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First record of *Kalanchoe laxiflora* as a casual and additional records of *K.* ×*houghtonii* (Crassulaceae) in Algeria

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Summary: Eight localities of *Kalanchoe laxiflora* and fifteen localities of *K.* ×*houghtonii* were recorded in northeastern Algeria, resulting from field surveys carried out in the wilayas (regions) of Skikda, Annaba, El Tarf, and Souk Ahras. *Kalanchoe laxiflora* is here reported for the first time from Algeria and for the second time from mainland North Africa. *Kalanchoe* ×*houghtonii* was recorded in Algeria before. Here we report additional occurrences in four wilayas. The substrate preferences, especially in human-made habitats, naturalisation status and future spread of the two taxa, are discussed.

Zusammenfassung: Im Nordosten Algeriens wurden acht Fundorte von *Kalanchoe laxiflora* und fünfzehn Fundorte von *K.* ×*houghtonii* gemeldet, als Ergebnis von Felduntersuchungen in den Wilayas (Provinzen) von Skikda, Annaba, El Tarf und Souk Ahras. *Kalanchoe laxiflora* wird hier zum ersten Mal aus Algerien und zum zweiten Mal vom nordafrikanischen Festland gemeldet. *Kalanchoe* ×*houghtonii* wurde bereits in Algerien nachgewiesen. Hier berichten wir über weitere Vorkommen in vier Wilayas. Die Substratpräferenzen, insbesondere in vom Menschen geschaffenen Lebensräumen, der Status der Einbürgerung sowie die zukünftige Ausbreitung der beiden Taxa werden diskutiert.

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Introduction

Succulents in general and the Crassulaceae in particular are among the most widely grown plants in urban environments in the Mediterranean region (Marco et al., 2010). In Algeria, where the coastline of the country experiences a Mediterranean climate (hot, dry summers and mild, wet winters) several Crassulaceae are cultivated including species belonging to the genera *Aeonium* Webb & Berthel., *Cotyledon* L., *Crassula* L., *Echeveria* DC., *Kalanchoe* Adans., *Sedum* L. and *Sempervivum* L. (Sakhraoui, 2021). Some of the exotic species used as garden ornamentals in Algeria have escaped from cultivation and in this paper the first record in urban habitats of *K. laxiflora* Baker and additional records of *K.* ×*houghtonii* D.B.Ward are reported. Both taxa were found in several localities in northeastern Algeria. Our study also reflects on their mode of reproduction which explains the success of their establishment and facilitates predictions about their future spread. Note that *Bryophyllum* Salisb. is here included in *Kalanchoe* at the rank of subgenus.

Material and methods

Kalanchoe ×*houghtonii* and *K. laxiflora* were recorded by the principal author during more

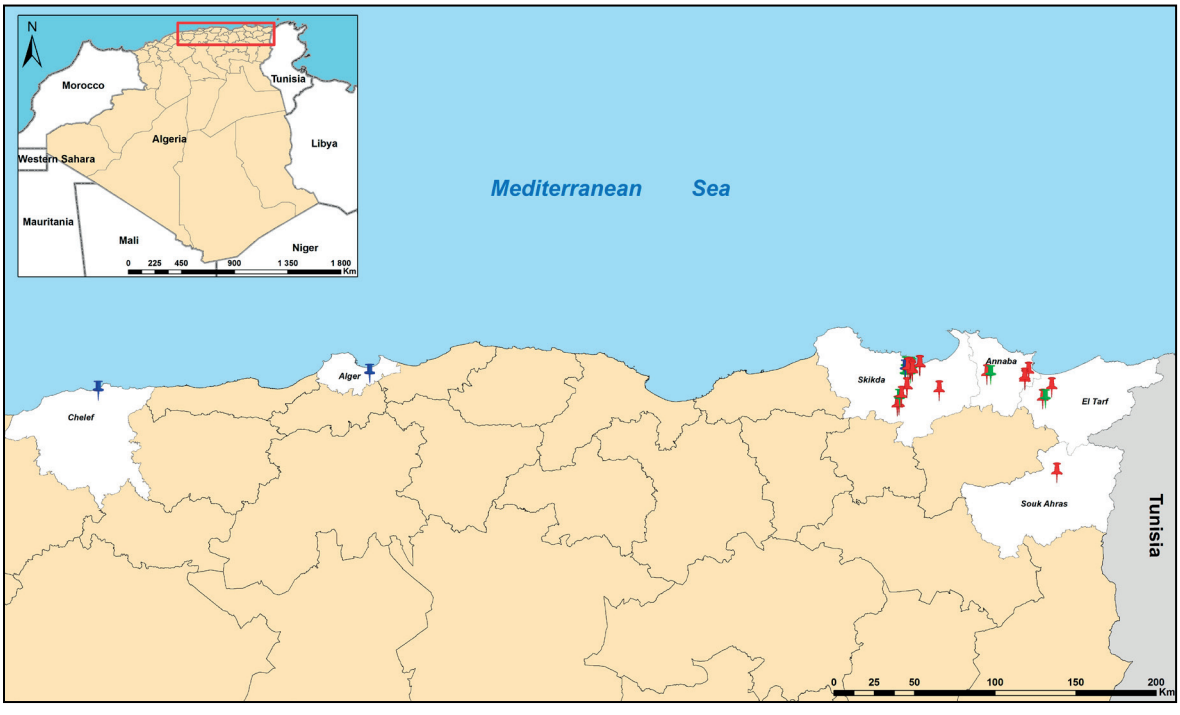

Figure 1. Distribution of *Kalanchoe laxiflora* (in green) and *K.* ×*houghtonii* (in red for populations recorded in this study and in blue for populations recorded by other authors) in northern Algeria.

than forty field surveys conducted between 2021 and 2023. During the surveys the urban vegetation of northeastern Algeria, specifically in the wilayas (regions) of Skikda, Annaba, El-Tarf and Souk Ahras were inventoried.

Specimens of *Kalanchoe* were identified based on botanical descriptions and photographs included in Wang et al. (2016), Smith & Figueiredo (2019) and González Gutiérrez et al. (2019). The following data were gathered in the field–type of colonised habitat, mode of reproduction and whether seed was produced. The degree of naturalisation was also assessed according to Richardson et al. (2000). In addition, a bibliographic search was carried out in international databases such as Global Biodiversity Information Facility (GBIF, 2023), Plants of the World Online (http://plantsoftheworldonline.org), iNaturalist (https://www.inaturalist.org/) and the African Plant Database (APD, 2023) to gain an improved understanding of the global distribution of both taxa.

Kalanchoe laxiflora Baker

Eight localities of *K. laxiflora*, spread over three wilayas, and fifteen localities of *K.* ×*houghtonii*, spread over four wilayas, were recorded in northeastern Algeria (Figure 1). *Kalanchoe laxiflora* Baker (= *Bryophyllum crenatum* Baker, = *B. laxiflorum* (Baker) Govaerts, = *Kalanchoe crenata* (Baker) Raym.-Hamet) is indigenous to Madagascar (Smith & Figueiredo, 2019) but has been introduced to different regions of the world as an ornamental plant. Its escape from cultivation has so far only been reported in a few countries and regions including in Hawaii, Mauritius, Réunion (Soubeyran, 2008; GBIF, 2023), Italy where it was recently reported as a casual (Stinca et al., 2021) and as invasive in Ecuador (Vargas et al., 2022). In North Africa, its potential naturalisation has not yet been reported, but the species has been recorded occasionally in Morocco (Dobignard & Chatelain, 2011). The records presented here are thus the first for Algeria and the second for mainland North Africa. All observations are by N. Sakhraoui.

Locations recorded in Algeria

Skikda, Municipality of Skikda (Merdj Eddib AADL)–nine to ten flowering individuals at the edge of the sidewalk, 19 October 2021 to 30 January 2022. This population has been destroyed, probably by weeding or otherwise removed. The following additional records are all associated with domestic buildings.

Figure 2. *Kalanchoe laxiflora* and inflorescence in urban habitats in Skikda region (northeastern Algeria). Young individuals at the edge of a sidewalk (Merdj Eddib AADL), 19 October 2021.

Skikda, Municipality of Hamadi Krouma–a small population of about thirty flowering individuals, growing on the roof of a house, 17 January 2021; Municipality of Skikda (Bouyaala and Salah Boulkeroua)–two populations of 5 to 10 clumps, flowering and non-flowering individuals, on the metal roofs of shops and the wall of a villa, 25 February 2021–20 February 2023; Municipality of El Hadaeik–a large clump bearing flowers (fresh and wilted) on the wall of a building, 14 June 2022 and 2 February 2023; Municipality of Salah Bouchaour–a large population with flowering individuals, on the roof of a building, 8 March 2023; **Annaba**, Municipality of Berrahal–a large population with dozens of individuals in bloom, on the metal roof of a store 17 March 2023; **El Tarf**, Municipality of El Besbes–two clumps without flowers then with flowers growing on the wall of a balcony, 1 June 2021 and 8 February 2023.

Habitats and distribution in Algeria

Kalanchoe laxiflora currently grows in urban habitats where it mainly colonises the walls and roofs of buildings and more rarely the edges of sidewalks (Figure 2). It is usually associated with other exotic species such as *Opuntia monacantha* (Willd.) Haw. and *K.* ×*houghtonii*, as well as with indigenous species that are common roof dwellers, including *Funaria hygrometrica* Hedw. and *Umbilicus rupestris* (Salisb.) Dandy.

Since *K. laxiflora* was first recorded in Algeria in 2021, in the capital of the municipality of Hamadi Krouma (Wilaya of Skikda), the number of known localities of this species has gradually increased to eight, spread over three wilayas in northeastern Algeria. The species mainly escapes from plant containers on balconies and terraces. Small plantlets that develop on the leaf margins become easily detached and dispersed, which facilitate the formation of populations some distance from the parent plants.

Extent of naturalisation

Using the criteria of Richardson et al., *K. laxiflora* can be considered casual in Algeria, although it is persisting in at least four localities. However, the short observation period (two years since the first observation) does not allow confirmation of its local naturalisation. In addition, it is not yet spreading beyond urban environments.

***Kalanchoe* ×*houghtonii* D.B.Ward**

Kalanchoe ×*houghtonii* is (= *Bryophyllum* ×*houghtonii* (D.B.Ward) P.I.Forst.) is a hybrid between *K. daigremontiana* Raym.-Hamet & H.Perrier and *K. delagoensis* Eckl. & Zeyh. It was created in the USA. in the 1930s (Guillot Ortiz et al., 2014), but was also produced artificially elsewhere, for example in Portugal (Smith, 2019; Shtein et al., 2021). Material of what is today known as *K.* ×*houghtonii* was soon introduced as an ornamental plant in different parts of the world and has escaped into natural vegetation in several places (Herrando-Moraira et al., 2020: Supplementary Material). These include Italy (Podda et al., 2012; Galasso et al., 2019), Portugal (Smith et al., 2015), Spain (Guillot Ortiz et al., 2014), Florida, USA. (Ward, 2006), Cuba (González Gutiérrez et al., 2019), China (Wang et al., 2016), Australia (Atlas of Living Australia, https://bie.ala.org.au /species/) and Aruba (Thomson pers. comm.). The invasive potential and behaviour of this nothospecies have already been recorded in different parts of the world including in the European Mediterranean region, for example in Portugal, Spain and Italy, where its area of occupancy is likely to increase in the foreseeable future (Herrando-Moraira et al., 2020; Stinca et al., 2021). In Northwest Africa, the nothospecies has been reported as naturalised in the Canary Islands (Otto & Verloove, 2016) and in North

Figure 3. *Kalanchoe* ×*houghtonii* in Skikda region (northeastern Algeria). Plants on the roadside growing as ruderals amidst the grasses, 17 February 2023.

Africa, it has been reported as a casual in Tunisia where only a few occurrences have been recorded in urban habitats, in the presence of both parents (Sukhorukov et al., 2018). Herrando-Moraira et al. (2020: Supplementary Material) recorded five locations where *K.* ×*houghtonii* had been found previously in Algeria. The five records were based on Zeddam & Raus (2012: 290), where this nothospecies was however recorded, exclusively in Algiers, under the name *K. daigremontiana*, one of its parents. Five additional occurrences of the nothospecies in Algeria are mentioned on the iNaturalist platform, of which only three, dating from January 2021, February 2022 and March 2022, respectively registered in Skikda, Algiers and Tenès (Wilaya of Chlef, northwestern Algeria), are escapes in urban environment. The records presented here from observations by N. Sakhraoui extend the range of *K.* ×*houghtonii* by over 340km (from Skikda) eastwards from the first report, highlighting its wide spread and great invasive potential in Algeria.

Additional locations recorded in Algeria

Skikda, Municipality of Skikda–numerous populations comprising hundreds of flowering and non-flowering individuals, on sidewalks, gutters, walls of balconies and terraces, paving slabs, metal roofs of shops and buildings and along roadsides, 5 January 2021 to 27 February 2023; Municipality of Hamadi Krouma–dense populations with fifty flowering and non-flowering individuals, on the roofs of old buildings and the paving slabs of new buildings, 12 January 2021 and 5 December 2022; Municipality of Ramdane Djamel–dense populations with flowering and non-flowering individuals on the paving slabs and terraces of new buildings, 7 February 2021 and 20 February 2023; Municipality of Salah Bouchaour–several populations with ten to twenty flowering and non-flowering individuals on the flagstones and the roofs, 7 February 2021 and 17 September 2022; Municipality of El Harrouch–very large populations with hundreds of flowering individuals, on the roofs of downtown arcades, 21 January 2021; Municipality of Azzaba–a population of about thirty flowering individuals, on a metal roof, 21 March 2022; **Annaba**, Municipality of Berrahal–a population of about eighty individuals on a wall at the entrance to the city, 5 June 2022 and 19 March 2023; Municipality of Sidi Amar–large populations with hundreds of individuals, on roofs, sidewalks, walls and paving slabs of building entrances, 5 June and 18 July 2022; Municipality of El Bouni–large populations with dozens of non-flowering individuals on balcony roofs, 27 September 2022; **El Tarf**, Municipality of El Besbes: several populations comprising dozens of individuals, on the walls and roofs of old buildings, 1 June 2021 and 8 February 2023; Municipality of Ben M'Hidi–dozens of populations with 10 to 15 individuals, on the roofs of buildings, 1 June 2021; **Souk Ahras**, Municipality of Souk Ahras–two populations of about 20 individuals each, on a wall and at the edge of a sidewalk, 22 May 2021.

Habitats and distribution in Algeria

Kalanchoe ×*houghtonii* mainly colonises urban habitats, in particular roofs, walls, gutters, balconies, paving slabs, and sidewalks (Figure 3). It has also been detected along roadsides in the Larbi Ben M'Hidi city (Wilaya of Skikda) however, where it grows amidst native ruderal species such as *Cynodon dactylon* (L.) Pers., *Hordeum vulgare* L., *Mercurialis annua* L., *Myosotis ramosissima* Rochel, and *Urtica membranacea* Poir. It also grows with exotic species such as *Kalanchoe laxiflora, Mirabilis jalapa* L., *Opuntia ficus-indica* (L.) Mill., and *Oxalis pes-caprae* L. In urban areas, *K.* ×*houghtonii* has been observed together with *Erigeron bonariensis* L., *Funaria hygrometrica* Hedw., *Sedum caeruleum* L., *Sonchus* cf. *oleraceus* L., and *Umbilicus rupestris*. However, in Algeria it has never been observed growing together with its parents.

Kalanchoe ×*houghtonii* has spread over an extensive part of the study area. It occurs widely in four wilayas of northeastern Algeria with 15 localities and 25 occurrences noted. In fact, the number of localities is larger than indicated here, because we only recorded localities with large populations. Dozens of localities with 3, 4 or 5 individuals, in each of the study areas, have therefore been neglected. In Algeria, *K.* ×*houghtonii* has therefore become a common component of urban vegetation. The large number of populations recorded and the wide distribution of the nothospecies in urban environments suggest that it has also escaped in other cities of the country where it is cultivated, notably in Constantine and Guelma. Its rapid reproduction by vegetative means, essentially from large numbers of plantlets that develop on the leaf margins and also on inflorescences, largely explains its successful dispersal.

Extent of naturalisation

Based on the criteria of Richardson et al., *K.* ×*houghtonii* can be considered as being in the process of naturalisation in Algeria, because it is growing successfully and reproducing unaided

in all recorded localities. Its spread beyond the urban environment is progressing in at least one locality.

Discussion

Kalanchoe laxiflora should be added to the list of non-indigenous escaped taxa of the Crassulaceae in Algeria, which now includes only one naturalised species, *Aeonium arboreum* (L.) Webb & Berthel. (Dobignard & Chatelain, 2011) and one nothospecies, *K.* ×*houghtonii* (Zeddam & Raus, 2012). *Kalanchoe laxiflora* still seems to be at the beginning of its spread in the study area, but it is possible that it could eventually show the same behaviour as *K.* ×*houghtonii*, especially since the two taxa have similar reproductive characteristics, notably vegetative reproduction by means of leaf marginal bulbils.

In this study, Larbi Ben M'Hidi city (Municipality of Skikda) is the only locality where *K.* ×*houghtonii* was found to have colonised roadsides and grows among indigenous ruderal species. In our opinion this nothospecies will soon appear in other semi-natural or even in natural environments, especially in the Skikda region where it has been observed at the edge of relics of coastal maquis vegetation, for example. Speculatively, the artificial creation of at least some of the forms of *K.* ×*houghtonii* might have improved its ability to adapt to colonise human-made infrastructures.

In both *K. laxiflora* and *K.* ×*houghtonii*, sexual reproduction has been recorded elsewhere (GFS, pers. obs.), but this has not been found in Algeria. However, the efficiency of their vegetative reproduction, through the production of large numbers of propagules with high viability, as has been demonstrated in some species of the genus (see Herrera & Nassar, 2009), requires the monitoring of their population dynamics and the possible implementation of control strategies, such as physical eradication, that will eliminate bulbils in the event of invasions. This is even more necessary for the control of *K.* ×*houghtonii* reported as invasive in the Mediterranean region, in particular in Italy (Stinca et al., 2021).

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