

Rapid Communication**First escaped populations of *Gazania ×splendens* Hend. & Andr. Hend. (Asteraceae) in Algeria**Nora Sakhraoui^{1,*}, Sonia Rouidi¹, Franz Essl², Filip Verloove³ and Azzedine Hadeff¹¹Department of Ecology and Environment, Faculty of Sciences, University 20 August 1955 Skikda, BP. 26 El-Hadaiek Road, Skikda, 21000, Algeria²BioInvasions. Global Change. Macroecology Group, Department of Botany and Biodiversity Research, University of Vienna, Rennweg 14, 1030 Vienna, Austria³Meise Botanic Garden, Nieuwelaan 38, B-1860 Meise, Belgium

*Corresponding author

E-mail: sakhraouinora05@gmail.com

Citation: Sakhraoui N, Rouidi S, Essl F, Verloove F, Hadeff A (2023) First escaped populations of *Gazania ×splendens* Hend. & Andr. Hend. (Asteraceae) in Algeria. *BioInvasions Records* 12(3): 659–666, <https://doi.org/10.3391/bir.2023.12.3.03>

Received: 24 January 2023**Accepted:** 30 April 2023**Published:** 19 June 2023**Handling editor:** Ioannis Bazos**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).

OPEN ACCESS**Abstract**

During field surveys carried out in north-eastern Algeria, the escape of *Gazania ×splendens* Hend. & Andr. Hend. was observed; it is reported here as in the process of naturalization for the first time in Algeria and continental North Africa. This hybrid of the Asteraceae family, highly appreciated and widely used in ornamentation, was discovered at a single locality on a coastal dune in the Skikda region, where it is currently colonizing disturbed habitats, in particular the edges of sidewalks. It grows on sandy soil, spreads from seeds and seems to have escaped from the countless green spaces in the region. *Gazania ×splendens* manages to cope well with summer heat and drought and has maintained itself at the site for more than three years. Field photos and a map marking the escaped populations and the cultivated populations in their vicinity are provided.

Key words: Arctotideae, degree of naturalization, first record, green spaces, habitat, introduced species, ornamental, spread

Introduction

In recent years, and in an unprecedented attempt, substantial effort has been put into botanical field work to update the knowledge of the Algerian native and alien flora (Véla et al. 2013; Miara et al. 2018; Sakhraoui et al. 2020; Meddour et al. 2020). In this context, field work by the first author has started in 2019 in the Skikda region (NE-Algeria). New surveys carried out as part of monitoring the population dynamics of potentially invasive alien species recorded in previous research (Sakhraoui et al. 2019), led to the discovery of another alien new for Algeria, i.e. *Gazania ×splendens* Hend. & Andr. Hend.

The genus *Gazania* belongs to the Asteraceae family and includes 16 species endemic to South Africa that are well adapted to arid and semi-arid conditions (Howis et al. 2009), often colonizing coastal dunes (Hesp and Mclachlan 2000).

Although *G. ×splendens* has so far solely colonized disturbed habitats in Algeria, it might in the future extend its distribution and establish in semi-natural or natural habitats. Here, we report the first escaped occurrence of *G. ×splendens* in Algeria, and provide relevant information on its biology and ecology as basis for monitoring.

Materials and methods

During field surveys carried out mainly in the south and east of the city of Skikda (north-eastern Algeria) between 2019 and 2023, the first author of this article discovered an escaped population of *Gazania ×splendens* in 2019. For further study, the first author executed several field surveys (at least twice per year) and re-visited the escaped population and the surroundings. The plants were photographed and the geographical coordinates of the population were recorded. An extensive literature search has revealed that this represents a new national record.

In order to collect as much information as possible relating to this recording, targeted surveys and surveys extended to the entire zone (Larbi Ben M'Hidi) were subsequently carried out on foot. The targeted surveys aimed on the one hand to verify the persistence of the taxon (i.e. if the population was present over several years) and to document population change over time and to evaluate its degree of naturalization at the site according to Pyšek et al. (2004); further, the surveys were used to record additional data mainly concerning the mode of reproduction, fruiting and germination of seeds. Further surveys were intended to identify the distribution of cultivated populations of *G. ×splendens*, and possible other escaped populations.

Finally, a bibliographic search was carried out in order to provide an overview of the alien distribution of this taxon worldwide. This was done by consulting various databases, in particular the African Plant Database (ADP 2023), Global Biodiversity Information Facility (GBIF 2023), Euro + Med Plant Base (2023) and Plants of the World Online (POWO 2023). The latter was also consulted to verify the synonymy of the studied taxon.

Results

Locality and population size

Only one locality and two occurrences with dozens of escaped individuals of *Gazania ×splendens* was recorded (Figure 1). Information about this record are detailed below.

***Gazania ×splendens* Hend. & Andr. Hend.**

= *G. ×aurantiaca* Jacob-Makoy, = *G. ×splendens* variegata Burb.

The study taxon was observed for the first time on 3rd March 2019 in the city of Larbi Ben M'Hidi (Municipality of Skikda). The population consisted

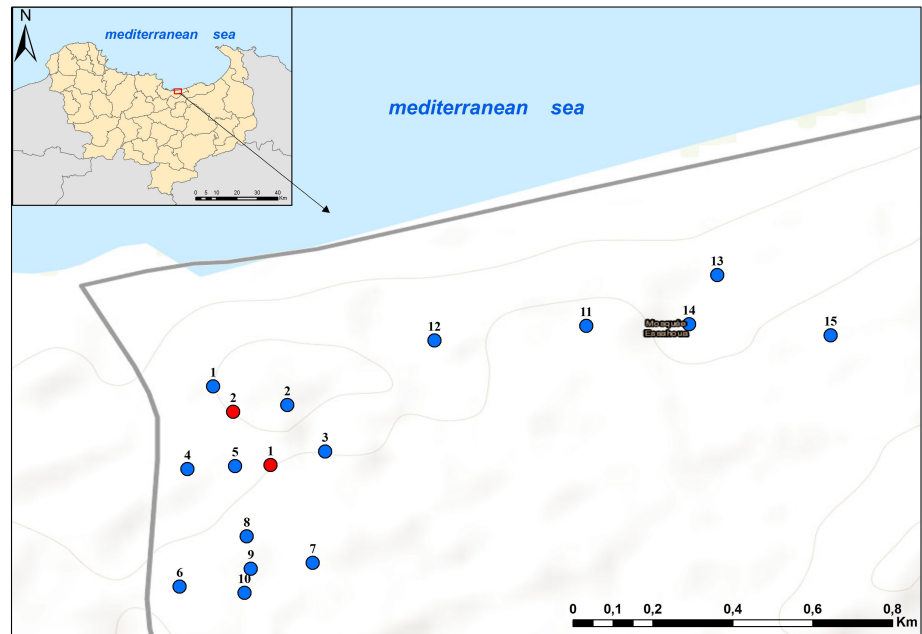


Figure 1. Distribution of recorded populations (escaped (red dots) and cultivated (blue dots)) of *Gazania ×splendens* in Larbi Ben M'Hidi (Skikda, north-eastern Algeria). The numbers of the populations correspond to Table 1.

of c. 30 mature individuals and more than fifty seedlings growing in sandy soil in the vicinity of a public green space arranged by the inhabitants of the city, where the plants were also cultivated. The individuals observed were 5 to 15 cm tall, and some were flowering (Table 1, Population n° 1).

On 7th November 2020 about ten individuals, also of varying sizes, were observed along a sidewalk about 50 m away from the first point of observation. Mature plants and seedlings were growing in sandy soil in cracks and crevices at about fifty meters from the coastal maquis and about ten meters from a semi-natural environment where *Asparagus acutifolius* L., *Daucus carota* L. subsp. *hispanicus* (Gouan) Thell., *Dittrichia viscosa* (L.) Greuter subsp. *viscosa* and *Rubus ulmifolius* Schott grow (Table 1, Population n° 2).

In 2021, five additional mature plants were found on 8th January and 7th May at the same location, by the side of a road on sandy ground about 20 m from the first point of observation. Other species present there were *Avena sterilis* L., *Borago officinalis* L., *Cerinthe major* L., *Cynodon dactylon* (L.) Pers., *Hordeum vulgare* L., *Lagurus ovatus* L., *Lobularia maritima* (L.) Desv., *Malva sylvestris* L., *Mercurialis annua* L., *Oxalis pes-caprae* L., *Plantago lanceolata* L., *Rumex bucephalophorus* L., *Urospermum dalechampii* (L.) Scop. ex F.W. Schmidt and *Urtica membranacea* Poir.

Targeted surveys carried out in 2022 and January 2023 revealed the persistence of most individuals recorded in the previous years, except those newly recorded in 2021, which had disappeared. These surveys also showed that this taxon is effectively resistant to summer heat and drought, as individuals exposed to full sun light observed on 19th August 2022 at the edge of the sidewalk still had green leaves after being exposed to temperatures exceeding 42 °C in July and August.

Table 1. Geographic coordinates of recorded populations (escaped and cultivated) of *Gazania ×splendens* in Larbi Ben M'Hidi (Skikda, north-eastern Algeria).

Population	Id	Habitat	Coordinates (DD)		
			Latitude	Longitude	Altitude (m)
Escaped	1	Roadside in the vicinity of green space	36,8826	6,9825	42
	2	cracks on the edge of sidewalk	36,8838	6,98166	40
Cultivated	1		36,8844	6,98121	41
	2		36,884	6,98288	54
	3		36,8829	6,98373	42
	4		36,8825	6,98063	46
	5		36,8826	6,9817	40
	6		36,8799	6,98045	45
	7	Green spaces fitted out along the roadsides and main facades of the villas	36,8804	6,98345	54
	8		36,881	6,98197	55
	9		36,8803	6,98206	51
	10		36,8797	6,98191	47
	11		36,8857	6,98961	49
	12		36,8854	6,98619	42
	13		36,8869	6,99256	27
	14		36,8858	6,99192	33
	15		36,8855	6,99511	56

Despite the extension of the surveyed area to the entire Larbi Ben M'Hidi region, no further escaped populations were detected. However, several cultivated occurrences in green spaces along roadsides (most often fitted out by the owners of the villas in front of the main facades of their dwellings) have been recorded (Figure 1).

Monitoring of the phenology of *G. ×splendens* revealed that the flowering period of individuals escaped from cultivation is quite prolonged; it lasts almost the whole year. Peak flowering was observed, however, in spring from March until the end of May, when it stops during summer, to resume occasionally in autumn from September onwards; sometimes even in winter, flowers have been recorded. The escaped individuals produce flowers of various colors, some are yellow, others are pink, or even of mixed colors (Figure 2).

Monitoring has shown that *G. ×splendens* manages to reproduce easily from seeds which are produced in large quantities from the beginning of June until the end of August. Hundreds of achenes have been observed at the edges of sidewalks among native herbs. However, it also reproduces vegetatively via creeping stems which can form mats, hence its ornamental use as ground cover. This reproductive strategy was observed only in a few individuals that were surrounded by bare earth. For the most part, the nature of the habitat (concrete sidewalk or road) prevented them from forming adventitious roots.

Status of naturalization

According to Pyšek et al. (2004), the escaped population of *G. ×splendens* can be considered as being in the process of naturalization, because the self-seeding individuals are producing fruits which points at a self-sustaining



Figure 2. *Gazania ×splendens* on the edge of sidewalk among native herbs at Larbi Ben M'Hidi, 30 October 2022 (A), Variability in flower color of escaped individuals, 09 August 2022 (B and C), involucre bracts, 21 March 2023 (D), (Skikda, north-eastern Algeria). Photos by N. Sakhraoui.

population and are gradually increasing in number. However, the time since the first record is too short to allow for a definite assessment as naturalized.

Discussion

Sources of the worldwide distribution of *G. ×splendens* (e.g. GBIF 2023; Euro+Med Plant Base 2023; POWO 2023) revealed the absence of records for Algeria, and also consulting specialized literature on the Algerian and African flora did not yield any records (e.g. Dobignard and Chatelain 2011; Meddour et al. 2020; ADP 2023). To our knowledge, this record is therefore the first for Algeria. However, these same sources have shown that the taxon is reported as alien in only a few regions of the world, such as Spain where it has been reported as naturalized (Laguna Lumbreras and Ferrer Gallego 2013; Verloove et al. 2019) and Italy where it has been reported as casual (Di Gregorio 2020). In the northern part of the Mediterranean, it is rather *G. rigens* (L.) Gaertn. which has a larger distribution since it has been reported

as casual in Turkey (Uludağ et al. 2017) and as naturalized in France (Euro+Med Plant Base 2023), Corsica (Puddu et al. 2016), Spain (Laguna Lumbreras and Ferrer Gallego 2013; Aymerich and Sáez 2019) and Italy (Galasso et al. 2021), although—given the complex taxonomy and nomenclature of this group (see below)—it is not always obvious which taxon exactly is referred to by these authors.

In North Africa as in southern Europe, *G. rigens* has so far been reported as a weed or as cultivated/subspontaneous in several countries, including Madeira, Morocco, Tunisia (Dobignard and Chatelain 2011) and Libya (Véla 2013), but these records require confirmation since confusion with *G. ×splendens* cannot be ruled out. Anyway, neither *G. rigens* nor *G. ×splendens* has been recorded before in Algeria.

In the field, determination proved to be difficult because the individuals showed substantial morphological variability, particularly in relation to leaf shape and flower color. Laguna Lumbreras and Ferrer Gallego (2013) presented a key for the identification of *Gazania* specimens escaped in the Valencia area (Spain). However, these authors admitted that, in fact, escaped plants never fully correspond with their wild relatives. Ornamental subjects refer to cultivars and/or complex hybrids and our own observations confirm that Algerian plant material can hardly be ascribed to any of the wild species. We therefore assigned our plants—in accordance with Laguna Lumbreras and Ferrer Gallego's final proposition—to *G. ×splendens*, under which name all ornamental plants from this genus (all of which indeed probably arose as a result of artificial hybridization) are preferably classified.

Gazania ×splendens is thus an artificial hybrid obtained from the cross between *G. rigens*, *G. rigida* (Burm.f.) Roessler and perhaps other species, all native to South Africa (POWO 2023). This hybrid is widely used in horticulture with different flower colors (Laguna Lumbreras and Ferrer Gallego 2013; Verloove et al. 2019).

Of the 13 Asteraceae species native to South Africa reported as invasive across the world (Pyšek et al. 2020), *G. rigens* is the only one that is considered invasive in five regions, i.e. Australia, Europe, North America, South America and Atlantic Islands (e.g. Azores, Bermuda, Canary Islands, Madeira, St. Helena). Like its parent, *G. ×splendens* might show, in the future, a significant invasive behaviour, especially since hybridization has been hypothesized to influence invasion through the generation of evolutionary novelty and/or increased genetic variation, either of which may provide the genetic material for rapid adaptation to new abiotic and biotic conditions (Ellstrand and Schierenbeck 2000; Rieseberg et al. 2007). Moreover, it has been shown that—despite the hybrid nature—the Algerian plant material is able to reproduce from seed.

Given the shown resistance to summer heat and drought and its ability to survive in relatively poor sandy soil, we expect that *G. ×splendens* might spread in the future in Algeria; in particular, coastal habitats seem to be

suitable, such as coastal rocks and cliffs that the plant colonizes in Spain (Verloove et al. 2019) and coastal dunes that its parent *G. rigens* colonizes in Italy (Galasso et al. 2021).

To conclude, we suggest that *G. ×splendens* should remain under surveillance. Given the small size of the sole escaped population, removing it manually would likely be the best solution.

As long as they exist, ornamental plantations serve as a permanent source for the spread of alien plants. To minimize the risk of spread, this would in addition require the phasing out of certain cultivated species in ornamental plantations.

Acknowledgements

Anonymous reviewers are thanked for constructive comments and correction of this paper.

Funding declaration

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

Author's contribution

Research conceptualization: Nora Sakhraoui. Sample design and methodology: Nora Sakhraoui. Investigation and data collection: Nora Sakhraoui. Data analysis and interpretation: Nora Sakhraoui, Sonia Rouidi and Azzedine Hadeif. Funding provision: Franz Essl. Writing: Nora Sakhraoui and Franz Essl. Review: Filip Verloove.

References

- 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>
- Di Gregorio B (2020) Noterella 0323: *Gazania ×splendens* Lem. *Acta Plantarum Notes* 7: 307
- Dobignard A, Chatelain C (2011) Index synonymique de la flore de l'Afrique du Nord. Conservatoire et Jardin Botaniques, Genève, Suisse, 428 pp
- Ellstrand NC, Schierenbeck KA (2000) Hybridization as a stimulus for the evolution of invasiveness in plants? *Proceedings of the National Academy of Sciences of the USA* 97: 7043–7050, <https://doi.org/10.1073/pnas.97.13.7043>
- Galasso G, Domina G, Angiolini C, Bacchetta G, Banfi E, Barberis D, Bardi S, Bartolucci F, Bonari G, Bovio M, Briozzo I, Brundu G, Buono S, Calvia G, Celesti-Grapow L, Cozzolino A, Cuenca-Lombraña A, Curuzzi M, D'Amico FS, Dagnino D, De Fine G, Fanfarillo E, Federici A, Ferraris P, Fiacchini D, Fiaschi T, Fois M, Gubellini L, Guidotti E, Hofmann N, Kindermann E, Laface VLA, Lallai A, Lanfredini P, Lazzaro L, Lazzeri V, Lonati M, Loreti M, Lozano V, Magrini S, Mainetti A, Marchini M, Marignani M, Martignoni M, Mei G, Minutillo F, Mondino GP, Motti R, Musarella CM, Nota G, Olivieri N, Pallanza M, Passalacqua NG, Patera G, Pilon N, Pinzani L, Pittarello M, Podda L, Probo M, Ravetto Enri S, Rosati L, Salerno P, Selvaggi A, Soldano A, Sotgiu Cocco G, Spampinato G, Stinca A, Terzi M, Tondi G, Turcato C, Wellstein C, Lastrucci L (2021) Notulae to the Italian alien vascular flora: 12. *Italian Botanist* 12: 105–121, <https://doi.org/10.3897/italianbotanist.12.78010>
- Hesp P, McLachlan A (2000) Morphology, dynamics, ecology and fauna of *Arctotheca populifolia* and *Gazania rigens* nabkha dunes. *Journal of Arid Environments* 44: 155–172, <https://doi.org/10.1006/jare.1999.0590>
- Howis S, Barker NP, Mucina L (2009) Globally grown, but poorly known: species limits and biogeography of *Gazania* Gaertn. (Asteraceae) inferred from chloroplast and nuclear DNA sequence data. *Taxon* 58: 871–882, <https://doi.org/10.1002/tax.583015>
- Laguna Lumbreras E, Ferrer Gallego PP (2013) *Gazania* Gaertn. (Asteraceae): Táxones escapados de cultivo en la Comunidad Valenciana (España). *Bouteloua* 13: 3–10
- 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>
- Miara MD, Boutabia L, Telailía S, Véla E (2018) Apparition de *Senecio angulatus* (Asteraceae) en Algérie. *Flora Mediterranea* 28: 111–118, <https://doi.org/10.7320/FIMedit28.111>
- Puddu S, Podda L, Mayoral O, Delage A, Hugot L, Bacchetta G (2016) Comparative Analysis of the Alien Vascular Flora of Sardinia and Corsica. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* 44: 337–346, <https://doi.org/10.15835/nbha44210491>

- Pyšek P, Richardson DM, Rejmanek M, Webster GL, Williamson M, Kirschner J (2004) Alien plants in checklist and floras: towards better communication between taxonomist and ecologist. *Taxon* 53: 131–143, <https://doi.org/10.2307/4135498>
- Pyšek P, Pergl J, Kleunen M, Dawson W, Essl F, Kreft H, Weigelt P, Wilson JR, Winter M, Richardson DM (2020) South Africa as a donor of naturalised and invasive plants to other parts of the World. *Biological Invasions in South Africa* 14: 759–758, https://doi.org/10.1007/978-3-030-32394-3_26
- Rieseberg LH, Kim SC, Randell RA, Whitney KD, Gross BL, Lexer C, Clay K (2007) Hybridization and the colonization of novel habitats by annual sunflowers. *Genetica* 129: 149–165, <https://doi.org/10.1007/s10709-006-9011-y>
- Sakhraoui N, Metallaoui S, Chefrour A, Hadeff A (2019) La flore exotique potentiellement envahissante d'Algérie: première description des espèces cultivées en pépinières et dans les jardins. *Biotechnologie Agronomie Société et Environnement* 23: 63–73, <https://doi.org/10.25518/1780-4507.17902>
- Sakhraoui N, Boussouak R, Metallaoui S, Chefrour A, Hadeff A (2020) La flore endémique du Nord-Est algérien face à la menace des espèces envahissantes. *Acta Botanica Malácitana* 45: 67–79, <https://doi.org/10.24310/abm.v45i.6138>
- Uludağ A, Aksoy N, Yazlık A, Filiz Arslan Z, Yazmış E, Üremiş I, Cossu TA, Groom Q, Perg J, Pyšek P, Brundu G (2017) Alien flora of Turkey: checklist, taxonomic composition and ecological attributes. *NeoBiota* 35: 61–85, <https://doi.org/10.3897/neobiota.35.12460>
- Véla E (2013) Notes et compléments sur quelques taxons traités dans les volumes 1 à 4. Note sur quelques xénophytes nouveaux pour la Libye. Addenda. Notes. Xénophytes, p 372
- Véla E, Rebbas K, Meddour R, de Bélair G (2013) Notes et compléments sur quelques taxons traités dans les volumes 1 à 4. Note sur quelques xénophytes nouveaux pour l'Algérie (et la Tunisie). Addenda. Notes. Xénophytes, pp 372–376
- Verloove F, Aymerich P, Gomez-Bellver C, Lopez-Pujol J (2019) Chorological notes on the non-native flora of the province of Tarragona (Catalonia, Spain). *Bulletí de la Institució Catalana d'Història Natural* 83: 133–146, <http://dx.doi.org/10.2436/20.1502.01.18>

Web sites and online databases

- ADP (2023) African Plant Database version 4.0.0. Conservatoire et Jardin botaniques de la Ville de Genève and South African National Biodiversity Institute, Pretoria, <https://africanplantdatabase.ch/en/search/gazania%20fna/1/fna/1/fna/1/bdm/1/page/1> (accessed 21 March 2023)
- Euro+Med Plant Base (2023) *Gazania rigens* https://europlusmed.org/cdm_dataportal/taxon/a091c016-187f-4981-a74c-7031825e086f#footnote-J (accessed 11 April 2023)
- GBIF (2023) Global Biodiversity Information Facility. Checklist dataset, *Gazania ×splendens* Hend. A.A. Hend. <https://www.gbif.org/species/7845652> (accessed 21 March 2023)
- POWO (2023) (Plants of the World Online), *Gazania ×splendens* Hend. & A.A. Hend. Facilitated by the Royal Botanic Gardens, Kew. <https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:208729-1> (accessed 19 March 2023)