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# Short Communication
# The ghost of climatic change in the geographic distribution of *Tillandsia aeranthos* (Bromeliaceae)

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**Abstract**
The geographic distribution of *Tillandsia aeranthos* is updated with new records. Its southern limit is extended 200 kilometers in a zone previously studied by many botanists and naturalists, but also in poorly explored areas. For this reason, the possibility that the change in distribution is recent is postulated and discussed. The coincidence of this change with the southward shift in the isohyets and the decrease of winter frost frequency are highlighted as a possible cause of the advance to the south. In addition, two petal color variants of this species are first mentioned for Argentina. The new findings display that it is necessary to further explore some dry forests of eastern Buenos Aires and study the possible consequences of the climatic change in the biota of South America.
**Key words**: climatic change, conservation, flower color variants, ornamental Bromeliaceae, Pampas, xerophytic forest.

**Resumen**
Se actualiza la distribución geográfica de *Tillandsia aeranthos* con nuevos registros. Su límite austral se extiende 200 kilómetros en una zona previamente estudiada por numerosos botánicos y naturalistas, pero también en áreas poco exploradas. Por esta razón, se postula y discute la posibilidad de que el cambio en la distribución sea reciente. Se remarca la coincidencia entre este cambio con el corrimiento de las isohietas y el descenso en la frecuencia de heladas invernales como una posible causa del avance hacia el sur. Adicionalmente, dos variantes de color de flor de esta especie son mencionadas por primera vez para Argentina. Los nuevos hallazgos muestran que es necesario explorar con más énfasis algunos bosques secos del este de Buenos Aires y estudiar las posibles consecuencias del cambio climático en la biota de Sudamérica.
**Palavras-chave**: cambio climático, conservación, variantes de color de flor, Bromeliaceae ornamentales, Pampa, bosques xerófilos.

Climatic change is considered as one of the mayor drivers of species' distribution shifts worldwide, producing area expansions or retractions and leading to deep changes in ecosystem properties (McCarty 2001; Walther *et al*. 2002; Parmesan 2006; Walther 2010; Hickling *et al.* 2006; García Molinos *et al.* 2018). The consequences of these processes on the biota were mainly studied in the northern hemisphere (Parmesan 2006). However, in the last decade there was an increase in works about climatic change and its ecological consequences in South America. Several publications focused on how some species' distributions may change facing future climate scenarios (*e.g.*, Nori *et al.* 2014; Medone *et al.* 2015; Ferretti *et al*. 2018; Silva Vieira *et al*. 2018; Silva *et al.* 2018), while others showed

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that range shifts of numerous species in the past century were probably a consequence of climate changes (*e.g.*, Serrentino *et al.* 2014; Guerrero & Agnolin 2016).

In eastern Buenos Aires province, Argentina, an increase in average rainfall amounts since 1960 shifted the isohyets an average distance of 100 km towards the south and west (Sierra *et al.* 1994; Berbery *et al.* 2006; Barros *et al.* 2015; Fig. 1), and the mean annual temperature increased about 0.5 ºC, so that the isotherms shifted 50 km southwards (Barros *et al.* 2015). Additionally, winter frost frequency decreased in some parts of the territory (Fernández Long & Müller 2006). A poleward shift in species distribution was found in 44 species of plants, 33 butterflies, 25 birds, eight arachnids, three mammals, and three turtles, coinciding with the direction that would be expected if these changes were climate-driven (Guerrero & Agnolin 2016; Delaloye 2017). Around 74% of the above-mentioned plant species showed a shift of about the same magnitude of the isohyet and isotherm displacements (Guerrero & Cellini 2017). Such changes were also reported for the tetrapod fauna of eastern Uruguay, where similar modifications in precipitation and temperature mean values were measured. The mean annual rainfall increase during the last century in this country had probably enabled the mammals *Cabassous tatouay* and

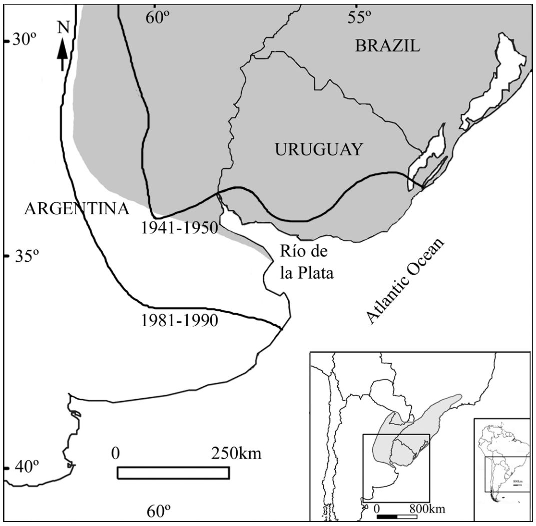


**Figure 1** – Map showing the study area and the shift of the 1,000 mm isohyet between the 1940-1950 and 1981-1990 decades (modified from Sierra *et al.* 1994). In gray, approximate south limit of distribution of *Tillandsia aeranthos*.

*Tamandua tetradactyla*, the crocodilian *Caiman latirostris* and the amphibian *Scinax uruguayanus* to colonize southern areas (Serrentino *et al.* 2014; Villalba *et al.* 2018). Other striking findings in the Pampean plains and surrounding areas were also found to be climate driven range shifts, such as the presence of the mammals *Dasypus novemcinctus* (Zamorano & Scillato-Yané 2008) and *Hydrochoerus hydrochaeris* (Doumecq-Milieu *et al.* 2012) in southern Buenos Aires province, the opossum *Didelphis albiventris* in northern Patagonia (Carrera & Udrizar Sauthier 2014), some insects in southeastern Buenos Aires (Farina 2006), the monkey *Alouatta caraya* in northern Uruguay (Prigioni *et al.* 2018), and some birds in Rio Grande do Sul (Franz *et al*. 2018).

Bromeliaceae, the "pineapple" family, is a characteristic family of the Neotropical Region (Cabrera & Willink 1973), with only a few species in temperate Chile (Zizka *et al.* 2009) and one in the Guinea region of western Africa (Porembski & Barthlott 1999). *Tillandsia* L. is its most species-rich genus, with at least 623 (Barfuss *et al*. 2016) or as much as 747 species (Gouda *et al.* continuously updated). *Tillandsia aeranthos* (Loisel.) L.B.Sm. is an epiphytic species (Fig. 2a), and occasionally epipetric species (Wanderley & Martins 2007; Melo & Waechter 2018), which usually presents bright pink bracts and sepals and deep blue corolla (Fig. 2b). These beautiful colors combined with easy cultivation, turned this species into a popular ornamental plant for growers and gardeners around the world (Oeser 1965; Reitz 1983; Reilly 2004), as many other bromeliads. It is also the most popular epiphytic species grown in gardens of Argentina (Mongiello & Otero 2017).

The native distribution area of *Tillandsia aeranthos* ranges from São Paulo (Brazil) to the Río de la Plata region (Uruguay-Argentina) and from the Atlantic seashore to the Humid Chaco (Paraguay-Argentina) (Smith & Downs 1977; Wanderley & Martins 2007). According to the biogeographical scheme of Cabrera & Willink (1973) the occurrence of *Tillandsia aeranthos* encompasses the Paranaean, Atlantic, Espinal, Chaco, and Pampean provinces, occurring from moist forests of the Paranean province to thorn woodlands of the Espinal province and gallery forests of the Pampean province.

In Brazil, *Tillandsia aeranthos* was found in São Paulo, Santa Catarina and Rio Grande do Sul (Reitz 1983; Wanderley & Martins 2007; Forzza *et al.* 2015); in Paraguay there are few records in the eastern part of the country (Smith

& Downs 1977); the species occurs throughout Uruguay (Smith 1972); in Argentina the species was mentioned for the more northern provinces Corrientes, Chaco, Misiones, Entre Ríos, Santa Fe and Buenos Aires (Schinini *et al.* 2008). Several citations for Catamarca, Jujuy, Salta, Santiago del Estero, Tucumán, and Córdoba (Schinini *et al.* 2008), were not proved with any specimen. The southern limit of this species was the gallery forest of the Río de la Plata, at 35º south latitude (Smith & Downs 1977; Cabrera 1968; Fig. 1). It is one of the species of the subgenus *Anoplophytum* that reaches the highest latitudes, together with *T. bergeri.*

During fieldworks in some sites of the Pampean biogeographical province, I found new records of *Tillandsia aeranthos* which enlarge considerably its distributional range to the south. Therefore, the main objective of this work is to update the distribution of this species using these records and herbarium specimens, and to discuss the possibility that the geographic expansion of the species is recent and climate related.

**Figure 2** – a-e. *Tillandsia aeranthos* – a. in habitat, on *Celtis tala* forest in Laguna La Escondida, Dolores; b. detail of a typical *T. aeranthos* flower; c. a view of a *Celtis tala* forest from eastern Buenos Aires province; d. *T. aeranthos* flower color variation with white petals; e. *T. aeranthos* flower color variation with pink petals.

Fieldtrips were conducted to several localities of Buenos Aires province, aiming to collect specimens of *Tillandsia aeranthos*. Most sites are xerophytic forests dominated by *Celtis tala* Gillies *ex* Planch. (Cannabaceae), locally known as "talares" (Fig. 2c).

The acronyms of the revised herbaria agree with Thiers (continuously updated). Dried specimens of *Tillandsia aeranthos* from the Museo de La Plata (LP) and the Museo Argentino de Ciencias Naturales (BA) herbaria were studied. Besides these dried samples, fifty living specimens from different locations of the study area were used for comparison.

Several varieties of *T. aeranthos* were described from southern Brazil (Strehl 2000, 2004; Strehl & Rohde 1998). All the non-typical varieties inhabit forests and urban sites in Rio Grande do Sul state (Martinelli *et al.* 2008; Varella 2011; Gouda *et al.* continuously updated). The taxonomy of these infra-specific taxa is still debatable, so, in accordance with Schinini *et al*. (2008) and BFG (2018), the flower color variations of *T. aeranthos* were not considered as valid taxonomic units in this work to avoid confusion.

The following new records of *Tillandsia aeranthos* extend the distribution range 200 km to the south (Fig. 3). The southernmost collection sites are Villa Gesell and the *Celtis tala* forests of General Madariaga, and it is also a common epiphyte in Dolores and Chascomús districts occurring on the same phorophyte.

**Examined material**: ARGENTINA. BUENOS AIRES: Vieytes, Ruta 36, Magdalena, 26.X.2004, *S. Torres Robles 1718* (LP); Chascomús (35°34.731'S, 58°0.840'W), epiphyte on many trees of the park and streets, 29.VIII.2018, *E.L. Guerrero 725* (LP); Talar de Estancia Rincón de López, 13.X.2002, *S. Torres Robles 897* (LP); 27.X.2004, *S. Torres Robles 1892* (LP); Loma de la Reducción, Castelli, *Calcagno* (coll.) (LP); Reserva Natural Laguna Salada Grande, 28.X.2004, *S. Torres Robles 1834* (LP); Villa Gesell (37°15.016'S, 56°57.849'W), epiphyte on *Pinus* sp. 2.5 m high, 29.VII.2017, *E.L. Guerrero 696* (LP); Paisaje Protegido Arroyo El Pescado, La Plata, on *Celtis tala*, 26.X.2015, *E.L. Guerrero 568* (LP); 26.X.2015, *E.L. Guerrero 569* (LP); Divisadero Station, General Madariaga, on Celtis tala, 3.I.2020, *E.L. Guerrero 798* (LP); road to Juancho, General Madariaga, on Celtis tala, 4.I.2020, *E.L. Guerrero 800* (LP).

**Additional examined material**: ARGENTINA, BUENOS AIRES: San Pedro, Refugio Histórico y Natural "Vuelta de Obligado", 28.X.2003, *S. Torres Robles 1574* (LP); X.2004, *S. Torres Robles 2284* (LP). Baradero, Estancia Los Álamos, Fundación Figueroa Salas, 27.X.2003, *S. Torres Robles 1428* (LP). Campana, Reserva Natural Estricta Otamendi, 1.XI.2004, *S. Torres Robles 2065* (LP); Otamendi, 23.X.1976, *Fernández Viloso* (BA). Isla Martín García, 30.X.2004, *S. Torres Robles 2016* (LP); XI.1950, *A. Castellanos* (BA); 12.X.1921, *A. Castellanos* (BA); 26.X.1948, *W. Partridge* (BA). Ramallo, Estancia Cuini, 29.X.2003, *S. Torres Robles 1637* (LP). San Isidro, 21.X.1928, *R.L. Pérez Moreau* (BA); XI.1924, *A. Castellanos* (BA); Barracas al Sud [old name for Avellaneda], 08.XI.1902, *S. Venturi 237* (BA). Quilmes, IX.1914, *A. Orlando* (LP); Bernal, 02.IV.2015, *E.L. Guerrero 531* (LP); 28.XII.2015, *E.L. Guerrero 582* (LP). La Plata, Parque Ecológico, 20.IX.1995, *G. Delucchi 1024* (LP); talar del Arroyo el Pescado, cerca de Villa Garibaldi, 20.XII.2015, *E.L. Guerrero 574* (LP); cerca de Villa Garibaldi, 20.XII.2015, *E.L. Guerrero 575* (LP); 20.XII.2015, *E.L. Guerrero 576* (LP); Ensenada, Punta Lara, 30.X.1932, *A.L. Cabrera 2436* (LP); 01.XI.1929, *A. Castellanos* (BA); 01.VI.1929, *R.L. Pérez Moreau* (BA); Ensenada, *C.L. Spegazzini 201* (LP). Berisso, Los Talas, 16.X.1932, *A.L. Cabrera 2358* (LP). San Nicolás, 12.X.1941, *A.L. Cabrera 7187* (LP). ENTRE RÍOS: Villaguay, Arroyo Villaguay, puente Urquiza viejo, 17.X.1981, *O. Bottino 7* (LP). SANTA FE: Rosario, Arroyo Frías, 06.X.1929, *A.L. Cabrera 921* (LP). URUGUAY. COLONIA: Riachuelo, 11.X.1936, *A.L. Cabrera 3824* (LP); X.1949, *H. Fabris 67* (LP).

The species was also observed in the following sites: Bahía de Samborombón, Chascomús district, on *Celtis tala*; Laguna Monasterio, Chascomús district, on *Celtis tala* forest; Santa Teresita, La Costa district, on *Pinus*

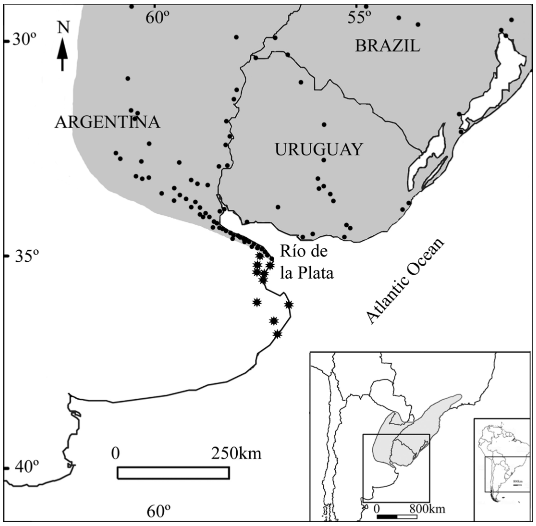


**Figure 3** – Map showing the new records of *Tillandsia aeranthos* (stars). Points: previous records. In gray: approximate south limit of distribution of the species.

sp.; and Laguna La Escondida, Dolores district, on *Celtis tala* forests (Fig. 2a).

Some *Tillandsia* specimens with pink or white petals, and pink bracts were found on *Celtis tala* in an isolated forest over the small cliff that limits the floodplain to the north side of the El Pescado Creek (34°59,854'S, 57°49,092'W). Some specimens bear pink floral bracts and pink petals (*e.g.*, Guerrero 569; Fig. 2e), while others have white petals (*e.g.*, Guerrero 568; Fig. 2d). These white-petal specimens have also longer petals than the typical *T. aeranthos* (2.66–2.8 *vs* 1.7–2.7) and longer floral bracts. Using the species keys (Cabrera 1968; Smith 1970; Smith & Downs 1977) these specimens seemed to fall into *T. bergeri* based on the distinctive flower color. However, the filament plication, and the length of petals and anthers agree with those of *T. aeranthos.* These are the first records of flower color variations of *Tillandsia aeranthos* in Argentina.

The new occurrence records of *Tillandsia aeranthos* may indicate that the species follows the *Celtis tala* forests from the Río de la Plata to General Madariaga, but it may range farther to the south in these forests that, according to Parodi (1940), extend to 37º55'S. As cultivated trees in parks and streets are well suitable for this species, it may be expanding from the native forests to cities and tree plantations, as seen in La Costa district and in Villa Gesell.

Taking into account that the east part of Buenos Aires province was studied by many botanists during the last century (*e.g.*, Cabrera 1936, 1941, 1963–1970; Vervoorst 1967; Frangi 1975; Faggi & Cagnoni 1991), it is quite noteworthy why this ornamental bromeliad was not detected previously. It seems unlikely that this plant passed unadvertised by so many botanists. Two other possible explanations are: 1) the plants inhabited isolated unexplored forests and expanded to rural areas and cities in the last decades; 2) the species advanced to the south in recent years following climate warming.

It might be questionable to propose a climate change-related expansion since there are still unexplored forests in Buenos Aires (i.e., isolated forests in La Postrera, El Tordillo, General Lavalle, etc.). We have scarce (or none) collections in herbaria or other museum repositories from these forest sites of eastern Buenos Aires. There are many works reporting new findings of bromeliads in poorly explored regions in south Brazil and northern Argentina (*e.g.*, Magalhaes *et al.* 2014; Miyamoto & Tardivo 2014; Büneker *et al.* 2015; Lima & Soares-Silva 2016; Guarçoni *et al.* 2018). However, the southern localities here reported, and their surroundings were explored in detail by the botanist A.L. Cabrera (Cabrera 1936, 1941), and he didn't collect neither mentioned *Tillandsia aeranthos.* Furthermore, Parodi (1940) didn't mention this species when he addressed the forest composition of the talares between General Madariaga and Villa Gesell (the southern sites presented in this contribution), but remarked the presence of an epiphytic *Blechnum* sp., showing that he paid attention to the epiphytic plants. This can tilt the balance towards the idea of a consequence of climate change.

An emblematic case in the same area is the range expansion of the butterfly *Morpho catenarius* which was well documented by J. Farina (2006). The feeding plant of the larvae (analogue of the phorophyte for *T. aeranthos*) is *Scutia buxifolia*, a tree that grows in the region since centuries (Delucchi & Charra 2012), and so Farina (2006) proposed that the expansion of the butterfly should be related to the loss of a barrier, probably a climatic one. Most of the ecological conditions that *Morpho catenarius* or *Tillandsia aeranthos* needed to colonize the southern *Celtis tala* forests already existed in the area before their arrival for both (i.e., forest vegetation, vertical structure, absence of competitors, low density of predators/herbivores, etc.). But only in the last decades both species apparently advanced to the south, coinciding with the shift of the isohyets (see Sierra *et al.* 1994; Sierra & Pérez 2006; Berbery *et al*. 2006). A similar case probably took place with the expansion of another butterfly, *Theochila maenacte maenacte*, which advanced 300 km to the south in the area in recent years (Nuñez Bustos 2016). Even more, the talares and some birds that feed and nest on them (*Cyanocompsa brissonii*, *Icterus cayanensis*, *Lepidocolaptes angustirostris*, *pachyramphus polychopterus* and *Paroaria capitata*) extended to the south in about 100 km (Chimento *et al.* 2012). This shift is possibly related to human modifications in the landscape, because these birds use groves to rest and then disperse the *Celtis tala* seeds (Chimento *et al.* 2012), but also to the climatic changes that allowed these birds to breed and nest in southern sites. A similar case is discussed in Apodaca & Guerrero (2019) for the expansion of *Tillandsia recurvata* in Buenos Aires province, which was frequently observed within implanted groves instead of natural environments.

Wetland species from north and northeast Buenos Aires province, such as trees (*e.g.*, *Enterolobium contortisiliquum*), bushes (*e.g.*, *Mimosa pigra*), herbs (*e.g.*, *Doryopteris pentagona*), climbers (*e.g.*, *Araujia angustifolia*) and epiphytes (*e.g.*, *Pleopeltis pleopeltifolia*), and many animals like birds (*e.g.*, *Anhinga anhinga*), mammals (*e.g.*, *Cerdocyon thous*), reptiles (*e.g.*, *Phrynops hilarii*), spiders (*e.g.*, *Nephila clavipes*), harvestmen (*e.g.*, *Metalibitia argentina*) and butterflies (*e.g.*, *Hamadryas februa*), were also possibly favored by the observed increase of rainfall in the area (Guerrero & Agnolin 2016; Guerrero & Cellini 2016). In the same way, some species that require forested physiognomies (*e.g.*, Chacoan birds, insects, and *Tillandsia aeranthos*) may be advancing to the south across the xerophytic forests, colonizing new areas of eastern Buenos Aires as humidity and temperature increase.

The possibility of a range expansion related to a climatic change must be considered for *Tillandsia aeranthos.* The new findings indicate the importance to study the possible consequences of the climatic change in the biota of South America. The new records of *T. aeranthos* also show that some of the eastern Buenos Aires xerophytic forests must receive more attention from a biodiversity conservation standpoint.

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