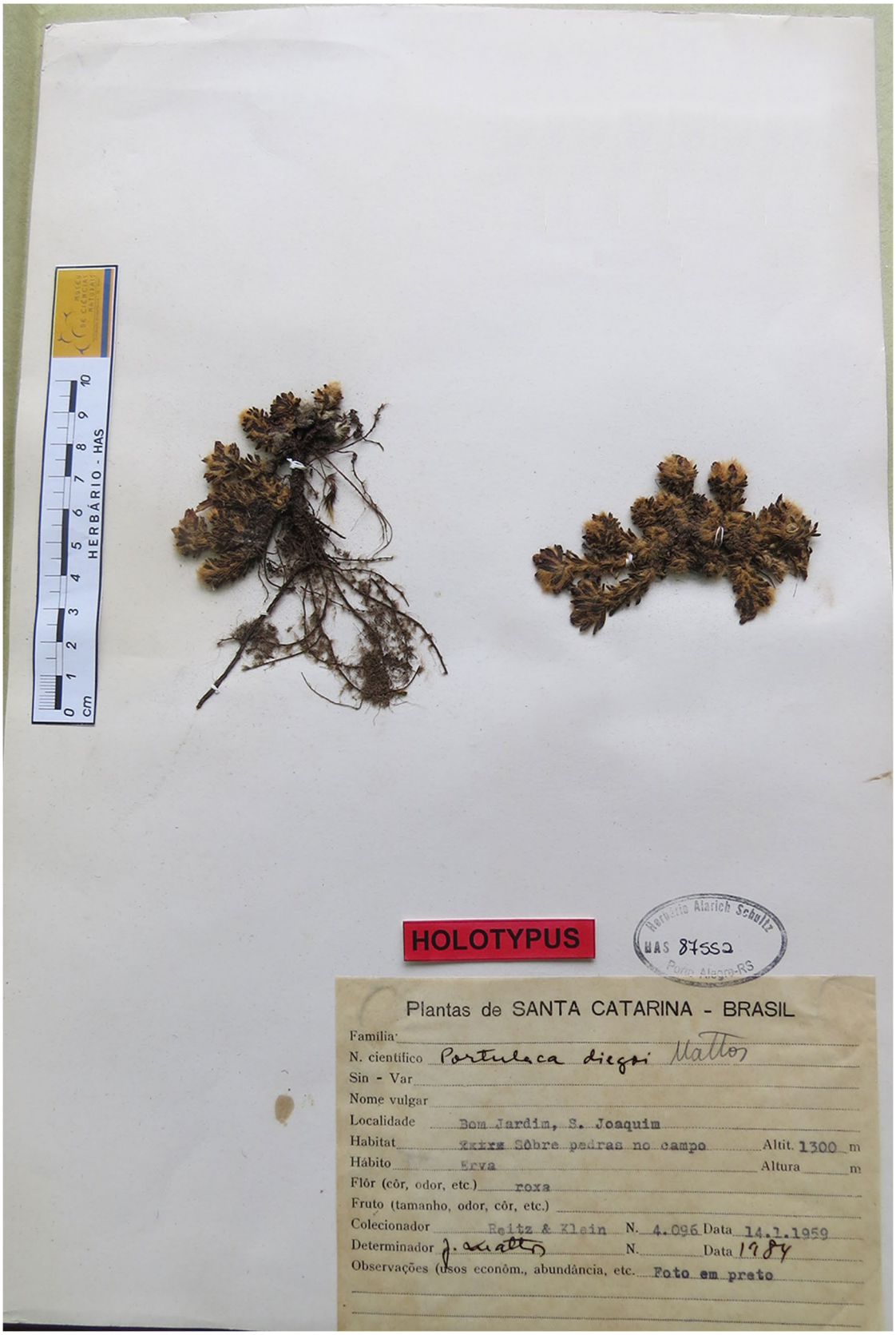


Fig. 4. Holotype of *Portulaca diegoi* (*Reitz & Klein* 4096, HAS).

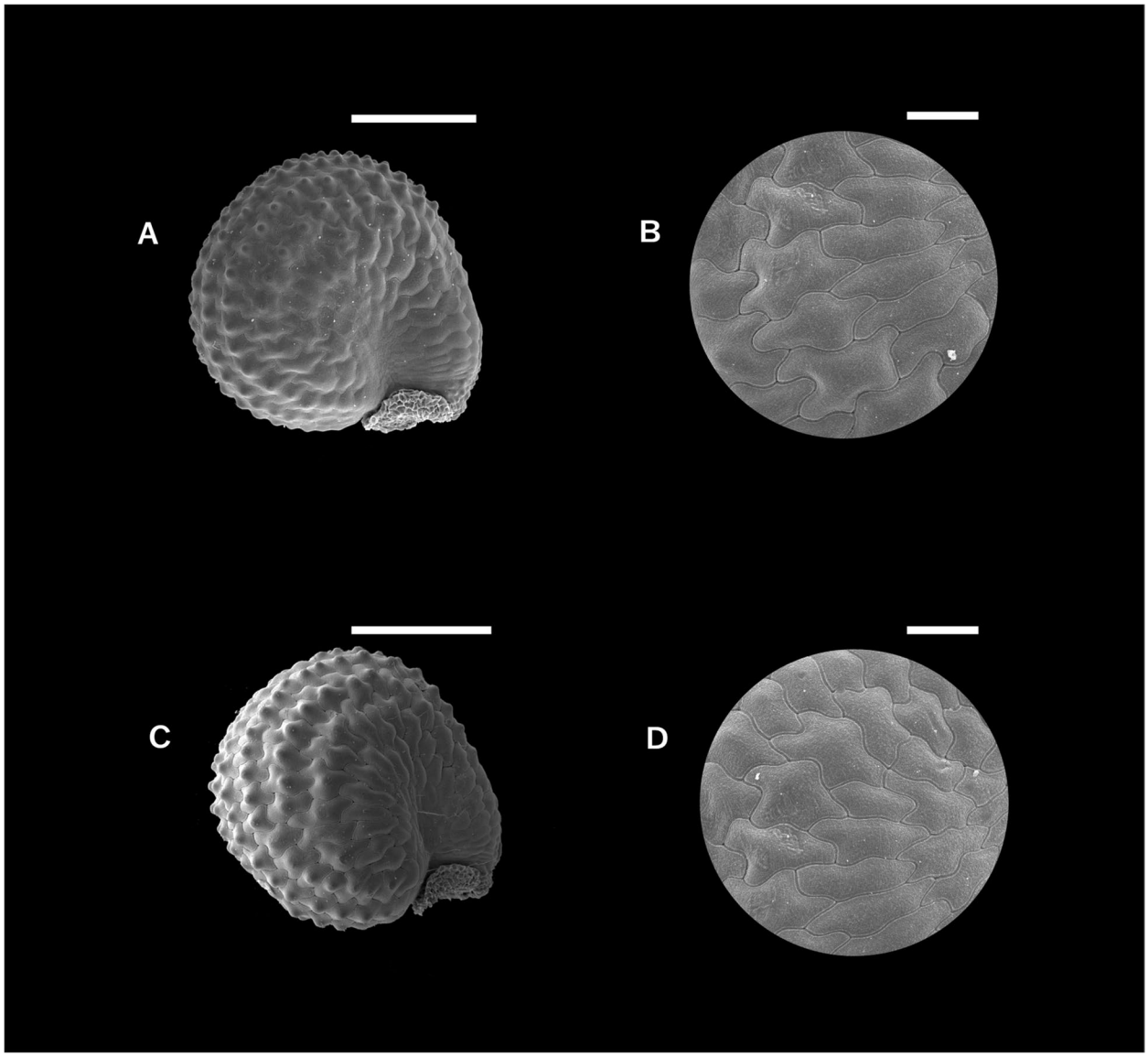


Fig. 5. SEM images of seeds. General aspect of seed (**A** and **C**) and anticlinal walls undulate with T-, U-, and V-type patterns (**B** and **D**) in *Portulaca hatschbachii* (**A, B**, *Ferraz* 167 [FUEL]), and former *Portulaca diegoi* (**C, D**, *Funez et al.* 8649 [FURB]).

Nov. 2019, *Ferraz* 703 (FUEL!); Cantagalo, km 423, 14 Dec. 1992, *Cervi et al.* 3876 (MBM!, UPCB!); BR-277, 21 Aug. 2017, *Ferraz* 169 (FUEL!); Clevelândia, near Sawmill Brandalize, 1 May 1966, *Lindeman & Haas* 1140 (L, NY, RB); Foz do Jordão, BR-373, 5 Nov. 2019, *Ferraz* 704 (FUEL!); PR-662, 6 Nov. 2019, *Ferraz* 845 (FUEL!); Guarapuava, Lagoa Seca, 16 Feb. 1963, *Hatschbach* 9719 (MBM!); Palmeirinha, 16 Nov. 1957, *Hatschbach* 4274 (MBM!); Rio Campo Real, 26 Oct. 1980, *Hatschbach* 43245 (MBM!, USF); Fazenda Capão Redondo, 22 Aug. 2017, *Ferraz* 171 (FUEL!); Honório Serpa, Pinho Fleck, 22 Aug. 2017, *Ferraz* 170 (FUEL!); Londrina, Distrito de Lerroville, Campo das Pedras, 17 Nov. 1969, *Hatschbach* 22892 (MBM!); ibid. 19 Sept 1970, *Hatschbach* 24866 (MBM); ibid. 5 Sept. 2017, *Ferraz* 179 (FUEL!); Luiziana, Pedreira abandonada, 8 Aug. 2017, *Ferraz* 164 (FUEL!); RPPN Depositozinho, 13 Feb. 2009, *Siqueira & Santos* 136 (HCF); ibid. 8 Aug. 2017, *Ferraz* 165 (FUEL!); Mangueirinha, Reserva Indígena de Chopinzinho, 15 Sept. 2009, *Silva et at.* 7355 (MBM!); Reserva Indígena de Mangueirinha, 5 Nov. 2019, *Ferraz* 721 (FUEL!); Turvo, arredores, 16 April 2009, *Caxambu et al.* 2607 (HCF); Reserva Indígena de Guarapuava, Rio Marrecas, 13 April 2002, *Silva & Poliquesi* 3615 (HUEFS, RB); Pedreira abandonada, 20 Aug. 2017, *Ferraz* 166 (FUEL!). Rio Grande do Sul:

Gramado, 12/13 April 1975, *Waechter* 27 (HAS!). Santa Catarina: Bom Jardim da Serra, 15 Dec. 1958, *Reitz & Klein* 7945 (HAS!, US); Morro da Igreja, 22 Jan. 1960, *Mattos* 25033 (HAS!); Urubici, Parque Nacional de São Joaquim, Cascata Véu de Noiva, na estrada de acesso ao Morro da Igreja, 1 Nov. 2014, *Fiaschi et al.* 4431 (FLOR!); Santa Bárbara, próximo ao alojamento, Parque Nacional de São Joaquim, 25 Jan. 2019, *Funez et al.* 8649 (FURB!).

HABITAT. This species is endemic to the BSHG and often grows in association with *Bryum argenteum* Hedw. (Fig. 3A), *Sphagnum recurvum* P.Beauv. and *S. cuspidatum* Ehrh. ex Hoffm. in shallow soils and on basaltic rocky outcrops at elevations of 549 – 1400 m.a.s.l. These basaltic rocky outcrops are surrounded by *Araucaria* forest, Seasonal Semideciduous forest and plantations of *Pinus taeda* L. and *P. elliottii* Engelm. In undisturbed rocky outcrops in north and central regions of Paraná, *Portulaca hatschbachii* forms dense and aggregate populations (Fig. 3D). However, *P. hatschbachii* is rare and occurs more sparsely in rocky outcrops disturbed by mining. We found several edaphically specialised species, endemic to the BSHG, occurring sympatrically with *P. hatschbachii*, such as *Dyckia walteriana* Leme, *Eryngium corallinum* Mathias & Constance, *Mimosa hatschbachii* Barneby, *Nierembergia hatschbachii* A.A.Cocucci & Hunz., *Nothoscordum exile* Ravenna, *N. gracilipes* Ravenna, *Paspalum redondense* Swallen, *Stylosanthes vallsii* Sousa Costa & Van den Berg and *Zephyranthes paranaensis* Ravenna.

CONSERVATION STATUS. We provisionally assess the conservation status of *Portulaca hatschbachii* as Critically Endangered [CR B2ab(i,ii,iii,iv)] (IUCN 2012, 2022). We found 33 populations, giving an AOO of c. 4 km^2. Between Aug. 2016 and Dec. 2021, eight of these populations were eradicated, indicating the considerable fragility of these grassland ecosystems. At this rate of population loss (1.3 per year), if effective conservation measures are not put in place, the remaining, known populations could become extinct within the next 30 years. The populations are mainly (94%) distributed in unprotected areas, only two are in protected areas, the National Park of São Joaquim (Santa Catarina) and the Private Natural Heritage Reserve Depositozinho (Paraná). The major threats to *P. hatschbachii* include its fragile habitat, severe population fragmentation, low levels of population genetic diversity (Feliciano *et al.* 2022), decline in the quality of its habitat caused by mining, invasion by alien species, especially the grass *Megathyrsus maximus* (Jacq.) B.K.Simon & S.W.L.Jacobs and *Pinus taeda*, fire, cutting and predation by cattle.

PHENOLOGY. Flowering and fruiting from August to April. Only 1 (– 2) flowers per inflorescence open in the morning, between 10:00 – 10:30 am, and close about 5h after anthesis. The seeds are wind dispersed. The leaves and branches turn black in late May and early June (Fig. 3C), disappearing entirely in July. After the dry season (June – August), plants produce new branches and leaves.

NOTES. Probably due to general morphological similarities, an isotype *Reitz & Klein* 4096 (US2323257) and a paratype *Reitz & Klein* 7945 (US2323626) of *Portulaca diegoi* were originally identified as *P. hatschbachii*. The analysis of the types and protologue of *P. diegoi* shows that this species has the same leaf, flower, fruit, and root morphology as *P. hatschbachii*. In both, the adaxial surface of leaves are convex, abaxial surfaces are flat and the blade is oblanceolate; sepals are ovate with margins scarious and petals are obovate with apices obcordate and emarginate; capsules are subspherical and the operculum is hemispherical; and the roots are tuberous, thick and elongated. We found that, in actuality, the range of variation of all the characters of *P. diegoi* overlaps with that of *P. hatschbachii*, and that the leaves of the former species also turn black in herbarium material (Fig. 4). Both species inhabit shallow soils and basaltic rocky outcrops, with *P. hatschbachii* found at elevations of 549 – 1100 m.a.s.l. and *P. diegoi* at elevations of 1200 – 1400 m.a.s.l.

Seed morphology is highly diverse in *Portulaca* (Ocampo 2013; Ocampo 2015) and it is widely applied in the taxonomic context (Domina & Raimondo 2009; Danin *et al.* 2016; Santos *et al.* 2016; Amini Rad *et al.* 2017). The seeds of *Portulaca hatschbachii* and *P. diegoi* have the same features (Fig. 5). Following Ocampo's (2013) terminology for morphological features of seeds, this species has seeds which are subreniform, with anticlinal walls undulate with T-, U-, and V-type

Table 1. Morphological comparisons of *Portulaca hatschbachii*, *P. eruca*, and *P. elatior*.

Character	*P. hatschbachii*	*P. eruca*	*P. elatior*
Plant height (cm)	5 – 10	8 – 15	12 – 40
Habit	decumbent	erect	erect
Roots	tuberous	tuberous	fibrous
Stem ramification	branched	simple	branched
Leaf shape	oblanceolate	subulate	linear-lanceolate
Type of indumentum	lanate	hirsute	lanate
Distribution	southern Brazil	Argentina and Paraguay	Caribbean region and tropical South America

patterns and the cells toward the peripheral face of the seed are par-domed.

Therefore, based on micro and macromorphological and ecological characters, we conclude that *Portulaca diegoi* and *P. hatschbachii* should be considered synonyms. In accordance with Art. 11.4 of the ICN, *P. hatschbachii,* as the earlier name, 1962 vs 1984, has priority and must be adopted as the correct name for the species.

According to Legrand (1962), *Portulaca hatschbachii* is characterised by the seeds light grey and the capsule sessile and subspherical. In our collections of specimens in the locus classicus, we also found individuals with black seeds and pedicellate fruits. Legrand (1962) also stated that *P. hatschbachii* has morphological affinities with *P. eruca* Hauman which is endemic to Argentina and Paraguay and *P. elatior* Mart. ex Rohrb. which occurs in the Caribbean region and tropical South America (Bolivia, Brazil, Colombia and Venezuela). However, based on our observations, *P. hatschbachii* can be distinguished from *P. eruca* by its leaf shape (oblanceolate vs subulate), leaf axillary trichomes (lanate vs hirsute) and branching and habit (very branched and decumbent or decumbent to erect vs usually simple and erect). *P. hatschbachii* can be easily distinguished from *P. elatior* by its height (5 – 10 cm vs 12 – 40 cm), habit (decumbent or decumbent to erect vs erect), leaf shape (oblanceolate vs linear-lanceolate), and roots (tuberous vs fibrous). Table 1 summarises the comparison of *P. hatschbachii* to both similar species and provides some additional details.

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Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

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