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# Addenda to the checklist of alien plants of Algeria

**Abstract**

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A thorough knowledge of the alien flora is an important basis for science and management. In Algeria, a first checklist of the alien flora was published in 2020. Since then, several new taxa have been observed for the first time in this country. This study therefore presents additions to the alien flora of Algeria, based on bibliographic and field research carried out since 2021. For each taxon recorded, the botanical family, life form, geographical origin, invasion status, distribution in Algeria, type of colonized habitat and introduction pathways were indicated. In total, 74 additional alien vascular plant taxa, belonging to 30 families and 53 genera were recorded. Data on the occurrence of seven alien species are reported here for the first time from Algeria: *Chlorophytum comosum*, *Helianthus annuus*, *Salvia hispanica*, *Sapindus mukorossi*, *Tradescantia pallida*, *Triadica sebifera*, and *Zinnia elegans*, four of these species are also new to North Africa.
Most of the newly recorded taxa originate from America (55.4%), Africa (14.8%) and Asia (9.4%). The most represented life forms, are phanerophytes (31 taxa), followed by therophytes (18 taxa) and geophytes (12 taxa). In terms of habitats, 43.2% of the taxa were found in human-made habitats, 12.1% in semi-natural habitats and the same percentage in natural habitats. Most of the taxa were introduced for ornamental purposes (71.6%). More than half (55.4%) of the taxa are naturalized, 14.8% are in the process of naturalization, and 33.7% are considered potentially invasive in Algeria.
As a result of our study, the alien flora of Algeria increases from 211 to 285 taxa, the naturalized flora from 108 to 156 taxa, and the potentially invasive flora from 15 to 40 taxa.

*Key words*: alien flora, distribution, habitats, naturalization, origin, pathway of introduction.

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## Introduction

Ecosystem management cannot be carried out properly without prior knowledge of the various threats. Invasive and potentially invasive alien species constitute one of the most significant threats that can have very serious negative effects on biodiversity and the natural environment (Pyšek & al. 2020a; Domina 2021). The recognition and correct identification of these species is therefore essential for conservation purposes.

In the northern part of the Mediterranean, national alien plants checklists have been published during the last decades for most countries and several major islands, such as for Spain (Capdevilla Argüelles & al. 2006), Italy (Celesti-Grapow & al. 2009), Montenegro (Stešević & Petrović 2010), Greece (Arianoutsou & al. 2010), Corsica (Jeanmonod & al. 2011), and Slovenia (Jogan & al. 2012), and updates are regularly carried out in certain countries such as Italy (see e.g. Galasso & al. 2018; Spampinato & al. 2022; Galasso & al. 2024). In the southern part of the Mediterranean, such lists have only recently been published for the most countries of North Africa, namely for Egypt where the first list was published in 2016 and an update in 2020 (Shaltout & al. 2016; El Beihery & al. 2020), Tunisia (Sayari & Mekki 2016), Libya (Alzerbi & al. 2020) and Algeria (Meddour & al. 2020).

The studies that we have published over the last five years (see e.g. Sakhraoui & al. 2019a, 2019b, 2019c; Sakhraoui & al. 2022a, 2022b, 2022c; Sakhraoui 2023) have shown that plant invasions continue in Algeria, as they do in different parts of the world, requiring continued field surveys. In addition, these studies as well as many others published by other researchers have resulted in reports of new records of alien plants in Algeria. Thus, compiling these records in checklists of alien plants is important for management and science alike, as they provide researchers with an important bibliographic tool that can greatly facilitate their work, and can also help neighboring countries to assess potential invasion threats (El Beihery & al. 2020).

Here we publish additions to the first checklist of the alien flora of Algeria published by Meddour & al. (2020), taking into consideration the latest publications relating to new recordings of alien plants. This addendum was therefore produced on the basis of extensive bibliographic research which allowed the addition of further alien species not yet reported by Meddour & al. (2020), (either because, according to these authors, they did not occur in the wild in Algeria (only cultivated), or because they were overlooked, or because the data were only published after the publication of the checklist of the alien flora of Algeria), as well as on the basis of recent field surveys which yielded records of alien species that had not previously been reported from Algeria.

In addition, we report the naturalization status of some species for which the status in Algeria was unknown according to Meddour & al. (2020); the status of these species was assessed based on field observations carried out by the first author of this article, but also based on scientific literature.

## Material and methods

First, a bibliographic data search was carried out focusing on: i) articles relating to reports of alien plant taxa in Algeria (mentioned in the bibliographic list) using appropriate keywords such as: plant, alien, exotic, introduced, new record, Algeria, Euro-Med checklist, notulae; in total, 44 publications were identified of which 27 reported new Algerian records (24 published between 2020 and 2024, and single publications for 2013, 2016 and 2019); ii) the five volumes of the 'Index synonymique de la flore de l'Afrique du Nord' (Dobignard & Chatelain 2010-2013); iii) the two volumes of the 'Flore d'Algérie' (Quézel & Santa 1962-1963) and the 5$^{th}$ volume of the 'Flore de l'Afrique du Nord' (Maire 1958), where only naturalized taxa were taken into consideration. Taxa that were reported as being

merely cultivated in Algeria by Dobignard & Chatelain (2010-2013) were ignored, unless they were observed outside of cultivation during the field surveys; in this case, a status was assigned to them according to Richardson & al. (2000) and Pyšek & al. (2004). Additionally, a search on iNaturalist (2024) was carried out, where only records clearly showing plants that had escaped from cultivation (confirmed by comments on the observation) were taken into consideration.

This bibliographic research was supplemented by field surveys, conducted from 2021 to 2024 by the first author of this article, in different areas of northeastern Algeria (Skikda, Annaba, Constantine, Guelma and El Tarf) and in different types of habitats. During this field work, very valuable data relating to the introduced flora was collected, some alien species were recorded for the first time in Algeria, and the invasion status for various species could be determined more precisely.

The following invasion status categories were considered (based on Richardson & al. 2000; Pyšek & al. 2004): 'casual' (alien plants that may reproduce occasionally outside cultivation in an area, but do not form self-replacing populations, and rely on repeated introductions for their persistence), 'naturalized' (alien plants that sustain self-replacing populations for at least 10 years), 'in the process of naturalization' (alien plants that maintain self-replacing populations but have not yet reached 10 years of persistence). The residence status in Algeria (native *vs* introduced) was checked against Plants of the World Online (POWO 2024) and the Euro+Med PlantBase (2024). The taxon was not retained when considered introduced in one database but native or doubtfully native in the other (e.g. *Acanthus spinosus* L., *Cephalaria syriaca* (L.) Roem. & Schult., *Cymbalaria muralis* G. Gaertn. & al., *Erysimum cheiri* (L.) Crantz and *Galega officinalis* L.). For taxa that were considered to be introduced in one and to be absent from Algeria in the other, two additional sources were consulted, the African Plant Database (APD 2024) and eflora maghreb (https://efloramaghreb.org/specie/148007); the taxon was then taken into consideration when it was considered naturalized by these two databases (e.g. *Eschscholzia californica* Cham.*, Trifolium alexandrinum* L.).

The taxa were subsequently organized in alphabetical order and are presented by their accepted names according to IPNI (2024). To maintain comparability in the presentation of data relating to the alien flora of Algeria, we followed, as far as possible Meddour & al. (2020). For each taxon we mention the respective family (according to APG IV 2016), life form (extracted from various bibliographical sources and given according to the classification of Raunkiær (1934)), the biogeographic region of origin (according to POWO 2024), invasion status (see above), the distribution in the four main natural zones in Algeria [i.e. coastal, Tellian Atlas, steppe (including high plateaus) and Sahara], the type of habitat colonized (according to bibliographic data and field observations, notably for new records; habitats were classified into natural habitats (divided into riparian habitats/wetlands and maquis/forests/steppe pastures), semi-natural habitats (including coastal habitats) and human-made habitats (divided into urban/ruderal habitats and agricultural land)) and the introduction pathways (identified from the scientific literature, but also from other bibliographic sources dealing with the ornamental flora in Algeria, in particular Carra & Gueit (1952) and Sakhraoui (2021a)).

The list of potentially invasive species in Algeria was established based, on the invasion history of the taxon elsewhere in Mediterranean countries or countries with a Mediterranean climate, and on the invasive behavior (i.e. taxon with increasing local or

regional distribution and with ability to form large populations and to colonize natural habitats) observed during field work by the first author of this paper.

## Results

Of the newly registered taxa, 67 come from bibliographic research and seven from field surveys; the latter are therefore reported for the first time in Algeria: *Chlorophytum comosum* (Thunb.) Jacques, *Helianthus annuus* L., *Salvia hispanica* L., *Sapindus mukorossi* Gaertn., *Tradescantia pallida* (Rose) D.R. Hunt, *Triadica sebifera* (L.) Small and *Zinnia elegans* Jacq., including one (*S. hispanica*) also reported on iNaturalist (2024). Additional data relating to these newly recorded species are given in supplementary material.

### *Number of alien plant taxa and their taxonomic affiliation*

As a result of our study, 74 new taxa were added to the alien plant species checklist (70 species, one subspecies and three hybrids) (Electronic Supplementary File 1. Table 1S). These taxa – all Angiosperms – belong to 30 families and 53 genera (Fig. 1a). 22 families and 39 genera are dicots whereas eight families and 14 genera are monocots. The most species-rich families are Cactaceae (9 species), Amaranthaceae and Asteraceae (7 species each), and Crassulaceae (5 species). The most species-rich genera are *Amaranthus* and *Opuntia* (6 species each), *Prunus* and *Solanum* (3 species each), the others are represented by two species such as *Aeonium, Aloe, Allium, Cyperus* and *Kalanchoe* or by a single species.

### *Invasion status*

More than half of the newly added taxa are considered to be naturalized (41 taxa, 55.4%), eleven taxa (14.8%) are in the process of naturalization and 22 taxa (29.7%) are casual.

The invasion status of six species (*Morus alba* L., *Prunus domestica* L., *P. persica* (L.) Batsch, *Solanum lycopersicum* L., *S. tuberosum* L. and *Zea mays* L.) that were reported so far as exclusively cultivated in Algeria changed (see Dobignard & Chatelain 2010-2013). Escaped specimens of *M. alba* have been observed in several different localities in the Skikda region (northeastern Algeria) where they most often grow next to streams, particularly in the coastal dune. This species is now locally naturalized, while it was still considered as cultivated/subspontaneous (= casual) in Algeria by Dobignard & Chatelain (2010-2013). The other species, in turn, are considered casuals, and have often been observed near homes, in landfills, on rubble or along roadsides.

### *Biogeographic origin*

Seven different areas of origin could be identified (Fig. 1b) with 5 taxa originating from multiple regions. Most taxa come from America (55.4%), of which 21.6% (16 taxa) from South America, 13.5% (10 taxa) from North America, 5.4% (4 taxa) from Central America and 2.7% (2 taxa) from Tropical America; the rest (9 taxa, 12.1%) come from various parts of America. Next come taxa of African origin (14.8%, of which 10.8% (8 taxa) from South Africa), followed by taxa of Asian origin (9.4%).

Taxa of Eurasiatic, Macaronesian and Mediterranean origin are the least represented with respectively 4.0%, 4.0% and 2.7%. However, three hybrids were recorded, two of which (*Gazania ×splendens* Hend. & Andr. Hend. and *Kalanchoe ×houghtonii* D.B. Ward) cannot be assigned to any region as they are artificial hybrids (see Guillot Ortiz & al. 2014; Sakhraoui & al. 2023a), hence keeping them in the hybrid category, while the last one (*Nothoscordum ×borbonicum* Kunth) is a natural hybrid whose region of origin is known (see Ravenna 1991).

***Life form***

Phanerophytes are the most represented life form (31 taxa), followed by therophytes (18 taxa) and geophytes (12 taxa). Hemicryptophytes and chamaephytes are the least represented, with only seven and six taxa respectively (Fig. 1c). Succulents are not treated separately in figure 1c as they belong to multiple life forms. However, they are represented by no fewer than 18 taxa (24.3%). Most phanerophytes (15 taxa (including 8 succulents) representing 48.4% of all phanerophytes recorded), geophytes (9 taxa, representing 75% of all geophytes recorded) and therophytes (11 taxa, representing 61.1% of all therophytes recorded) are naturalized.

***Distribution in Algeria***

Most taxa (68 taxa or 91.8%) are found in the coastal zone of Algeria, of which 64 taxa occur exclusively in this part and four taxa also occur in other parts, especially in the Tellian Atlas (3 taxa). Four taxa for which data on their distribution in Algeria are lacking were placed under the 'coastal' category as this best matches their climatic requirements (the Mediterranean climate is favorable for their installation, in other areas the climate is harsher). Five taxa are found in the Tellian Atlas, including three with an exclusively tellian distribution and two that also occur in the steppe. Finally, one taxon is exclusively found in the steppe. No taxon has an exclusively Saharan distribution, the only one species recorded in the Sahara (*Oenothera stricta* Link) also occurs in coastal areas and in the Tellian Atlas.

Among the 34 taxa from northeastern Algeria, 27 taxa (79.4%) are exclusively present in the Skikda region, of which 16 taxa (21.9%) are recorded in a single locality.

***Colonized habitats***

Of the 74 taxa recorded in this study, 32 (43.2%) are exclusively established in human-made habitats, among which 33.7% colonize urban/ruderal habitats (balconies, roofs, sidewalks, gutters, roadsides, railways, rubble, landfills, ruins) and 9.4% colonize agricultural land (fields, crops, orchards, abandoned gardens), nine taxa (12.1%) are exclusively established in semi-natural habitats (beaches, degraded coastal dunes, relict of coastal scrubland, wasteland near houses on the coast, sea cliffs near houses), and also nine taxa (12.1%) exclusively colonize natural habitats, among which 6.7% colonize riparian habitats/wetlands (edges of wadis and lakes, wetland meadows) and 5.4% colonize maquis/forests/steppe pastures (Fig. 1d and Table 1). Four taxa are capable of colonizing the three types of habitat at the same time: *Austrocylindropuntia subulata* (Muehlenpf.) Backeb., *Opuntia monacanthos* (Willd.) Haw., *O. stricta* (Haw.) Haw. and *Phoenix canariensis* H. Wildpret.

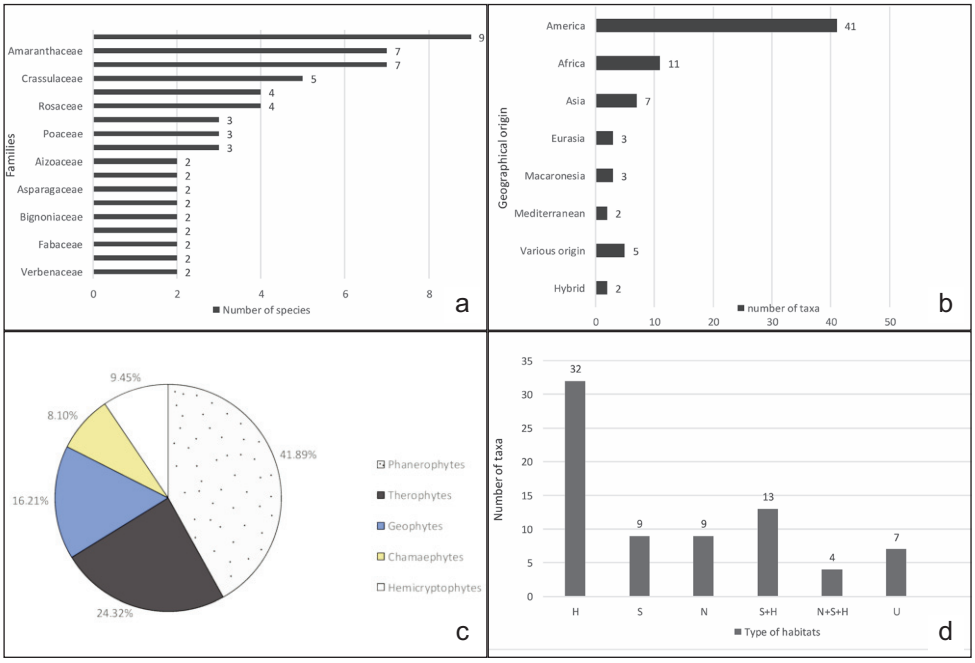


Fig. 1. a) The richest families ranked by the number of newly recorded alien plant taxa in Algeria; b) regions of origin of newly recorded alien plant taxa in Algeria; c) life forms of newly recorded alien plant taxa in Algeria; d) Number of newly recorded alien plant taxa in each colonized habitat. H: human- made, S: semi-natural, N: natural, U: unknown.

Table 1. Number of plant taxa and their invasion status in the various colonized habitats (C: casual, I/N: in the process of naturalization, N: naturalized).

| **Type of habitat** | **Number of taxa per status** | | |
|---|---|---|---|
| | C | I/N | N |
| Urban/ruderal habitats | 17 | 2 | 6 |
| Agricultural land | 1 | | 6 |
| Coastal habitats | 1 | 1 | 7 |
| Riparian habitats/wetlands | | | 5 |
| Maquis/forests/steppe pastures | | 1 | 3 |
| Coastal + Urban/ruderal habitats | 1 | 7 | 5 |
| Coastal+ Urban/ruderal + Maquis/forests/steppe pastures | | | 4 |
| Unknown | 2 | | 5 |
| **Total** | **22** | **11** | **41** |

***Introduction pathways***

Our results indicate that the majority of the newly reported taxa in Algeria were deliberately introduced (65 taxa, 87.8%). Of these, 53 taxa (71.6%) were introduced for ornamental purposes, 11 taxa (14.8%) for agriculture (food, fodder, pasture restoration) and one taxon (1.3%) for the sericultural industry. Accidental introductions only represent nine taxa (12.1%).

***Potentially invasive taxa in Algeria***

Potentially invasive taxa are fairly well represented among the newly registered taxa. In total, 25 taxa (33.7%) were classified as such. 19 are reportedly invasive in the Mediterranean region (15 naturalized, three in the process of naturalization and one casual) and two in regions with a Mediterranean climate type (one naturalized and one casual). For four taxa, invasive behavior has recently been observed in the field in Algeria by the first author of this article. The list of these taxa is shown in table 2.

Among the species in the first category, *Arctotheca calendula* (L.) Levyns, *Austrocylindropuntia subulata* (Muehlenpf.) Backeb. and *Opuntia stricta* (Haw.) Haw. already show invasive behavior in the field in Algeria (strongly increasing populations and an increasing number of new growing sites in natural habitats) (Sakhraoui, pers. obs.).

***Taxa with unknown invasion status***

For nine species reported by Meddour & al. (2020) as alien with unknown naturalization status in Algeria, the updated status is shown in table 3. Seven taxa are considered to be naturalized and two are casual. The observation sites either refer to data from the scientific literature or were obtained during field surveys by the first author of this article.

## Discussion

As a result of our research, the list of alien plant species observed in Algeria increases by 35.0%, from 211 taxa recorded by Meddour & al. (2020) to 285 taxa. This also increases the ratio compared to the total Algerian flora, which is estimated at 4 449 taxa according to Dobignard & Chatelain (2010-2013), from 4.7% to 6.4%. Despite this increase, the rate of Algerian alien flora still remains far from that recorded in most countries in the northern part of the Mediterranean. For instance, in Italy, this proportion varies between 14% for Calabria and 21.6% for the whole country (see Spampinato & al. 2022; Galasso & al. 2024), while in Spain, the proportion for established plants in Catalonia, is 12% (see Aymerich & Sáez 2019). In comparison with countries from the southern part of the Mediterranean, the numbers recorded in Algeria are higher than those reported for Morocco and Tunisia, where the rates are 3.2% and 2.4% respectively (Dobignard & Chatelain 2010-2013; Sayari & Mekki 2016), but is substantially lower than the 11.7% reported for Egypt where 250 alien plant taxa were recorded (El Beihery & al. 2020) or the 17.7% reported for Libya where 361 alien plant taxa were recorded (Alzerbi & al. 2020).

North Africa is experiencing a considerable increase in the number of alien plants, particularly Tunisia where dozens of new reports have been recorded over the last ten years (see e.g. El Mokni & Verloove 2019; El Mokni 2023), which will undoubtedly increase the rate of alien flora in this country in future updates.

Table 2. List of alien plant taxa considered potentially invasive in Algeria.

| **Taxa reported as invasive in the Mediterranean region or in regions with a Mediterranean climate** | | |
|---|---|---|
| **Taxon** | **Region where invasive** | **Reference** |
| *Amaranthus albus* L. | Italy and Spain | Galasso & al. (2018), Aymerich & Sáez (2019) |
| *Amaranthus cruentus* L. | Italy and Spain | Galasso & al. (2018), Aymerich & Sáez (2019) |
| *Amaranthus deflexus* L. | Italy and Spain | Galasso & al. (2018), Aymerich & Sáez (2019) |
| *Amaranthus powellii* S. Watson | Italy and Spain | Galasso & al. (2018), Aymerich & Sáez (2019) |
| *Amaranthus retroflexus* L. | Italy, Libya and Spain | Galasso & al. (2018), Mahklouf (2019), Aymerich & Sáez (2019) |
| *Anredera cordifolia* (Ten.) Steenis | Italy | Galasso & al. (2018) |
| *Arctotheca calendula* (L.) Levyns | Italy and Tunisia | Stinca & al. (2021), Sakhraoui & al. (2024) |
| *Austrocylindropuntia subulata* (Muehlenpf.) Backeb. | Italy | Galasso & al. (2018) |
| *Bidens aurea* (Aiton) Sherff | Italy | Musarella & al. (2024) |
| *Canna indica* L. | South Africa | Rambuda & Johnson (2004) |
| *Cyperus alternifolius* subsp. *flabelliformis* Kük. | Italy | Galasso & al. (2018) |
| *Cyperus eragrostis* Lam. | Italy and Spain | Galasso & al. (2018), Aymerich & Sáez (2019) |
| *Eclipta prostrata* (L.) L. | Italy | Galasso & al. (2018) |
| *Kalanchoe ×houghtonii* D.B. Ward | Italy | Stinca & al. (2021) |
| *Melia azedarach* L. | South Africa, Libya and Italy | Henderson (2007), Mahklouf (2019), Musarella & al. (2024) |
| *Opuntia stricta* (Haw.) Haw. | Italy and Spain | Galasso & al. (2018), Aymerich & Sáez (2019) |
| *Paspalum vaginatum* Sw. | Spain | Aymerich & Sáez (2019) |
| *Phoenix canariensis* H. Wildpret | California | CALIPC (2024) |
| *Solanum rostratum* Dunal | Libya | Mahklouf (2019) |
| *Tetragonia tetragonoides* (Pall.) Kuntze | Libya | Mahklouf (2019) |
| *Tradescantia fluminensis* Vell. | Italy and Spain | Galasso & al. (2018), Aymerich & Sáez (2019) |
| **Taxa with invasive behavior in Algeria based on field observations** | | |
| **Taxon** | **Ability to proliferate in natural habitats** | **Population size observed in the field** |
| *Heliotropium amplexicaule* Vahl | + | Very large populations over large areas |
| *Opuntia monacanthos* (Willd.) Haw. | + | Large populations |
| *Opuntia robusta* H.L. Wendl. ex Pfeiff. | + | Very large population over large area |
| *Tecomaria capensis* (Thunb.) Spach | + | Large populations |

Table 3. Species reported by Meddour & al. (2020) as alien with unknown naturalization status in Algeria with their updated status (locations without bibliographic reference concern finds by the first author of this article). Status, N: naturalized, C: casual.

| Species | Site of observation | Type of colonized habitat | Status |
|---|---|---|---|
| *Agave sisalana* (Engelm.) Perrine | Tipaza (Véla & al. 2013) | Roman ruins | N |
| *Asparagus setaceus* (Kunth) Jessop | Larbi Ben M'Hidi (Skikda) | Sidewalks near houses | C |
| *Chasmanthe floribunda* (Salisb.) N.E.Br. | Filfilla, Stora (Skikda), Algies (Zeddam 2012) | Maquis, roadsides, cliffs, fallow land near houses | N |
| *Iris albicans* Lange | Salah Chebel (Skikda), Constantine | Cemeteries, roadsides | C |
| *Mirabilis jalapa* L. | Stora, Larbi Ben M'Hidi (Skikda), El Chat (El Tarf) | Roadsides, rubble, landfills, coastal dunes, near houses | N |
| *Podranea ricasoliana* (Tanfani) Sprague | Stora (Skikda), Algies (Zeddam 2011) | Relict of maquis near houses | N |
| *Senecio angulatus* L.f. | Larbi Ben M'Hidi, Salah Chebel (Skikda), Bejaia (Miara & al. 2018) | Maquis, near houses | N |
| *Tropaeolum majus* L. | Stora, Filfilla, Larbi Ben M'Hidi, Salah Chebel, El Hadaeik (Skikda), Algies (Zeddam & Raus 2010) | Maquis, fields, wastelands, roadsides, near houses | N |
| *Yucca gloriosa* L. | Tipaza (Véla & al. 2013) | Roman ruins | N |

However, although the alien flora in the southern part of the Mediterranean region, notably in North Africa, is poorer compared to the northern part, the situation in the field is more alarming, because actions to control invasive plants are very rarely undertaken in this part of the Mediterranean (Brunel & al. 2013).

Following our study, the number of naturalized taxa in Algeria is increasing, from 108 taxa mentioned by Meddour & al. (2020) to 156 taxa. The potentially invasive flora also increased from 15 to 40 taxa. This deserves special attention; regular monitoring makes early detection possible before a real invasion occurs. Particular attention should be paid to monitoring the populations of *Solanum rostratum* Dunal which remains the most worrying in Tellian and steppe zones, given its capacity to colonize varied environments and produce a large quantity of seeds ensuring strong dissemination (Chelghoum & al. 2020). This also applies to *Arctotheca calendula* (L.) Levyns in coastal areas (Sakhraoui & al. 2024a). Furthermore, these two species are considered invasive in neighboring countries (Libya (Mahklouf 2019), and Tunisia (Sakhraoui & al. 2024a) respectively and probably also Morocco, for the latter species), making them particularly threatening in Algeria.

Our study could therefore contribute to the development of monitoring lists that still do not exist in Algeria.

America is the main source area for the alien flora of Algeria with 107 taxa (66 already recorded by Meddour & al. (2020)). This dominance has also been recorded in other Mediterranean countries, such as Spain (Aymerich & Sáez 2019), Italy (Spampinato & al. 2022), Greece (Arianoutsou & al. 2010), Turkey (Uludağ & al. 2017), Egypt (El Beihery & al. 2020) and Tunisia (Sayari & Mekki 2016). Asia and Africa also contribute significantly to the alien flora in the Mediterranean region (Arianoutsou & al. 2010; Uludağ &

al. 2017; El Beihery & al. 2020; Spampinato & al. 2022). This undoubtedly explains the large number of naturalized taxa originating from these continents in the Mediterranean region (Arianoutsou & al. 2013), which was also observed in this study (24 American taxa and 7 African taxa are naturalized). Among the genera best represented and best adapted in Algeria, including species of American origin, are *Opuntia* (seven species of which only a single recorded by Meddour & al. (2020)) and *Amaranthus* (ten species of which four already reported by Meddour & al. (2020), eight of which are of American origin). The latter genus, which is usually introduced accidentally, is also most represented in Europe (Lambdon & al. 2008) and in other countries of North Africa, such as Egypt where 10 species were recorded (see El Beihery & al. 2020) and Tunisia where eight species were recorded (see Sayari & Mekki 2016). On the other hand, species of the genus *Opuntia* and other Cactaceae are prized in Algeria and are often used around fields and houses as fences, which has probably contributed to their spread (Sakhraoui & al. 2022b). *Opuntia ficus-indica* (L.) Mill. is one of the most common species in Algeria; it is cultivated throughout the country and has escaped from cultivation in many regions.

Taxa of South African origin are among the best represented in our study (10.8%). The native flora of South Africa includes many species of horticultural importance, which has led to their introduction to many parts of the world. South Africa is recognized worldwide as an important donor of naturalized or invasive plants (Pyšek & al. 2020b). South African plants are also among the most naturalized in Algeria (Vilà & al. 1999), probably due to the similarity of climate.

In our results, phanerophytes (including 13 succulents), therophytes and geophytes predominate. However, if the numbers reported by Meddour & al. (2020) are taken into account, the life form distribution for the Algerian alien flora is as follows: therophytes (108 taxa), phanerophytes (68 taxa), hemicryptophytes (41 taxa) and geophytes (33 taxa). Therophytes are also dominant in the Tunisian and Egyptian alien floras, but they are followed by geophytes and phanerophytes for Tunisia (see Sayari & Mekki 2016), and by phanerophytes and geophytes for Egypt (see El Beihery & al. 2020). According to our results, therophytes, succulents and geophytes have the highest naturalization rates (26.8%, 24.4% and 22.0% respectively). This may be due to their ability to adapt and their resistance characteristics allowing them to survive in unfavorable conditions. Therophytes are able to sustain themselves through the production of seeds during a short vegetative cycle, which allows them to avoid the stress of the summer season in the Mediterranean (Verlaque & al. 2001). Annuals are among the most commonly naturalized taxa throughout North Africa (Vilà & al. 1999). Succulents, on the other hand, are adapted to high temperatures and can easily cope with the hot summers in Algeria. Finally, geophytes are capable of accumulating significant nutritional reserves that allow them to survive in unfavorable conditions. They very easily adapt to environmental changes (e.g. low and high temperatures, drought, etc.) in climatic areas with marked seasons such as the Mediterranean basin (Steinfort & al. 2012). They have also shown high values of invasion success in European and Mediterranean coastal habitats (Giulio & al. 2021). These three biological types are therefore most likely to succeed in Algeria and future naturalization events are likely to emerge from these categories.

The distribution of taxa in Algeria clearly follows a decreasing north-south gradient, which was also found by Meddour & al. (2020). The climatic factor seems to be responsible for this spread. The northern part of the country has a milder climate, especially on the coast, where the Mediterranean climate is favorable for the cultivation of various alien species.

However, for some species, data concerning distribution and type of colonized habitats, are significantly outdated or nonexistent and require new research. These species have been reported as escapes from cultivation for a very long time in Algeria (see Battandier 1895; Battandier & al. 1914; Ducellier & Maire 1923). No monitoring of the dynamics of their populations has been carried out, leaving scientists with only very old information that does not reflect their current distribution. This type of research is therefore very important, because these essential data allow to correctly assess the risk of invasion of species. Algerian scientists are called upon to make more efforts in this research topic.

The high number of new records recorded exclusively in the wilaya of Skikda (representing 79.4% of the taxa recorded in northeastern Algeria) does not reflect any peculiarity of the region. Like all other wilayas on the Algerian coast, Skikda has a varied topography and is subject to the Mediterranean climate. However, the field surveys conducted by the first author of this article are mainly carried out in this region. It is very likely that plant invasions have also occurred in other regions of the Algerian coast, but have not been detected yet due to the lack of fieldwork.

The urban/ruderal habitats are home to a wide range of alien taxa, many of which are still in the early stages of their spread and have not yet succeeded in becoming permanently established. This habitat therefore has the highest percentage of casual taxa (23.0%); it includes: *Chlorophytum comosum* (Thunb.) Jacques, *Crassula ovata* (Mill.) Druce, *Helianthus annuus* L., *Kalanchoe laxiflora* Baker, *Salvia hispanica* L., *Tradescantia fluminensis* Vell., *T. pallida* (Rose) D.R. Hunt, *Triadica sebifera* (L.) Small and several fruit trees. Urban habitats are considered as secondary launching sites (McLean & al. 2017), which can largely enhance the adaptability of taxa and lead to invasive behavior, allowing their further spread into adjacent semi-natural or natural environments (Borden & Flory 2021). It will therefore not be surprising to note the change in the status of these species in the near future.

However, coastal habitats (beaches, rock cliffs, coastal dunes) have the highest naturalization rate (7 taxa, 9.6%) and share 17 taxa with other habitats, which represents 23.0% of all represented taxa. These habitats are known for their vulnerability to plant invasions, as they are subject to strong anthropogenic pressure that is causing increasing disturbance (Giulio & al. 2020). In recent years, the Algerian coast has experienced an increase in land development projects leading to the destruction of natural habitats (Ghodbani & Bougherira 2019), and many new alien ornamental species were introduced in public green spaces. Among the most threatening species in coastal dunes are: *Austrocylindropuntia subulata* (Muehlenpf.) Backeb. and *Opuntia stricta* (Haw.) Haw., but also *Acacia saligna* (Labill.) H.L. Wendl. and *Carpobrotus edulis* (L.) N.E. Br. In certain places, these species form very large populations that invade the natural environment and expand every year (Sakhraoui pers. obs.).

In Algeria, wetlands and the edges of wadis also provide favorable habitats for the establishment of alien species, as they provide the humidity necessary for their survival

(Sakhraoui 2023). Several species preferentially colonize these habitats, such as *Arctotheca calendula* (L.) Levyns, *Justicia adhatoda* L., *Tipuana tipu* (Benth.) Kuntze and many others. The prospection of these habitats, although often difficult due to their inaccessibility, therefore, remains useful in Algeria.

## Conclusion

The present study demonstrates the dynamic nature of the alien flora in Algeria. No fewer than 74 taxa were added to the catalogue of Algeria's alien flora, i.e. an increase of 35.0%.

Further efforts such as field surveys in under-sampled parts of the country are needed to gain a truly complete picture of the alien flora of Algeria. In addition, management activities to halt the spread of invasive or potentially invasive taxa should be implemented, particularly for taxa established in natural areas. In this regard, the Algerian authorities are called upon to demonstrate greater commitment in defining and applying the most adaptable solutions to this growing problem, starting with the development of appropriate legislation.

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