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A new record of Portulaca (*Portulacaceae*) to La Réunion Island, *Portulaca*. cf. *pilosa* L.: native or recently (re-)introduced?

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ABSTRACT

Two species of *Portulaca* were currently reported from La Réunion Island, the native *P. oleracea* and the introduced *P. quadrifida*. A third species was presumed but never confirmed, *P. pilosa*. We recently found a population of *P.* cf. *pilosa* in a restricted area in the southwestern part of La Réunion, exclusively growing on tiles of tuff, a very singular and restricted habitat that also shelters some native and rare species, but is largely surrounded by alien vegetation. Given the cosmopolitan distribution of *P. pilosa* in warm regions, we suggest that the species could be alien. However, based on the wide infrageneric taxonomic resolution problems of *Portulaca*, coupled with the species' alleged past records for the Mascarene and its presumed rarity, we call for more in-depth studies to assess the true origin and ecological significance of the species.

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KEYWORDS
Portulacaceae; *Portulaca pilosa* complex; Mascarene islands; species origin, La Réunion Island

Introduction

Previously, Portulacaceae was known to include 20 to 30 genera and about 450 species (Botineau 2010; Carolin 1993; Eggli 2002). In response to molecular evidence showing that the family was polyphyletic, Nyffeler and Eggli (2010) restricted Portulacaceae to the single genus *Portulaca* L., which is estimated to cover up to ca.100 species (Nyffeler and Eggli 2010; Ocampo and Columbus 2012). However, as a limited number of species of *Portulaca* were taken into account by Nyffeler and Eggli (2010), the phylogenetic relationships within the genus remains unclear (Ocampo and Columbus 2012).

Referring to the suborder Portulacinaceae, the Mascarene Islands would comprise two genera (*Portulaca* – Portulacaceae, *Talinum* Raf. – Talinaceae), with up to five species. Two species of *Portulaca* are currently reported to exist on La Réunion Island (i.e. the native *P. oleracea* L. and the introduced *P. quadrifida* L., Marais 1980; Picot and Lucas 2017), although a third species, *P. pilosa* L., was cited by Cordemoy (1895). Marais (1980) believed that the said record of *P. pilosa* was probably mistaken with hairy individuals of *P. quadrifida*, as there was no herbarium material to support its record for La Réunion or Mauritius, hence mentioning *P. pilosa* as a synonym for *P. quadrifida* in the region. However, it is unlikely that the two species were once confused as one has opposite leaves (*P. quadrifida*), and the other alternate (*P. pilosa*). Historically, *P. pilosa* was cited by Bojer (1837) and Baker (1877) for Mauritius (Bojer also mentioned it for Agalega). Bojer lived in Mauritius for over three decades and had made extensive herbarium collections, many of which unfortunately did not survived. On the other hand, while Baker used mostly herbarium material available to him to compile information for his flora, he based the distribution data on Bojer and an unpublished manuscript by Ayres (Baker 1877). More recently, *P. pilosa* was collected by J. Guého in 1969 (MAU 0018052) on the Diamond Island, an islet within the Rodrigues lagoon. There has been no collection of the species in the last decade in any of the Mascarene Islands based on available herbarium collections and online databases (MAU, REU, P, KEW, G, MO). Recently, a putative *P. pilosa* was found in a restricted area in the southwestern part of La Réunion. The plants were remarkable for their annual habit, having alternate, subulate leaves, with axillary hairs and sessile purple flowers. Here, we: (1) intend to determine the newly discovered population relation to *P. pilosa* s.l. and, (2) discuss the status of the species for La Réunion.

Material and methods

The study site was located in the southwestern part of La Réunion (Figure 1). The site to which the *Portulaca* species belongs was mapped with a handheld GPS (Garmin GPS Map62), and the number of plants recorded. Measurements of leaves, flowers and stems sizes were conducted with an electronic caliper on four different specimens picked up from three different subsites.

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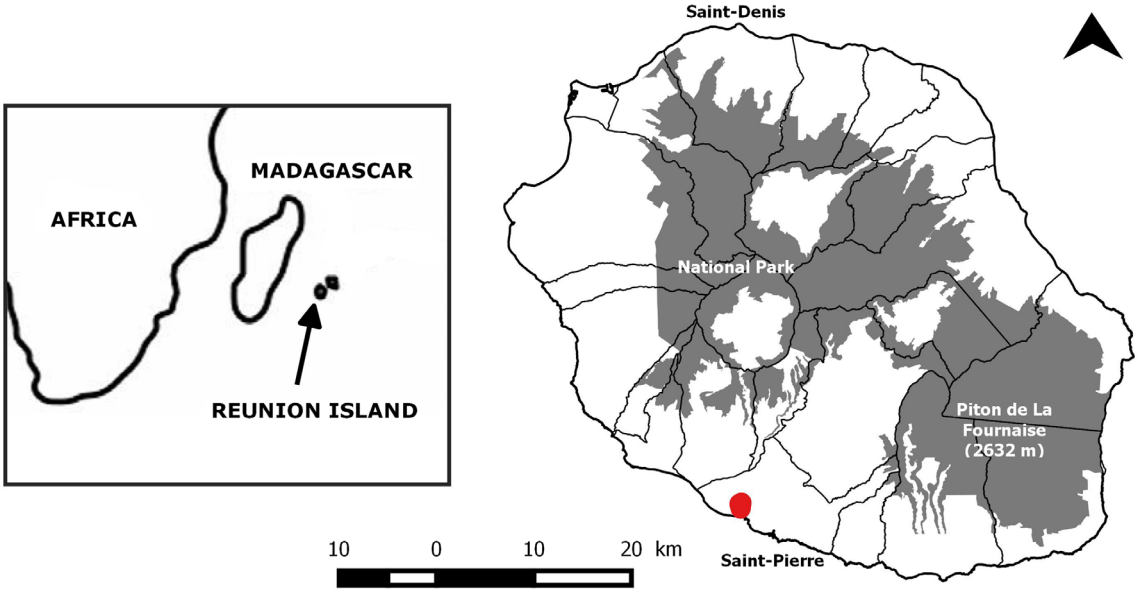

Figure 1. The recorded population of *P.* cf. *pilosa* on La Réunion. In grey, the area of La Réunion National Park.

Descriptions of morphological characters were compared to *Portulaca pilosa* from Marais (1980, who based part of his description from that of von Poellnitz 1934), Geesink (1969), and Matthews and Levins (1985a, 1985b). Seeds were collected in April 2017, during the flowering peak season, and photographed using a macroscope NIKON® AZ100 Multizoom on a camera NIKON® DS-Ri2.

In order to characterize the species communities where *Portulaca* specimens were found to grow on La Réunion, three 10 x 10 m quadrats were surveyed. Species richness was determined as the total number of species present in a quadrat. We calculated the percent relative cover by dividing the total cover of all species by the cover of a given species or group of species (i.e. introduced vs. native species); hence, it is expressed as a percentage ranging from 0–100%. Abundance scale (Braun-Blanquet, Roussine, and Negre 1952) was transformed into mean cover percentage (see Baudière and Serve 1975). Botanical names, author citations, regional status and invasibility index follows Picot and Lucas (2017). IUCN Red List categories for La Réunion are based on IUCN and MNHN (2010). Geology and soils of the study area are based on Raunet (1991), and habitat typology on Lacoste and Picot (2014).

Results

Portulaca was found over a large area (34 ha) dominated by alien herbaceous-shrubby vegetation (20 ha), and with native savannah (14 ha). The location was partly used as an illegal dumping ground. Some parts of this area were subject to at least three botanical surveys in the past decade (S. Augros, unpublished data; Picot and Lucas 2017), only one of which, in 2010, seemed to specifically cover the present study site, with no report of *Portulaca* (Biotope, unpublished data). A total of 23 clumps with 47 specimens were recorded, within an estimated area of 11 ha. Specimens were only recorded away from anthropogenic sites (i.e. waste places, pathways), within savannah areas and, more specifically, growing on tiles of tuffs. This singular substratum is composed of rocks formed of compacted volcanic fragments. This kind of geological formation is noticeably rare as it covers only 6% of the island surface (Raunet 1991) and is sought as a primary resource to produce concrete.

Portulaca specimens were characterized by having hairs restricted to the axils of the leaves with purple flowers (Table 1, Figure 2). Leaves were 13.4–18.8 mm long (mean = 16.1 ± 2.7 mm) and 1.9–2.7 mm wide (mean = 2.3 ± 0.4 mm). One to 11 flowers per specimen were counted amongst the subsites. Flowers had four to five purple petals, 4–7.5 mm long (mean = 5.7 ± 0.9 mm). Stamens varied from 8–20 (mean = 14.5 ± 4.5). The rounded, laterally flattened seeds had testa tesselate with pits and stellate cells (Figure 3).

A total of 17 species (Table 2) representing 14 genera were recorded in the three quadrats. Species richness ranged from nine to 11 species, with four to five native species (when the newly recorded *Portulaca* is included) within each quadrat. The vegetation cover ranged from 40 to 70%, with eight native species representing 39 to 90% of the total cover. Fabaceae (N = 5 species) and Poaceae (N = 4) were the dominant families, followed by Malvaceae and Portulacaceae (N = 2), while other families were represented by only one species. Most species were herbaceous, with nine annual plants and eight perennials.

Discussion

Measurements and observations of the newly recorded Reunionese population of *Portulaca* fall within those reported in the literature for *P. pilosa* (Table 1). However,

Table 1. Comparison of morphological features of *P. pilosa* from description of different authors and the new Portulaca recorded from La Réunion.

		Marais 1980 (mostly based on von Poellnitz 1934)	Geesink 1969	Matthews and Levins 1985a	Specimen from La Réunion
Type		Annual herb or perennial, short life span	Annual herb	Annual herb	Annual herb
Leaves	*Shape*	Alternate, subulate	Linear to obovate	Alternate, subulate	Alternate, subulate
	Size	10–20 mm long	2–30 mm long	5–20 mm long	13.4–18.8 mm long
		–	< 4 mm wide	1–3 mm wide	1.9–2.7 mm wide
Hairs		Axillary hairs (longer or shorter than leaves)	Axillary hairs	Axillary hairs	Axillary hairs
Stem	*Length*	10–20 cm	–	3–25 cm	7–20 cm
Flowers	*Type*	Sessile	Surrounded by membranous bracteoles and hairs	Sessile	Sessile
	Color	Purple, carmine or yellow (sample from Rodrigues had purple flowers)	Various depending on the subspecies (pink, yellow, red, white)	Pink to purple	Purple
	Width	1.7–2 cm (for Rodrigues' specimen)	–	5–12 mm	8–10 mm
	Number	2–6, terminals	1–12 flowered, clustered		1–11, terminals
	Petals	N = 5	N = 4–6	–	N = 4–5
		4–8 mm long	–	7 mm long	4–7.5 mm long (mean 5.7 ± 0.9)
	Sepals	none	–	–	none
	Stamens	15–25	(6–) 10	11–37	8–20 (mean 14.5 ± 4.5)
	Style	3–6 lobes	4–18 lobes	4–5(6) lobes	–
Fruit		Capsule, Ovate to obovate	Capsule, Ovate to obovate, operculum as high as the fruit	Capsule	Capsule
		7 mm long		1.5–4.3 mm diameter	6.2 mm long 2.5 mm diameter
Seed	*Diameter*	0.5 mm	Depends on the subspecies	0.5–0.65 mm	0.5 mm
	Color	Black		Black or blue-black	Black
	Shape	Tubercular		Flattened, round	Flattened, round
	Testa cells	–	Elliptic to stellulate	Small tubercles dorsally, stellate on sides	Stellate on sides

it is important to note that traits such as color of flower, number of stamens and capsule size varied between descriptions (Table 1).

For example, Geesink (1969) included virtually all species of *Portulaca* with linear to elliptic leaves within *P. pilosa*, coming to the conclusion that *P. pilosa* was a compound species combining about 60 names. Nevertheless, he described eight subspecies that showed distinct characters, basically based on seed color and morphology, and floral features. The Reunionese species might be attached to the *pilosa* subspecies complex, which was itself divided into six different "races" distinguished by the features of their seed and petals. However while the "race" *pilosa* is the only one described as having pink petals (versus yellow petals for the other five races), the seed color does not match with our specimen. Using Geesink's treatment, the exact lower identity of the Reunionese material remains inconclusive within the subspecies level.

The color of the flower of *Portulaca pilosa* is not mentioned in the original description by Linnaeus (1753), but Herman (1705) and Commelin (1697) mentioned them to be red or purple. Some confusion is brought about by von Poellnitz's (1934) description, which refers to flowers varying from purple to carmine, but also yellow. Matthews and Levins (1985b) and Matthews, Ketron, and Zane (1992) said the flowers were pink to purple. Based on the color of the flower, the *Portulaca* collected could be *P. pilosa*.

The number of stamens of *Portulaca pilosa* is lowest for Geesink's description (6–10), and highest for Matthews and Levins (11–37) (Table 1). Using this feature, the Reunionese specimen would not be *P. pilosa*, as per Matthews and Levins (1985a).

The *Portulaca* infrageneric classification still needs more detailed studies (Hernández-Ledesma et al. 2015). Based on molecular work, two main lineages of *Portulaca* are separated based on their leaf arrangement. The species with opposite leaves are primarily from the Old World (Africa, Asia and Australia), whereas those with alternate leaves have evolved in the New World (Ocampo and Columbus 2012). However, species from the New World had colonized the Old World. In fact, the Mauritius and Rodrigues endemic, *P. mauritiensis* Poelln., has alternate leaves.

Portulaca pilosa would be part of the AL clade, which ancestral area is probably South America, although the species occurs in the whole continent, from the United States to Mexico, Central America, Caribbean, Venezuela, Bolivia, Colombia and Brazil (Coelho et al. 2010). The species' origin elsewhere is controversial. In Asia, the species is considered native to (and critically endangered in) Singapore (Chong, Tan, and Corlett 2009), but also to Papua New Guinea (Conn 1995) and China (Dequan and Gilbert 2003). Other authors considered it to be mostly a widespread weed of warm regions (Geesink 1969; Ocampo and Columbus 2012).

In fact, it seems that *Portulaca pilosa* is a complex of species. For example, *P. mundula* I.M.Johnst., a conspecific with *P. pilosa*, was shown to be a different species (Matthews, Ketron, and Zane 1992; Matthews and Levins 1985b), or *P. pilosa* L. var. o*kinawensis*

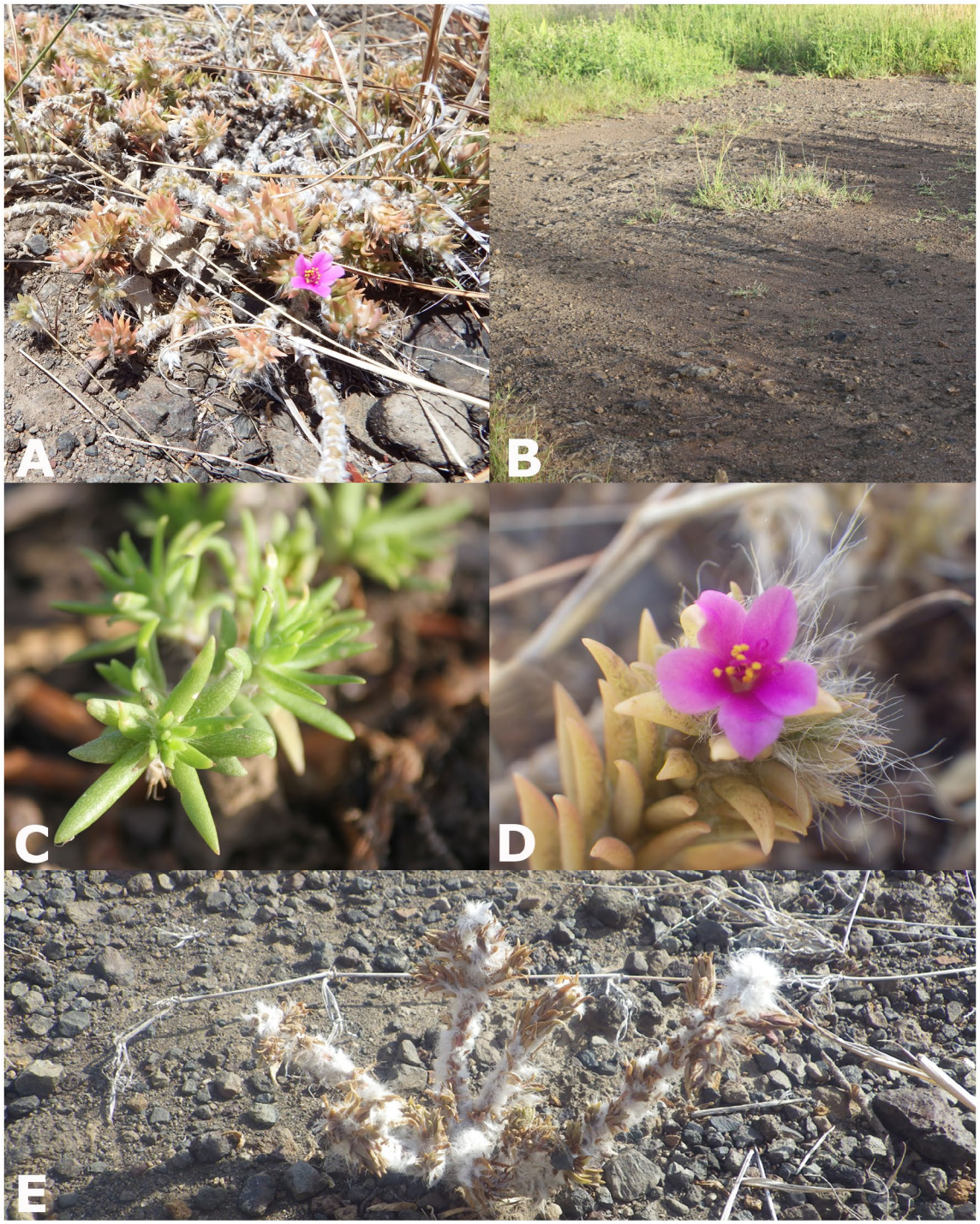

Figure 2. The recently discovered Reunionese specimens of *Portulaca* cf. *pilosa* L. f: (a) Overall plant habit; (b) Habitat (tile of tuff); (c) Leaves; (d) Flower; (e) Hairy individual after a period of drought and detail of hairs which are restricted to axils of the leaves.

Walker and Tawada, which was recently re-erected to *P. okinawensis* Walker and Tawada (Kokubugata et al. 2013).

Portulaca are distinctly heliophilous herbs, found mainly in savannahs, steppes and grasslands, and along shores, some of them being salt-tolerant (Geesink 1969). *Portulaca pilosa* s.l. in its supposed native range occurs in waste areas, along waysides, near the shore (Dequan and Gilbert 2003; Geesink 1969) or in disturbed habitats (Matthews and Levins 1985a). While our study site was mostly within disturbed habitats under heavy human influence (illegal waste area, with records of past fires and high level of biological invasion), the here presumed *P.* cf. *pilosa* was found to be closely associated with a singular geological substratum – tiles of tuff (see Raunet 1991) (Figure 2b). In this type of substratum, most alien invasive species are rare, with vegetation cover mostly comprising native species, or being bare. Moreover, some native species that are considered to be susceptible to local extinction on La Réunion were recorded growing together in this substratum and forming a unique plant assemblage closely associated with the tuff-related micro-habitat (i.e. *Zornia gibbosa* Span., *Tephrosia pumila* (Lam.) Pers.

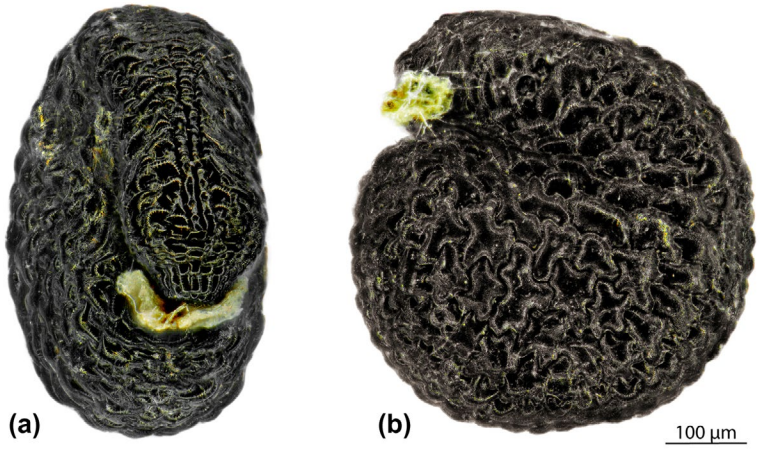

Figure 3. Seed photographs of a Reunionese specimen: (a) lateral view; (b) frontal view. Photo: A. Franck.

Table 2. Species with their respective family, status (N: native, A: alien), scarcity (C: common, R: rare) and invasibility (5: known as invasive within native habitats, 4: supposed invasive within native habitats, 3: invasive within disturbed anthropogenic habitats as per Picot and Lucas [2017]).

Family	Species	Q1	Q2	Q3	Status	Scarcity	IUCN 2010	Invasibility	Type
Poaceae	*Cenchrus echinatus* L.	+		2	A	?	NA	3	Annual
Cyperaceae	*Cyperus iria* L.		+		N	?	DD	X	Annual
Poaceae	*Eragrostis tenuifolia* (A.Rich.) Hochst. ex Steud.		+	2	A	AC?	NA	3	Annual
Euphorbiaceae	*Euphorbia hirta* L.	1		1	A	C?	NA	3	Annual
Poaceae	*Heteropogon contortus* (L.) P.Beauv. ex Roem. et Schult.	4	2	2	N	PC?	LC	X	Perennial
Portulacaceae	*Portulaca oleracea* L.		+	1	N	AC?	LC	X	Annual
Poaceae	*Urochloa maxima* (Jacq.) R.D.Webster	+	1		A	CC?	NA	4	Annual
Fabaceae	*Zornia gibbosa* Span.	1		+	N	R?	EN	X	Annual
Portulacaceae	*Portulaca pilosa* L.	1	+	1	?	RR?*	?	?	Annual
Malvaceae	*Melochia pyramidata* L.		+		A	AR?	NA	3	Perennial
Asparagaceae	*Furcraea foetida* (L.) Haw.	1	1		A	CC?	NA	5	Perennial
Fabaceae	*Leucaena leucocephala* (Lam.) de Wit	+			A	C?	NA	5	Perennial
Pteridaceae	*Pellaea viridis* (Forssk.) Prantl		+		N	AC	LC	X	Perennial
Malvaceae	*Sida acuta* Burm. f.	+		+	A	RR?	NA	3	Perennial
Fabaceae	*Tephrosia candida* (Roxb.) DC.	+	+		A	RR?	NA	3+	Perennial
Fabaceae	*Tephrosia pumila* (Lam.) Pers. var. *aldabrensis* (J.R.Drumm. et Hemsl.) Brummitt			+	N	E?	CR	X	Perennial
Fabaceae	*Tephrosia purpurea* (L.) Pers. subsp. *purpurea*	+			N	PC?	LC	X	Perennial
	Total species	11	10	9					

subsp. *aldabrensis* (J.R.Drumm. & Hemsl.) Bosman & A.J.P.de Haas, *Cyperus iria* L.) (Table 2).

The range of *Portulaca pilosa* in its supposed primary native latitudinal area (i.e. South America) would be a good predictor of the species' potential invasiveness (see Rejmánek and Richardson 1996). In the case of the species' recent introduction (or old introduction if the record of Cordemoy in 1895 is correct), we can hypothesize that *P. pilosa* may have taken advantage of an empty niche inside the tiles of tuff community and thus benefit from unused resources (see the empty niche hypothesis in Hierro, Maron, and Callaway 2005) where other alien or native plants failed to achieve community dominance. If it is a recent introduction, the species' presence is expected to spread to other human-influenced areas (i.e. along waysides or waste areas, as the species is recorded to grow elsewhere). However, as the species was cited to be rare in cultivated fields in La Réunion in the nineteenth century (Cordemoy 1895), be present on Mauritius and Agalega (Bojer 1837) and have been collected once on Rodrigues on a small offshore islet (growing on rock crevices near the shore), there is reason to believe that the species might be present in the region, as it seems to occur in similar habitat in the Mascarenes and is always rare.

Given the historical prevalence of human-mediated transportation of plants and animals, combined with the lack of data that would either support or dismiss such movements, and the cosmopolitan distribution of *Portulaca pilosa* in warm regions, we suggest that the species could be alien. However, based on the wide infrageneric taxonomical problems of *Portulaca*, coupled with the species' past records in the Mascarene, its rarity, and the largely destroyed and disturbed coastal Mascarene habitats, we call for more in-depth studies on its taxonomical position and to assess the ecological significance of the species. The Mascarenes (mostly Mauritius and Rodrigues) have high levels of endemic plant extinction (Baider et al. 2010), and it is not rare for newly described species to be on the brink of extinction

(Baider and Florens 2013, 2016; Fournel, Micheneau, and Baider 2015; Pailler and Baider 2012), and even sometimes known by a single individual (Byng, Florens, and Baider 2015).

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Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Stéphane Augros specializes in tropical ecosystems in the Indian Ocean area since 2005, working as a private ecologist. He earned a first MSc from Orleans University (France) in molecular and cellular physiology and a second MSc in biology and terrestrial ecosystems from Bordeaux University (France) in 2002. Eventually, he received his engineer degree in 2005 from the National School for Agronomy of Toulouse (France). His chosen fields are botany, herpetology and chiropterology. He actively participates in research and regularly publishes papers in scientific peer-reviewed journals.

Dominique Hoareau earned a MSc in tropical ecology from the University of La Réunion in 2012 and specializes in botany and conservation of Reunionese plants. *Contribution:* He helped on the field surveys and measurements on *P.* cf. *pilosa* specimens.

Cláudia Baider is the curator of The Mauritius Herbarium. Her research focuses on Mascarene plant taxonomy, also in ecology and conservation of Amazon and Mascarenes plants. *Contribution:* She checked material available at different herbaria and co-wrote the paper .

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