






Recommendations for the conservation of *Crassula peduncularis* (Sm.) Meigen, a critically endangered species in Brazil

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ABSTRACT

Crassula peduncularis (Sm.) Meigen is a critically endangered herbaceous species in Brazil, with an occurrence restricted to the states of Santa Catarina and Rio Grande do Sul. The last recorded collection of the species in Rio Grande do Sul occurred in 2016 in the municipality of Caçapava do Sul. Herein, we record for the first time *C. peduncularis* in two conservation units in the Southern Brazilian Grasslands. The populations discovered are small, growing in wet areas under sandstone rocky outcrops and halomorphic soils, popularly known as *blanqueales*. The main threats to the species in these protected areas are habitat loss caused by biological invasion, cattle trampling, and fires. To mitigate these threats, we recommend the encouragement of scientific research and the popularization of knowledge, as well as the adoption of good cattle management practices and the protection of habitats where the species occurs.

Keywords: Conservation, Halomorphic soil, Pampa biome, Park grassland, Rocky outcrop.

Crassula L. is a genus of terrestrial, succulent, annual, or perennial plants of aquatic or semiaquatic and even arid environments, distributed worldwide (Fujii *et al.*, 2019). Although almost cosmopolitan, species of this genus are mainly observed in temperate regions, in shallow soil habitats covering rocky outcrops (Bruyns *et al.*, 2019) and on wet soils, occurring from sea level to altitudes of 1500 m (Bywater & Wickens 1984). *Crassula peduncularis* (Sm.) Meigen is the only native of the nine species of the genus that occur in Brazil (Flora & Funga do Brasil 2023).

Crassula peduncularis occurs only in Southern Brazil, in the states of Santa Catarina and Rio Grande do Sul, in grassland environments of the phytogeographic domains

of the Atlantic Forest and Pampa (CNCFLORA 2023). This species is usually associated with rocky outcrops and granitic depressions, where water accumulates after rainfall and persists for only a few days (Cabido *et al.*, 1990). Due to its small area of occurrence (less than 100 km²) and the increasing degradation of its natural habitat (Martinelli *et al.*, 2013), *C. peduncularis* is classified as critically endangered - Ordinance n° 148 (MMA 2022). In Rio Grande do Sul, there are only 19 records for the species, the first being in 1954, in Porto Alegre (Consulted material: Rambo B., PACA-AGP 1506) and the most recent in 2016, in Caçapava do Sul (Consulted material: Rabuske C. *et al.*, ICN 188167) (CRIA 2023).

Received June 27, 2023; Accepted February 23, 2024

Editor-in-Chief: Thaís Elias Almeida; Associate Editor: Marina Corrêa Scalon

How to cite:

Granzotto F, Fockink GD, Silva PS *et al.*, 2024. Recommendations for the conservation of *Crassula peduncularis* (Sm.) Meigen, a critically endangered species in Brazil. *Acta Botanica Brasilica* 38: e20230235. doi: [10.1590/1677-941X-ABB-2023-0235](https://doi.org/10.1590/1677-941X-ABB-2023-0235)



From floristic surveys carried out in the phytogeographic domain of the Pampa, we identified *C. peduncularis* in the Espinilho State Park (ESP) and the Ibirapuitã Biological Reserve (IBR), both fully protected conservation units to conserve different phytoecological formations. The ESP contains the last conserved remnants of Park grassland in Brazil, while the IBR maintains the typical Pampa landscape, sheltering conserved remnants of grassland, forest (riparian forests), and shrub formations. In both protected areas, these are the first records of populations of this species. Given these findings, we deepened investigations into the occurrence of *C. peduncularis* to promote the conservation of the species and the environments where it occurs.

The survey of *C. peduncularis* populations was carried out using the walking method (Filgueiras *et al.*, 1994). We carried out eight expeditions between September and November 2022 and between June and August 2023. We followed the methodological procedures of collection and herborization according to Rotta *et al.*, 2008 and taxonomic identification according to Bywater & Wickens 1984. The location map was prepared using QGIS software (QGIS Development Team 2023).

In the ESP, we verified the presence of two populations of *C. peduncularis* on patches of halomorphic soils in the Park grassland, popularly known as *blanqueales* (Fig. 1A),

due to their whitish coloration and low vegetation cover. The sampled patches are separated by an average distance of 0.4 km and have an area of 0.2 hectares. The *blanqueales* are characterized by high sodium content in the superficial layers, conditioning the occurrence of rarefied vegetation, composed mostly of halophyte species (Marchiori *et al.*, 2014). Due to their occurrence in flat relief associated with the sedimentary plain of the Uruguay River, with an average altitude of 60 m above sea level, these soils present drainage limitations and, consequently, water accumulation during rainy periods (Marchiori *et al.*, 2014). These conditions create suitable microhabitats for the establishment of *C. peduncularis*. In the IBR we recorded the species in three basaltic rocky outcrops, separated by an average distance of 1.3 km and with an average area of 0.36 hectares (Fig. 1B). The rocky outcrops in this region are formed by sedimentary sandstone rocks (cornices) and to a lesser extent by basaltic resurfacing, under gently undulating relief and altitudes ranging from 80 to 150 m (Kormann & Robaina 2021).

We found that *C. peduncularis* populations occur in microhabitats (vegetated rocks and depression) with rainwater accumulation, mainly on shallow outcrops that have contact with the soil. In *blanqueales*, water accumulation is caused by the surface sealing of the soil, due to the high concentration of sodium. In both environments, populations

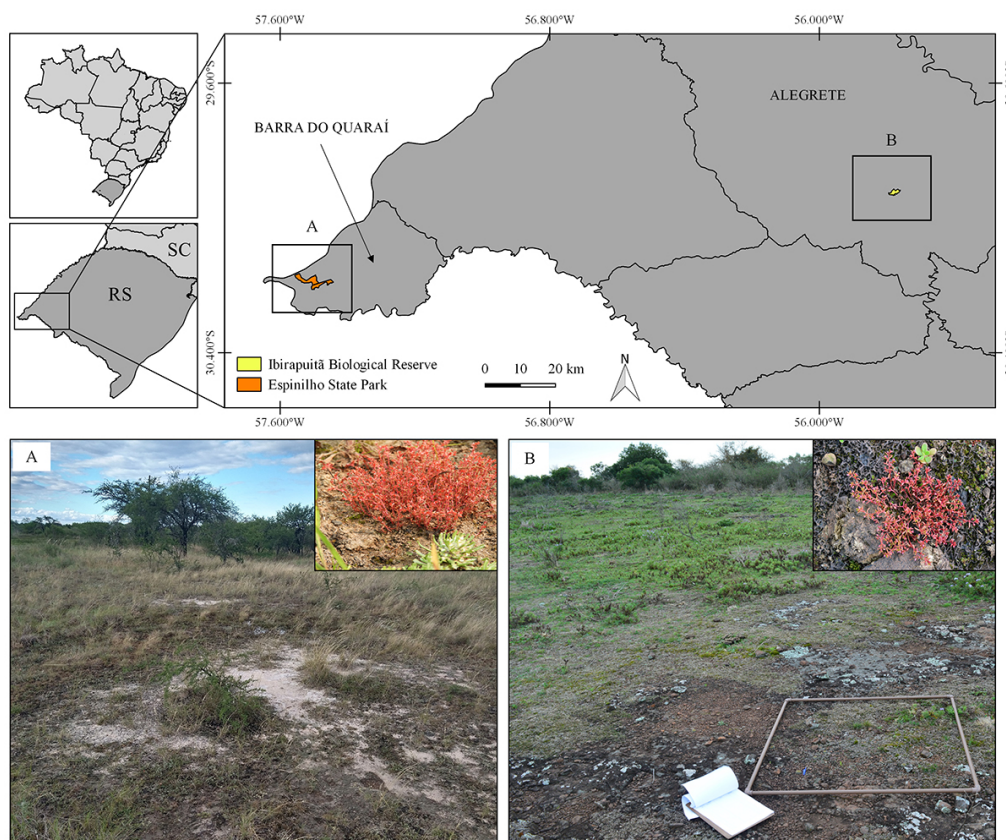


Figure 1. Occurrences of *C. peduncularis* in halomorphic soils (*blanqueales*) in the Espinilho State Park (A) and rocky outcrops in the Ibirapuitã Biological Reserve (B), Rio Grande do Sul, Brazil.

form small groups of individuals that tend to senesce in dry periods (Fig. 2).

The occurrence of *C. peduncularis* in rocky outcrops and *blanqueales* is associated with its adaptation to limiting environmental conditions. Crassulaceae species present anatomical adaptations (e.g. succulence and variations in stomatal density) that enable their colonization and permanence in more severe, humid, or arid environments (Jones 2011). Because *C. peduncularis* is an annual species, it has a life cycle directly related to climatic seasonality. In the study region, its seeds germinate in the most humid periods (at the end of winter and spring), and the plant quickly develops its flowers and seeds. Because they have a short life cycle, the plants enter senescence shortly after the reproductive period, which, in the study region, generally coincides with periods of lower rainfall (at the end of spring and summer). The seeds remain in the soil until conditions are favorable for germination.

The areas where populations of this species occur are under increasing threat from degradation factors. In the rocky outcrops, the main threats to the maintenance of recorded populations are biological invasion by tough lovegrass (*Eragrostis plana* Nees) and natal grass (*Melinis repens* (Willd.) Zizka), which form dense clusters and compete with native plant species for light and other

resources. Another problem observed was trampling by cattle. In addition to our findings, other threats need to be considered for the IBR, such as the absence of a management plan, susceptibility to the occurrence of fires, and conflicts related to use in 12% of the area (Kormann 2022).

In the *blanqueales*, the main threats are the biological invasion by tough lovegrass (*E. plana*) and bermuda grass (*Cynodon dactylon* (L.) Pers) and the eventual occurrence of fires, especially in periods of lower rainfall or extreme drought, as recorded in the summer of 2022. This aspect alerts us to the possible loss of species related to global climate change. The intensification of climatic extremes is a reality, and in the Brazilian Pampa, it was expressed through the extreme drought experienced in the spring-summer periods of 2022 and 2023.

The records of *C. peduncularis* in protected areas highlight the importance of these areas for the maintenance of habitats (rocky outcrops and *blanqueales*), as well as the rare and endangered species associated with these environments. Our results show that *C. peduncularis* has disjunctive populations since the conservation units are located 170 km from each other and are associated with environments with very specific humidity regimes. Other records of the species in Rio Grande do Sul have also verified its presence in shallow soil environments on granitic and



Figure 2. Populations of *C. peduncularis* in halomorphic soils (*blanqueales*) in the Espinilho State Park (A) and rocky outcrops in the Ibirapuitã Biological Reserve (B), Rio Grande do Sul, Brazil.



periodically flooded rocky outcrops, in Guaíba (Consulted material: Matzenbacher NI, ICN 096446) and moist mossy fields on rocky outcrops, in Caçapava do Sul (Consulted material: Rabuske C. *et al.*, ICN 188167) (CRIA 2023). The restricted occurrence and habitat specificity of this species highlight the need for scientific research to support conservation and restoration measures of the habitats where this species occurs, and consequently, ensure the conservation of its populations.

The rocky outcrops and *blanqueales* have a high richness of endemic and endangered species, with specimens from the families Cactaceae, Bromeliaceae, Malvaceae, and Asteraceae, among other botanical families (Marchiori *et al.*, 2014; Carneiro *et al.*, 2016). The main threats to their conservation are biological invasion (Guido *et al.*, 2016), herbivory action by cattle (Curtis *et al.*, 2013), the occurrence of burning (Carneiro *et al.*, 2016), external pressures from crops (Mengue *et al.*, 2020), and the limited number of conservation units in the Pampa (Kormann 2022). In the specific case of *C. peduncularis*, the main threats that make it critically endangered in Brazil are habitat loss for real estate expansion, conversion of areas to agriculture and pasture, and loss of habitat quality (Martinelli *et al.*, 2013). In addition, the increased severity of droughts in southern Brazil in recent years due to climate change (Grimm *et al.*, 2020) may be a threat to the survival of the population of this species, mainly because of the disappearance of the humidity necessary for its permanence for long periods.

Based on the scenario observed in both protected areas studied and the conditions of the habitats where populations of the species have been recorded, below we list recommendations for its conservation:

1. Direct efforts to scientific work aiming to fill knowledge gaps on *C. peduncularis* in Brazil, identifying aspects of its ecology, geographic distribution, and habitats of occurrence;
2. Encourage good practices in cattle ranching activities, protecting habitats from herbivory by cattle in protected areas;
3. Adopt biological invasion control (e.g., selective chemical control, mulching techniques, or periodic mowing) to reduce habitat pressure and promote ecological restoration;
4. Prioritize the conservation and restoration of rocky outcrops and Park grassland, where the *blanqueales* are found, due to their fragility, and high richness of endemic and endangered species, to ensure the maintenance of populations of *C. peduncularis* and other native species associated with these environments;
5. Prepare informational material and disseminate the importance of conservation and restoration of these habitats for the conservation of *C. peduncularis*

and other endangered species to the public of the ESP and IBR and local community;

6. Encourage the exercise of citizen science as a means of increasing information about the occurrence of the species.

Acknowledgments

This work was part of FG post-doctorate carried out at the Federal University of Santa Maria, Graduate Program in Agricultural Engineering, developed in the Project “RestauraPampa: Recovery plan for degraded areas in conservation units of the Pampa biome”. We thank the Global Fund for the Environment for financing this project under the Strategies for Conservation, Restoration and Management Project for the biodiversity of the Caatinga, Pampa, and Pantanal, coordinated by the Ministry of the Environment, implemented by the Inter-American Development Bank and executed by the Brazilian Fund for Biodiversity. We also thank the State Secretariat for the Environment and Infrastructure, especially for the logistical support in conservation units.

Author's Contributions

Conceptualization and visualization: FG and GDF; Methodology: FG, GDF, PSS and APMR; Data curation, formal analysis, validation and writing – original draft: FG, GDF and PSS; Investigation: FG, JM, BBC, GDF, PSS and PJSF; Project administration, resources and supervision: APMR; Writing – review and editing: FG, GDF, PSS, BBC, JM, PJSF and APMR; Funding acquisition: APMR.

Conflicts of Interest

The authors declare no conflict of interest (personal, scientific, commercial, political, or financial).

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