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CHANGES IN THE DISTRIBUTION RANGE OF *POTENTILLA TUCUMANENSIS* (ROSACEAE), AN ENDANGERED CRYPTIC SPECIES[1]

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Summary: A correct taxonomic identification is essential for the preservation of biodiversity. In this paper we present simple morphological characters for the identification of the new species recently described, *Potentilla tucumanensis*. The reproductive period of this species occupies about 10% of the last part of its life cycle, is considered cryptic because in the vegetative stage it has many morphological similarities with other cohabiting related species; it can be easily confused with them and it is reproductively isolated. Our study also revealed that for the last hundred years *P. tucumanensis* has suffered a dramatic habitat retraction. Possible causes of this area retraction are discussed. If *P tucumanensis* had not been recognized as a new species, it would have most likely disappeared without being noticed.

Key words: *Potentilla tucumanensis*, *Duchesnea indica*, *Fragaria vesca*, endangered species, cryptic species, anthropogenic changes.

Resumen: Cambios en el rango de distribución de *Potentilla tucumanensis* (Rosaceae), una especie críptica en peligro de extinción. Una correcta identificación taxonómica es esencial para la preservación de la biodiversidad. En este trabajo se presentan caracteres morfológicos sencillos para diferenciar la nueva especie, *Potentilla tucumanensis* recientemente descripta. Esta especie, cuyo período reproductivo ocupa el 10% final de su ciclo de vida, es considerada críptica debido a que puede ser confundida por su similitud en estado vegetativo, con especies con las cuales cohabita y está aislada reproductivamente. Además, se muestra que en los últimos cien años, *P. tucumanensis* ha sufrido una dramática retracción de su hábitat: desde 1900 a 1925 se encontraron ejemplares de esta planta distribuidos en diferentes ambientes ecológicos de la región del noroeste argentino, mientras que en la actualidad, esta especie es raramente encontrada y siempre confinada a un sólo tipo de hábitat. Se discuten las posibles causas de este proceso de retracción. Si *P. tucumanensis* no hubiese sido reconocida como una especie nueva, probablemente hubiese desaparecido sin dejar rastro de su existencia.

Palabras clave: *Potentilla tucumanensis, Duchesnea indica*, *Fragaria vesca*, especie en peligro de extinción, especie críptica, cambios antropogénicos.

INTRODUCTION

The genus *Potentilla*, typical from cold and temperate regions of the northern hemisphere, belongs to the family *Rosaceae* and has two major groups: Trichocarpae, bushy or woody species and Gymnocarpae, herbaceous species (Wolf, 1908). More than 500 species of *Potentilla* are known, and most of them are found in central and boreal Eurasia and North America (Davidson, 1995).

In Argentina there are two species of *Potentilla* described so far, *P. tucumanensis* Castagnaro & Arias (Castagnaro *et al*., 1998) and *P. anserina* L. (Zardini, 1999), corresponding to a northern and a southern species, respectively (see Fig. 1B). Lillo was the first to report in 1900 the occurrence of a species of *Potentilla* in Northwestern of Argentina, and according to the systematic key proposed by Linnaeus (1753) he classified these plants as *P. norvegica*. However, it has been recently shown that the species identified as *P. norvegica* by Lillo was erroneously determined, being a new species, *P. tucumanensis* (Castagnaro *et al*., 1998). This species is an annual herb with very small solitary flowers (3-6 mm) compared with others of the same genus (Castagnaro *et al*., 1998). Confusion between *P. tucumanensis* and *P. norvegica* is highly unlikely because they are not sympatric and there are morphological, anatomical and genetic characters that permit a precise identification of both species

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(Castagnaro *et al.*, 1998). However, chances of confusion persist when comparing *P. tucumanensis* with *Duchesnea indica* (Andr.) Focke and *Fragaria vesca* L. because they look alike in vegetative stage (Arias *et al.,* 1998; Ontivero *et al.,* 2000).

In this study, we report the reduction in the distribution range of *P. tucumanensis* in the same area studied by Lillo from 1900 to 1925. We also consider the distribution *of P. tucumanensis* in relation to *Duchesnea indica* and *Fragaria vesca,* species that may share the same habitat of *P. tucumanensis,* and describe some vegetative-morphological traits that allow to identify the three species.

Materials and Methods

Specimens of *P. tucumanensis*, *D. indica* and *F. vesca* were collected from various locations of Tucumán province, Argentina (see shaded area in Fig. 1), in the four seasons of 1996, deposited at Miguel Lillo Herbarium (LIL) and included in a greenhouse collection. To confirm the presence of the species collected, the places of collection were visited at least three times during 1997 and 1998. The material was determined following procedures of traditional taxonomy using exomorphological characters of flowers, fruits and leaves. The material was confronted with specimens available in the same herbarium. Seeds of *P. tucumanensis* were collected and germinated every year, whereas the specimens of the other two species were asexually reproduced by stolons.

Material examined.

Potentilla tucumanensis.- *Prov. Tucumán*: San José, 2200 m, 19-XII-1900, Lillo 2625; La Ciénaga, 2600 m, 17-IV-1904, Lillo 3737; Cañada del Muñoz, 1700 m, VII-1911, Castillón 2790; Yerba Buena, forest, 550 m, 6- XI-1913, Lillo 13242 ; El Potrerillo, 600 m, 22-XI-1913, Monetti 14872; Tafí del Valle, Río Blanco Creek, 2000 m, I-1914, Castillón 3505; Parque Centenario, 450 m, 6-XI-1913, Castillón 3049; Chañar Pozo, 300 m, X-1919, Venturi 446; Las Pavas, 2700 m, 17-III-924, Venturi 3292; Embarcación F. C. C. N., 450 m, 18-XII-1925, Schreiter 5175; Trancas, Potrero, 1500-1600 m 12-IX-1996, Kirschbaum holotype, 11.

Duchesnea indica.- *Prov. Tucumán*: Tafí, Quebrada de los Sosa, 12-IX-1962, Cuezo *et al.* 3015; Monteros, Pueblo Viejo, 900 m, 12-XII-.1962, Neuman 28; Tafí, Quebrada de los Sosa, 8-X-1963, Meyer *et al.* 4198 c; Tafí, Quebrada de los Sosa, Monumento Indio, 963 m, 11-XI-1963, Meyer 23102; Chicligasta, Rio Cochuna, 20-XI-1965, Lefebure s/n (LIL 557162); Burruyacú, Nogalito, 29-XI-1988, Slanis *et al.* 119; Yerba Buena, El Rulo, 1000 m, 25-X-95, Arias *et al.* 527; Tafí del Valle, Monumento al Indio, 29-X-1996, Lucena 335; El Nogalar; Ruta 307, Km 34,5, 18-VIII-1997, Sidán *et al.* s/n (LIL 603220 a); Tafí, Taficillo. 1600 m, 17-VIII-1998, Arias *et al.* 522; Tafí Viejo, Taficillo,1,850 m, 17-VIII-1998, Arias *et al.* 527, Tafí del Valle way, 30-IX-1999, Lucena s/n (LIL 604301); Trancas, Potrero 1,600 m, 12-IX-1996, Arias *et al.* 524.

Fragaria vesca. - *Prov. Tucumán*: Tafí, San Javier - Villa Nougués, 12-VI-1945, Ortiz (LIL 132984); Tafí, Villa Nougués - Anta Muerta, 1000 m, 20-XI-1949, Meyer 15539; Tafí, Anta Muerta - Villa Nougués, 1000 m, 28-X-1954, de la Sota 34; Tafí, Taficillo, 1800 m, 21-X-1955. de la Sota 357; Villa

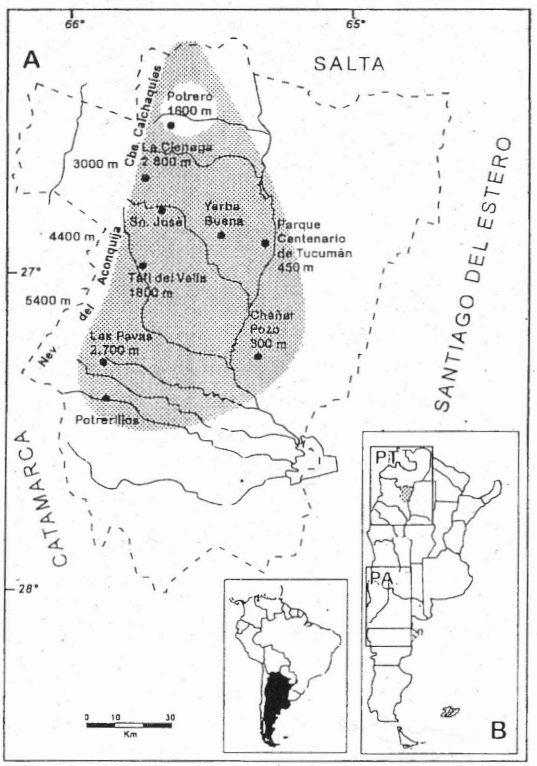

Fig. 1. A: Early (shaded area) and present (clear area) distribution of *Potentilla tucumanensis* (PT) in Tucumán. **B**: Putative distribution of *P. tucumanensis* and *P. anserina* (PA) in Argentina.

Nougués, 22-XII- 1996, Arias *et al.* 521; El Nogalar, Km 34, 26-X-96, Lucena 328; El Nogalar, 19-VIII-1997, Sidán *et al.* s/n (LIL 603298); Tafí Viejo, Taficillo, 1850 m, 17-VIII-1998, Arias *et al.* 523.

Results and Discussion

According to herbarium records of specimens collected by Lillo, *P. tucumanensis* (= *Potentilla norvegica*) was an abundant species in Argentina that used to grow from 65° to 66° W longitude and from 26° to 28° S latitude (Castagnaro *et al.*, 1998). This area covered lowland and mountain dry Chaco regions, subtropical rain forest (Las Yungas), and mountain grasslands (Cabrera, 1976; Fig. 1A). Whereas in 1973 specimens of that species were confirmed in Northwestern Argentina (Zardini, 1973; see Fig. 1B), twenty years later, it was reported as a rare species located at the north of the 26° S latitude (Novara, 1993; place not shown in Fig.1). In a flora survey comprising the same area studied earlier by Lillo (Fig. 1A), we found that *P. tucumanensis* is under a severe process of range reduction. The outcome showed that it has completely disappeared from localities where it used to ocurr profusely, being now confined to a very restricted area similar to that reported by Novara (1993) and shown in the clear area indicated in Fig. 1A (locality of Potrero de Trancas, 1600 m). According to these findings, following the IUCN (1994) criteria, we consider *P. tucumanensis* to be critically endangered because: i) at the present day range of *P. tucumanensis* corresponds to less than 80% of the original area reported by Lillo (Castagnaro *et al.*, 1998), ii) the area reduction has occurred over a period of 100 years, which represents 100 generations (as an annual herb), and iii) the complete disappearance of this endemic species from many locations where it used to grow profusely in the past (Castagnaro *et al.*, 1998; see Fig. 1A). By contrast, from field observations and records available at the Miguel Lillo Herbarium, we confirmed that the area of *Duchesnea indica* and *Fragaria vesca* has not been reduced accordingly.

Cryptic species are those that show only slight morphological differences with related species and even in sympatry remain reproductively isolated (Grant, 1989; Naranjo *et al.*, 1989). For the appropriate identification of sympatric wild species growing in Northwestern Argentina related to the cultivated strawberry, we have used the characters shown in Table 1. The annual *P. tucumanensis* has not only very small and ephemeral flowers (easy falling petals), but also remain vegetative during approximately 90% of its life cycle. We observed that *D. indica* shares its habitat with *P. tucumanensis* and *F. vesca,* but the latter does not share the habitat with *P. tucumanensis*. The last species was observed only in one place corresponding to the dry-Chaco region (Fig. 1A) and *F. vesca* was only observed in grasslands and forests above 1,200 m altitude. Hence, we consider *P. tucumanensis* as a cryptic species, because it is sympatric, reproductively isolated, and morphologically similar in vegetative stage to *D. indica*. Furthermore, although *P. tucumanensis* is not cryptic with respect to *F. vesca* in these days, considering the earlier distribution reported by Lillo in 1900-1925, *F. vesca* and *P. tucumanensis* might have been cryptic because they shared the same habitat.

The range reduction detected in the distribution of *P. tucumanensis* could be attributed to the interaction of different processes of environmental and anthropogenic origin. Analysis of climatic records available for Northwestern Argentina revealed that a statistically significant climatic shift has occurred in the last 50 years and that this change affected mean temperatures and rainfall regimes (Minetti & Neder, 1979; Minetti & Poblete, 1989; Minetti, 1995). Since this climatic change rendered a measurable agricultural impact on sugar cane (Minetti & Neder, 1979; Minetti, 1995) and dry-bean (Feijóo *et al.*, 1997) crops, it seems likely that *P. tucumanensis* may have been equally affected.

Assuming that the climate change reported by Minetti & Poblete (1989) could be the cause of the habitat retraction observed, we may speculate that such a climate change would have also affected all habitats included those of *D. indica* and *F. vesca*. However, the latter has not been observed. The arising question would be then, why *P. tucumanensis* shows higher sensitivity to this climate change than *D. indica* and *F. vesca*. The answer to this question is not easy to find because the origin of this climatic change has not been elucidated yet. Nonetheless, a plausible explanation may be found if we assume that the genetic plasticity is somehow correlated with the ploidy level (Grant, 1989). Hence, the diploid species *P. tucumanensis* and *F. vesca* would be more vulnerable to environmental changes than the octoploid *D. indica*. Although this speculation would explain the phenomenon of area retraction in *P. tucumanensis* it would not explain the stable RANGE

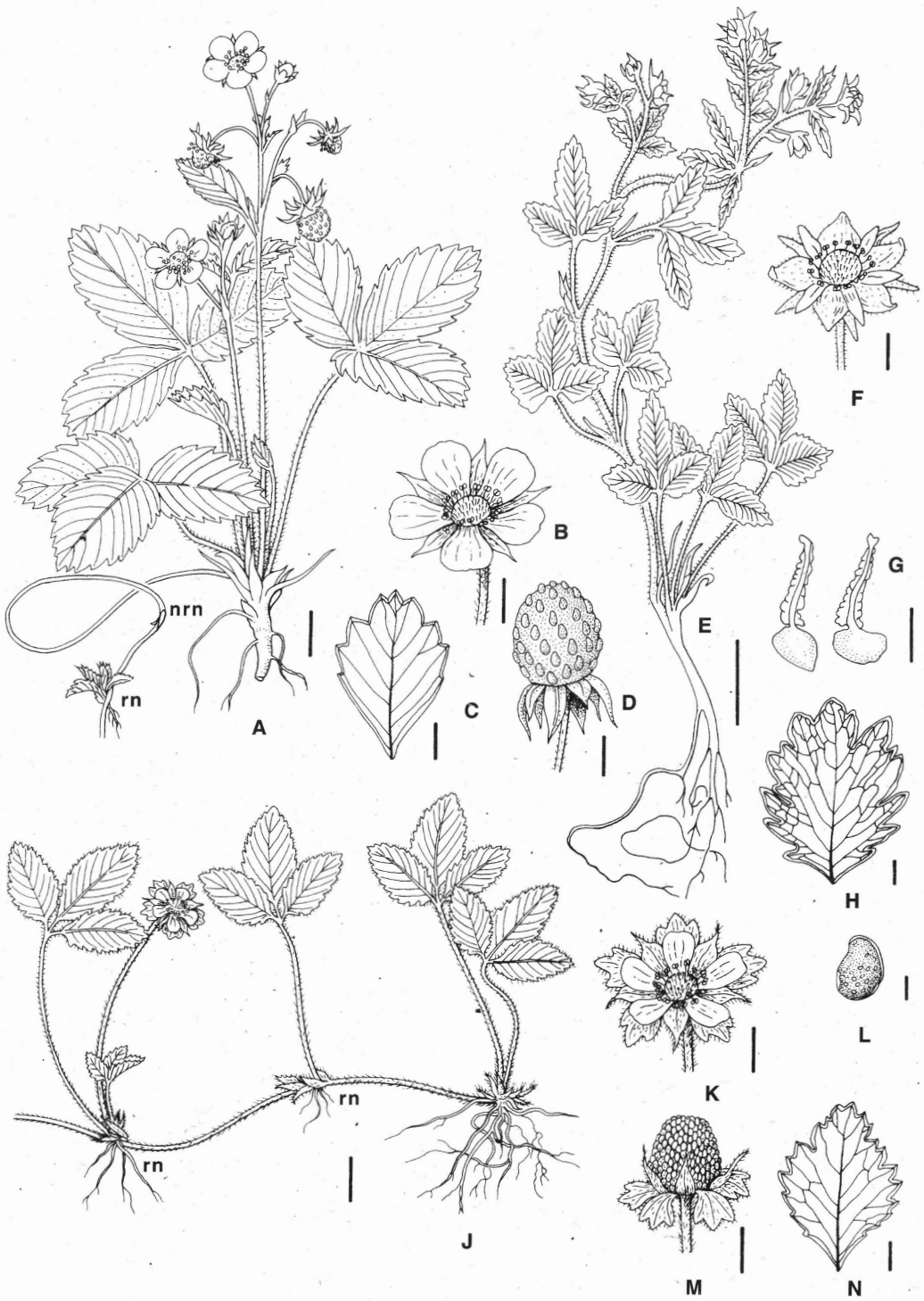

Fig. 2. *Fragaria vesca.* **A**: plant with flowers showing a stolon with a rooting node (rn) and non-rooting node (nrn); **B**: open flower; **C**: leaf venation; **D**: fruiting receptacle. *Potentilla tucumanensis.* **E**: plant with flowers; **F**: open flower; **G**: achene; **H**: leaf venation. *Duchesnea indica.* **J**: plant with flowers showing stolons with a rooting node (rn); **K**: open flower; **L**: achene; **M**: fruiting receptacle; **N**: leaf venation. (**A**: Sidán LIL 603298; **B**, **C**: Arias *et al.* 521; **D**: Kirschbaum 11; **E**, **F**, **G**, **H**: Slanis *et al.* 119; **J**, **K**, **N**: Arias *et al.* 522; **L**, **M**: Lucena LIL 604301 Scale bars: **A**: 1 cm; **B**, **C**, **N**: 5 mm; **D**: 1 cm; **E**: 3 cm; **F**: 2 mm; **G**: 0.5 mm; **H**: 2.5 mm; **J**: 2 cm; **K**: 6 mm; **L**: 0.1 mm; **M**: 8 mm.

observed in *F. vesca*. However, the latter could be still plausible because: i) the habitat of *F. vesca* is less exposed to anthropogenic FACTORS than the habitat of *P. tucumanensis,* and ii) whereas *P. tucumanensis* is an annual herb without stolons, *F. vesca* is able to propagate asexually by stolons.

Although the climate change may be an acceptable hypothesis, we are inclined to think that the habitat reduction in *P. tucumanensis* is caused by a combination of multiple factors. The systematic disturbance of natural habitats due to agriculture, pastoralism, expansion of urban areas or environmental pollution can cause the extinction of species critically dependent on those habitats (Chebez, 1994). That was the case of *Tapirus terrestris* and *Ramphastos toco*, among animals, and *Odontocarya asarifolia* and *Mandevilla grata* among plants, species that have not been detected in Tucumán since 1968 (Vides-Almonacid *et al.,* 1998). It has been reported that during the period 1985-1991, different areas of Tucumán underwent significant agroecological changes due to urban area expansion, grazing practices, deforestation, and industrial contamination that impact mainly in the area where *P. tucumanensis* has completely disappeared (Pucci, 1997). On the contrary, the area where *P. tucumanensis* was observed is one of the areas which remained underdeveloped during the same span of time, compared with the rest of the agroecological area of the region (Pucci, 1997). The latter can be explained due to the fact that those areas where *P. tucumanensis* was observed, are places unsuitable

Table 1. - Comparison of morphological vegetative and reproductive characters among *Potentilla tucumanensis, Duchesnea indica* and *Fragaria vesca*.

Characters	*P. tucumanensis*	*D. indica*	*F. vesca*
Habitat	Herbaceous, annual	Herbaceous, perennial	Herbaceous, perennial
Leaves	3-foliolate	3-foliolate	3-foliolate
Leaf color	Dark green	Dark-green	Bright-green
Leaf pubescence	Intermediate	Scarce	Abundant
Leaf venation	Very branched	Branched	Scarcely branched
Foliar stipules	Bipartite	Bipartite	Bipartite
Petiole	Long and short	Long	Long
Petiole color	Green	Green	Pinkish
Petiole pubescence	Intermediate	Scarce	Abundant
Runners	Absent	Rooting nodes	Alternating rooting and non-rooting nodes
Caulinar stipules	Absent	Tripartite	Tripartite
Runner color	Green	Green	Pinkish
Part of epicalyx	Entire	Parted	Entire
Flowers	Yellow, 4-5 mm diameter	Yellow, 15-20 mm diameter	White, 15-20 mm diameter
Petals	Lanceolate-spatulate	Obovate-oblong	Suborbiculate
Fruiting receptacle	Brown, dry	Fleshy red	Fleshy red
Achene color	Light brown, smooth coat, occasionally winged	Red	Red

for agriculture (Maldonado & Llanes Navarro, 1985). It is also noteworthy that in places near Trancas, grazing or traditional pastoralism (which is the only agricultural practice in the region) does not appear to contribute to the environmentally erosive processes (Molinillo, 1993).

Finally, as shown in Table 1 and Fig. 2, the reproductive characters show clear differences but the vegetative traits present striking similitude that could easily lead to a wrong identification of these species. This situation, as well as the great seasonal fluctuation observed along the year (*P. tucumanensis* is an annual herb that can be easily observed growing in discrete disturbed land patches, clustered in dense bundles at midsummer, but cannot be observed during the winter season) and its phenologic behavior (it remains in vegetative state most of its lifetime) contributes to its cryptic condition. Confusion among taxa may also push an endangered species toward extinction, as reported for reptiles of the genus *Sphenodon* (Daugherty *et al.*, 1990). Additionally, the status of *P. tucumanensis* as a cryptic species becomes particularly critical because it is endemic (Zardini, 1999). A negligent taxonomy could have doomed a cryptic species like *P. tucumanensis* to its extinction without any previous warning about this irreversible process. As stated above, a combination of factors is perhaps the most accurate explanation for the reduction of the distribution range of *P. tucumanensis.*

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