Rapid Communication

Aeonium haworthii Webb & Berthel. and Crassula ovata (Mill.) Druce (Crassulaceae): New records for the Algerian alien flora

Nora Sakhraoui¹, Amel Boudries¹, Azzedine Hadef¹, Filip Verloove² and Franz Essl³

¹Department of Ecology and Environment, Faculty of Sciences, University 20 August 1955 Skikda, BP. 26 El-Hadaiek Road, Skikda, 21000, Algeria
²Meise Botanic Garden, Nieuwelaan 38, B-1860 Meise, Belgium
³BioInvasions. Global Change. Macroeology Group, Department of Botany and Biodiversity Research, University of Vienna, Rennweg 14, 1030 Vienna, Austria

Corresponding author: Nora Sakhraoui (sakhraouinora05@gmail.com)

Abstract

This paper expands the list of alien species of Crassulaceae that escaped from cultivation in Algeria and mainland North Africa, as a result of the discovery of two new alien species in the Skikda region (northeastern Algeria) in 2021 and 2023. Aeonium haworthii was recorded in a semi-natural habitat, the maritime cliff of the Stora region, and seems completely naturalized in this locality. Crassula ovata was recorded in an urban environment, where it colonizes balconies and roofs; at present, this species is considered to be a casual. These results are supported by field photos of both species, a distribution map and an updated list of alien Crassulaceae species reported so far from mainland North Africa (Algeria, Morocco and Tunisia).

Key words: alien species, escapes, green spaces, habitat, naturalization, North Africa, succulents

Introduction

The Crassulaceae family includes herbs, shrubs and more rarely trees (Simpson 2010) that belong to about 35 genera and 1400 species (Christenhusz and Byng 2016). The family is widely distributed, with diversity centers in some semi-arid regions of the world including South Africa, Mexico, southwestern North America, Mediterranean Europe and parts of the Orient (Smith et al. 2019).

Most species of this family proliferate in arid conditions and can cope well with drought stress thanks to water reserves stored in their leaves and/or stems and the CAM (Crassulacean Acid Metabolism) photosynthetic pathway which allows them to reduce evapotranspiration (Chen and Blankenship, 2021). These characteristics, together with easy vegetative propagation, have probably facilitated the introduction and wide use of many species of this family as ornamental plants in different parts of the world.

In Algeria, the Crassulaceae family is represented, according to Dobignard and Chatelain (2011), by four native genera (Crassula L., Pistorinia DC.,
Sedum L. and Umbilicus DC.) and one introduced genus (Aeonium Webb & Berthel.); in total, 28 species including one Algerian endemic (Sedum multiceps Coss. & Durieu) and one naturalized species (Aeonium arboreum (L.) Webb & Berthel.) have been recorded so far in Algeria. However, more recently the study of Zeddam and Raus (2012) increased the number of alien Crassulaceae established in Algeria by adding one genus with one species (Kalanchoe × houghtonii D.B. Ward, erroneously identified as K. daigremontiana Raym.-Hamet & H. Perrier, see Herrando-Moraira et al. 2020).

The present work, once again, extends the number of alien Crassulaceae in Algeria, since it reports the escape from cultivation of two alien species not previously reported in the country. Aeonium haworthii Webb & Berthel. and Crassula ovata (Mill.) Druce were discovered in the Skikda region (northeastern Algeria) during field surveys between 2021 and 2023. Both species are widely cultivated in gardens and nurseries in the region, along with other species of the Crassulaceae family (Sakhraoui 2021); they are particularly appreciated for their foliage and their decorative habit.

For this study, we recorded information concerning these occurrences, in particular data on the mode of spreading and the nature of the colonized habitats of the studied species in Algeria. Further, we provide a distribution map of the localities, photographs of the species in the colonized habitats, and a list of alien species species of Crassulaceae reported so far in Algeria and other countries of the mainland North Africa (Morocco and Tunisia).

Materials and methods

The escaped populations of Aeonium haworthii and Crassula ovata were found during field surveys, carried out by the first author, for monitoring the dynamics of previously recorded potentially invasive alien plants species (see Sakhraoui et al. 2019, 2022a, b) in the Skikda region. Both species were observed on several occasions (at least twice per season) between 2021 and 2023. The species were identified by consulting Maire (1977), Hernández Romero et al. (2012) and Flora de Canarias (http://www.floradecanarias.com/aeonium_haworthii.html); however, the descriptions given in this paper are mainly based on our own field observations of the Algerian plants.

The determination of the biological characteristics relating to flowering, fruiting and reproduction required seasonal monitoring. The latter was done in situ with the exception of the monitoring of fruiting in C. ovata which was carried out in the gardens of the Joint Research Service “Botanical Extension Pole” of the University of Skikda where a few individuals are cultivated in pots, because the individuals that have escaped from cultivation grow at inaccessible heights that do not allow their examination. The degree of naturalization of the escaped individuals was assessed according to Pyšek et al. (2004). The status categories used are casual (alien plants that may flourish and even reproduce occasionally outside cultivation in an area, but that eventually die out because they do not form self-sustaining populations, and rely on repeated introductions for their persistence), and naturalized
Two new records of alien Crassulaceae in Algeria


Figure 1. Distribution of recorded populations of *Crassula ovata* (red dots) and *Aeonium haworthii* (blue dot) in the Skikda region (northeastern Algeria). The numbers of the populations correspond to Table 1.

(alien plants that sustain self-replacing populations for at least 10 years without direct intervention by people (or in spite of human intervention) by recruitment from seeds or ramets (tillers, tubers, bulbs, fragments, etc.) capable of independent growth).

Further, a literature search was carried out to assess the distribution of the studied species in adjacent regions particularly in Morocco and Tunisia, as well as to confirm the absence of previous records for Algeria. The sources that have been consulted in this regard are the African Plant Database (APD 2023), Euro+Med PlantBase (2023), Global Biodiversity Information Facility (GBIF 2023), and Plants Of the World Online (POWO 2023).

Results

Localities and populations size

*Aeonium haworthii* and *Crassula ovata* have been exclusively recorded in the town of Skikda where they colonize different habitats. The population of *A. haworthii* is larger than the one of *C. ovata*, however, the number of localities of the latter is higher (Figure 1). Information relating to these records, including the characterization of the localities and their geographic coordinates, is detailed below.


Syn.: *Sempervivum haworthii* (Webb & Berthel.) Salm-Dyck ex Christ.

This species was found at a single locality, more precisely on a rocky cliff exposed to sea spray (Figure 2A, B), at the edge of the ledge road leading to
Table 1. Geographic coordinates of recorded localities of *Aeonium haworthii* and *Crassula ovata* escaped from cultivation in Skikda city (northeastern Algeria).

<table>
<thead>
<tr>
<th>Id</th>
<th>Species</th>
<th>Locality</th>
<th>Habitat</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Altitude (m)</th>
<th>Population size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Aeonium haworthii</em></td>
<td>Stora</td>
<td>Coastal cliff</td>
<td>36.888172°</td>
<td>6.893359°</td>
<td>34</td>
<td>dozens of individuals</td>
</tr>
<tr>
<td>1</td>
<td><em>Crassula ovata</em></td>
<td>Mekki Ourtilani street</td>
<td>Balcony</td>
<td>36.877048°</td>
<td>6.908383°</td>
<td>48</td>
<td>1 individual</td>
</tr>
<tr>
<td>2</td>
<td><em>Crassula ovata</em></td>
<td>Belizidia street</td>
<td>Balcony</td>
<td>36.879078°</td>
<td>6.906919°</td>
<td>51</td>
<td>1 individual</td>
</tr>
<tr>
<td>3</td>
<td><em>Crassula ovata</em></td>
<td>Avenue of Revolution</td>
<td>Balcony</td>
<td>36.879731°</td>
<td>6.906715°</td>
<td>54</td>
<td>1 individual</td>
</tr>
<tr>
<td>4</td>
<td><em>Crassula ovata</em></td>
<td>Avenue of Bachir Boukadoum</td>
<td>Gutter of a house</td>
<td>36.868851°</td>
<td>6.908028°</td>
<td>27</td>
<td>1 individual</td>
</tr>
<tr>
<td>5</td>
<td><em>Crassula ovata</em></td>
<td>Avenue of Houari Boumediene</td>
<td>Metal roof</td>
<td>36.860476°</td>
<td>6.923604°</td>
<td>32</td>
<td>1 individual</td>
</tr>
</tbody>
</table>

**Figure 2.** Population of *Aeonium haworthii* on a coastal cliff at Stora (Skikda, northeastern Algeria): individuals without flowers, 21 January 2021 (A), rosette of fleshy leaves, 21 January 2021 (B), individuals with flowers, 06 May 2021 (B), details of flowers, 06 May 2021 (D). Photos by N. Sakhraoui.

the port of Stora (Municipality of Skikda); there, dozens of individuals of different sizes were first observed on 09.02.2021 (15 tufts were identified with sizes varying from 25 cm to more than 1 m in diameter), then re-observed on 15.05.2022 and 05.03.2023 (Table 1, Population no. 1); during
these surveys, young individuals were recorded several times. This species grows on shallow soil at platforms and cracks together with native species, in particular *Achyranthes aspera* L., *Antirrhinum majus* L., *Centranthus ruber* (L.) DC., *Dactylis glomerata* L., *Dittrichia viscosa* (L.) Greuter, *Daucus carota* L., *Echium creticum* L., *Lobularia maritima* (L.) Desv., *Lotus drepanocarpus* Durieu, *Malva sylvestris* L., *Matthiola incana* (L.) R. Br., *Pallenis maritima* (L.) Greuter, *Parietaria judaica* L., *Plantago serraria* L., *Sedum caeruleum* L. and *Senecio leucanthemifolius* Poiret. Naturalized alien species were also recorded in this locality, including *Drosanthemum floribundum* (Haw.) Schwantes (Sakhraoui et al. 2023), *Nephrolepis exaltata* (L.) Schott and *Oxalis pes-caprae* L. Further, native shrubs and large tussock grasses were also noted, such as *Ampelodesmos mauritanicus* (Poir.) Durand et Schinz, *Artemisia arborescens* (Vaill.) L., *Chamaerops humilis* L., *Genista numidica* (Spach) Batt. subsp. *numidica*, *Pistacia lentiscus* L. and *Olea europaea* L.

In Skikda, *A. haworthii* is often grown in pots as an ornamental plant at balconies and terraces, from where it probably escaped to colonize the semi-natural habitat. In the field, we noticed that the flowering period of this species is short. Pale yellow flowers were observed at the beginning of May, and the flowering period was already over at the end of the same month (Figure 2C, D). Seeds were not collected because the plants did not produce fruit in Algeria. The dispersal is probably from stem fragments and leaves which root easily once detached from the mother plant. This species also produces adventitious roots which facilitate vegetative spread.

**Status of naturalization of Aeonium haworthii**

According to the criteria used, *A. haworthii* can be considered naturalized, since it has been growing in this semi-natural habitat, according to the testimony of inhabitants, for several years, mixes with the native flora and the size of the population has steadily increased.

2. *Crassula ovata* (Mill.) Druce

This species was mainly observed in the old town of Skikda where four out of five recorded individuals were found. It was first observed on 18.04.2021 at Mekki Ourtilani street, where an individual up to 80 cm tall and carrying flowers was found hanging on the wall of a balcony of an old house (Table 1, individual no 1). About 300 m from this spot, in Belizidia street, another mature individual exceeding 80 cm in height was found on 21.05.2021, again clinging to the wall of a balcony where other alien species were cultivated in pots, including *Euphorbia milii* Des Moul., *Coleus scutellarioides* (L.) Benth., *Dracaena trifasciata* (Prain) Mabb. and *Heptapleurum arboricola* Hayata (Table 1, individual no. 2). On the same day, an individual, more than 90 cm tall, was observed clinging to a balcony at the Revolution Avenue (Table 1, individual no. 3); the two latter individuals were re-observed on
19.05.2022 and 15.02.2023. On 25.04.2022, another individual was found at Bachir Boukadoum Avenue growing in the gutter of an old house (Table 1, individual no 4).

In the new town of Skikda, the fifth individual, measuring around 25 cm, was observed on 17.10.2021 and re-observed on 09.05.2022 and 27.02.2023 at Houari Boumediene street (Table 1, individual no. 5), hanging from the metal roof of a store where it grows on a thin substrate resulting from the accumulation of dust (Figure 3A, B); there, further alien species were also recorded such as Kalanchoe × houghtonii D.B. Ward and Nephrolepis exaltata. In all these localities, C. ovata occurred with single individuals.
In Algeria, the flowering period of *C. ovata* extends from mid-January to the beginning of March. The flowers are of variable colors, i.e., white or light pink (Figure 3C). Seeds and fruit were not seen in the gardens of the Joint Research Service “Botanical Extension Pole” of the University of Skikda, and the field observations indicate that *C. ovata* is probably dispersed only by stem fragments or detached leaves.

**Status of naturalization of Crassula ovata**

*Crassula ovata* is represented by only a few individuals that persist in the recorded localities but do not form self-sustaining populations and do not spread beyond the urban environment yet, therefore, it should be considered a casual species in Algeria according to the criteria used.

**Discussion**

**Status of A. haworthii and C. ovata in Algeria and North Africa**

The literature research revealed no previous reports for *A. haworthii* in Algeria. In contrast, there are two observations for *C. ovata* on the iNaturalist platform (https://www.inaturalist.org/observations/91779260, https://www.znaturalist.org/observations/107543445) included in GBIF (2023). However, the two photos posted on iNaturalist, taken respectively in April 2008 and February 2022 in urbanized sites in the wilaya (= district) of Algiers, unfortunately do not allow to identify the colonized habitat, i.e., to assess whether these observations refer to planted or escaped individuals. Either way, these occurrences indicate that *C. ovata* is present in other parts of the country where it is also likely to escape cultivation.

In mainland North Africa, the escape of *A. haworthii* from cultivation has been reported so far only in Tunisia where it was reported as alien with unknown status by El Mokni et al. (2019). Thus, the record from Skikda is the first one for mainland North Africa where the species is clearly naturalized. *Crassula ovata* on the other hand, has been reported only from the Canary Islands (https://www.biodiversidadcanarias.es/biota/especie/E07446) and Madeira (Vieira 2002), but there are no records for mainland North Africa.

**Species description, distribution and spreading in Algeria**

*Aeonium haworthii* is a succulent subshrub native to Tenerife (the largest of Spain’s Canary Islands) (Walker 2021) from where it was introduced to different regions of the world as an ornamental plant. Its escape from cultivation has been reported in a few countries, notably in New Zealand (Webb et al. 1988) and in the United States where it is naturalized in California (https://www.calflora.org/entry/occdetail.html?seq_num=mu20189). In Europe, *A. haworthii* has been reported as casual in Spain (Aymerich and Sáez 2019) and naturalized in Italy (Galasso et al. 2019) and Portugal (Domingues De Almeida and Freitas 2006).
Individuals naturalized in Algeria are characterized by slender and branched stems that can exceed 50 cm in height, with numerous adventitious roots. Leaves are thick and ciliate on the margin, green or a little glaucous, often bordered with purple. They are organized in rosettes that can exceed 10 cm in diameter. The petals of the flowers are pale yellow and the sepals are slightly pink. *Aeonium haworthii* closely resembles *A. castello-paivae* Bolle which was also cultivated in Algeria (Maire 1977) and probably still is. Both species can easily be confused, however, their separation is facilitated by examining the flowers which are greenish-white in *A. castello-paivae*

*Aeonium haworthii* is endemic to the Anaga mountains in northeastern Tenerife, where it grows commonly on dry cliffs and rocks from sea level to 1,000 m altitude (Walker 2021). To some extent, the Stora region, where the Algerian population is located, offers habitats (mostly rocky areas at sea level) that fit the species well and that are similar to those in the native range. Thus, further spread seems likely – as has already been observed with its congener *A. arboreum* Webb & Berthel. which occurs in a large population at the same site among native shrubs.

*Crassula ovata* is a succulent subshrub native to Cape Provinces, KwaZulu-Natal and Mozambique (POWO 2023). It has been introduced in many regions of the world as an ornamental plant. It is reported as an alien species in China (Wang et al. 2015), California, Mexico, Australia and New Zealand (CABI Compendium 2023). In the northern part of the Mediterranean, it has been reported as a casual species in Spain (Aymerich and Sáez 2019), Italy (Galasso et al. 2019) and Portugal (Domingues de Almeida 2018).

The individuals observed in Algeria do not exceed 90 cm in height, but in cultivation in open ground, the plant can exceed 1m in height (Sakhraoui pers. obs.). The individuals are branched, bearing small oval leaves, about 4 cm long, of jade green color often reddish at the leaf edge. The leaves at the base of the stems may desiccate during the flowering period, while those on the top of the stems persist. Flowers are small and white or light pink.

*Crassula ovata* has medicinal properties, in particular it is used to disinfect wounds and cure diarrhea (Muiruri and Mwangi 2015). However, these properties do not seem to be known in Algeria, where the species is exclusively used in ornamentation.

Until now, it solely colonizes urban habitats. Many species of the genus *Crassula* are known to be highly adaptable to a wide range of environments (Jones 2011). Further, cities are known to offer a greater diversity of environmental conditions compared to rural regions of the same size (Schmidt et al. 2014). As propagule pressure by ornamental plants is also higher in cities, the spread of alien species often starts there (Marco et al. 2010; Mclean et al. 2017).

In the study area, *A. haworthii* and *C. ovata* are widely used as indoor plant (Sakhraoui pers. obs.). The plants cultivated on balconies and terraces are exposed to wind and rainfall, which can contribute to mechanical...
Table 2. Overview of alien species of the Crassulaceae family recorded from continental North Africa.

<table>
<thead>
<tr>
<th>Species</th>
<th>Native range (POWO 2023)</th>
<th>Country</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotyledon orbiculata L.</td>
<td>South west Angola to Cape Provinces</td>
<td>Tunisia (El Mokni et al. 2019)</td>
<td>Naturalized</td>
</tr>
<tr>
<td>Crassula decumbens Thunb.</td>
<td>South Africa, Australia, Central Chile</td>
<td>Tunisia (Dobignard and Chatelain 2011)</td>
<td>Naturalized</td>
</tr>
<tr>
<td>Crassula helmsii (Kirk) Cockayne &amp; Hamet &amp; H. Perrier</td>
<td>South west Madagascar</td>
<td>Tunisia (Dobignard and Chatelain 2011), Tunisia (Sukhorukov et al. 2018)</td>
<td>Naturalized</td>
</tr>
<tr>
<td>Kalanchoe daigremontiana Raym.-Hamet &amp; H. Perrier</td>
<td>South Central &amp; South Madagascar</td>
<td>Tunisia (Sukhorukov et al. 2018)</td>
<td>Casual?</td>
</tr>
<tr>
<td>Kalanchoe fedtschenkoi Raym.-Hamet &amp; H. Perrier</td>
<td>Central &amp; South Central Madagascar.</td>
<td>Tunisia (Sukhorukov et al. 2018)</td>
<td>Naturalized (in urban habitat)</td>
</tr>
<tr>
<td>Kalanchoe ×houghtonii D.B. Ward</td>
<td>Artificial hybrid</td>
<td>Algeria (erroneously identified by Zeddam and Raus (2012) as K. daigremontiana see Herrando-Moraira et al. 2020), Tunisia (Sukhorukov et al. 2018),</td>
<td>Escaped from cultivation (= casual?)</td>
</tr>
<tr>
<td>Kalanchoe laxiflora Baker</td>
<td>East Central Madagascar</td>
<td>Morocco (Dobignard and Chatelain 2011)</td>
<td>Casual</td>
</tr>
<tr>
<td>Kalanchoe marmorata Baker</td>
<td>Eritrea to Rwanda and North Tanzania</td>
<td>Tunisia (El Mokni and Sáez 2019)</td>
<td>Casual</td>
</tr>
<tr>
<td>Sedum praealtum A. DC.</td>
<td>Mexico to El Salvador</td>
<td>Morocco (Dobignard and Chatelain 2011), Tunisia (El Mokni et al. 2019)</td>
<td>Casual in Morocco, Locally escaped (= casual?) in Tunisia</td>
</tr>
</tbody>
</table>

Damage to shoots and leaves enhancing vegetative reproduction and spread. In addition, it is probable that garden waste is responsible for the appearance of A. haworthii in the locality where it was observed.

Although the invasion history and impact of both species are still unknown, they could spread in the local environment and compete with the native flora. This is more likely for A. haworthii which has already naturalized in a semi-natural environment, showing a great capacity of adaptation.

**Alien Crassulaceae in continental North Africa**

Besides the studied species, several other species of the Crassulaceae family have already been reported as alien for continental North Africa. So far, 13 species that belong to 5 genera have been listed (Table 2). However, this number is considerably smaller than the number of species recorded in the northern part of the Mediterranean (see Galasso et al. 2018; Aymerich and Sáez 2019) where Aeonium and Crassula are both among the best represented genera in relation to the number of species (e.g. 6 species of Aeonium and 6 species of Crassula in Italy and 4 species of Aeonium and 7 species of Crassula in Spain).

Among all alien taxa of the Crassulaceae recorded in continental North Africa, species of the genus Kalanchoe are the most likely to expand their range considerably in the future, because they have the ability to produce large numbers of clonal propagules from their leaf margins that facilitate their spread (see Guerra-García et al. 2014). Moreover, several species of this genus have been reported as invasive in different regions of the world including the Mediterranean, where K. daigremontiana Raym.-Hamet &
H. Perrier and K. ×houghtonii D.B. Ward have been reported as invasive in Spain and Italy (Guillot Ortiz et al. 2015; Herrando-Moraira et al. 2020; Stinca et al. 2021).

**Conclusion**

Based on our results, *C. ovata* should be added to the list of alien Crassulaceae reported from continental North Africa, the future spread of *A. haworthii* and *C. ovata* should be monitored in the Skikda region, and they should be searched for in other regions of northern Algeria. This work has shown that alien plant escapes still occur in Algeria, emphasizing the need for further field surveys.

**Acknowledgements**

The authors would like to thank the associate editor C. Lambertini and the anonymous reviewers for their corrections and comments, Dr. J. Alfredo Reyes-Betancort, director of the Botanical Garden of Puerto de la Cruz, Tenerife for his contribution in the identification of *Aeonium haworthii*, and the Austrian Science Foundation FWF (grant no. I5825-B) for its funding.

**Funding declaration:**

FE appreciates funding by the Austrian Science Foundation FWF (grant I 5825-B).

**Author’s contribution:**

Research conceptualization: Nora Sakhraoui; sample design and methodology: Nora Sakhraoui; investigation and data collection: Nora Sakhraoui and Amel Boudries; data analysis and interpretation: Nora Sakhraoui and Azzedine Hadef; funding provision: Franz Essl; writing: Nora Sakhraoui and Franz Essl; review: Filip Verloove and Franz Essl.

**References**


Web sites and online databases