

# Inventory of the Spontaneous Alien Flora in Tunisia

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## ABSTRACT

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The first step in any management strategy to control plant invasion is the compilation of a national and regional inventory of alien plant species. In this paper, we present a comprehensive inventory of the spontaneous alien vascular flora of Tunisia, including accepted names, family, biological form, habitat type, native origin, and invasive status. National flora accounts were the main source of information. Data were completed with new flora records and field surveys. The Raunkiaer's life forms were adopted to distinguish plant biological forms. Information on species habitats, geographical origins and invasive status were checked based on literature and online databases. The alien flora of Tunisia comprises 92 taxa belonging to 33 families, with 80% *Dicotyledoneae* and 20% *Monocotyledoneae*. The families represented most in the Tunisian alien flora are *Asteraceae* (15%), *Amaranthaceae* (14%) and *Poaceae* (12%). *Amaranthus* is the most represented genus. The most numerous are the therophytes followed by geophytes and phanerophytes. The majority of the alien taxa has its native range in the Americas followed by Africa (tropical and south), Eurasia and Australia. About 90% of the alien taxa are recognized as weeds of disturbed habitats. On other hand, almost 40% of these alien taxa are listed in the invasive alien plants lists of many regions i.e. Mediterranean Basin and Sardinia or institutions i.e. EPPO, CAB International and Invasive Species Specialist Group. Hence, all these alien taxa are likely to be invasive in Tunisia.

*Keywords:* Alien flora, invasive status, inventory, native origin, Tunisia

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Biological invasions are recognized as major environmental problems and one of the major threats to biodiversity (11, 44, 61). Their impacts on native plants and animals, human health and economic activities are being studied and reported in many regions of the world (30, 41, 55). Considering that the adverse effects of invasive alien plants (IAP) are increasingly recognized worldwide, management strategies implementation is becoming crucial (8, 38).

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The first step in any management strategy to control plants invasion is the compilation of a national and regional inventory of alien plant species (4, 48). Annotated checklists of IAP were made by many institutions. The European and Mediterranean Plant Protection Organization (EPPO) maintains lists of known and emerging IAP; the DAISIE (Delivering Alien Invasive Species Inventories for Europe) project (2004-2008) provides an inventory of invasive species that threaten European terrestrial, freshwater and marine environments (4), and the Bern Convention of the Council of Europe has aggregated existing official lists of invasive species (24). Such data compilation is of fundamental importance

in the establishment of a national system of early detection and rapid response (62).

Tunisia is one of the contracting countries in the CBD since 1993 and member of EPPO since 1955. However, IAP inventories are missing. Therefore, the primary aims of this research are to (i) provide an inventory of the spontaneous alien flora in Tunisia including accepted names, family, biological form, habitat type and geographical origin, (ii) categorize alien plant species according to their invasive status in Tunisia and over the world.

## **MATERIALS AND METHODS**

### **Study area.**

Tunisia is the northernmost country in Africa, covering 165,000 km<sup>2</sup>. It lies between latitudes 30° and 38°N, and longitudes 7° and 12°E. It is separated from Europe by the Mediterranean Sea which spans about 1,300 km of Tunisian coastline in the North and East. It is bordered to the West by Algeria, throughout 965 km, and to the South East by Libya, throughout 459 km.

According to the Köppen-Geiger Climate Classification (40) Tunisia's climate is Mediterranean in the North, with mild rainy winters and hot dry summers. The South of the country is semi-arid and merges into the Sahara. Annual rainfall ranges from 1000 mm in the North, between 300 and 200 mm in the Center and below 50 mm in the South (27).

### **Data sources and terminology.**

The main source of data for the inventory of the Tunisian alien flora is the national flora of Cuénod *et al.* (10) and Pottier-Alapetite (42, 43). We cross-checked considering the updated national flora catalogue of Le Floch *et al.* (36). Data were completed with new flora

records such as El Mokni and El Aouni (17, 18) and El Mokni *et al.* (21).

Nomenclature follows Le Floch *et al.* (36) and has been cross-checked considering online databases, i.e. The Plant List (56) and the African Plants Database (1). Names of the families of Angiosperms follow APG III (28).

### **Field explorations.**

Field surveys were made by the authors during the period July-September 2011 at Hencha-Sfax (Lat. 35°07' N, Long. 10°45'E, Altitude: 62 m; (2)) in the purpose to confirm the presence of some species. Within an area of 40 km<sup>2</sup> and along 35 km of roadsides floristic explorations were made to record and collect specimens from agricultural fields and pathway borders. Specimens were identified based on dichotomous keys (26), relevant literature (34, 39, 54, 58) and online databases (1, 22).

### **Life form and habitat types.**

The Raunkiaer's life forms (49) were adopted to distinguish plant biological forms. Information on species habitat was checked based on national floras (10, 36, 42) and we cross-checked considering literature and online databases. In the purpose to standardize habitat types, two categories were adopted (i) disturbed habitats (i.e. crop fields, roadsides, waste land, fallows) and (ii) natural habitats (i.e. forest, open woodlands, natural grasslands).

### **Native range and invasive status.**

Information on species geographical origins was checked based on literature (4, 11, 13, 48) and online databases (i.e. CAB International (5); California Invasive Plant Council (6); Delivering Alien Invasive Species Inventories for Europe (14); EPPO Lists of IAP (16); Hawaiian Ecosystems at

Risk (29); Invasive plant atlas of US (31); Invasive Species of South Africa (32); Invasive Species Specialist Group (33); Weeds of Australia (60)). We follow the above-cited authors and online databases to collect information on alien plant status

over the world and particularly in neighboring countries to Tunisia. Species were divided into weeds, alien naturalized plants and alien invasive plants as defined in Table 1.

**Table 1.** Terminology adopted in the present study

| Status                    | Definition                                                                                                                                                                                        | Source |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| <b>Weed</b>               | Species that has a perceived negative ecological or economic effect on agricultural or natural systems.                                                                                           | (3)    |
| <b>Alien</b>              | (Synonymes: allochthonous, introduced, non-indigenous, exotic, xenophytes). Plant taxa in a given area whose presence is due to intentional or unintentional human involvement.                   | (47)   |
| <b>Naturalized plants</b> | (Synonym: established). Alien plants that sustain self-replacing populations without the direct intervention of people, through the recruitment of seeds or ramets capable of independent growth. | (47)   |
| <b>Invasive plants</b>    | A subset of naturalized plants whose establishment and spread threaten ecosystems, habitats or species.                                                                                           | (53)   |

## RESULTS

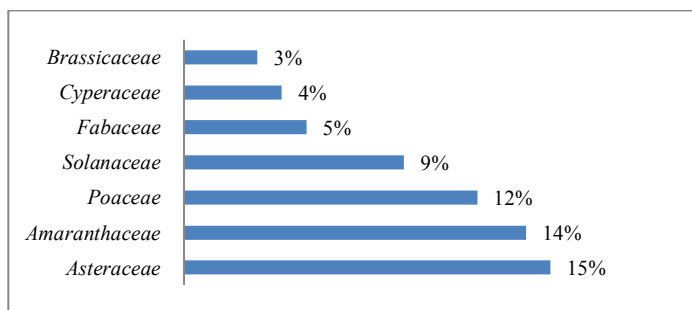
### Taxonomy.

Our field explorations at the region of Hencha-Sfax allowed us to firstly report the presence of a new alien species: *Verbesina encelioides*. This finding provided an updated of the range of *Asteraceae* family in Tunisia and reported the genus *Verbesina* for the first time (52). In addition, these results allowed to confirm the presence of some other alien species such as *Nicotiana glauca*, *Solanum elaeagnifolium*, and *Amaranthus albus*.

Data compilation and field explorations totals 92 alien taxa including 82 species, 7 subspecies and 2 varieties. This spontaneous alien flora belongs to

33 families, with 80% *Dicotyledoneae* and 20% *Monocotyledoneae*. The families represented most in the Tunisian spontaneous alien flora are *Asteraceae* (15%), *Amaranthaceae* (14%), *Poaceae* (12%), *Solanaceae* (9%), *Fabaceae* (5%), *Cyperaceae* (4%), and *Brassicaceae* (3%) (Fig. 1).

Eight families are represented by only two taxa and 18 families are represented by only one taxon. The total number of alien taxa belongs to 68 genera. The genera that account for the highest number of alien entities are *Amaranthus* with eight taxa, followed by *Erigeron* and *Cyperus* with four taxa each, and *Solanum* and *Xanthium* with three taxa for each genus.

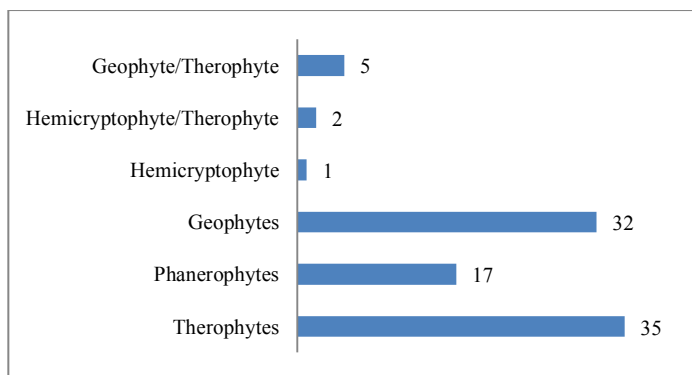


**Fig. 1.** The most represented families in the Tunisian spontaneous alien flora (% total number of taxa).

### Life form and habitat type.

Among the 92 Tunisian alien taxa, the most numerous are the therophytes (35 taxa), followed by geophytes (32 taxa) and phanerophytes (17 taxa).

Hemicryptophytes are represented only by one taxon. We counted also two taxa as therophytes and hemicryptophytes and five taxa as therophytes and geophytes (Fig. 2).



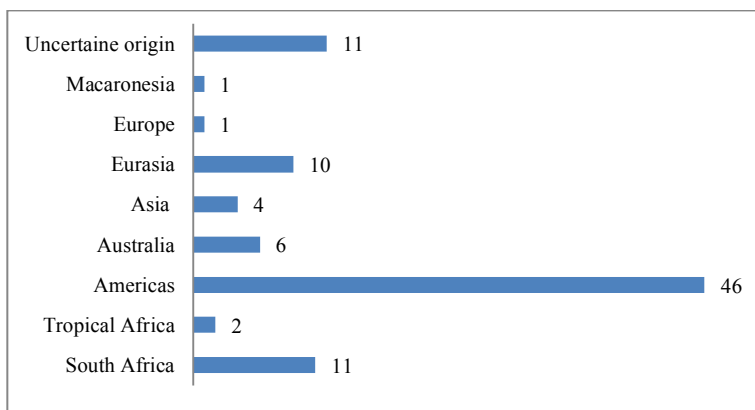
**Fig. 2.** Life forms of the Tunisian spontaneous alien flora (Number of taxa).

Up to 90% of the alien taxa occur in disturbed habitats. They are mainly recognized, in Tunisia or in other regions of the world, as common weeds in cultivated fields, pasture and roadsides (i.e. *Abutilon theophrasti*, *Agave americana*, *Amaranthus retroflexus*, *Datura stramonium*, *Erigeron bonariensis*, *S. elaeagnifolium*, *Symphyotrichum squamatum*, and *Xanthium spinosum*). On the other hand, 10% of this alien flora occurs both in disturbed and natural habitats (i.e.

*Ehrharta calycina*, *Ipomoea purpurea*, *Lamium amplexicaule*, and *Lantana camara*.

### Native range.

The majority of the alien taxa has its native range in the Americas (46 taxa), followed by Africa (tropical and South) (13 taxa), Eurasia (10 taxa), Australia (6 taxa), and Asia (4 taxa). Europe and Macaronesia are each represented by one taxon. Eleven taxa have uncertain origin (Fig. 3).



**Fig. 3.** Geographical origins of the Tunisian spontaneous alien flora (Number of taxa).

### Alien plant status.

According to the Tunisian literature, 34 alien taxa are naturalized in Tunisia, among them nine are categorized as weeds (36, 42, 43), three species (*Cardaria draba*, *Crassula helmsii*, and *S. elaeagnifolium*) are invasive (36) and one species (*Verbesina encelioides*) was newly detected in 2011 (52).

According to the international literature, four taxa are invasive in the Mediterranean Basin (25) and 18 are invasive in Sardinia-Italy (11). According to the EPPO IAP list, *S. elaeagnifolium* is listed on the A2 List of pests recommended for regulation and *V. encelioides* is listed on the observation List of IAP. Six other taxa (*Arctotheca calendula*, *Carpobrotus edulis*, *Cyperus esculentus*, *C. rotundus*, *Paspalum distichum*, and *Oxalis pes-caprae*) are listed on the EPPO list of IAP (16). In addition, the Invasive Species Specialist Group, listed three taxa (namely *Arundo donax*, *Lantana camara*, and *Schinus terebenthifolius*) among the 100 World's Worst Invasive Alien Species and according to the CAB International five taxa are invasive in Europe (*Acacia saligna*, *Alternanthera sessilis*,

*Echinochloa colona*, *I. purpurea*, and *Oxalis corniculata*).

### DISCUSSION

*Asteraceae* and *Amarantaceae* are the most represented families in Tunisian spontaneous alien flora. However, *Asteraceae* and *Poaceae* are the most represented families in European alien flora (35). On a worldwide scale, *Asteraceae* and *Poaceae* are the most represented families in alien floras (9, 37, 45, 59). In fact, they are among the largest families (9, 12, 46).

*Amaranthus* is the most represented genus in Tunisian spontaneous alien flora and it is the most represented in alien floras of many Mediterranean countries i.e. Greece (13) and Italy (9).

Therophytes are the most common life form in Tunisia, Sardinia (11) and California (50). Usually, the rich annual flora is characteristic of California and the Mediterranean type regions whereas there are relatively few annuals in the Cape flora (11, 23).

The majority of alien taxa in Tunisia come from Americas, which is similar to the total non-native floras of

many Mediterranean regions i.e. Sardinia (7, 57) and Portugal (15).

Alien taxa account for 3% of the whole Tunisian flora (3067 taxa). This is the lowest percentage in comparison to 12% in Spain (51) and 13.4% in Italy (9).

We note that almost 40% of alien taxa in Tunisia are listed in IAP lists of

many countries and regions i.e. Mediterranean Basin (25) and Sardinia (11) or institutions i.e. EPPO, CAB International and Invasive Species Specialist Group. Hence, all these alien taxa are likely to be invasive in Tunisia.

## RESUME

**Sayari N. et Mekki M. 2016. Inventaire de la flore exotique spontanée en Tunisie. Tunisian Journal of Plant Protection 11: 229-237.**

La première étape de toute stratégie de gestion des plantes exotiques envahissantes est la compilation des inventaires nationaux et régionaux de ces espèces. Dans ce travail, nous présentons un inventaire de la flore vasculaire exotique en Tunisie, comportant les noms scientifiques acceptés, les familles, les formes biologiques, les types d'habitats, l'origine géographique et le statut malherbologique. Les trois volumes de la flore de Tunisie ont été la principale source de données. La littérature signalant la découverte de nouveaux taxons et l'exploration du terrain ont été également pris en considération. Les types biologiques ont été adoptés d'après la classification de Raunkiaer. Le type d'habitat, l'origine géographique des espèces et leurs statuts malherbologiques ont été vérifiés en se basant sur la littérature et les bases de données en ligne. La liste élaborée comprend 92 taxons exotiques appartenant à 33 familles, avec 80% de dicotylédones et 20% de monocotylédones. Les familles qui contribuent le plus dans cet inventaire sont les *Asteraceae* (15%), les *Amaranthaceae* (14%) et les *Poaceae* (12%). Le genre *Amaranthus* est le plus représenté. Les thérophytes sont les plus nombreuses suivies des géophytes et des phanérophyles. D'autre part, la majorité des taxons exotiques sont originaires du continent américain, suivis par ceux originaires de l'Afrique tropicale, de l'Afrique du Sud, de l'Eurasie et de l'Australie. Nous notons que près de 40% de ces taxons sont classés dans les listes des plantes exotiques envahissantes dans nombreuses régions du monde telles que le Bassin méditerranéen et la Sardaigne, ainsi que les listes élaborées par l'OEPP, le CAB International et l'*Invasive Species Specialist Group*. Ces taxons exotiques sont susceptibles de devenir envahissants en Tunisie.

**Mots clés:** Flore exotique, inventaire, origine géographique, statut invasif, Tunisie

## ملخص

السياري، نجلاء ومنير المكي. 2016. دراسة حول النباتات الغريبة التلقائية بتونس.

**Tunisian Journal of Plant Protection 11: 229-237.**

يعتبر إعداد القوائم الوطنية والجهوية للنباتات الغريبة الغازية الخطوة الأولى في تركيز أي استراتيجية تهدف للقضاء على هذه الأنواع من النباتات. هذا العمل يعرض قائمة متكاملة للنباتات التلقائية الغريبة بتونس حيث يقدم أسماء هذه النبات والعائلات النباتية والأشكال البيولوجية والأصول الجغرافية. لإنجاز هذا العمل تم الاعتماد على المراجع والدراسات المتعلقة بالنباتات التونسية وكذلك الاعمال الميدانية. تعد القائمة 92 نبتة غريبة موزعة على 33 عائلة نباتية وتتضمن 80% من النباتات ذات الفلقتين و20% من النباتات ذات الفلقة الواحدة. إن العائلات النباتية 15% *Asteraceae* و 14% *Amaranthaceae* و 12% *Poaceae* و النوع *Amaranthus* هم الأكثر تمثيلا بهذه القائمة، وكذلك بالنسبة إلى النباتات البذرية الحولية وتتبعها النباتات الأرضية والأشجار. إن أغلب النباتات الغريبة بتونس قادمة من أمريكا وإفريقيا الجنوبية والمنطقة الأورو-آسيوية وأستراليا. وتعد القائمة 40% من النباتات الغازية بعدة مناطق بالعالم مثل الحوض المتوسطي وسردينيا وكذلك القوائم المعدة من طرف المنظمة الأوروبية لحماية النبات (OEPP) والمركز الدولي للعلوم البيولوجية الزراعية (CAB International) والفريق المتخصص في النباتات الغازية

(*Invasive Species Specialist Group*). يمكن لهذه النباتات الغريبة التلقائية أن تتحول إلى نباتات غازية تمثل خطرا بيئيا.

كلمات مفتاحية: أصول جغرافية، نباتات غريبة، تونس، جرد، وضع الغزو

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