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The exotic and invasive flora of Portugal

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Abstract

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The presence of exotic plants in Portugal has increased during the last two centuries. Aliens represent today more than 15 % of the Portuguese flora. We present a report of the exotic flora of Portugal, based on available bibliography, herbarium specimens and field surveys. We have used the Country's traditional division in eleven provinces, and the species geographical distribution is given accordingly, since this is the usual taxonomical methodology. The progression of alien plants by families along time and some ecological characteristics are also discussed.

Keywords: Flora, exotic species, Portugal.

Resumen

ALMEIDA, J.D. & FREITAS, H. 2001. La flora exótica e invasora de Portugal. *Bot. Complutensis* 25: 317-327.

La presencia de plantas exóticas en Portugal se viene incrementando en los dos últimos siglos. Las plantas exóticas representan hoy más de 15 % de la flora portuguesa. Presentamos un relatorio de la situación actual de la flora exótica de Portugal basado en la bibliografía disponible, pliegos de herbario y prospecciones en el campo. Utilizamos la división tradicional de Portugal en once provincias para indicar la distribución geográfica de las especies, de acuerdo con la metodología taxonómica usual. La progresión de las especies exóticas por familias durante el tiempo y algunas características ecológicas son también discutidas.

Palabras-clave: Flora, especies exóticas, Portugal.

Resumo

ALMEIDA, J.D. & FREITAS, H. 2001. A flora exótica e invasora de Portugal. *Bot. Complutensis* 25: 317-327.

A presença de plantas exóticas em Portugal tem-se vindo a incrementar nos dois últimos séculos. As plantas exóticas representam hoje mais de 15 % da flora portuguesa. Apresentamos um relatório da situação actual da flora exótica de Portugal baseado na bibliografia disponível, exemplares de herbário e prospecções no campo. Utilizamos a divisão tradicional de Portugal em onze províncias para indicar a distribuição geográfica das espécies, de acordo com a metodologia taxonómica usual. A progressão das espécies exóticas por famílias ao longo do tempo e algumas características ecológicas também são discutidas.

Palavras-chave: Flora, espécies exóticas, Portugal.

INTRODUCTION

The expansion of exotic invasive plants is threatening the Portuguese native flora and is becoming a severe environmental problem. This work will give a brief historical background and an overview of the present situation.

Subspontaneous plants are introduced plants effectively naturalised (Franco 1971), adapted to the ecological conditions of our Country. Subspontaneous plants were almost all introduced by man, although their success doesn't require human intervention, since they reproduce and spread spontaneously. They present advantages relatively to the majority of our native plants, for example, the absence of their natural enemies and a greater environmental resistance or a faster growth. They overtake our native plants in competition, tending to replace them. This replacement can be partial or total, depending on the propagating capacities of the invasive plants, and the more or less effective isolation of the populations of our indigenous species. We can classify introduced plants according to their characteristics, geographic provenience, the aim for introduction or by their degree of threat for the native flora.

Human intervention is not necessary for the reproduction and expansion of invasive species, as these plants can propagate themselves efficiently by their own means. Man, however, usually enhances spread of invasive alien plants, creating ruderal habitats which are favourable to the large majority of them. For example, the construction of roads and railways constitutes a precious help to the expansion of synanthropic plants.

Colmeiro (1891) quoted, for the whole Iberian Peninsula, 111 introduced plant species for a total number of 6145 species of vascular plants (6064 species of phanerogamics and 81 species of vascular cryptogamics). In 1890, non-indigenous plants represented 1.8 % of the total number of species of the Iberian flora.

Pereira Coutinho (1920) considered 2696 species in the Portuguese flora, including 142 species frequently cultivated and 97 subspontaneous. Thus, in 1920, naturalised introduced species represented 3.6 % of the total number of species of the Portuguese flora; twice the number that Colmeiro (1891) referred thirty years before for the Iberian Peninsula.

In 1939, 2853 species of vascular plants were known in continental Portugal. From these, 211 (7.4%) could have been considered subspontaneous (Pinto da

Silva 1971). Fernandes (1955) reported 33 new cases of subspontaneity detected between 1939 and 1954. Between 1955 and 1961, 41 new species were introduced in Portugal, therefore exceeding the 35 new introductions which had been detected during the preceding fifteen years (Pinto da Silva 1963).

Between 1961 and 1970, 28 new introductions occurred in continental Portugal (Pinto da Silva 1971), raising to 315 the number of synanthropic species (10.2 %), among a total number of 3089 species. Between 1939 and 1971, an introduction of 104 exotic species was observed, ascending the total number from 211 to 315 (Pinto da Silva 1971). Pinto da Silva (1975), considered 3117 species in the Portuguese flora, including 316 synanthropic (10.1 %). We are now considering the figure of 500 exotic naturalised species for Portugal, representing a huge growth of 184 species from 1974 to 1999.

MATERIAL AND METHODS

Based on the available literature, herbarium material (from the Portuguese herbaria AVE, BRESA, COI, ELVE, HVR, LISE, LISFA, LISI, LISU and PO) and field surveys (mainly on the provinces of Algarve, Alto Alentejo, Baixo Alentejo, Beira Alta, Beira Litoral, Douro Litoral, Estremadura, Ribatejo and Trás-os-Montes e Alto Douro), we considered the figure of 500 species and subspecies of introduced vascular plants naturalised in continental Portugal. We have tried to include all the exotic species which are effectively naturalised (subspontaneous plants). We have also included exotic cultivated plant species which have occasionally escaped from cultivation (adventive species).

Species considered native by the majority of authors, species which are exclusively cultivated (even at a large scale) and the apophytes, were not included.

RESULTS

The flora of Portugal is constituted by approximately 3200 *taxa*. The families of our selected 500 *taxa* of exotic vascular plants are shown in Table 1.

The 500 aliens were distributed according to their origin, as shown in Table 2.

These data were obtained mainly from «Nova Flora de Portugal», the most recent Flora of Portugal (Franco 1971, 1984; Franco & Rocha Afonso 1994, 1998), from the 5th volume of «Flora Europaea» (Tutin & al. 1980) and from the available volumes of «Flora iberica» (Castroviejo & al. 1986-2000).

America (with 168 species) and Eurasia and the Mediterranean Region (with 185 species), are the regions which contribute the greatest to the number of naturalised exotic plants (34 % and 37 %, respectively). Africa (including South Africa or Capense Region, Tropical Africa and Macaronesia) gives 12 % (60) of the total 500 species of exotic naturalised plants. Australia, Tasmania, New Zealand and New Caledonia (grouped in Oceania) contribute with 29 species (about 6 % of total).

Table 1
The families of exotic naturalised plant species in Portugal

Families	*N.º of species*	*Families*	*N.º of species*
PTERIDOPHYTA		*DICOTYLEDONES*	
Azollaceae	2	*Martyniaceae*	1
Blechnaceae	2	*Mimosaceae*	14
Hymenophyllaceae	1	*Molluginaceae*	1
Lycopodiaceae	1	*Moraceae*	2
Pteridaceae	2	*Myoporaceae*	2
Selaginellaceae	1	*Myrtaceae*	6
GYMNOSPERMAE		*Nyctaginaceae*	1
Cupressaceae	4	*Oleaceae*	2
Pinaceae	7	*Onagraceae*	9
ANGIOSPERMAE		*Oxalidaceae*	6
DICOTYLEDONES		*Papaveraceae*	3
Aceraceae	3	*Passifloraceae*	1
Aizoaceae	8	*Phytolaccaceae*	2
Amaranthaceae	12	*Pittosporaceae*	3
Anacardiaceae	3	*Platanaceae*	1
Apiaceae (Umbelliferae)	7	*Plumbaginaceae*	1
Apocynaceae	1	*Polygonaceae*	10
Aristolochiaceae	1	*Portulacaceae*	5
Asclepiadaceae	2	*Proteaceae*	2
Asteraceae (Compositae)	61	*Punicaceae*	1
Balsaminaceae	1	*Ranunculaceae*	3
Brassicaceae (Cruciferae)	12	*Rosaceae*	14
Basellaceae	1	*Rubiaceae*	1
Betulaceae	1	*Salicaceae*	6
Boraginaceae	3	*Scrophulariaceae*	8
Buddlejaceae	2	*Simaroubaceae*	1
Cactaceae	3	*Solanaceae*	24
Caesalpiniaceae	4	*Styracaceae*	1
Callitrichaceae	1	*Tamaricaceae*	1
Campanulaceae	2	*Tetragoniaceae*	1
Cannabaceae	1	*Tropaeolaceae*	1
Capparaceae	1	*Ulmaceae*	1
Caprifoliaceae	2	*Urticaceae*	1
Caryophyllaceae	7	*Verbenaceae*	4
Chenopodiaceae	4	*Vitaceae*	6
Clusiaceae (Guttiferae)	3	*MONOCOTYLEDONES*	
Convolvulaceae	6	*Agavaceae*	4
Coriariaceae	1	*Alliaceae*	2
Cornaceae	1	*Amaryllidaceae*	2
Crassulaceae	12	*Araceae*	3
Cucurbitaceae	3	*Arecaceae (Palmae)*	1
Dipsacaceae	1	*Asparagaceae*	1
Euphorbiaceae	8	*Asphodelaceae*	2
Fabaceae (Papilionaceae)	33	*Cannaceae*	1
Fagaceae	2	*Commelinaceae*	1
Geraniaceae	4	*Cyperaceae*	8
Haloragaceae	1	*Hydrocharitaceae*	2
Hydrangeaceae	2	*Iridaceae*	13
Hydrophyllaceae	2	*Juncaceae*	2
Juglandaceae	1	*Juncaginaceae*	1
Lauraceae	1	*Lilaeaceae*	1
Lamiaceae (Labiatae)	7	*Liliaceae*	3
Lythraceae	2	*Poaceae (Gramineae)*	44
Magnoliaceae	1	*Pontederiaceae*	3
Malvaceae	6	*Zingiberaceae*	1

Table 2
The regions of origin of the naturalised exotic plant species found in Portugal

Regions	*N.º of species*	*% total*
Mediterranean Region	70	14,0
Europe	28	5,6
Eurasia	46	9,2
Asia	41	8,2
North America	65	13,0
South America	56	11,2
America (N and S)	47	9,4
Macaronesia	7	1,4
Tropical Africa	7	1,4
South Africa (Capense Region)	46	9,2
Australia, Tasmania, New Zealand and New Caledonia	29	5,8
Tropical Regions	17	3,4
Uncertain or unknown origin	15	3,0
Hybrids	11	2,2
Plants of various origins	15	3,0

Finally, the more heterogeneous group, the plants of other origins, which congregates about 11 % of the total number (56 species). Fifteen of these species are from tropical regions, being pantropical, paleotropical, thermocosmopolitan species or species which live in several tropical regions. Twelve species have uncertain or unknown origin and 12 are hybrids (being exotic one or both parental species). We have considered yet another heterogeneous group, constituted by 17 species of plants of other proveniences, which are considered to be native in different regions —America and Australia or Africa and Asia, for example.

The 500 exotic species were distributed according to their life-form (Raunkiaer 1934) as shown in Table 3. These data were obtained mainly from Franco (1971, 1984) and Franco & Rocha Afonso (1994, 1998).

The Portuguese exotic *Pteridophyta* can be divided in three categories: chamaephytes (2), hemicryptophytes (5) and aquatic cryptophytes or hydrophytes (2). All of the *Gymnospermae* subspontaneous in Portugal (11) are phanerophytes. *Dicotyledones* include the large majority of phanerophytes (122 species, 89 %) and chamaephytes (32 species, 94 %), while *Monocotyledones* include almost 2/3 of cryptophytes (42 species, or about 66 %).

The large majority of therophytes are *Dicotyledones* (147 species, 83 %), including 3 parasites, which includes all the exotic parasites of Portugal. Hemicryptophytes are proportionally divided between *Monocotyledones* and *Dicotyledones*: 45 hemicryptophytes in *Dicotyledones* (more than 67 %) and 15 hemicryptophytes in *Monocotyledones*, more than 22 %.

Table 3
Life-forms (Raunkiaer 1934) of the naturalised exotic plant species

Life-forms	*N.º of species*	*% total*
Phanerophytes	139	27.8
Chamaephytes	34	6.8
Cryptophytes	65	13.0
Geophytes	50	
Hydrophytes	7	
Helophytes	3	
Hemicryptophytes	65	13.0
(Including 14 proto-hemicryptophytes)		
Therophytes	174	34.8
(Including 3 parasites)		
Dubious cases	23	4.6

Table 4
Exotic naturalised plant species, according to the classification of Kornas (1990)

Types	*N.º of species*	*% total*
Archeophytes	11	2.2
(Plants which arrived before 1500)		
Holoagriophytes*	27	5.4
(Plants permanently established in natural habitats)		
Hemiagriophytes		
(Plants permanently established in semi natural habitats)	49	9.8
Epoecophytes		
(Plants permanently established in ruderal and cultivated habitats)	220	44.0
Ephemerophytes		
(Plants temporarily introduced)		
Ergasiophygophytes	23	4.6
(Plants temporarily established, escaped from cultivation)		
Dubious cases	158	31.6
We include in this group some species of doubtful spontaneousity and several species of uncertain position, acc. to this classification of synanthropic plants.	12	2.4

* In the holoagriophytes we are including 2 species which are not synanthropic: *Hydrocotyle bonariensis* Commerson ex Lam. and *Lilaeopsis attenuata* (Hooker & Arnott) Fernald (*Apiaceae*), which have probably been introduced in Portugal by migratory birds from America (Fernandes 1960).

The distribution of exotic naturalised plants according to their synanthropic type (Kornas 1990) is shown in Table 4. These informations were obtained partly from Pinto da Silva (1971). As expected, the highest percentage are epoecophytes, plants permanently established in ruderal and cultivated habitats, followed by ergasiophygophytes, which are plants temporarily established, escaped from cultivation.

The distribution of exotic naturalised plants by type of introduction is presented in Table 5. As expected, deliberate introduction for ornamental reasons is the most common type. These informations were taken from a large amount of bibliography.

Table 5
The type of introduction of exotic naturalised plant species

Type of introduction	*N.º of species*	*% of total*
Accidental	18	25.6
Deliberate	367	73.4
1) Ornamental plants	261	52.2
2) Other plants of economic interest	106	21.2
Dubious cases	5	1.0

The distribution of exotic naturalised plants according to the Portuguese provinces is shown in Table 6. A higher number of exotic species is found in the littoral provinces, particularly in the more populated areas, with more intensive agriculture and industry, and where a greater density of roads can be observed. Human density determines concentration of roads and railways and modern industry and agriculture. These increasing pressures are responsible for the introduction of exotic plants, and they also contribute to their propagation. Roads, railways and rivers are very important for the diffusion of alien species, as, for example, *Chamaesyce maculata* (L.) Small, a «railway plant» (Rainha 1980). Industrial activities are responsible for the introduction of many exotic plants, for instance through the import of raw materials from other regions, as, for example, *Cotula australis* (Sieber ex Sprengel) Hook. f., which had come to Portugal together with foreign wool (Pinto da Silva 1952). With modern agriculture, this fact is even more significant, with the introduction of many seeds from other countries, which are often accompanied by seeds of other plants, frequently dangerous weeds, as *Eclipta prostrata* (L.) L., for example.

The provinces with the higher number of alien species are Estremadura, Beira Litoral and Douro Litoral which are also the provinces where the major centres of botanical research are located. Of course, the presence of these centres is important to detect and identify new exotic species. Two other relatively well known provinces from a floristic point of view are Trás-os-Montes e Alto Douro and Alto

Table 6
The distribution of exotic naturalised plant species according to the Portuguese provinces

Province	*Province's abbreviature*	*Province's surface (km²)*	*N.º of alien species*	*% of total of alien species*
Minho	Mi	4 889	155	31.0
Trás-os-Montes e Alto Douro	TM	11 965	158	31.6
Douro Litoral	DL	3 363	216	43.2
Beira Litoral	BL	7 693	262	52.4
Beira Alta	BA	9 521	92	18.4
Beira Baixa	BB	7 409	83	16.6
Estremadura	E	5 238	314	62.8
Ribatejo	R	7 294	134	26.8
Alto Alentejo	AAl	12 618	139	27.8
Baixo Alentejo	BAl	13 751	160	32.0
Algarve	Ag	4 960	138	27.6

For a map of Portugal with the province's boundaries, see Castroviejo & *al*. (1986-2000).

Alentejo. Fortunately, these two provinces are still not largely affected by invasive species with 31.6 and 27.8 % of the national total of exotic species, respectively. This might be explained by their isolation and low human population pressure. The provinces with the lower number of exotic naturalised species are Beira Baixa, with 83 species, or 16.6 %, and Beira Alta, with 92, or 18.4 % of the total number. Baixo Alentejo, Minho, Algarve and Ribatejo are provinces placed in an intermediate position. The number of exotic species in these provinces ranges between 138 and 160.

The accumulation/recognition of the number of *taxa* of exotic naturalised plants during the last centuries is found in Table 7. The data in this table are accumulated, thus not considering the extinctions which had already occurred.

As usual, 1500 is the date chosen for starting point and the recording of 11 archeophytes is considered. The second half of the 19th century and the beginning of the 20th century are also singular due to the development of railways, which greatly contributed to the expansion of exotic flora. Also very significant was the intensification of gardening, with the introduction of many exotic ornamental species; some of which escaped from cultivation and eventually became naturalised.

From 1945 till present, the number of new introduced species known raised even more. Human population growth, industrialization, modernization of agriculture —frequently with the introduction of exotic seeds, which bring together other undesired seeds—, development of transport and intensification of transportation are responsible for the increase of exotic plants. During the last decades, a great number of new alien species, more or less naturalised, have been found and identified by many authors.

Table 7
The accumulation (and recognition) of number of *taxa* of exotic naturalised plant species during the last centuries

Year	*N.º of species*	*Increment*	*Increment . year^{-1}*
1500	11	0	
1600	11	0	
1700*	28	+17	+0.17
1800	29	+1	+0.01
1810**	68	+39	+3.90
1820	68	0	
1830	69	+1	+0.10
1840	69	0	
1850	72	+3	+0.30
1860	73	+2	+0.20
1870	77	+4	+0.40
1880	88	+11	+1.10
1890	125	+37	+3.70
1900	157	+32	+3.20
1910	181	+24	+2.40
1920	216	+35	+3.50
1930	224	+8	+0.80
1940	242	+18	+1.80
1950	386	+44	+4.40
1960	334	+48	+4.80
1970	383	+49	+4.90
1980	412	+29	+2.90
1990	442	+30	+3.00
2000	500	+58	+5.80

* 1661: Publication of Grisley´s *Viridarium lusitanum* (...).
** 1804: Publication of Brotero´s *Flora Lusitanica*.

CONCLUSIONS

The introduction of alien plants occurs deliberately —by culture for any purpose— or involuntarily, in an accidental way, mixed with desired seeds, together with goods, or by other processes. Many were introduced because of their economic interest, for food, medicine, gardening or an industrial purpose. Frequent intercontinental voyages contribute decisively to promote the global exchange of plant or animal species. Also important is the possibility of introduction of plants by migratory birds. They can, occasionally, transport seeds clasped to their paws or feathers.

Today there are about 500 exotic species of naturalised vascular plants in Portugal, according to our criteria and the available information. The majority of

Portugal's exotic species is constituted by *Dicotyledones* (more than three-quarters), including *Asteraceae*, the greatest family of invasive plants, contributing with almost one-eight of the total number of species.

More than a third of the exotic species are from the Palearctic Region (Eurasia and North Africa). America also provides more than a third of the total. South and Tropical Africa (including the Capense Region) supplies almost one-eight of the studied species. The Oceanic Region (Australia, Tasmania, New Zealand, New Caledonia), although providing a smaller number of species (only 5.8 % of the total number), have the majority of species of the genera *Eucalyptus* and *Acacia* — which are, doubtlessly, among the more dangerous invaders to our native flora.

According to our data, the number of exotic species introduced in Portugal in the last 25 years is 184; almost quadruple of the number of spontaneous species that have been identified in Portugal during the same period (about 50). So, Portugal gone from 316 subspontaneous species to 500. Considering a total of about 3200 species, the proportion of exotic naturalised species raised from 10.1 % to 15.6 %!

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