

**Rapid Communication****First records of *Opuntia monacantha* (Willd.) Haw. and *Opuntia tomentosa* Salm-Dyck (Cactaceae) from Algeria**Nora Sakhraoui<sup>1</sup>, Filip Verloove<sup>2</sup>, Franz Essl<sup>3,\*</sup>, Azzedine Hadeif<sup>1</sup> and Hamdi Dziri<sup>1</sup><sup>1</sup>Department of Nature and Life Sciences, Faculty of Sciences, University 20 August 1955 Skikda, BP. 26 El-Hadaiek Road, Skikda, 21000, Algeria<sup>2</sup>Meise Botanic Garden, Nieuwelaan 38, B-1860 Meise, Belgium<sup>3</sup>BioInvasions. Global Change. Macroecology Group, Department of Botany and Biodiversity Research, University of Vienna, Rennweg 14, 1030 Vienna, Austria

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**OPEN ACCESS****Abstract**

We report here the first occurrences of two alien cacti species from Algeria. During field surveys from 2016 to 2022 in the Skikda region (north-eastern Algeria), ten populations of *Opuntia monacantha* (Willd.) Haw. were recorded. This species is reported here as naturalized alien species for the first time for Algeria and the second time for mainland North Africa. The same surveys also yielded three localities of *Opuntia tomentosa* Salm-Dyck, reported here as casual species for the first time for Algeria and mainland North Africa. Both species colonize various habitats (coastal dune, maquis, cliffs, roofs, gutters, tree trunks) and they propagate by stem fragments. However, *O. tomentosa* also reproduces from seeds, and birds seem to play a role in the dispersal of this species. We discuss the potential of both species for further spread in Algeria, and argue that increased botanical surveys may lead to the recording of further alien cacti species.

**Key words:** cacti, distribution, habitats, naturalization, northeastern Algeria, spread**Introduction**

Since the discovery of the Americas, hundreds of Cactaceae species have been introduced to (semi-)arid regions all over the world. The family is divided into four subfamilies, of which the Opuntioideae can be easily recognized by their flattened, broadened stem segments (cladodes), specialized glochidia and arillate seeds (Simpson 2010). The Opuntioideae has particularly attracted the attention of scientists because it contains several species that are useful for humans (e.g. providing food for humans and fodder for farm animals). The genus *Opuntia* with approximately 300 species is the most important one for human use given the many possibilities of exploitation (Rodriguez-Lopez et al. 2020). However, several species of this genus are also notorious in terms of their high invasive potential (Novoa et al. 2015) and their often substantial negative impacts on the environment.

In Algeria, several species of *Opuntia* were introduced, particularly during the colonial period, mainly as ornamental plants or fodder (Chevalier 1947). *Opuntia ficus-indica* (L.) Mill, introduced already before the French colonization, is currently widely cultivated. Despite being classified as an invasive alien plant, it has also been used for some years for rehabilitation purposes in the green dam project that was designed to halt the advance of the Sahara towards the north of the country. It has also been classified as a species capable of providing a sustainable livelihood for rural populations, especially those located in arid and semi-arid areas.

Despite their wide range throughout the country and their abundant presence in gardens and public greens, only a few *Opuntia* species have escaped these localities, most of which were reported by Véla (2013).

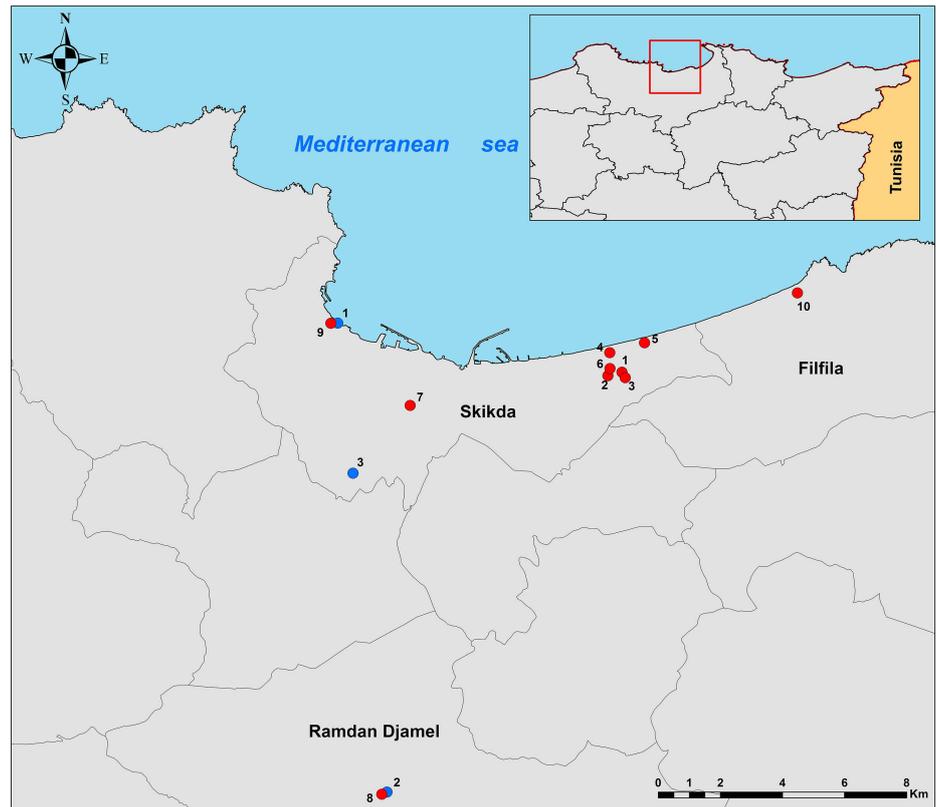
Between 2016 and 2022, the first author of this paper has carried out extensive botanical surveys in the Skikda region (north-eastern Algeria). This work resulted in recording escaped populations of two further *Opuntia* species that were not reported before in Algeria, i.e. *O. monacantha* (Willd.) Haw. and *O. tomentosa* Salm-Dyck. Here, we present these localities and provide further information on biological and ecological characteristics of the study species in Algeria. Such information is essential for monitoring or managing the study species in the future. In addition, we provide a list of all *Opuntia* species having been reported to date as alien in mainland North Africa.

## Materials and methods

During floristic surveys carried out by the first author of this paper between 2016 and 2022 in several municipalities in the center and east of the wilaya (= district) of Skikda (north-eastern Algeria), escaped populations of *Opuntia monacantha* and *O. tomentosa* were discovered. During a total of 35 field trips, the geographical coordinates, the colonized habitats and the degree of naturalization (according to Pyšek et al. 2004) was assessed. Species identification was done by consulting Britton and Rose (1919) and Véliz (2008).

In addition, we performed a bibliographic search on the focal species distribution in North Africa; in particular, we consulted the checklist of the alien flora of Algeria (Meddour et al. 2020), the Global Biodiversity Information Facility (GBIF 2022), African Plant Database (APD 2022) and Plants Of the World Online (POWO: <http://plantsoftheworldonline.org>). Further, all localities were revisited several times during different seasons for studying the phenology and the mode of reproduction of the species.

It should be noted that the surveys were done in two different ways: either by car following main or secondary roads, or by foot for inspecting areas that are inaccessible by car such as wastelands, abandoned gardens, edges of orchards and fields, semi-natural habitats and the coastal maquis



**Figure 1.** Distribution of recorded populations of *Opuntia monacantha* (red dots) and *Opuntia tomentosa* (blue dots) in the Skikda region (northeastern Algeria). The numbers of the populations correspond to Table 1.

of the city Larbi Ben M’Hidi that extends over a length of 1.74 km. Further areas surveyed included the mobile dunes and the fixed dunes of Filfila beach, the mouth of the Righa wadi, several garaets (= ponds or natural retentions of fresh or salt water) of the Guerbes-Sanhadja wetlands and the city of Skikda.

## Results

### *Localities and population size*

Field surveys yielded, spread over a large perimeter of the study area, ten localities for *Opuntia monacantha* and three localities for *O. tomentosa* (Figure 1). However, the populations of the former are larger than those of *O. tomentosa*. The different records, including the description of the colonized habitats and the degree of naturalization of the two species, are given below.

### **1. *Opuntia monacantha* (Willd.) Haw.**

This species has been observed at several places for several years. In the Larbi Ben M’Hidi city, located east of the city of Skikda, two small populations were observed for the first time in 2016 and then re-observed several times until January 2022. The populations of *O. monacantha* are mostly confined to edges of sandy paths or to uncultivated land. One population

**Table 1.** Geographic coordinates of recorded localities of *Opuntia monacantha* and *Opuntia tomentosa* in Algeria.

Id	Species	Locality	Municipality	Habitat	Coordinates (DD)		Altitude (m)
					Latitude	Longitude	
1	<i>Opuntia monacantha</i>	Larbi Ben M'Hidi	Skikda	Abandoned garden in coastal sand dune	36,880452	6,988198	65
2	<i>Opuntia monacantha</i>	Larbi Ben M'Hidi	Skikda	Coastal sand dune	36,879329	6,983133	52
3	<i>Opuntia monacantha</i>	Larbi Ben M'Hidi	Skikda	Citrus orchards in coastal sand dune	36,878857	6,989434	48
4	<i>Opuntia monacantha</i>	Larbi Ben M'Hidi	Skikda	Coastal maquis	36,886081	6,983654	37
5	<i>Opuntia monacantha</i>	Larbi Ben M'Hidi	Skikda	Coastal maquis	36,889182	6,996135	32
6	<i>Opuntia monacantha</i>	Larbi Ben M'Hidi	Skikda	Coastal sand dune	36,881454	6,983833	66
7	<i>Opuntia monacantha</i>	Skikda city	Skikda	Concrete slab	36,8694	6,91196	22
8	<i>Opuntia monacantha</i>	Roundabout leading to Château Morel	Ramdan Djamel	Maquis	36,756126	6,906659	32
9	<i>Opuntia monacantha</i>	Stora	Skikda	Maritime cliff	36,893002	6,88514	21
10	<i>Opuntia monacantha</i>	Filfilla beach	Fifilla	Maritime sands	36,904687	7,051018	12
1	<i>Opuntia tomentosa</i>	Stora	Skikda	Maritime cliff	36,893002	6,88514	21
2	<i>Opuntia tomentosa</i>	Roundabout leading to Château Morel	Ramdan Djamel	Maquis	36,756126	6,906659	32
3	<i>Opuntia tomentosa</i>	University of 20 August 1955	Skikda	Gutter of a greenhouse	36,849201	6,89187	20

consisted of five well-formed young individuals and two or three smaller ones that were developing from fallen cladodes. These individuals are often trampled by sheep or cows preventing their further growth (Table 1, Population no. 6). The other population includes three old individuals of 2.5 m height that flower and bear fruit regularly (Table 1, Population no. 2).

By expanding the surveys in the Larbi Ben M'Hidi city, further recordings were made: In 2017, a much larger population was recorded in an abandoned garden of an old colonial farmhouse among other alien plants such as *Ailanthus altissima* (Mill.) Swingle, *Aloe arborescens* Mill., *Austrocylindropuntia cylindrica* (Lam.) Backeb., *Opuntia ficus-indica* (L.) Mill. and *O. robusta* H.L. Wendl. ex Pfeiff. At this locality, visited for the first time on 14 May 2017, then revisited several times until January 2022, the species is represented by about twenty large individuals which flower and fruit regularly and spread in the adjacent fallow land to mingle with a large population of *O. stricta* (Haw.) Haw. (Table 1, Population no. 1). Surveys in neighboring areas led to the discovery of another locality of *O. monacantha* at the edge of citrus orchards where it was planted under *Cupressus sempervirens* L. About ten escaped plants were observed there between May 2017 and January 2022. They are confined to the edge of a sandy path leading to large fields of vegetables and cereal crops (Table 1, Population no. 3).

From 2017 and 2018 onwards, the species was found in coastal maquis of the city of Larbi Ben M'Hidi (Figure 2A), where it occurs (together with *Chamaerops humilis* L. and *Pistacia lentiscus* L.) at the edge of the road to the municipality of Filfilla. At this locality, two mature individuals were observed on 10 April 2017 and 19 September 2018 (Table 1, Population no. 5).

These records encouraged us to carefully prospect the nearby coastal maquis in search of *Opuntia monacantha*. The field surveys led to the discovery of a large population consisting of about thirty old fruit-bearing individuals



**Figure 2.** *Opuntia monacantha* in disturbed coastal maquis at Larbi Ben M'Hidi city, 31 January 2022 (A) and on the slab of the main entrance of a building, 16 September 2021 (B). *Opuntia tomentosa* among *Olea europaea* and *Pistacia lentiscus* at Ramdan Djamel, 25 September 2021 (C), on the roof of the greenhouse of "20 August 1955 University" in Skikda, 29 September 2021 (D) and two seedlings, 16 November 2021 (E), (Skikda, northeastern Algeria). Photos by N. Sakhraoui.

of variable size, the taller ones reaching about 2 m in height. This population was observed from March 2017 until January 2022. Other alien species observed at this site were *Agave americana* L., *Carpobrotus edulis* (L.) N.E. Br., *Opuntia stricta* (Haw.) Haw. and *Ricinus communis* L. (Table 1, Population no. 4).

From January 2019 to January 2021, a small population, comprising five or six well-developed and fruit-bearing individuals, was observed at the edge of the maritime sands of Filfilla beach, not far from the mouth of Wadi Righa. There, *O. monacantha* grows amidst *Anthemis maritima* subsp. *maritima* (Table 1, Population no. 10).

From 2020 until January 2022, a medium-sized population of 10 to 15 old individuals, some of which reach 2 m in height, was recorded in the maquis among olive trees and mastic trees on clay soil in Ramdan Djamel, located south of the city of Skikda, at the edge of the roundabout leading to Château Morel (Table 1, Population no. 8).

In 2021, new localities of *O. monacantha* were recorded, notably in Stora where the species was found in a sea cliff on at the edge of the road leading to the port of the village, among native species such as *Ampelodesmos mauritanicus* (Poir.) Durand and Schinz. and *Chamaerops humilis*. The small population consisting of five or six old fruit-bearing individuals (Table 1, Population no. 9).

In January 2021, the species was observed in the city of Skikda, where an individual about 1 m tall was found growing on the slab of the main entrance of a building in the city (Figure 2B). In September 2021, it had considerably grown and occupied the entire slab of c. 4.5 m<sup>2</sup> size (Table 1, Population no. 7).

In Algeria, *O. monacantha* flowers and fruits abundantly from June to August. However, the fruits can persist on the plant for several months. Seed germination has never been recorded but vegetative propagation from stem fragments, which root easily especially in sandy soils, has been observed at several localities.

According to the criteria proposed by Pyšek et al. (2004), *O. monacantha* can be considered as naturalized in Algeria, as it persisted at the locality of Larbi Ben M'Hidi for at least 15 years (according to the testimony of the inhabitants). At other localities, populations have recently spread considerably.

## 2. *Opuntia tomentosa* Salm-Dyck

This species was first observed in the gardens of the “Service Commun de Recherche, Pôle de Vulgarisation Botanique” located at the University of Skikda. In April 2018, a 70 cm tall individual was found there clinging to the trunk of *Phoenix canariensis* Chabaud. Then, further 17 young individuals which vary in size from 0.1 to 1 m were observed in May 2018 in the same green space on the gutter of a 3 m tall greenhouse which were still alive in February 2022 (Figure 2D) (Table 1, Population no. 3). Two further young individuals, 1 m tall and growing on the ground, were observed close to the greenhouse. The species is cultivated nearby and the planted individuals are up to 7 m tall.

A second locality of *O. tomentosa* is located in Ramdan Djamel at the edge of the roundabout leading to Château Morel; there a population of

more than 20 individuals, some of which are 3 m tall, was observed from 2020 to January 2022 (Figure 2C). At this locality, the species grows on clay soil in open maquis among *Olea europaea*, *Pistacia lentiscus* and other species of *Opuntia* including *O. monacantha* (see above) and *O. dejecta* Salm-Dyck (Table 1, Population no. 2).

Finally, *O. tomentosa* was recorded in the Stora region, at the edge of the road leading to the port of Stora. The species was found in flower in March 2021. The population consists of c. 30 individuals, up to 4 m tall. They colonize a maritime cliff in which other alien species such as *Acacia saligna* (Labill.) Wendl., *Canna indica* L., *Opuntia ficus-indica*, *O. stricta* and *Tropaeolum majus* L. occur (Table 1, Population no. 1).

At the presented sites, *O. tomentosa* flowers and sets fruits abundantly. It flowers from March to July, fruits ripen in August but can persist on the plant until autumn (October–November). Seed germination was observed several times in the field (Figure 2E).

According to the criteria proposed by Pyšek et al. (2004), *O. tomentosa* should be classified as a casual alien species in Algeria as it does not yet show substantial spread to adjacent environments, despite its persistence in the three recorded localities.

## Discussion

To our knowledge, the reported occurrences of *Opuntia monacantha* and *O. tomentosa* are the first ones for Algeria, as no reports are given in the databases consulted (APD 2022; GBIF 2022) nor in the most up to date checklist of alien plants of Algeria (Meddour et al. 2020).

In North Africa, *O. monacantha* has so far been reported as naturalized only for the Canary Islands (Verloove et al. 2017) and Tunisia (El Mokni et al. 2020), so this record is the second one for mainland North Africa. Conversely, *O. tomentosa* has so far only been reported from the Canary Islands (Dobignard and Chatelain 2011), making our records the first for mainland North Africa.

Based on our surveys, *O. tomentosa* should be added to the list of alien *Opuntia* species reported for mainland North Africa which are fewer than those of the northern part of the Mediterranean area (see Galasso et al. 2018; Aymerich and Sáez 2019). So far, only eight species have been reported from mainland North Africa (if *O. stricta* is considered conspecific with *O. dillenii*, Table 2). However, it is likely that further surveys will record additional alien *Opuntia* species for North Africa, as shown by our study.

*Opuntia monacantha* is native to Argentina (Chevalier 1947), Brazil, Paraguay and Uruguay, and has been introduced into different regions of the world as an ornamental plant. The escaped populations in Algeria are characterized by a bright and shiny green color of the cladodes and one or two spines per areole with often a spine larger than the other, the longest reaching up to 4 cm, with yellow base and brown top. The species has escaped

**Table 2.** Overview of alien species of the genus *Opuntia* recorded from continental North Africa.

Species	Country	Degree of naturalization
<i>Opuntia dejecta</i> Salm-Dyck	Algeria (El Mokni and Saci 2020) and Tunisia (El Mokni et al. 2020)	Casual
<i>Opuntia elatior</i> Mill.	Morocco (Véla 2013)	Naturalized
<i>Opuntia ficus-indica</i> (L.) Mill.	Algeria, Tunisia and Morocco (Véla 2013)	Naturalized, invasive (in Algeria)
<i>Opuntia lindheimeri</i> Engelm.	Tunisia (El Mokni et al. 2020)	Casual
<i>Opuntia microdasys</i> (Lehm.) Pfeiff.	Algeria (Véla 2013) and Tunisia (El Mokni et al. 2020)	Naturalized in Algeria, casual in Tunisia
<i>Opuntia monacantha</i> (Willd.) Haw.	Tunisia (Véla 2013 ; El Mokni et al. 2020)	Naturalized
<i>Opuntia robusta</i> H.L. Wendl. ex Pfeiff.	Algeria (Véla 2013) and Tunisia (El Mokni et al. 2020)	Naturalized in Algeria, casual in Tunisia
<i>Opuntia stricta</i> (Haw.) Haw. (incl. <i>O. dillenii</i> (Ker Gawl.) Haw.)	Algeria, Tunisia, Morocco and Libia (Véla 2013)	Naturalized

from cultivation in several countries such as South Africa, China, the USA, Réunion, Sri Lanka, Vietnam and several European countries where it has become naturalized such as in Greece (Arianoutsou et al. 2010) and Portugal (Domingues De Almeida and Freitas 2006).

*Opuntia monacantha* colonizes a range of different habitats (e.g. coastal dunes, coastal maquis, maritime cliffs, clay soils and slabs of buildings in urban environments), and has an extensive record of successful invasions in the Mediterranean region, particularly in France (Corsica), Italy and Spain (Novoa et al. 2015; Puddu et al. 2016) and in regions with a Mediterranean climate such as South Africa where it colonizes coastal dunes (Moran et al. 2013). Thus, we argue that *O. monacantha* has a high risk of further spread in Algeria, and possibly it could become invasive such as *O. ficus-indica* and *O. stricta*. Therefore, we recommend that the occurrences of this species should be monitored.

The largest populations of *O. monacantha* have been recorded in coastal dunes, in particular the coastal maquis of the city of Larbi Ben M'Hidi. This natural habitat is rich in endemic species such as *Cyclamen africanum* Boiss. & Reut. (endemic to North Africa), *Genista ulicina* Spach. (Algerian-Tunisian endemic), *Genista ferox* Poir. (North African endemic) and *Iris unguicularis* subsp. *unguicularis* Poir. (Algerian-Tunisian endemic) (Sakhraoui et al. 2020). It forms a protective belt for the internal dune but has been considerably disturbed and altered in recent years by land development projects which are constantly increasing on the coast east of the city of Skikda including the beaches of Larbi Ben M'Hidi and Filfilla. These anthropogenic disturbances have probably favored the appearance and spread of several alien species including *O. monacantha*. The protection of the remaining natural maquis could therefore prevent further plant invasions and will undoubtedly have positive repercussions on the ecosystem. Despite all the efforts made so far within the framework of the national coastal protection project, the degradation of coastal habitats is ongoing, requiring the application of much more rigorous measures.

*Opuntia tomentosa* is native to Guatemala, Honduras and Mexico (Véliz 2008; Villaseñor 2016); it can easily be identified based on the velvety

appearance of its cladodes that are entirely covered with very fine hairs. This species has been introduced in several regions of the world as an ornamental plant where it has escaped from cultivation (e.g. Australia). Alien occurrences are particularly reported from regions with a Mediterranean climate such as Spain, Italy and South Africa (Smith and Figueiredo 2012; Galasso et al. 2018; Aymerich and Sáez 2019). In the Canary Islands, the species is considered to be invasive (Acebes Ginovés et al. 2010).

The spread of individuals of *O. tomentosa* on roofs and trees indicates that birds are involved in the dispersal of the species and that reproduction via seeds plays an important role. This has also been observed in the field (e.g. at the Service Commun de Recherche, Pôle de Vulgarisation Botanique) where we recorded the presence of small individuals resulting from the germination of seeds.

Like several other Opuntioideae, the seeds of *O. tomentosa* possess physiological dormancy (Olvera-Carrillo et al. 2003) and have a very hard coating. In addition to their role in spread, digestion of seeds by birds probably also has positive effect on seed germination of this species as demonstrated in *O. ficus-indica* and *O. robusta* (Mokotjomela et al. 2021). In the future, the biogeographic status of the species is therefore likely to change, favored by its mode of reproduction (vegetative and sexual) and seed dispersal (zoochory); the latter facilitates the spread of seeds across large distances, thus further spread and establishment seems probably. This species also hybridizes with *O. ficus-indica*. Two hybrids of this parentage are currently known in Spain: *O. × elisae* (Guillot and Van Der Meer 2004; Ferrer-Gallego et al. 2014) and *O. ficus-indica × tomentosa*, the latter reported recently from the Canary Islands (Verloove et al. 2017). These hybrids might also be found in Algeria in the future, especially since *O. ficus-indica* has a wide distribution in this country.

The use of Cactaceae as living fences contributes enormously to the spread of several species of this family in Algeria and elsewhere. *Opuntia ficus-indica* remains the most popular species for this purpose in Algeria, but certain regions have distinguished themselves by selecting other species such as the village of Dem El Bagrat (municipality of Ben Azzouz, wilaya of Skikda), where *Austrocylindropuntia subulata* (Muehlenpf.) Backeb. is widely used, the Larbi Ben M'Hidi city where *O. monacantha* is widely used on the outskirts of citrus orchards and the region between Oued Fragha and Bouchegouf (wilaya of Guelma), where *O. robusta* is widely used. We believe that it will be necessary to inform rural people on the risks of this practice to limit the further spread of Cactaceae species in Algeria.

Finally, we recommend that occurrences of the two study species should be searched for in other regions of Algeria, particularly in the vicinity of old farms and colonial villas, from which we believe several of the reported populations escaped. These most often were surrounded by exotic gardens where several introduced species, including cacti, were grown.

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## Author's contribution

Nora Sakhraoui – research conceptualization, sample design and methodology, investigation and data collection, data analysis and interpretation, writing; Azzedine Hadeef and Hamdi Dziri – data analysis and interpretation; Filip Verloove and Franz Essl – writing.

## References

- Acebes Ginovés JR, León Arencibia MC, Rodríguez Navarro ML, Del Arco Aguilar M, Garcia Gallo A, Pérez De Paz PL, Rodríguez Delgado O, Martín Osorio VE, Wildpret De La Torre W (2010) Pteridophyta, Spermatophyta. In: Arechavaleta M, Rodríguez S, Zurita N, García A (eds), Lista de especies silvestres de Canarias, Hongos, plantas y animales terrestres (2<sup>nd</sup> edn). Gobierno de Canarias, Santa Cruz de Tenerife, pp 122–172
- APD (2022) African Plant Database, *Opuntia monacantha* (Willd.) Haw., *Opuntia tomentosa* Salm-Dyck. Conservatoire et Jardin botaniques; Pretoria: South African National Biodiversity Institute. <http://www.villege.ch/musinfo/bd/cjb/africa/details.php?langue=an&id=23817/> (accessed 19 January 2022)
- Arianoutsou M, Bazos I, Delipetrou P, Kokkoris Y (2010) The alien flora of Greece: Taxonomy, life traits and habitat preferences. *Biological Invasions* 12: 3525–3549, <https://doi.org/10.1007/s10530-010-9749-0>
- Aymerich P, Sáez L (2019) Checklist of the vascular alien flora of Catalonia (northeastern Iberian Peninsula, Spain). *Mediterranean Botany* 40: 215–242, <https://doi.org/10.5209/mbot.63608>
- Britton NL, Rose JN (1919) The Cactaceae, Descriptions and Illustrations of plants of the cactus family. Carnegie Institution of Washington Publication, Washington, USA, 236 pp, <https://doi.org/10.5962/bhl.title.46288>
- Chevalier A (1947) Dossier sur les Cactus (Opuntias), Espèces fruitières et fourragères, Espèces nuisibles. *Revue Internationale de Botanique appliquée et d'Agriculture tropicale* 301–302: 444–454, <https://doi.org/10.3406/jatba.1947.6121>
- Dobignard A, Chatelain C (2011) Index synonymique de la flore de l'Afrique du Nord. Conservatoire et Jardin Botaniques, Genève, Suisse, 449 pp
- Domingues DeAlmeida J, Freitas H (2006) Exotic naturalized flora of continental Portugal - a reassessment. *Botanica Complutensis* 30: 117–130
- El Mokni R, Saci A (2020) *Opuntia dejecta* Salm-Dyck. In: Raab Straube EV, Raus Th (eds), Euro+Med-Checklist Notulae 12. *Willdenowia* 50: 305–341, <https://doi.org/10.3372/wi.50.50214>
- El Mokni R, Verloove F, Guiggi A, El Aouni ME (2020) New records of cacti (Opuntioideae & Cactoideae, Cactaceae) from Tunisia. *Bradleya* 38: 35–50, <https://doi.org/10.25223/brad.n38.2020.a6>
- Ferrer-Gallego PP, Laguna Lumbreras E, Guillot Ortiz D (2014) Sobre el híbrido *Opuntia × elisae* D. Guillot & Van Der Meer ex D. Guillot (Cactaceae). *Bouteloua* 17: 42–48
- Galasso G, Conti F, Peruzzi L, Ardenghi NMG, Banfi E, Celesti-Grappo L, Albano A, Alessandrini A, Bacchetta G, Ballelli S, Bandini Mazzanti M, Barberis G, Bernardo L, Blasi C, Bouvet D, Bovio M, Cecchi L, Del Guacchio E, Domina G, Fascetti S, Gallo L, Gubellini L, Guiggi A, Iamónico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Podda L, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhelm T, Bartolucci F (2018) An updated checklist of the vascular flora alien to Italy. *Plant Biosystems* 152: 556–592, <https://doi.org/10.1080/11263504.2018.1441197>
- GBIF (2022) Global Biodiversity Information Facility. Checklist dataset. *Opuntia monacantha* (Willd.) Haw., *Opuntia tomentosa* Salm-Dyck, <https://doi.org/10.15468/39omei> (accessed 19 January 2022)
- Guillot D, Van Der Meer P (2004) *Opuntia × elisae* Guillot & Van Der Meer, un híbrido natural de *Opuntia ficus-indica* Haw. y *Opuntia tomentosa* Salm.-Dyck var. *hernandezii* (DC.) Bravo. *Toll Negre* 3: 7–10

- Meddour R, Sahar O, Fried G (2020) A preliminary checklist of the alien flora of Algeria (North Africa): taxonomy, traits and invasiveness potential. *Botany Letters* 167: 453–470, <https://doi.org/10.1080/23818107.2020.1802775>
- Mokotjomela TM, Thabethe V, Downs C (2021) Comparing germination metrics of *Opuntia ficus-indica* and *O. robusta* between two sets of bird species (Pied Crows and smaller species). *Acta Oecologica* 110: 103676, <https://doi.org/10.1016/j.actao.2020.103676>
- Moran VC, Hoffmann JH, Zimmermann HG (2013) 100 years of biological control of invasive alien plants in South Africa: History, practice and achievements. *South African Journal of Science* 109(9/10): 1–6, <https://doi.org/10.1590/sajs.2013/a0022>
- Novoa A, Roux JJ, Robertson MP, Wilson JRU, Richardson DM (2015) Introduced and invasive cactus species: a global review. *AoB Plants* 7: plu078, <https://doi.org/10.1093/aobpla/plu078>
- Olvera-Carrillo Y, Marquez-Guzman J, Barradas VL, Sanchez-Coronado ME, Orozco-Segovia A (2003) Germination of the hard seeds of *Opuntia tomentosa* S.D., a cactus from the Mexico Valley. *Journal of Arid Environments* 55: 29–42, [https://doi.org/10.1016/S0140-1963\(02\)00268-9](https://doi.org/10.1016/S0140-1963(02)00268-9)
- Puddu S, Podda L, Mayoral O, Delage A, Hugot L, Petit Y, Bacchetta G (2016) Comparative Analysis of the Alien Vascular Flora of Sardinia and Corsica. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* 44(2): 337–346, <https://doi.org/10.15835/nbha44210491>
- Pyšek P, Richardson DM, Rejmánek M, Webster GL, Williamson M, Kischner J (2004) Alien plants in checklist and floras: towards better communication between taxonomist and ecologist. *Taxon* 53(1): 131–143, <https://doi.org/10.2307/4135498>
- Rodriguez-Lopez AD, Melgar B, Conidi C, Barros L, Ferreira ICFR, Cassano A, Garcia-Castello EM (2020) Food industry by-products valorization and new ingredients: Cases of study, chapter 5. In: Betoret N, Betoret E (eds), Sustainability of the Food System. Academic Press, London, UK, pp 71–99, <https://doi.org/10.1016/B978-0-12-818293-2.00005-7>
- Sakhraoui N, Boussouak R, Metallaoui S, Chefrou A, Hadeff A (2020) La flore endémique du Nord-Est algérien face à la menace des espèces envahissantes. *Acta Botanica Malacitana* 45: 67–79, <https://doi.org/10.24310/abm.v45i.6138>
- Simpson MG (2010) Diversity and Classification of Flowering Plants: Eudicots. In: Simpson MG (ed), Plant Systematics, 2<sup>nd</sup> Edn. Academic Press, London, UK, pp 275–448, <https://doi.org/10.1016/B978-0-12-374380-0.50008-7>
- Smith G, Figueiredo E (2012) South Africa’s ongoing *Opuntia* Mill. (Cactaceae) problem: The case of *Opuntia tomentosa* Salm-Dyck. *Bradleya* 30: 61–64, <https://doi.org/10.25223/brad.n30.2012.a9>
- Véla E (2013) Notes sur les cactus du genre *Opuntia* s.l. en Algérie et en Tunisie. In: Dobignard A, Chatelain C (éds), Addenda-Notes-Xénophytes, Index Synonymique de la Flore d’Afrique du Nord. Conservatoire et Jardin Botaniques, Genève, Suisse, pp 376–379
- Véliz M (2008) Las Cactáceas de Guatemala. Unidad de Investigación Herbario BIGU, Universidad de San Carlos de Guatemala, 129 pp
- Verloove F, Ojeda-Land E, Smith GF, Guiggi A, Reyes-Betancort JA, Samarin C, Gonzalez Hernandez A, Barone R (2017) New records of naturalized and invasive cacti (Cactaceae) from Gran Canaria and Tenerife, Canary Islands, Spain. *Bradleya* 35: 58–79, <https://doi.org/10.25223/brad.n35.2017.a6>
- Villaseñor JL (2016) Checklist of the native vascular plants of Mexico. *Revista Mexicana de Biodiversidad* 87: 559–902, <https://doi.org/10.1016/j.rmb.2016.06.017>