

Preliminary analysis of the naturalized flora of northern Africa

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Abstract

There is an urgent need to list regional data on alien species diversity in order to explore worldwide patterns of species invasion. In this sense, developing countries have received little attention. We have characterized the alien flora of northern Africa with regard to the taxonomic composition, life history characteristics, geographic origin and habitats invaded. A total of 343 vascular plant species from 69 families non-native to the regions were found in the literature. Alien species richness ranged from 143 (Algeria) to 60 (Tunisia). Most of these were of Mediterranean and North American origin. Over 40% of the alien species were therophytes. Crop fields, dumps and wet areas such as fresh water streams were the habitats with the highest number of aliens. About 10 % of species in the alien flora are considered to be serious plant invaders in other places of the world. Among these species there are many shrubs and trees such as *Acacia* and *Eucalyptus*. The impact of these species must be surveyed in the field.

Key words: alien plants, invasive species, northern Africa, origin of aliens, regional flora, species distribution

Resum. *Anàlisi preliminar de la flora naturalitzada del nord d'Àfrica.*

Per tal d'establir patrons globals d'espècies invasives és necessari i urgent determinar la diversitat de la flora al·lòctona a escala regional. En aquest sentit els països en vies de desenvolupament han rebut poca atenció. Per aquest motiu, hem caracteritzat la flora naturalitzada dels països del nord d'Àfrica per conèixer la seva composició taxonòmica, el tipus de forma de vida, el seu origen geogràfic i els hàbitats que ocupen. Segons la recerca bibliogràfica feta hem trobat 343 plantes superiors repartides en 69 famílies. El nombre d'espècies per país va des de 143 (Algèria) a 60 (Tunícia). La major part d'aquestes espècies té un origen mediterrani o nordamericà. Un 40% de les espècies són teròfits. Els camps de conreu i els ambients humits són els hàbitats amb major nombre d'espècies al·lòctones.

Un 10% d'aquestes espècies (ex. *Acacia*, *Eucalyptus*) són considerades espècies molt invasives en altres regions del món. L'impacte d'aquestes espècies s'hauria d'estimar directament al camp.

Paraules clau: plantes al·lòctones, espècies invasives, nord d'Àfrica, origen de la flora al·lòctona, flora regional, distribució d'espècies.

Introduction

Invasions by alien plant species are causing major conservation problems in many regions of the world and are viewed as an important component of human caused global change (Vitousek et al., 1997). Results of the spread of alien plant species include the loss of biodiversity (Lodge, 1993; Huston, 1994), changes in disturbance regime (Van Wilgen & Richardson, 1985; D'Antonio & Vitousek, 1992) and the creation of new landscapes (Atkinson & Cameron, 1993; Vitousek et al., 1997). In most instances, the spread of alien species (invasion) is associated with the consequences of human activities, e.g. disturbance, fragmentation, urbanization, cropping and the use of alien plants for landscaping and erosion control.

A full understanding of the process of invasion requires both information on the ecological attributes of the alien species as well as on the susceptibility of habitats to be invaded (Roy, 1990). Before detailed investigations on the ecological relationship between invader and invaded habitats can take place, information on the extent of naturalized species is needed. The composition and distribution of naturalized floras are fairly well documented at the regional scale for European countries (Di Castri, 1990; Weber, 1997) and regions where European have settled since the 15th century, e.g. southern Australia (Kloot, 1984), southwestern Africa (Brown & Gubb, 1986), and California (Rejmánek & Randall, 1994). There is still a lack of quantitative information on naturalized plants for major regions of the world, especially for those of Asia and Africa. Floras of these regions are not existent or are incomplete, making it difficult to assess both native and alien plant diversity. There is an urgent need to have data on the distribution of native and alien species in order to perform a risk assessment of plant invasions (Cronk & Fuller, 1995). A global perspective of biological invasions needs to incorporate the distribution of alien species in these countries (Heywood, 1989; Lonsdale, in press).

Here, we focus on the alien flora of northern Africa, i.e. Algeria, Egypt, Libya, Morocco and Tunisia. The flora of northern African countries is very rich and highly diverse due to the presence of Mediterranean, Saharian and Macaronesian elements (White, 1983). The five countries above mentioned vary greatly in climate, size, and topography. Morocco is the country with the largest area having Mediterranean climate. Algeria and Tunisia also have Mediterranean climate in the north but become increasingly arid towards the south. Libya is arid and desertic, and finally, Egypt is classified as an arid and hyperarid country

(Emberger, 1971). This biogeographic region is limited to the south by the Sahara desert.

White (1983) distinguishes three climatic zones within this area. First, a Mediterranean zone which stretches along the coast from Morocco to Tunisia, and includes the Atlas mountains in the northwest. From this region, approximately 4000 vascular plant species are known (White, 1983). Before human settlement, the landscape was probably dominated by evergreen forest. The most fertile lowlands have been used for agriculture since Roman times, and the natural vegetation is confined to small patches. Soil erosion is common mainly due to overgrazing (El Hattab, 1989).

Secondly, a Mediterranean/Sahara transition zone which includes mainly the low coastal plain in the eastern part, and the high plateau between the Haut Atlas and the Saharian Atlas in the western part. Rainfall is low (100-250 mm) and concentrated in the winter months. The flora is relatively poor (ca. 2500 species). In the western part of Morocco, the landscape is dominated by winter cereal fields and pastures. The coastal plain of Tunisia is rich in agriculture and olive groves and the original forests have completely disappeared. Rainfall decreases towards the east. Extensive agriculture also exists in Egypt and Libya, and the vegetation in noncultivated areas is highly degraded due to overgrazing.

Finally, a Saharian zone where the rainfall is low and episodic, specially in the central region. Large areas of the Libyan desert are virtually rainless. The natural vegetation of the oasis has been almost completely replaced by plantations of date palm (*Phoenix dactylifera*) together with other crop plants.

There are few studies on the extent and patterns of invasions in arid lands (Loope et al., 1988; Bennett et al., 1996; Brock & Farkas, 1997). Although pristine arid environments appear to be unfavorable for the establishment of alien species, disturbed arid ecosystems can be very sensitive to changes caused by established alien species (Burgess et al., 1991; Brock & Farkas, 1997). In addition, riparian habitats within arid regions are often seriously invaded by alien trees and shrubs (Loope et al., 1988; Rejmánek, 1989; Stromberg et al., 1997). In arid environments, alien species can cause strong ecological changes such as changes in fire frequency and intensity (Schmid & Rogers, 1988).

In this paper we focus on naturalized plant species that have been established in agroecosystems and other types of habitats. The origin and historical background of species introductions into northern African countries have been synthesized by Guillermet et al. (1990) and Le Floch et al. (1990). Our objective here is to evaluate the extent of the naturalized flora in northern Africa countries and to quantify the taxonomic composition and life history characteristics, geographic origin and main habitats invaded. The questions addressed are: 1) How many naturalized plant species do northern African countries have? 2) Which families account for most of the naturalized species? 3) What is the geographical origin of these naturalized species? 4) Which habitats have the highest number of naturalized species?

Methods

Terminology

For the purpose of this study, some terms commonly but not equally used in the literature, are defined here following Pyšek 1995, Weber 1997 and Richardson 1998.

Native (indigenous) species are the ones that evolved in an area or which arrived there by one means or another before the beginning of the neolithic period or which arrived there since that time by a method entirely independent of human activity.

Alien species are the ones that are not indigenous in a given geographical unit (here Northern African countries), regardless of their origin and that reached the area as a consequence of the activities of neolithic or postneolithic man. Alien species is synonymous of exotic, adventive and introduced.

Naturalized species are those alien species that often regenerate freely, but mainly under their own canopies. On the contrary, invader species are those that frequently recruit seedlings in natural or seminatural vegetation at distances far from parent plants and most times have an effect on the community structure they establish.

Bibliographical survey

We have compiled a list of all naturalized plant species from the following floras: Cuénod et al. (1954), Greuter et al. (1984), Jafri & El-Gadi (1983), Jahandiez et al. (1931-1941), Pottier-Alapetite (1979-1981), Quézel & Santa (1962) and Täckholm (1974). This listing represents an appropriate starting point from which to begin a field survey across the region.

We use the term naturalized species throughout the paper. We tend to avoid the term invasive species because we do not know if the naturalized species listed can be considered to have an effect on the community structure where they occur (Pyšek 1995). Species listed as «cultivated» or «planted» without details of naturalization were excluded.

We identified origin, life form and habitats colonized by each species as far as possible. Based on the literature, we identified naturalized species that are considered to be serious plant invaders elsewhere in the world.

The percentage of naturalized species per country was calculated according to the approximate number of total number of species per country presented by Médail and Quézel (1997). Overrepresentation of species within a family was assessed if the ratio obtained by dividing the number of naturalized species from one family by the total number of naturalized species was higher than the ratio between the number of species in the family worldwide by the total number of species in the flora of the world (Pyšek 1998).

Table 1. Summary statistics for the naturalized flora of northern Africa.

Country	Area (km ²)	Gymnosperms	Dicots	Monocots	Total	alien/ log(area)	% aliens
Algeria	2300980	2	107	18	143	22.5	4.5
Egypt	997739	0	89	12	101	16.8	4.9
Libya	1760000	0	77	3	80	12.8	5
Morocco	458730	0	72	4	76	13.5	1.8
Tunisia	154530	0	54	6	60	11.6	3.3

Table 2. The largest angiosperm families (with more than 5 species) in the naturalized flora of north Africa.

Family	Number	Percentage	WorProp*
Brassicaceae	39	11.11	1.2
Fabaceae	39	11.11	6.5
Asteraceae	33	9.33	8.4
Amaranthaceae	23	6.55	0.3
Poaceae	21	5.98	3.2
Solanaceae	18	5.13	1
Chenopodiaceae	17	4.84	0.5
Euphorbiaceae	15	4.27	3.1
Caryophyllaceae	13	3.7	0.8
Convolvulaceae	9	2.56	0.7
Malvaceae	9	2.56	0.6
Aizoaceae	6	1.71	1
Oxalidaceae	6	1.71	0.2
Liliaceae	5	1.42	1.8
Onagraceae	5	1.42	0.3
Scrophulariaceae	5	1.42	1.8

* World Proportional representation = ratio between the number of species in the family worldwide by the total number of species in the world's flora (Data from Pyšek 1998).

Table 3. Percentage of the lifeforms of the naturalized plants of northern African countries.

Therophytes	46.34
Hemicriptophytes	40.76
Nanophanerophytes	5.92
Macrophanerophytes	6.27
Suculents	0.70

Results

Size and composition of the naturalized flora of northern Africa

We have found 343 vascular plant species naturalized in northern Africa belonging to 69 families. The number of naturalized species varied from 60 (Tunisia) to 143 (Algeria) with species density from 11.57 to 22.5 species /log area respectively. Libya was the country with the highest percentage of naturalized species (5%) and Morocco the one with the least number of naturalized species (1.8%) (Table 1).

Most of the naturalized species belong to the Dicotyledoneae (Table 1). The largest families were the Brassicaceae, Fabaceae, and Asteraceae with more than 30 species each (Table 2). These were also overrepresented families. The Poaceae is the monocotyledon family with the highest number of naturalized species (5.6%). The naturalized species were members of a wide range of life forms, including shrubs and trees, but the majority belonged to annual and perennial herbaceous species (Table 3).

Geographical origin of the naturalized flora of northern Africa

Considering the whole naturalized flora, most of the species had their origin in the northern shore of the Mediterranean, followed by America and Asia as source regions (Table 4). A rather small fraction originated from Eurasia and from sub-saharian Africa. There were, however, substantial differences among the regions considered: the predominance of American origin is well represented in Egypt, Morocco and Tunisia. Naturalized species of Algeria and Libya originated mostly from Eurasia or the northern Mediterranean Basin, respectively. Species of sub-saharian African origin, mainly from Southafrica were well represented in Algeria, Morocco, and Tunisia. Naturalized species of tropical origin are especially numerous in Morocco.

Table 4. Percentage of the origin of naturalized plants in northern Africa by country.

	Algeria	Egypt	Libya	Morocco	Tunisia	Total
African	15.17	7.84	10.00	16.88	15.55	7.49
American	17.24	31.37	13.75	23.37	22.22	17.00
Asiatic	6.89	10.78	11.25	20.77	13.33	9.22
Circumboreal	11.03	–	–	–	–	3.45
Eurasian	18.62	2.94	8.75	12.98	11.11	6.05
Mediterranean	11.03	15.68	20.00	11.68	8.88	23.91
Tropical	2.75	5.88	3.75	9.09	2.22	7.78
Not specified	17.27	25.51	32.50	5.23	26.69	18.27

African = Subsaharian Africa; Mediterranean = northern Mediterranean Basin.

Habitats occupied by the naturalized flora of northern Africa

Beside crop fields, dumps and freshwater were the habitats with most naturalized species (Table 5). Other important natural or semi-natural habitats with naturalized species included dunes and sandy places, rocky habitats, and oasis. The highest diversity of naturalized species, expressed as numbers of families, was present in crop fields, followed by freshwater habitats and wetlands. A rather low number of families was represented by naturalized species in roadsides and in old fields.

Table 5. Percentage of habitats occupied by naturalized plants in northern Africa.

Habitat	% occupied	N° families	% families
Crop fields	24.80	26	35.13
Dumps	10.78	10	13.51
Freshwater	10.45	20	27.02
Dunes & sands	6.86	7	9.45
Rocks	6.53	12	16.21
Oasis	5.55	9	12.16
Old fields	5.22	6	8.10
Wetlands	4.57	14	18.91
Roadsides	3.60	6	8.10

Species that are serious plant invaders elsewhere

We found several species that are considered as serious plant invaders in other regions of the world (Table 6). Thirty-six species out of the 344 naturalized species (9.7%) are considered to be serious plant invaders in other regions of the world, among which there are shrubs and trees such as *Acacia saligna*, *Eucalyptus camaldulensis*, *Melia azederach* and *Mimosa pigra* (Daehler 1998).

Discussion

We found a rather low number of established alien plant species in northern Africa, both as absolute numbers and species density. This confirms the findings of Le Floc'h et al. (1990) and of Vitousek et al. (1997) that African countries generally have few naturalized species compared to other regions of the world. Although this may partly reflect the status of knowledge and available information, there are other potential reasons for this fact.

The Mediterranean Basin and in general the New World is more resistant to invasion than the other Mediterranean regions of the world and the Southern Hemisphere (Di Castri, 1989; Fox, 1990). The Mediterranean Basin has been subjected to ancestral frequent human migrations and to a continuous intermediate

Table 6. Naturalized plants of northern Africa which are also invasive elsewhere according to Daehler (1998).

Species	Family	Life form	Origin
<i>Carpobrotus edulis</i>	Aizoaceae	S	Africa
<i>Mesembryanthemum crystallinum</i>	Aizoaceae	S	Africa
<i>Eleagnus angustifolia</i>	Aleagnaceae	P	Europe
<i>Alternanthera pungens</i>	Amaranthaceae	H	America
<i>Amaranthus spinosus</i>	Amaranthaceae	H	America
<i>Conyza bonariensis</i>	Asteraceae	T	America
<i>Eupatorium adenophorum</i>	Asteraceae	H	Mediterranean
<i>Senecio mikanoides</i>	Asteraceae	H	Africa
<i>Tagetes minuta</i>	Asteraceae	T	Tropics
<i>Xanthium spinosum</i>	Asteraceae	T	America
<i>Brassica tournefortii</i>	Brassicaceae	T	Mediterranean
<i>Cardaria draba</i>	Brassicaceae	H	Europe
<i>Opuntia imbricata</i>	Cactaceae	S	America
<i>Ricinus communis</i>	Euphorbiaceae	P	Asia
<i>Acacia cyclops</i>	Fabaceae	P	Australia
<i>Acacia decurrens</i>	Fabaceae	P	Australia
<i>Acacia melanoxydon</i>	Fabaceae	P	Australia
<i>Acacia saligna</i>	Fabaceae	P	Australia
<i>Mimosa pigra</i>	Fabaceae	P	America
<i>Robinia pseudacacia</i>	Fabaceae	P	America
<i>Elodea canadensis</i>	Hydrocharitaceae	Hy	America
<i>Hydrocharis morus-ranae</i>	Hydrocharitaceae	Hy	America
<i>Melia azederach</i>	Meliaceae	P	Asia
<i>Eucalyptus camaldulensis</i>	Myrtaceae	P	Australia
<i>Argemone mexicana</i>	Papaveraceae	H	America
<i>Anthoxanthum odoratum</i>	Poaceae	H	Europe
<i>Arundo donax</i>	Poaceae	H	Europe
<i>Panicum maximum</i>	Poaceae	H	Tropics
<i>Pennisetum setaceum</i>	Poaceae	H	Asia
<i>Eichornia crassipes</i>	Pontederiaceae	Hy	America
<i>Ailanthus altissima</i>	Simarubaceae	P	Asia
<i>Datura stramonium</i>	Solanaceae	H	America
<i>Nicotiana glauca</i>	Solanaceae	P	America
<i>Solanum nigrum</i>	Solanaceae	H	America
<i>Tropaeolum majus</i>	Tropaeolaceae	T	America

H = hemicriptophytes; Hy = hydrophytes; P = phanerophytes; S = succulent; T = therophytes.

disturbance regime that has led to old and frequent invasions of different biogeographic origin that nowadays cannot be detected. This is specially true for species of Mediterranean origin. Human traffic between the northern and southern shores of the Mediterranean sea have continued uninterrupted for at least 3000 years and thus it is difficult to determine with certainty which are native and which are naturalized.

Generally, the number of naturalized species per area and the percentage of naturalized species in a country is lower for the southern Mediterranean Basin countries than for northern Mediterranean Basin countries (Groves & Di Castri, 1991). For instance, continental Spain, France and Italy have 43.8, 83.5 and 53.7 species/log area (Weber, 1997). Although there has been less effort in botanical studies in the southern countries than in the northern countries, these differences may be also due to a higher proportion of arid land in the south. A large part of the regions considered here is occupied by dry lands. Arid environments generally seem to have few naturalized species. For example, Burgess et al. (1991), identified only 20 naturalized species that were either widespread and common, or locally common within an area of the Sonoran desert. Other differences in land use, agriculture practices and rates of species introduction should not be discarded.

Naturalized species are distributed in a large number of families. However, more than 75% of the families had less than 5 naturalized species and few families (Brassicaceae, Asteraceae, Amaranthaceae and Poaceae) had more than 40% of the naturalized species. This is a common pattern in introduced floras (Weber, 1997; Pyšek, 1998). The taxonomic composition of naturalized floras is not random (Pyšek, 1998) and the families with the largest number of naturalized species belong also to the largest families worldwide. Furthermore, some of these families have more naturalized species than expected. This may partly be explained by deliberate and repeatedly introductions of certain species and by specific features of these species, making them more invasive. For example, the northern African vegetation has been subjected to agricultural conversion (grazing, pastoralism) for a long time. Thus, it is not surprising that annuals were the prevalent life form among the species found. It may also reflect the identity of naturalized plants, e.g. the Amaranthaceae and Poaceae contain many weeds of agroecosystems. Pyšek (1998) found that the Chenopodiaceae, Amaranthaceae and Brassicaceae were among the most invasive families worldwide.

Le Floch et al. (1990) distinguishes several periods in which plants have been introduced into northern Africa and relate plant invasions to the agricultural development. In terms of naturalized species, the most important period was the 19th century and the first half of the 20th. During these colonial times, species from all over the world were introduced into northern Africa.

Beside crop fields, most naturalized species were found in human-disturbed habitats (e.g. dumps) and in habitats with high water availability (fresh water courses, wetlands and oasis). Water courses are especially prone to invasion by naturalized plants because they act as effective corridors providing a route for the dispersal of water-borne propagules (de Waal et al., 1994). However, dry habitats such as dunes, sand and rocks are also invaded habitats. Very few succeed

in closed forest and shrublands. High diversity and low disturbance levels may prevent invasion of closed forest and shrublands (Hobbs & Huenneke, 1992). Nevertheless, it would be daring to state that some naturalized species cannot colonize certain habitats because there is no information on naturalized species immigration rates.

Despite the fact that this survey was based on published floras of different dates and written by different authors who may cope in varying ways with the status of naturalized species (Webb, 1985) some conclusions can be drawn: 1) northern African countries have generally few alien species compared to other countries within or outside the Mediterranean Basin, 2) most aliens are herbs originating in America or in other Mediterranean countries, 3) beside crop fields, the most invaded habitats are aquatic environments, 4) the naturalized flora of northern Africa includes many species that are serious invasive species elsewhere.

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