

**Rapid Communication****First record of *Austrocyllindropuntia cylindrica* (Lam.) Backeb. and first data about the naturalization of *Austrocyllindropuntia subulata* (Muehlenpf.) Backeb. in Algeria**Nora Sakhraoui<sup>1</sup>, Filip Verloove<sup>2</sup>, Franz Essl<sup>3,\*</sup> and Azzedine Hadeff<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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**Received:** 5 November 2021**Accepted:** 8 February 2022**Published:** 25 April 2022**Handling editor:** Joana Vicente**Thematic editor:** Giuseppe Brundu**Copyright:** © Sakhraoui et al.This is an open access article distributed under terms of the Creative Commons Attribution License ([Attribution 4.0 International - CC BY 4.0](https://creativecommons.org/licenses/by/4.0/)).**OPEN ACCESS****Abstract**

During field work carried out in northeastern Algeria between 2016 and 2021, a population of *Austrocyllindropuntia cylindrica* (Lam.) Backeb. was discovered, a casual species not reported before from Algeria. We also report, for the first time, further data on the naturalization of *Austrocyllindropuntia subulata* (Muehlenpf.) Backeb. in Algeria, a species already reported by the first author in 2019. We present a map of the current distribution of the two species in Algeria, field photographs, as well as information concerning their habitat and their biological characteristics, in particular their mode of reproduction.

**Key words:** alien species, Cactaceae, colonized environments, distribution, garden escapes, invasive, ornamental plants, status

**Introduction**

Given their importance as ornamental plants and for food production, species of the Cactaceae family remain highly valued across different regions of the world where they have been introduced. Nearly exclusively of American origin, species of the Cactaceae are, however, among the most impactful invasive alien species, because of their significant environmental and socioeconomic impacts (Novoa et al. 2015). In addition, invasive alien cacti are often difficult to contain or eradicate.

In Algeria, as in other regions with suitable climatological conditions, dozens of species of the cacti family were formerly introduced by the Hamma Acclimatization Garden (Carra and Gueit 1952). Many of these are still widely cultivated today in green spaces such as gardens and nurseries, from which some have escaped, particularly those belonging to the genus *Opuntia* Mill. Vela (2013) provided an overview of species that have recently established in the country. In 2019 and 2020, *Austrocyllindropuntia subulata* (Muehlenpf.) Backeb. was reported by the first author of this study as naturalized in Algeria (see Sakhraoui et al. 2019, 2020), but detailed data (e.g. population size, population growth) were not presented there.

In this paper, we therefore provide, for the first time, more details concerning the naturalization of this South American species, in particular in relation to the different localities, its distribution across the national territory and the size of the populations observed. We further present the discovery of another species of the same genus: *Austrocylindropuntia cylindrica* (Lam.) Backeb., native to Peru and Ecuador (Chinnock 2015), reported here for the first time in Algeria. The two species look very similar and are often subject to confusion, however, they can be differentiated from each other on the basis of the small leaves, which are persistent and more numerous in *Austrocylindropuntia subulata*, while leaves are deciduous in *Austrocylindropuntia cylindrica*.

## Materials and methods

About 30 field trips were made between 2016 and 2021 in northeastern Algeria, more precisely in the *wilayas* (= districts) of Skikda, Guelma and El-Tarf. The trips were scheduled during different seasons with at least one field trip per season. The surveys were carried out mainly by car, but the regions of Larbi Ben M'Hidi and Filfilla were surveyed on foot, which allowed us to visit both private and public properties.

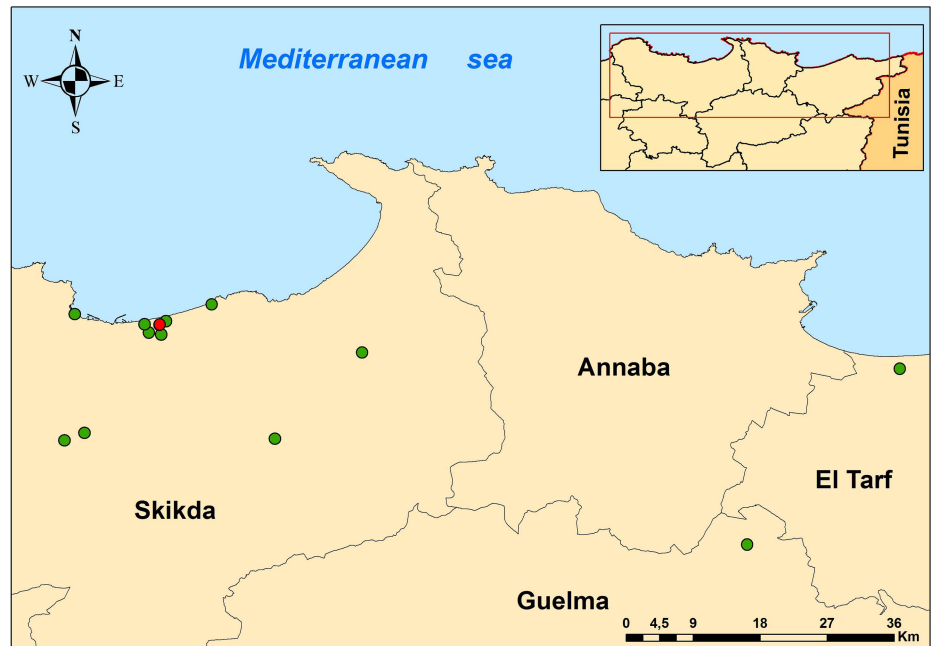
First, the geographical coordinates and the physical description of the different localities were recorded and photos of the specimens encountered in the field were taken by the first author; identification was done by using specialized literature (e.g. Britton and Rose 1919). Subsequently, several targeted surveys were organized to verify the occurrence of the two species in the newly detected localities, as well as to record their biological characteristics, in particular those relating to reproduction, fruiting and seed germination, in order to better understand their behavior in Algeria.

For retrieving information on the known alien distribution of the study species in North Africa, we used various international databases such as Global Biodiversity Information Facility (GBIF 2021), African Plant Database (APD 2021) and Plants Of the World Online (POWO: <http://plantsoftheworldonline.org>). Finally, the invasion status (i.e. being casual or naturalized) of both species has been assessed according to Pyšek et al. (2004).

## Results

### *Records and population size*

A total of three populations located in a single small region were identified for *Austrocylindropuntia cylindrica* and 14 populations, of varying sizes, some of which very large, distributed over twelve localities were identified for *Austrocylindropuntia subulata* (Figure 1, Supplementary material Table S1).



**Figure 1.** Map of *Austrocyllindropuntia cylindrica* (red dot) and *Austrocyllindropuntia subulata* (green dots) recorded localities in northeastern Algeria.

### 1. *Austrocyllindropuntia cylindrica* (Lam.) Backeb.

Syn.: *Austrocyllindropuntia intermedia* Rauh & Backeb., *Cylindropuntia cylindrica* (Lam) F. M. Knuth, *Cylindropuntia intermedia* Rauh & Backeb.

The species was observed for the first time on 3 March 2016 in an abandoned garden of a former colonial farm in Larbi Ben M’Hidi (Wilaya of Skikda) where a small population, consisting of at most 30 individuals, grows among other alien succulent species including *Aloe arborescens* Mill., *Opuntia ficus-indica* (L.) Mill., *Opuntia robusta* H.L.Wendl. ex Pfeiff. and *Opuntia stricta* (Haw.) Haw. (36°52’49.6272”N; 6°59’17.5128”E, 59 m). On 19 January 2019, another small population was observed not far from the first, confined to the edge of a sandy path under *Eucalyptus camaldulensis* (Figure 2A) where individuals of small size, not exceeding 90 cm for the tallest, grow among native grasses (36°52’48.4752”N; 6°59’15.8676”E, 53 m). At 70 m from this point, additional individuals were observed that are escaping from the edge of a private garden where the species is used for fencing, along with *Opuntia ficus-indica* and *Opuntia stricta*. In the intervening years, the locality has been visited several times. The populations are stable and are even gradually, but slowly, increasing in size and numbers of individuals. However, flowers and fruits have not been observed, despite repeated visits in all seasons, and the plants barely reach 90 cm in height; thus, it is assumed that the species reproduces exclusively clonally via detached stem fragments.

Despite our intensified surveys in different areas of the study area, the Larbi Ben M’Hidi city, we could not find further localities for *Austrocyllindropuntia cylindrica* outside of cultivation, although the species is regularly planted in gardens and is also offered for sale in the local garden centers.



**Figure 2.** *Austrocyllindropuntia cylindrica* among native grasses and *Oxalis pes-caprae* at Larbi Ben M'Hidi village, 19 September 2019 (A) and *Austrocyllindropuntia subulata* with flowers and fruits on the roadside at Dem El Bagrat village, 10 March 2019 (B) and at Salah Bouchaour (C), 25 September 2021 (Skikda, northeastern Algeria). Photos by N. Sakhraoui.

Although the species obviously persists very well in all known localities and grows amidst native flora, it can only be considered casual in Algeria as it occurs only in few small populations.

## **2. *Austrocyllindropuntia subulata* (Muehlenpf.) Backeb.**

Syn.: *Opuntia subulata* (Muehlenpf.) Engelm., *Pereskia subulata* Muehlenpf.; incl.: *Austrocyllindropuntia exaltata* (A. Berger) Backeb., *Opuntia exaltata* A. Berger.

This species has been observed at several localities spread over a large perimeter of the study area. The first recordings were made in 2016 in the city of Skikda, more precisely in Larbi Ben M'Hidi, located to the east of the city, where the species was found in different parts of this locality: a large population with more than fifty individuals was observed on 19 March 2016 in a landfill not far from an old colonial farm, locally called “Dar Echitane or House of the Devil” (36°5'51.5028"N; 6°58'32.3148"E, 62 m).

Individuals at this locality are morphologically different from those found at other localities: their stems are thinner and their color is darker.

Another population of around fifty, fairly large individuals was spotted a month later at the edge of the 'Sonatiba' camp where the species escaped from gardens and colonized uncultivated land in which other alien species have also been recorded such as *Ipomoea indica* (Burm.) Merr., *Ricinus communis* L. and *Opuntia stricta* (36°52'41.0304"N; 6°58'52.5108"E, 47 m). By expanding surveys to the city level, another point of proliferation was found at the camp "Trico" by the side of the road, growing among native species; very large individuals exceeding 2 m in height were observed on 5 May 2016 (36°53'4.5168"N; 6° 59'43.1052"E, 50 m).

In 2017, very large populations of *Austrocyllindropuntia subulata* were observed on 20 April at Dem El Bagrat (municipality of Ben Azzouz), where it was introduced, according to the testimony of the inhabitants, after 1962 by an old man as ornamental plant. It was subsequently propagated by the locals who used it for hedging from which it escaped. Huge specimens with lignified trunks and stems exceeding 2 m in height are found on site (36°50'48.0876"N; 7°13'57.3456"E, 80 m). The species is observed everywhere in this locality, escaping from the edges of the gardens in several places, growing together with native species including *Olea europaea* L., *Pistacia lentiscus* L. and *Smilax aspera* L. From there it spreads along the edge of the road that leads towards the center of the town where it occupies a large area. Flowers and fruits and hundreds of young individuals have been observed for several years at this locality (Figure 2B) which is part of the coastal dune just like that of the Larbi Ben M'Hidi city. It is by far the most important locality among all those listed in the region of Skikda.

In 2019, another population of around 30 small individuals was observed on 13 June at the edge of the road connecting Larbi Ben M'Hidi to the town of Skikda at the place called locally "Embranchement" which is part of the municipality of Hamadi Krouma (36°52'11.8380"N; 6°59'9.7764"E, 73 m). There, the species grows among *Opuntia ficus-indica* and *Pelargonium zonale* (L.) L'Hér., on clayey soil that is subject to erosion.

On 13 December 2020, a small population of up to 10 individuals was spotted in a landfill on the outskirts of the town of Filfilla in front of the beach; there, it grows on coastal sands amidst native species such as *Anthemis maritima* L. and other alien species, in particular *Carpobrotus edulis* (L.) N.E. Br. (36°54'16.8732"N; 7°03'3.6648"E, 12 m).

On 7 February 2021, a medium-sized population, with individuals of about 2 m in height, was observed leaving the town of Ramdan Djamel heading towards Salah Bouchaour (36°44'58.6284"N; 6°53'49.7652"E, 52 m). At this locality, the species also grows in vegetation that is composed of native species. This discovery encouraged us to continue the road to Salah Bouchaour in search of the species, where it was indeed found on the same day. First of all, it was seen in a wasteland about 200 m from the gas station

located in the exit of the village, then at the edge of the road about 300 m from the communal market of vegetables and fruits (Figure 2C). In this locality, the species is particularly abundant, hundreds of individuals of various sizes have been recorded there. It occupies the roadside for a long distance and seems to further expand from year to year with dozens of new individuals each year (36°44'25.9548"N; 6°52'22.6560"E, 58 m).

On 9 March 2021, several small populations distributed along the road connecting the village of Beni Bechir to the city of Azzaba were observed. The species was subsequently found on the outskirts of the city of Azzaba where it is confined to the edge of the railway in front of the cemetery. In this locality, a large population of more than a hundred individuals of varying sizes, is found among native species (36°44'32.7732"N; 7°07'37.9740"E, 78 m). The last locality of *Austrocyllindropuntia subulata*, located in the region of Skikda, was spotted in Stora on 21 March 2021, more exactly at the edge of the road leading to the port of Stora, where the species colonizes a hilly site in which other alien species have also been recorded including *Acacia saligna* (Labill.) Wendl., *Canna indica* L., *Opuntia ficus-indica*, *Opuntia stricta* and *Tropaeolum majus* L. (36°53'34.8000" N; 6°53'6.5040"E, 26 m).

The extension of the prospecting area to neighboring wilayas, allowed us to discover other localities of *Austrocyllindropuntia subulata* in the wilayas of Guelma and El-Tarf, located about 150 km east of the wilaya of Skikda.

The population of Guelma was observed in the locality of Jmili Talhi which belongs to the village of Aïn Ben Baïda. About fifty individuals, without flowers and fruit, confined to the edge of the road leading to the wilaya of Souk Ahras, were observed on 22 May and 12 September, growing amidst native herbs (36°36'54.0504"N; 7°41'52.4760"E, 104 m).

The population of El Tarf, observed on 1 June 2021, is bigger and includes one hundred individuals without flowers and fruit. Plants grow in a meadow among native species at the edge of the road leading to the village of El Chat (36°49'37.4340"N; 7°52'55.5924"E, 12 m).

In the two localities of these two wilayas, the species seems to be still at the beginning of its propagation, because the recorded individuals are rather small and likely rather young.

Flowering and fruiting are abundant, but the species seems to reproduce only vegetatively via suckers, stem fragments or even fruits which can take root and give rise to new plants. Young individuals resulting from vegetative reproduction have been observed in large numbers in different localities including those of Dem El Bagrat, Salah Bouchaour and Azzaba. The species persists in all observed localities and appears to be completely naturalized.

## Discussion

This is the first time that *Austrocyllindropuntia cylindrica* has been reported in Algeria and that the naturalization of *Austrocyllindropuntia subulata* has

been thoroughly documented as demonstrated by photos from the field. The latter has already been reported as naturalized by the first author in 2019 and then in 2020, following the completion of botanical surveys in the Skikda region, but no data describing the various field observations has been provided previously. So far, *Austrocyllindropuntia subulata* has been officially reported only in the wilaya of Skikda; we mention in this document its presence in other wilayas in northeastern Algeria, the wilayas of El-Tarf and Guelma, where it also appears to be naturalized. However, another occurrence of the said species dating from 2015 was mentioned on the iNaturalist platform (<https://www.inaturalist.org/observations/16257036>), taken up only by GBIF, where the plant was observed in the wilaya of Mila, located south of the wilaya of Skikda, but no details on the exact locality or the nature of the colonized environment were given, requiring a verification in the field to assess the status of the species in that region.

In North Africa, both species have been reported in only a few countries: *Austrocyllindropuntia cylindrica* has been cited as naturalized in the Canaries (Verloove et al. 2018) and in Morocco (Dobignard and Chatelain 2011; Véla 2013), so our record is the second for continental North Africa. *Austrocyllindropuntia subulata*, in turn, has been reported as naturalized in Morocco (Véla 2013) and Tunisia (El Mokni et al. 2020) where it mainly colonizes roadsides. In addition, it is commonly and widely naturalized in the Canary Islands as well (Verloove et al. 2017).

Although both species belong to the same genus, in Algeria they behave remarkably differently. *Austrocyllindropuntia subulata* shows a much greater proliferation capacity than *Austrocyllindropuntia cylindrica*, allowing it to expand its populations and to colonize more space in a relatively short period of time, reflecting a high invasiveness potential. This may be due to its mode of reproduction which includes several strategies (see above) and its rapid growth, which considerably increases the likelihood of becoming invasive in our region, especially since its invasiveness has already been demonstrated elsewhere in the Mediterranean basin or in countries with a Mediterranean climate such as Spain (Sanz-Elorza et al. 2004; Capdevilla Argüelles et al. 2006) and South Africa (Novoa et al. 2015). Its establishment in the coastal dunes, where the largest populations and the most numerous occurrences have been recorded, is particularly worrying. Dunes have been shown to be sensitive to the introduction of alien plants (Stanisci et al. 2010; Padrón et al. 2011) and are among the ecosystems most affected by biological invasions (Lazzaro et al. 2020). In Algeria, this ecosystem is characterized by a rich and diverse native flora but it is subject to threats from other invasive species including *Acacia saligna*, *Carpobrotus edulis* and *Opuntia ficus-indica* (Sakhraoui et al. 2020). The population dynamics of the populations of *Austrocyllindropuntia subulata* should therefore be constantly monitored, in order to avoid potential environmental or socio-economic impacts generated by a further proliferation.

*Austrocyllindropuntia cylindrica* should not be excluded from this surveillance action either, although it does not yet show signs of invasiveness in Algeria. Its behavior could change in the future under the influence of climate change and the permanent disruption of environments that have been described by some authors as amplifying factors of biological invasions (Gritti et al. 2006; Walther et al. 2009; Hulme 2017; Robinson et al. 2020). Like other countries of North Africa, Algeria is experiencing significant global warming (Sahnoune et al. 2013) and significant degradation of natural and semi-natural environments which are shrinking year by year giving way to bare land that is devoid of any native vegetation which greatly favors the establishment of alien species.

Plant invasions are only rarely taken into consideration in Algeria. Several alien plants have already been reported as invasive in Algeria (Sakhraoui et al. 2020) but no control measures have been applied so far. More serious attention should be paid to this category of plants if we really want to preserve our natural environments. Unfortunately, there is currently no legal basis regulating the importation of invasive plant species in Algeria.

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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 – data analysis and interpretation; Filip Verloove – review and contribution to writing; Franz Essl – review and contribution to writing.

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### Supplementary material

The following supplementary material is available for this article:

**Table S1.** Geographic coordinates of recorded localities of *Austrocyllindropuntia cylindrica* and *Austrocyllindropuntia subulata* in Algeria.

This material is available as part of online article from:

[http://www.reabic.net/journals/bir/2022/Supplements/BIR\\_2022\\_Sakhraoui\\_etal\\_SupplementaryMaterial.xlsx](http://www.reabic.net/journals/bir/2022/Supplements/BIR_2022_Sakhraoui_etal_SupplementaryMaterial.xlsx)