



GOING BEYOND THE LIMITS OF CHAPADA DIAMANTINA: FIRST RECORD OF *Thelyschista ghillanyi* (ORCHIDACEAE: SPIRANTHINAE) IN THE ATLANTIC FOREST

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Abstract: *Thelyschista ghillanyi* (Orchidaceae) is a rare species hitherto endemic to *campos rupestres* (rocky fields) of Chapada Diamantina, in the state of Bahia, northeastern Brazil, within the phytogeographic domain of Caatinga. We report here the first record of *T. ghillanyi* in the Atlantic Forest and present an ecological niche model of the species under current and future (2041-2060) scenarios. We found approximately 15-20 individuals of *T. ghillanyi* in a shrubby restinga formation in Parque Municipal das Dunas, in the municipality of Salvador, Bahia, but this population is exposed to the risk of local suppression due to habitat destruction and stochastic events. The ideal conditions for the occurrence of *T. ghillanyi* include precipitation in the warmest quarter approximately 350 mm and elevation approximately 900 meters. Our results suggest that the species may have a wider distribution in the Atlantic Forest, which is not limited to the coast of Bahia.

Keywords: Bahia; ecological niche modeling; orchid; rare species; restinga.

Thelyschista Garay (Orchidaceae: Spiranthinae) is a monotypic genus represented by *Thelyschista ghillanyi* (Pabst) Garay, hitherto endemic to *campos rupestres* (rocky fields) of Chapada Diamantina, in the central region of the state of Bahia, northeastern Brazil, within the phytogeographic domain of Caatinga (IBGE 2024, van den Berg 2024). Chapada Diamantina is a set of mountains and plateaus located in the northern extension of Serra do

Espinhaço, covers 65,619 km², occupies more than 10% of Bahia's territorial area and stands out in terms of biodiversity, complexity of vegetation types and level of endemism of plant species (Gonçalves & Gonçalves 2023, Parra *et al.* 2023). *Thelyschista ghillanyi* is considered a rare species (van den Berg *et al.* 2009) and was previously assessed as Vulnerable due to its reduced Area of Occupancy, AOO hereafter, and the continuous decline in the quality of its

habitat due to several factors, such as the expansion of agriculture and the occurrence of fires (Menini Neto *et al.* 2013, MMA 2022).

Recently, during the development of the project “Orquídeas da Bahia: estudos ecológicos em remanescentes florestais e de restinga na região metropolitana de Salvador” (Orchids of Bahia: ecological studies in forest and restinga remnants in the metropolitan region of Salvador), we identified a small population of *T. ghillanyi* in an urban remnant of restinga (coastal vegetation) in the municipality of Salvador. We report here the first record of *T. ghillanyi* under the Atlantic Forest. We also performed ecological niche modeling of *T. ghillanyi* in current and future (2041–2060) scenarios to identify the main bioclimatic variables determining the distribution and potential new areas of occurrence of the species.

We collected coordinates and information on the occurrence of the species available in the electronic databases CRIA (2024), Gbif (2024), JABOT (2024) and Re flora (2024). We confirmed the identification of all specimens previously identified as *T. ghillanyi*, except for two specimens (R.M. Harley *et al.* H50303, HUEFS, and B.M.T. Walter *et al.* 4343, SP), which correspond to other species. Duplicate data were removed from the analyses. The conservation status of *T. ghillanyi* was reassessed according to the criteria of the IUCN (2012), based on the AOO and the Extent of Occurrence, EOO hereafter, obtained using the Geospatial Conservation Assessment Tool (GeoCAT) platform, considering a cell width of 2 km (Bachman *et al.* 2011). Two specimens of *T. ghillanyi* were collected manually and deposited at the herbarium ALCB (acronym according to Thiers (2024)) as voucher material. The plants were identified using the protologue of the species (Pabst 1977) and the study of Toscano de Britto & Cribb (2005).

The Maxent ecological niche model was used to analyze the current and future distributions due to its high accuracy, robustness (Ortega–Huerta & Peterson 2008, Liu *et al.* 2024) and excellent predictive ability compared with those of other algorithms, especially in scenarios with limited data and few records (Elith *et al.* 2006, Valavi *et al.* 2022), as is the case of *T. ghillanyi*. Bioclimatic factors of temperature, precipitation (variables Bio 1 to Bio 19) and elevation were obtained from the Worldclim platform (<https://www.worldclim.org/>) with a resolution of 10 m. The shapefile with the boundaries of Brazil was used for

spatial clipping of environmental variables and model projections. Environmental predictors with variance inflation factor (VIF) > 10 were excluded from the final model construction to avoid instability in model performance (Naimi & Araújo 2016). Among the 20 abiotic factors, four were used in the model execution: precipitation seasonality (Bio 15), precipitation of the wettest quarter (Bio 16), precipitation of the warmest quarter (Bio 18) and elevation. The Area Under the Curve (AUC) and True Skill Statistic (TSS) metrics were used to evaluate model performance, with calibration of 70% training points and 30% test points, with 20 optimizations per model, 1,000 replicates in each optimization and 10,000 background points (Phillips *et al.* 2009). Future climate data were based on the MIROC6 model (Model for Interdisciplinary Research on Climate version 6), which is one of the most commonly used models in niche modeling and allows the reduction of scale problems (Kataoka *et al.* 2020). We adopted the SSP1-2.6, SSP3-7.0 and SSP5-8.5 scenarios, corresponding to optimistic, intermediate and pessimistic social development paths, respectively, regarding global cooperation for efforts dedicated to climate change (Eyring *et al.* 2016, O’Neill *et al.* 2016). We converted the suitability maps into binary presence/absence maps using the Youden Index based on the ROC Curve as a threshold (Baddeley *et al.* 2021). All analyses were performed in R 4.3.0 (R Core Team 2024) using the packages “ggspatial”, “sdm”, “raster”, “terra” and “tidyverse” (Naimi & Araújo 2016, Dunnington *et al.* 2023, Wickham 2023, Hijmans *et al.* 2023, 2024). Maps were generated in QGIS software version 3.22.5.

Pabst (1977) described *T. ghillanyi* as *Odontorrhynchus ghillanyi*, and Garay (1982) transferred it to *Thelyschista* when the genus was established. *Thelyschista ghillanyi* is a terrestrial herb characterized by an inconspicuous stem; rosette-shaped, sessile, elliptical to oblong-lanceolate, membranaceous to succulent leaves; a terminal, racemose and pilose inflorescence; resupinate flowers; green, pilose sepals, oblique lateral sepals dilated at the base, forming a small mentum; alveolate petals, adherent to the dorsal sepal, with a reflexed apex and serrated margins; a trilobed, oblong, whitish lip, a reflexed terminal lobe with wavy margins; a stigma divided in 2; and a triangular rostellum (Toscano de Britto & Cribb 2005, Azevedo & van den Berg 2007, van den Berg 2024; Fig. 1).

The species was first collected in 1892 and has been systematically recorded since 1974. To date, slightly more than 50 specimens of *T. ghillanyi* have been deposited in herbaria, all of them from the municipalities of Abaíra, Andaraí, Lençóis, Mucugê, Palmeiras and Piatã in the region of Chapada Diamantina (CRIA 2024, JABOT 2024). The specimens from Salvador were collected in October 2022 (T.S. Sousa 52, ALCB 145549) and October 2024 (T.S. Sousa 70, ALCB 151103) and are the most recent records of *T. ghillanyi*. We found approximately 15-20 individuals occurring as terrestrial plants under the shade of a clump of bushes in an area of just a few square meters in a shrubby restinga formation in Parque Municipal das Dunas (12° 54'S and 38° 19'W). They were found in a location approximately 320 km east of the nearest locality where the species was previously recorded. Thus, the EOO of *T. ghillanyi* has expanded by more than 500% (from 3,777.595 km² to 21,621.653 km²), and the AOO has increased from 72 km² to 76 km². Nonetheless, this scenario leads us to suggest maintaining the conservation status of the species as vulnerable because although the EOO is > 20,000 Km², the AOO is still small (<

500 Km²) and the threats to *T. ghillanyi* in Chapada Diamantina are persistent. Furthermore, the species is not protected in the new locality in Salvador. This newly found population of *T. ghillanyi* is subjected to the risk of local extinction due to habitat destruction, which is related mainly to urban growth and real-estate speculation, as well as stochastic events. This disjunct distribution in *campos rupestres* of the Serra do Espinhaço and in restingas of the Atlantic Forest recorded here for *T. ghillanyi* has also been reported for several other species (Giulietti & Pirani 1998, Alves *et al.* 2007), including the orchid *Prescottia leptostachya* Lindl. (Barberena *et al.* 2021).

High AUC and TSS values, 0.92 and 0.82, respectively, were found in the MaxEnt Model, indicating high reliability and accuracy of the data (Allouche *et al.* 2006, Ray *et al.* 2016). The most important bioclimatic variable was the precipitation of the warmest quarter (47.2%), followed by elevation (27.6%), precipitation of the wettest quarter (26.1%) and precipitation seasonality (17.7%). Thus, the suitable range for the occurrence of *T. ghillanyi* includes precipitation in the warmest quarter approximately 350 mm, high altitudes,

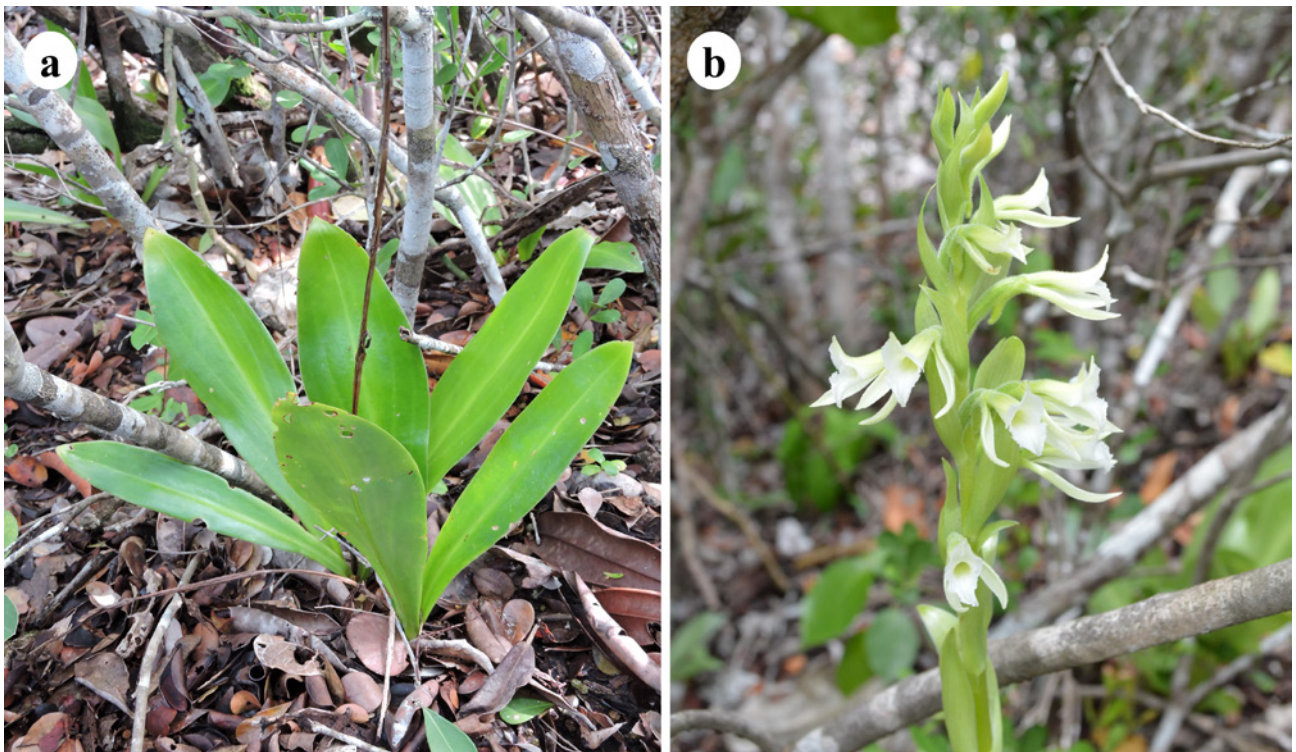


Figure 1. *Thelyschista ghillanyi* (Pabst) Garay. A. Habitat in the municipality of Salvador, state of Bahia, Brazil. B. Inflorescence (T.S. Sousa 70, ALCB 151103). Photographs by Felipe Fajardo Villela Antolin Barberena (a) and Tainan da Silva Sousa (b).

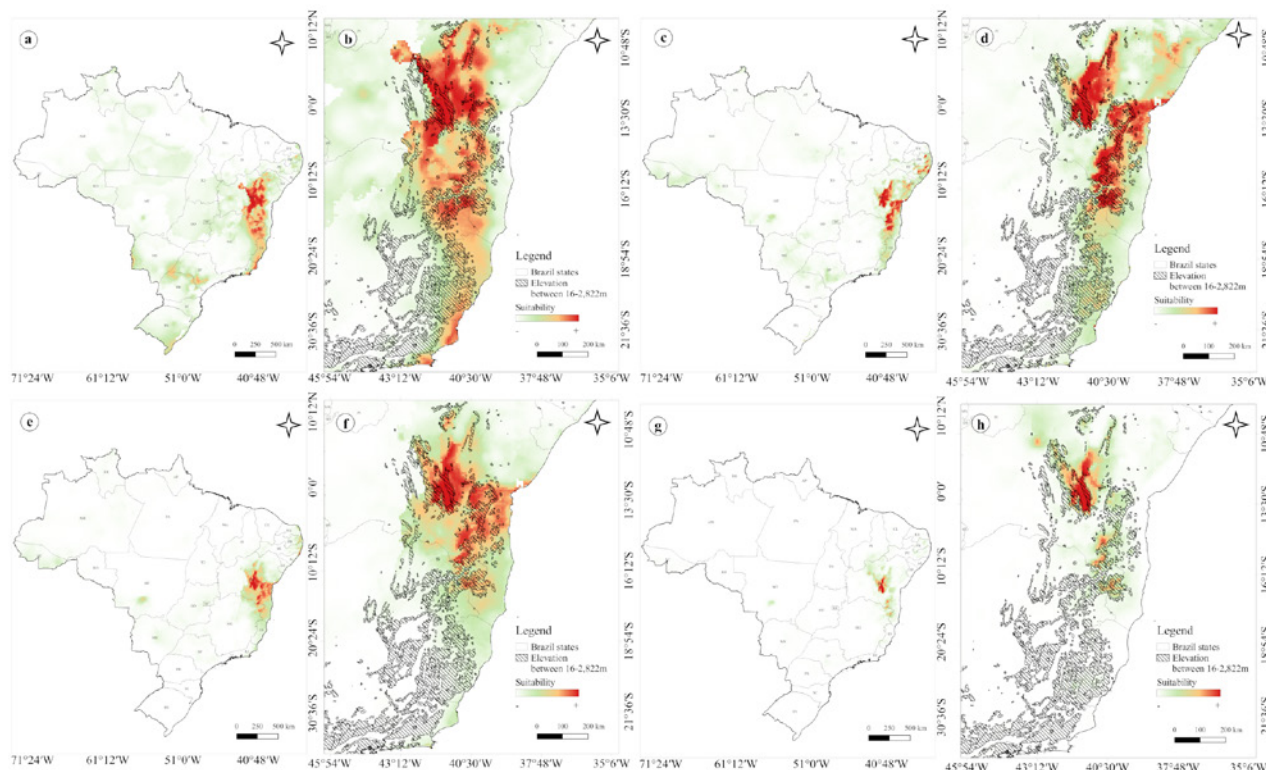


Figure 2. Ecological niche modeling of *Thelyschista ghillanyi* (Pabst) Garay under current (a-b) and future (2041-2060) scenarios in Brazil, considering the optimistic (c-d), intermediate (e-f) and pessimistic (g-h) scenarios. Maps produced by Ana Laura da Silva Luz.

approximately 900 meters, precipitation in the wettest quarter ≥ 400 mm, and a precipitation coefficient ≥ 50 .

The ecological niche model of *T. ghillanyi* for the current scenario indicated high suitability of distribution not only in Chapada Diamantina (Serra do Sincorá, Serra da Jacobina, Serra da Jibóia, Serra da Mangabeira and Serra do Tombador) and areas of Cerrado in Bahia (Serra do Angelim) but also in mountainous areas of the Atlantic Forest in the states of Espírito Santo (Serra do Caparaó), Minas Gerais (Serra do Caparaó and Serra do Chifre) and Rio de Janeiro (Fig. 2), with an area of 233,321.076 km² (Fig. 3).

The above results suggest that *T. ghillanyi* may have a wider distribution in the Atlantic Forest, which is not limited to the coast of Bahia. Compared with the current scenario, there was a tendency for a loss of suitability areas in the future of approximately 44%, 63% and 89% in the optimistic, intermediate and pessimistic scenarios, respectively. Furthermore, there was a change in potentially suitable habitats for the states of Paraíba, Pernambuco, Alagoas and Sergipe in the optimistic and intermediate

scenarios, which are predicted to disappear in the pessimistic scenario. Therefore, potentially suitable areas in Southeast and Northeast Brazil will tend to become unsuitable for the occurrence of *T. ghillanyi* in the next 17-36 years if the predictions hold and the species will become strictly endemic to Chapada da Diamantina (Fig. 2). Potential future losses of suitable habitat and even more pronounced habitat restrictions have been reported for another orchid, *Prosthechea jauana* (Carnevali & I. Ramírez) W.E. Higgins (Orchidaceae), revealing the importance of protecting refuge areas for species that are more susceptible to climate change (Vieira *et al.* 2024). Therefore, we encourage field expeditions to the potential occurrence areas of *T. ghillanyi* revealed here and recommend monitoring and conservation efforts for presently known populations so that extinction threat level of the species does not increase.

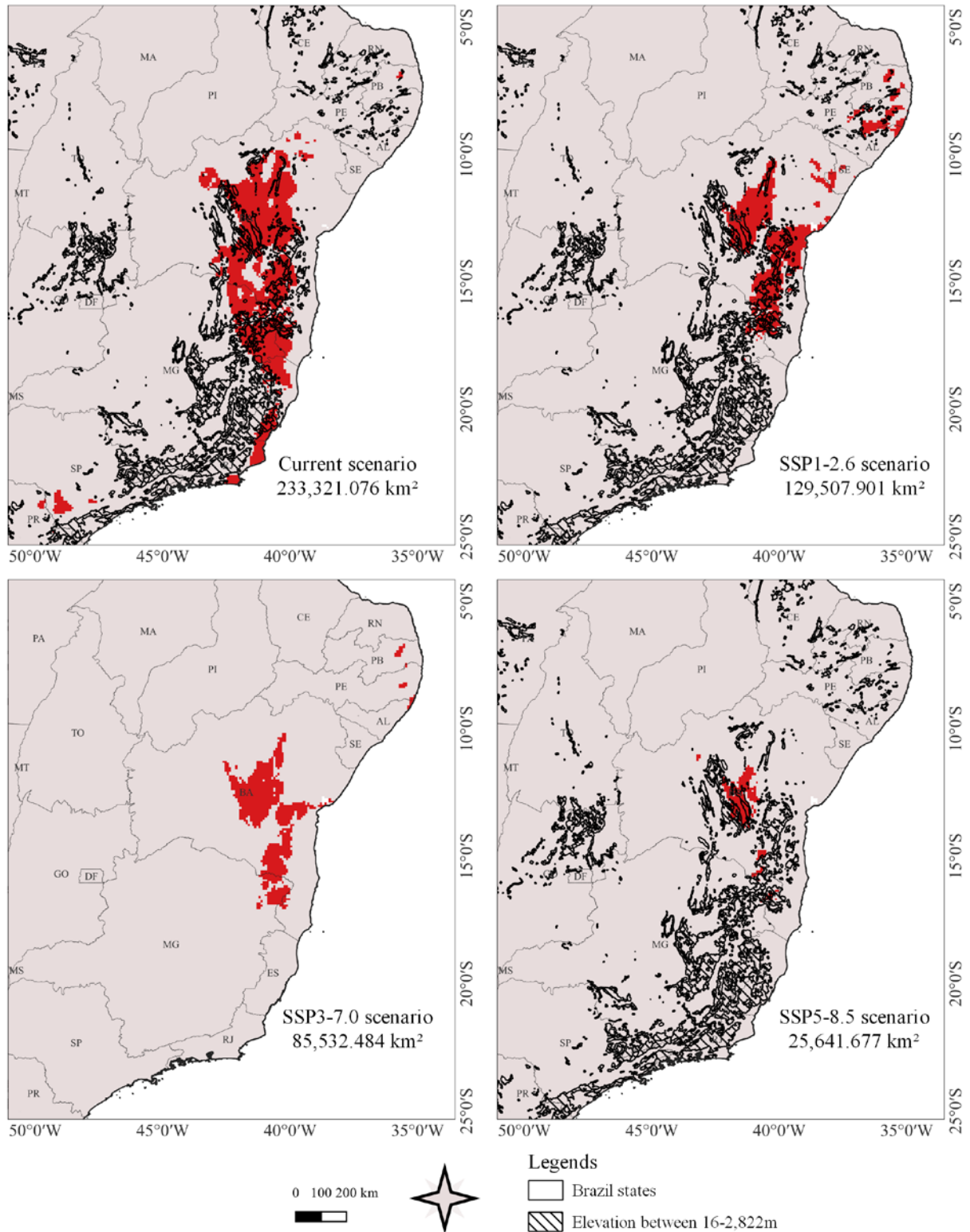


Figure 3. Binary maps of the ecological niche modeling of *Thelyschista ghillanyi* (Pabst) Garay under current (a) and future (2041-2060) scenarios in Brazil, considering the optimistic (b), intermediate (c) and pessimistic (d) scenarios. Maps produced by Ana Laura da Silva Luz.

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