

Tradescantia crassula (Commelinaceae) naturalised outside the Americas: first records of the species in Taiwan

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ABSTRACT – We present here the first records of *Tradescantia crassula* Link & Otto outside the Americas, due to the discovery of populations of the species in Taiwan, on Formosa Island. The species is native to northeastern Argentina, southern Brazil, Paraguay and Uruguay, and is naturalised in Arkansas state, southeastern USA. It is not known how the species was introduced to Taiwan. We also provide an identification key to the four species of *Tradescantia* that occur in Taiwan.

Keywords: Asia, distribution extension, identification key

RESUMO – *Tradescantia crassula* (Comelinaceae) naturalizada fora das Américas: primeiros registros da espécie em Taiwan. Apresentamos aqui os primeiros registros de *Tradescantia crassula* Link & Otto fora das Américas, devido à descoberta de populações da espécie em Taiwan, na Ilha Formosa. Essa espécie é nativa no nordeste da Argentina, sul do Brasil, Paraguai e Uruguai, e é naturalizada no estado do Arkansas, sudeste dos EUA. Não é conhecida a forma como decorreu a introdução da espécie em Taiwan. Nós também fornecemos uma chave de identificação para as quatro espécies de *Tradescantia* que ocorrem em Taiwan.

Palavras-chave: Ásia, chave de identificação, expansão de distribuição

INTRODUCTION

Tradescantia L. (Comelinaceae Mirb., tribe Tradescantieae Meisn.) is a genus comprising ca. 70 species, all native to the American continent (Hunt 1975, 1980, 1986, Barreto 1997, Faden 1998, 2000, Hong & DeFilipps 2000, Turner 2006, Funez *et al.* 2016). The genus has a complex floral morphology (Ochiai *et al.* 2004, Panigo *et al.* 2011, Hertweck & Pires 2014) and nomenclature (see *e.g.* Hassemer *et al.* 2017a, Hassemer & Büneker 2018), and taxonomic discoveries are still being made (Funez *et al.* 2016, Büneker *et al.* 2017, Hassemer *et al.* 2017b).

Some species of *Tradescantia* were introduced to and became naturalised in areas where they are not native, such as *T. fluminensis* Vell., *T. pallida* (Rose) D.R.Hunt (= *Setcreasea purpurea* Boom), *T. spathacea* Sw. (= *Rhoeo discolor* (L'Hér.) Hance *ex* Walp.) and *T. zebrina* hort. *ex* Bosse (= *Zebrina pendula* Schnizl.). A number of species of Comelinaceae were recently reported as naturalised in Taiwan: *T. fluminensis* (Yang *et al.* 2008), *Callisia fragrans* (Lindl.) Woodson (Wang & Chen 2008) and *C. repens* (Jacq.) L. (Tseng *et al.* 2010). In this work we present the first records of *T. crassula* Link & Otto outside the

Americas, due to the discovery of populations of the species in Taiwan, on Formosa Island. This discovery was made in the context of the continuous monitoring of the non-native plant species occurring in the Yangmingshan National Park, in northern Taiwan. The species is native to South America, and is known to be naturalised in Arkansas state, southeastern USA (Sundell *et al.* 1999). We also provide an identification key to the four species of *Tradescantia* that occur in Taiwan, in order to facilitate the identification of these species.

MATERIAL AND METHODS

We studied specimens of *Tradescantia* kept at ASE, B, C, EFC, FI, FLOR, FT, FURB, GB, HAST, HBR, HUFJSJ, K, MA, MBM, P, TAI, TAIF, UPCB and UPS, and images of specimens kept at CEN, CVRD, EAC, ESA, F, FCAB, GH, HUEFS, INPA, MO, NY, RB, RON, SP, UB, UEC, UFRN, US, VIES and WU (acronyms according to Thiers 2019). The conservation status of *T. crassula* was assessed following the International Union for Conservation of Nature (2012, 2017) criteria. For the elaboration of the distribution maps, we used ArcGIS v.10 (ESRI, Inc.),

while the orthoimages were provided by the Yangmingshan National Park.

In order to investigate the populations of *T. crassula* and *T. fluminensis* in the Yangmingshan National Park we set up ten transects, totalling 58.5 km in length. For each population, the area of occupancy was measured with a measuring tape. It was not possible to count the number of individuals of both species because the stems are entwined within a population; for this reason we investigated the area of occupancy of each population, rather than the number of individuals. At the centre point of each population, the geographical coordinates and the elevation above sea level were recorded using a handy GPS receiver, and an image of the canopy was taken using a fish-eye lens. The coordinates were then used to calculate the distance between the population and the closest developed (*i.e.* anthropised) area. The canopy images were used to calculate the coverage in Gap Light Analyzer software (Simon Fraser University, Cary Institute of Ecosystem Studies). Soil pH was averaged over ten random sites in the population. Stone to soil rate was estimated by visual observation.

RESULTS AND DISCUSSION

Tradescantia crassula Link & Otto, Icon. Pl. Rar.: 13–14, t. 7. 1828.

Lectotype (designated by Funez *et al.* 2016: 71): [illustration] Plate 7 in Link & Otto (1828).

Epitype (designated by Funez *et al.* 2016: 71): BRAZIL. RIO GRANDE DO SUL, XI–XII.1825, *F. Sello* 3033 (Barcode B100521014!).

Description: Herbs up to 45 cm tall, terrestrial, rupicolous or epiphytes. Stems erect, succulent, green, glabrous, generally poorly branching. Leaves distichously or spirally-alternate, sessile; ptyxis convolute; sheaths 0.8–2.1 cm long, light green, glabrous, margin ciliate, hairs hyaline; blades 4.0–12.0 × 1.5–2.7 cm, elliptic to ovate to lanceolate, succulent, glabrous on both faces, margin slightly revolute; apex acute to obtuse, rarely acuminate; midvein not conspicuously distinct from the secondary veins; secondary veins on both faces not impressed, rather inconspicuous. Inflorescences in the distal portion of the stems, 1 per leaf axis, consisting of a pedunculate double-cincinni, 9–20-flowered; peduncles 1.0–3.5 cm long, green, glabrous; peduncle bracts absent; supernumerary bracts absent; cincinni bracts 1.0–3.7 × 0.8–2.0 cm, leaf-like, generally equal (or almost so) in size, rarely unequal or reduced, ovate, glabrous, green, base cordate to obtuse, not saccate, slightly revolute, apex acute. Flowers 0.8–1.3 cm wide, pedicels 0.6–1.6 cm long, green, glabrous; floral buds broadly ovoid; sepals 4.5–7.4 × 2.8–4.3 mm, dorsally keeled, green, setose, with long hyaline hairs along the keel; petals 6.2–7.2 × 4.6–5.3 mm, flat, white; filaments 5.0–6.5 mm long; anthers 0.6–0.8 × 1.0–1.3 mm; ovary

1.7–2.0 × 1.5–1.7 mm, style 4.1–5.1 mm long; pistil longer than the stamens. Fruits not seen from Taiwanese material.

Etymology: The specific epithet refers to the fleshy aspect of the stems and leaves of the species.

Illustrations: Plate 7 in Link & Otto (1828)—also available in Fig. 1 in Hassemer *et al.* (2017a); Plate 2935 in Curtis & Hooker (1829); Plate 1560 in Loddiges (1829).

Photographs of living specimens: Fig. 1 (specimens from Taiwan); Fig. 6 in Funez *et al.* (2016) (specimens from Brazil).

Photographs of herbarium specimens: Fig. 2 (specimen from Taiwan); Fig. 5 in Funez *et al.* (2016) (the epitype).



Figs. 1A–D. *Tradescantia crassula* in Taiwan. **A.** Overview of a population; **B.** Flowering specimens; **C.** Inflorescence; **D.** Detail of flower. Photographs by Mong-Huai Su. Scale bars: **C** = 1 cm; **D** = 2 mm.



Fig. 2. Herbarium specimen of *Tradescantia crassula* from Taiwan (M.-H. Su 724, TAIF).

Distribution: *Tradescantia crassula* is native to northeastern Argentina (Misiones province), southern Brazil (Minas Gerais, Paraná, Rio Grande do Sul, Santa Catarina and São Paulo states), Paraguay (Paraguari department) and Uruguay. The species is also recorded as naturalised in Arkansas state, southeastern USA (Sundell *et al.* 1999). In this work we confirm its naturalised distribution in Taiwan (Fig. 3), which is the first record of the naturalised occurrence of the species outside the Americas.

Conservation status: Least Concern (LC). *Tradescantia crassula* is a widespread species and is not currently threatened with extinction.

Observations: In 2018, when conducting an investigation on alien plants in Yangmingshan National Park, in northern Taiwan, we found populations of an unknown species of *Tradescantia* in the area (Fig. 1). The species was morphologically similar to *T. fluminensis*, which was already known to be naturalised in Taiwan (Yang *et al.*

2008), but had larger, fleshy leaf blades and prominently pilose sepals. After careful study of specimens the plants were identified as *T. crassula*, a herbaceous species native to South America. Directed searches throughout the Park found ten populations of the species, which occupy an area of 193.1 m² in total (Tab. 1). These populations are distributed in the western part of the Park (Fig. 4).

Both the number of observed populations and the occupied area were less for *T. crassula* than that of *T. fluminensis*, which could perhaps be explained by the history of invasion of the two species in Taiwan. *Tradescantia fluminensis* became naturalized in Taiwan in 1987 (Wu *et al.* 2010), much earlier than *T. crassula*. Unlike *T. fluminensis*, all populations of *T. crassula* were distributed adjacent to developed (*i.e.* anthropised) areas. Compared to *T. fluminensis*, *T. crassula* prefers lower canopy coverage, which suggests that the latter benefits from stronger sunlight

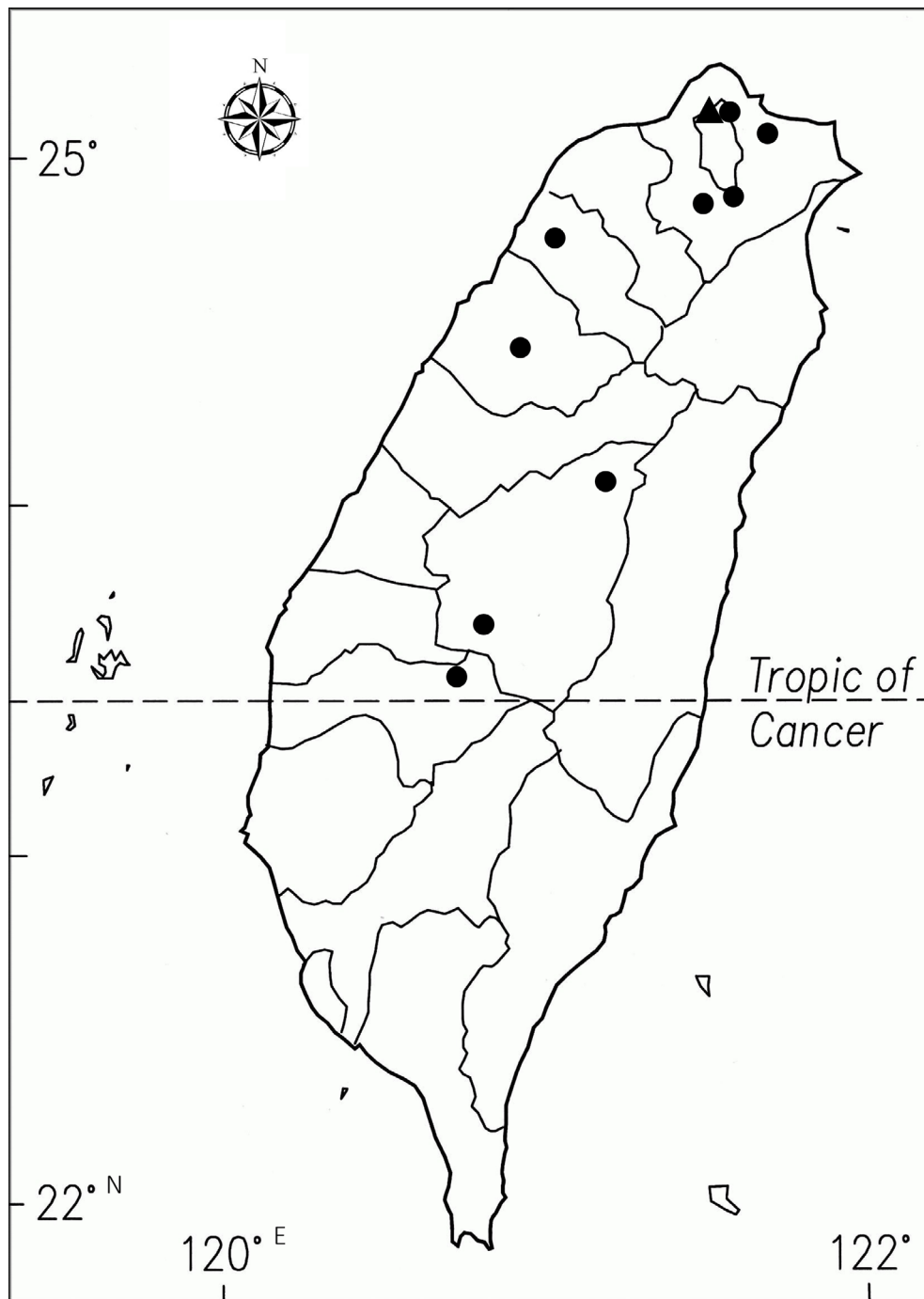
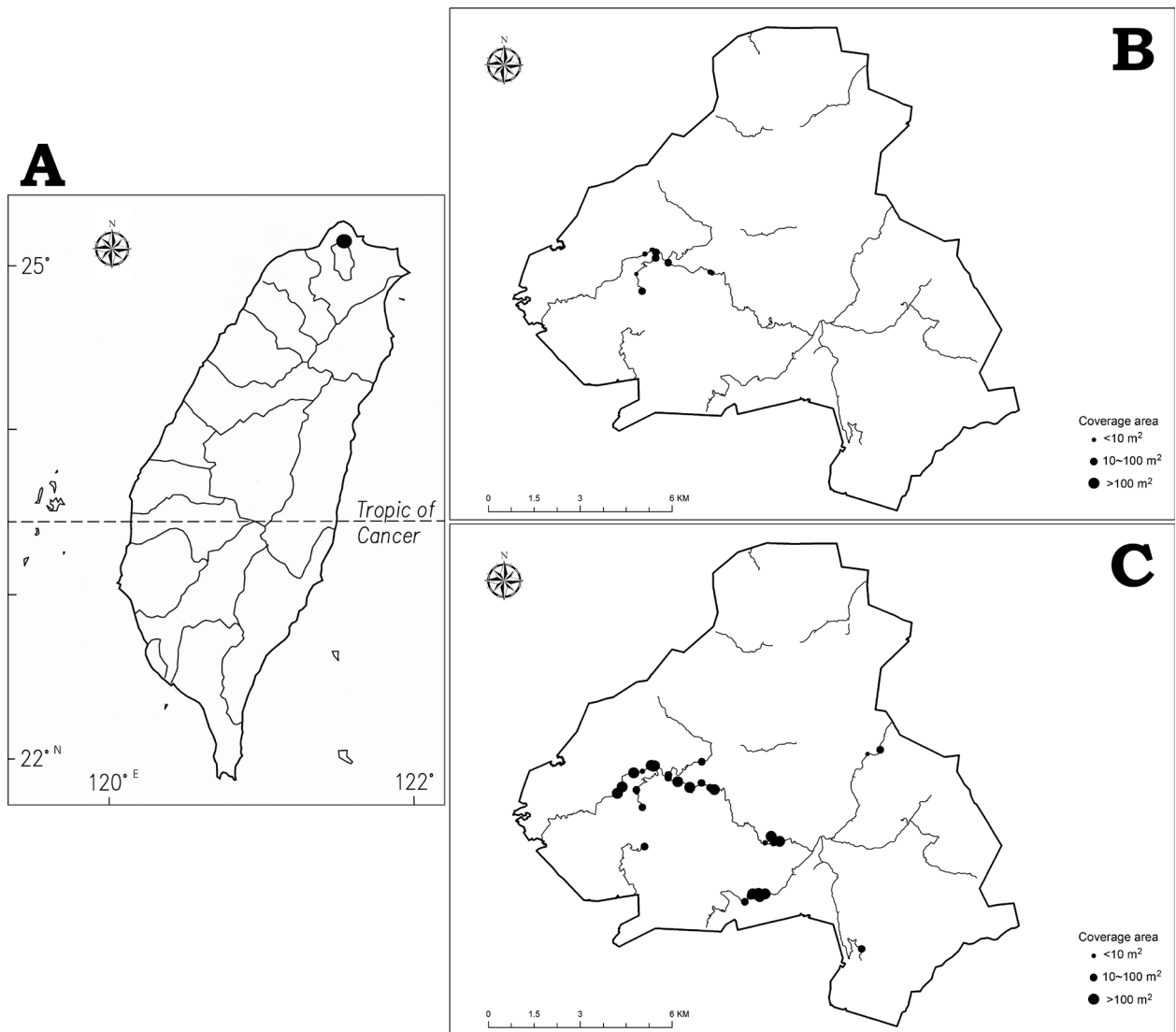


Fig. 3. Distribution map of *Tradescantia crassula* (triangle) and *T. fluminensis* (circles) in Taiwan.

Table 1. Population and environmental factors of *Tradescantia crassula* and *T. fluminensis* in Yangmingshan National Park, northern Taiwan.

Species	<i>T. crassula</i>	<i>T. fluminensis</i>
Number of populations observed	10	34
Area occupied (m ²)	193.1	14029.6
Canopy coverage (%)	43 ± 27	65 ± 27
Soil pH	5.8 ± 1.0	5.2 ± 1.0
Stone / soil rate (%)	35 ± 15	31 ± 16
Distance to developing area (m)	0 ± 0	80 ± 17
Elevation (m)	872 ± 104	741 ± 197



Figs. 4A–C. A. Location of the Yangmingshan National Park in Taiwan; B. Distribution and coverage of *Tradescantia crassula* in the Park; C. Distribution and coverage of *T. fluminensis* in the Park. In B and C, lines inside the Park indicate the main trails.

(Tab. 1). This is probably the reason why the populations of *T. crassula* in the Park are concentrated close to developed areas, where the arboreal vegetation was suppressed for farming or paving. The greater dependence of *T. crassula* of more direct sunlight exposure suggests that the control of this species would probably be easier than that of *T. fluminensis*, which is much more shade-tolerant.

According to an interview with staff members of the Park, it is believed that *T. crassula* has been occurring in the area since at least 2003. However, so far they were misidentifying those plants as *T. fluminensis* because of their morphological similarity. Both species are native to South America and belong to *Tradescantia* subg. *Austrotradescantia* (D.R.Hunt) M.Pell. It is known that *T. fluminensis* was introduced into Taiwan for ornamental purposes (Yang *et al.* 2008, Wu *et al.* 2010), but there is no information about the means of introduction of *T. crassula*,

and this species is not commercialised in Taiwan. There is no evidence that *T. crassula* is cultivated in Taiwan or that it has been cultivated in the past. It is important to mention that *T. crassula* was described in Germany based on specimens that grew from seeds accidentally transported along with substrate with which ornamental plants were shipped from southern Brazil (Link & Otto 1828, Hassemer *et al.* 2017a). Considering that *T. crassula* is not cultivated or commercialised in Taiwan, it is possible that this was also the manner in which the species was accidentally introduced to this country.

We are here following the circumscription of *T. crassula* as in Barreto (1997), Funez *et al.* (2016) and Hassemer *et al.* (2017b), which does not include the southern Brazilian endemic species *T. schwirkowskiana* Funez *et al.*—see Funez *et al.* (2016) and Hassemer *et al.* (2017b)

for information on *T. schwirkowskiana* and a thorough explanation of the differences between these two species.

Tradescantia crassula is the fourth species of *Tradescantia* to become naturalised in Taiwan. In addition to this species and *T. fluminensis*, *T. pallida* and *T. zebrina* also occur in the country (Wu *et al.* 2010). Furthermore, two other species of Commelinaceae are naturalised in Taiwan: *Callisia fragrans* and *C. repens* (Wang & Chen 2008, Tseng *et al.* 2010).

The monitoring of non-native species is critically important to biodiversity conservation (Pyšek 1995, Blossey 1999, Richardson *et al.* 2000, Pyšek & Jarošík 2005, Graham *et al.* 2007, Kočovský *et al.* 2018). For instance, *T. fluminensis* is an important invasive species

in most tropical and subtropical regions (Standish *et al.* 2001, Butcher & Kelly 2011, Fowler *et al.* 2013, Hogan & Myerscough 2017, Akbulut & Karaköse 2018). The populations of *T. crassula* in Taiwan will be continuously monitored, but judging from the information available we do not believe that the species will become invasive in this country (see definition of invasiveness in Pyšek 1995 and Richardson *et al.* 2000).

Material examined (herbarium specimens from Taiwan): TAIWAN. Taipei City, Yangmingshan National Park, Mt. Datun, 25°11'08" N, 121°31'34" E, 28.IV.2019, *M.-H. Su* 724 [Fig. 2], 725, 726 (TAIF), 727, 728 (TAI), 729, 730, 731, 732 (FURB).

Identification key to the species of *Tradescantia* that occur in Taiwan

All four *Tradescantia* species in this key are non-native in Taiwan.

1. Flowers tubular. Sepals unequal, irregularly fused. Petals pinkish. Stamens subequal 2
 2. Stems normally erect to decumbent. Leaves sessile; blade coriaceous, succulent, pale purple *T. pallida*
 - 2'. Stems normally prostrate. Leaves petiolate; blade papyraceous, green with white stripes adaxially *T. zebrina*
- 1'. Flowers flat. Sepals equal, free. Petals white. Stamens equal 3
 3. Stems normally erect. Leaves with convolute ptyxis; sheath margins ciliate; blade fleshy, falcate to complicate. Cincinni bracts not saccate at base. Petals flat. Pistil longer than the stamens *T. crassula*
 - 3'. Stems normally prostrate. Leaves with involute ptyxis; sheath glabrous; blade membranous to slightly fleshy, flat. Cincinni bracts saccate at base. Petals plicate. Pistil about the same length as the stamens *T. fluminensis*

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